ANSWERS

TO THE

PRACTICAL QUESTIONS AND PROBLEMS

CONTAINED IN

THE FOURTEEN WEEKS COURSES

IN

Physiology, Philosophy, Astronomy, and Chemistry (Old and New Edition).

BY

J. DORMAN STEELE, PH.D., F.G.S.,

AUTHOR OF THE FOURTEEN WEEKS SERIES IN PHYSIOLOGY, PHILOSOPHY, CHEMISTRY, ASTRONOMY, AND GEOLOGY.

A. S. BARNES & COMPANY,

NEW YORK AND CHICAGO.

THE FOURTEEN WEEKS' COURSES

IN

NATURAL SCIENCE,

BY

J. DORMAN STEELE, A.M., PH.D.

Fourteen Weeks in Natural Philosophy,
Fourteen Weeks in Chemistry,
Fourteen Weeks in Descriptive Astronomy,
Fourteen Weeks in Popular Geology,
Fourteen Weeks in Human Physiology,
Fourteen Weeks in Zoology,
Fourteen Weeks in Botany,
A Key, containing Answers to the Questions and Problems in Steele's 14 Weeks' Courses,

---

A HISTORICAL SERIES,

ON THE PLAN OF STEELE'S 14 WEEKS IN THE SCIENCES.

A Brief History of the United States,
A Brief History of France,

The same publishers also offer the following standard scientific works, being more extended or difficult treatises than those of Prof. Steele, though still of Academic grade.

Peck's Ganot's Natural Philosophy,
Porter's Principles of Chemistry,
Jarvis' Physiology and Laws of Health,
Wood's Botanist and Florist,
Chambèrs' Elements of Zoology,
McIntyre's Astronomy and the Globes,
Page's Elements of Geology,

PREFACE.

This little work is designed to aid teachers who are using the Fourteen Weeks Course. The problems contained in all the books are fully, and, it is thought, accurately solved. Great pains have been taken to revise and compare them carefully. The practical questions are answered, often not in full, yet enough so to give the key to the more perfect reply. The use of the text-books is presupposed, and the statements merely supplement, or apply the fuller theories therein contained and explained. On many points there may be a difference of opinion. The author often finds in his own classes a wide diversity. On mooted questions he has merely advanced one view, leaving the subject open for the discussion of other theories. Minute directions are given, pages 71–82 inclusive, for performing a course of experiments in Chemistry. It is hoped that these may be of service to teachers who, with incomplete apparatus, are trying to illustrate to their pupils some of the principles of that science. In all cases of doubt or misunderstanding with regard to the answers or solutions, the author will be pleased to correspond with any teacher using the Series

Elmira, March 19, 1870

ANSWERS

TO THE PRACTICAL QUESTIONS

IN THE

FOURTEEN WEEKS COURSE

IN

NATURAL PHILOSOPHY.

[The bold-faced figures refer to the pages of the Philosophy; the others to the number of the Practical Questions.]

INERTIA.

26. 1. *If one is riding rapidly, in which direction will he be thrown when the horse is suddenly stopped?*

In the same direction in which he is going. He has the motion of the carriage, and his inertia carries him forward.

2. *When standing in a boat, why, as it starts, are we thrown backward?*

Because the inertia of our bodies keeps them stationary, while the boat carries our feet forward.

3. *When carrying a cup of tea, if we move or stop quickly, why is the liquid liable to spill?*

The inertia of the tea tends to keep it still or in motion, as the case may be. If we move the cup quickly, the motion is not imparted to the liquid soon enough to overcome the inertia. When, therefore, we start, the tea spills out backward; or, when we stop, it spills out forward. We understand this if we can tell why a cup of tea is more liable to spill than one of sugar.

4. *Why, when closely pursued, can we escape by dodging?*

We turn sharply. Our pursuer, ignorant of our design, cannot overcome his inertia so as to turn as quickly, and hence is carried past.

5. *Why is a carriage or sleigh, when sharply turning a corner, liable to tip over?*

Because its inertia tends to carry it directly forward. A puzzling question in this connection is—Why is a sleigh more liable to tip over than a wagon?

6. *Why, if you place a card on your finger, and on top of it a cent, can you snap the card from under the cent without knocking the latter off your finger?*

Because the friction between the card and the cent is so slight that, by a quick snap, you can overcome the inertia of the former without imparting any force to the latter.

7. *Why, after the sails of a vessel are furled, does it still continue to move; and why, after the sails are all spread, does it require some time to get under full headway?*

Its inertia must be overcome in the one case by the resistance of the air and water, and in the other by the force of the wind.

COHESION.

40. 1. *Why can we not weld a piece of copper to one of iron?*

Cohesion acts only between molecules of the same kind.

2. *Why is a bar of iron stronger than one of wood?*

Because its force of cohesion is stronger.

3. *Why is a piece of iron, when perfectly welded, stronger than before it was broken?*

By the hammering, more particles are brought within the range of cohesion.

4. *Why do drops of different liquids vary in size?*

Because they vary in cohesive force.

5. *Why, when you drop medicine, will the last few drops contained in the bottle be of a larger size than the others?*

The pressure of the liquid in the bottle is less, and therefore they form more slowly.

6. *Why are drops larger if you drop them slowly?*

There is more time for the adhesive force of the bottle to act on the liquid, and so a larger drop can be gathered.

7. *Why is a tube stronger than a rod of the same weight?*

Let a rod supported at both ends be broken in the middle. We shall see that it yields first on the circumference. So true is this, that long beams heavily loaded have been broken by a mere scratch of a pin on the lower side. The particles along the centre break last. They rather aid in the fracture, since they afford a fulcrum for the rest of the rod, acting as the long arms of a lever, to act upon. In a tube the particles at the centre are removed and all concentrated at the outside, where the first strain is felt. (See Physiology, p. 20).

8. *Why, if you melt scraps of zinc, will they form a solid mass when cooled?*

The heat overcomes, in part, the attraction of cohesion, so that the particles flow freely on each other. They now all come within the range of cohesion, so that when the metal cools they are held by that force in a solid mass.

9. *In what liquids is the force of cohesion greatest?*

Mercury, molasses, etc.

10. *Name some solids that will volatilize without melting?*

Arsenic, camphor.

ADHESION.

47. 1. *Why does cloth shrink when wet?*

By capillary attraction the water is drawn into the pores of the cloth. The fibres are thus expanded sidewise and shortened lengthwise. The cloth "*fulls up*" or thickens while it shortens and narrows (*shrinks*) in the process.

2. *Why do sailors at a boat-race wet the sails?*

The pores being full and expanded make the sails more compact. They will therefore hold the wind better.

3. *Why does not writing-paper blot?*

Because the pores are filled with size. (See Chemistry, p. 161.)

4. *Why does paint prevent wood from shrinking?*

Because it fills the pores of the wood.

5. *What is the shape of the surface of a glass of water and one of mercury?*

Ordinarily the former is concave and the latter convex.

6. *Why can we not dry a towel perfectly by wringing?*

Because of the strength of the capillary force by which the water is held in the pores of the cloth.

7. *Why will not water run through a fine sieve when the wires have been greased?*

Because the grease repels the water and so prevents capillary action.

8. *Why will camphor dissolve in alcohol and not in water?*

Because there is a strong adhesion between the alcohol and camphor, and little, if any, between the water and camphor.

9. *Why will mercury rise in zinc tubes as water does in glass tubes?*

Because of the strong adhesion between zinc and mercury.

10. *Why is it so difficult to lift a board out of water?*

Because of the adhesion between the board and the water.

11. *Why will ink spilled on the edge of a book extend further inside than if spilled on the side of the leaves?*

Because the capillary pores of the paper are short, being only the thickness of a leaf, while the capillary spaces between the leaves are longer and continuous.

12. *If you should happen to spill some ink on the edge of your book, ought you to press the leaves together?*

No. Because you would make the capillary spaces between the leaves smaller, and so the ink would rise in them further.

13. *Why can you not mix oil and water?*

Because there is no adhesion between them.

15. *Why will water wet your hand while mercury will not?*

Because in the former case there is an adhesion, in the latter none.

16 *Why is a tub or pail liable to fall to pieces if not filled with water or kept in the cellar?*

Because the moisture dries out of the pores, and the wood shrinks so as to let the hoops fall off.

17. *Name instances where the attraction of adhesion is stronger than that of cohesion.*

Wood fastened by glue will often split before the glue will yield. Paper stuck with paste, and bricks with mortar, are also examples.

GRAVITATION.

63. 1. *When an apple falls to the ground, how much does the earth rise to meet it?*

The earth falls as much less distance than the apple, as its mass is greater.

2. *What causes the sawdust in a mill-pond to collect in large masses?*

The attraction of gravity which exists between all bodies, whereby they attract each other. All bodies on the earth would tend to approach each other, and the big ones would gather all the little ones around them were they as free to move as the sawdust floating on water.

3. *Will a body weigh more in a valley than on a mountain?*

It will, because the attraction of the earth is greater.

4. *Will a pound weight fall more slowly than a two-pound weight?*

They will both fall in the same time, except the slight difference which is caused by the resistance of the air. Galileo propounded this view and proved it, in the presence of a vast crowd, by letting unequal weights fall from the leaning tower of Pisa.

5. *How deep is a well, if it takes three seconds for a stone to fall to the bottom of it?*

(2) equation of falling bodies, $d = 16t^2$; hence $d = 16 \times 3^2 = 144$ feet.

6. *Is the centre of gravity always within a body—as, for example, a ring?*

It is not. In the case given it is at the centre of the circle.

7. *If two bodies, weighing respectively* 2 *and* 4 *pounds, be connected by a rod* 24 *inches long, where is the centre of gravity?*

To be in equilibrium the weight of one multiplied by its distance from the centre of gravity must equal the weight of the other multiplied by its distance. $24 \div 6 = 4$; hence 4 in. is the unit for each pound. Therefore the centre of gravity is 8 in. from the larger weight and 16 in. from the smaller.

8. *In a ball of equal density throughout, where is the centre of gravity?*

At the centre of the ball.

9. *Why does a ball roll down hill?*

Because the line of direction falls without the small base of the ball.

10. *Why is it easier to roll a round body than a square one?*

Because the base of the ball is so much smaller, and therefore the centre of gravity need not be raised to bring the line of direction without.

11. *Why is it easier to tip over a load of hay than one of stone?*

Because the centre of gravity in a load of hay is very high, and in a load of stone very low. Therefore the centre of gravity in the former need not be raised much to bring the line of direction without the base, while in the latter it must be.

12. *Why is a pyramid the stablest of structures?*

Because the base is so broad and the centre of gravity so low. The centre of gravity must therefore be lifted very high before the line of direction will fall without the base.

13. *When a hammer is thrown, on which end does it always strike?*

On the heavy end or head, because that part is attracted by the earth more strongly.

14. *Why does a rope-walker carry a heavy balancing-pole?*

Because in this way he can easily shift his centre of gravity.

15. *What would become of a ball if dropped into a hole bored through the centre of the earth?*

In falling, it would gain a momentum which would carry it past the centre of the earth. But as it is constantly coming to a part having a slower axial revolution than itself, it would scrape on the east side of the hole until it reached the centre; beyond that point it would scrape on the west side. This friction would prevent its reaching the opposite side of the earth. It would therefore vibrate to and fro, each time through a shorter distance, until, at last, it would come to rest at the centre of the earth.

16. *Would a clock lose or gain time if carried to the top of a mountain?*

It would lose time, because the force of gravity would be lessened. At the North Pole it would gain time, because there the force of gravity would be increased.

17. *In the winter, would you raise or lower the pendulum-bob of your clock?*

I would lower it, since the cold of winter shortens the pendulum, and this movement of the bob would counteract that change.

18. *Why is the pendulum-bob always made flat?*

To decrease the friction of the air.

19. *What beats off the time in a watch?*

The vibration of the balance-wheel.

20. Is solved in the book.

21. *What should be the length of a pendulum at New York to vibrate half-seconds?*

$$(1 \text{ sec.})^2 : (1/2 \text{ sec.})^2 :: 39.1 \text{ in.} : x = 9.7 + \text{inches.}$$

To vibrate quarter-seconds?

$$(1 \text{ sec.})^2 : (1/4 \text{ sec.})^2 :: 39.1 \text{ in.} : x = 2.4 + \text{inches.}$$

To vibrate hours?

$$(1 \text{ sec.})^2 : (3600 \text{ sec.})^2 :: 39.1 \text{ in.} : x = 7997.7 \text{ miles.*}$$

* Nearly the diameter of the earth.

22. *What is the proportionate time of vibration of two pendulums,* 16 *and* 64 *inches long, respectively?*

According to the 2nd. law of pendulums,

Time of vib. of 1st : Time of vib. of 2d :: $\sqrt{16} : \sqrt{64} :: 4 : 8 :: 1 : 2$.

23. *Why, when you are standing erect against a wall, and a piece of money is placed between your feet, can you not stoop forward and pick it up?*

By leaning forward you bring the centre of gravity in front of your feet, and, as on account of the wall, you cannot throw any part of your body back to preserve the balance, you fall forward.

24. *If a tower were* 198 *feet high, with what velocity would a stone dropped from the summit, strike the ground?*

According to equation (3), $v^2 = 64\ d$. $v^2 = 64 \times 198$. $v = 112.5$ feet.

25. *A body falls in* 5 *seconds: with what velocity does it strike the ground?*

According to equation (1), $v = 32\ t$. $v = 32 \times 5$. $v = 160$ feet.

26. *How far will a body fall in* 10 *seconds?*

According to equation (2), $d = 16\ t^2$. $d = 16 \times 10^2 = 1600$ feet.

With what velocity will it strike the ground?

According to equation (1), $v = 32\ t$. $v = 32 \times 10 = 320$ feet.

27. *A body is thrown upward with a velocity of* 192 *feet the first second; to what height will it rise?*

Equation (1), $v = 32\ t$. $192 = 32\ t$. $t = 6$ sec.
" (2), $d = 16\ t^2$. $d = 16 \times 6^2 = 576$ feet.

28. *A ball is shot upward with a velocity of* 256 *feet; to what height will it rise? How long will it continue to ascend?*

Using equations (1) and (2), as in the last problem, we have:

$t = 8$ sec.

$d = 1024$ feet.

30. *Are any two plumb-lines parallel?*

They are not, since they point to the earth's centre of gravity. No two spokes of a wheel can be parallel.

31. *A stone let fall from a bridge strikes the water in three seconds. What is the height?*

Equation (2), $d = 16t^2$. $d = 16 \times 3^2 = 144$ feet.

32. *A stone falls from a church steeple in* 4 *seconds. What is the height?*

Equation (2), $d = 16t^2$. $d = 16 \times 4^2 = 256$ feet.

33. *How far would a body fall the first second at a height of* 12,000 *miles above the earth's surface?*

$(16{,}000 \text{ mi.})^2 : (4000 \text{ mi.})^2 :: 16 \text{ feet} : x = 1$ foot.

34. *A body at the surface of the earth weighs* 100 *tons: what would be its weight* 1,000 *miles above?*

$(5000 \text{ mi.})^2 : (4000 \text{ mi.})^2 :: 100 \text{ tons} : x = 64$ tons.

35. *A boy wishing to find the height of a steeple lets fly an arrow that just reaches the top and then falls to the ground. It is in the air* 6 *seconds. Required the height.*

Equation (2), $d = 16t^2$. $d = 16 \times 3^2 = 144$ ft.

36. *A cat let fall from a balloon reaches the ground in* 10 *seconds. Required the distance.*

Equation (2), $d = 16 \times 10^2 = 1600$ ft.

37. *In what time will a pendulum* 40 *feet long make a vibration?*

According to the 2nd. law of pendulums, and taking the length of a seconds pendulum as 39 in., we have:

$$1 \text{ sec.} : x :: \sqrt{39} : \sqrt{40 \times 12 \text{ in.}}$$

$$x = \sqrt{\frac{480}{39} = 12.30+}$$

$$x = 3.5+ \text{ sec.}$$

—*In what time will a pendulum* 52 *feet long make a vibration?*

$$1 \text{ sec.} : x :: \sqrt{39 \text{ in.}} : \sqrt{52 \times 12 \text{ in.}}$$

$$x = \sqrt{\frac{624}{39}} = 4 \text{ sec.}$$

—How long would it take for a pendulum one mile in length to make a vibration?

—How long would it take for a pendulum reaching from the earth to the moon to make a vibration?

—Required the length of a pendulum that would vibrate centuries. (To be solved like problem 20.*)*

38. *Two meteoric bodies in space are* 12 *miles apart. They weigh* 100 *and* 200 *lbs. respectively. If they should fall together by force of their mutual attraction, what portion of the distance would be passed over by each body?*

The distance passed over by the two bodies is inversely as their mass; hence one moves 8 miles and the other 4 miles.

39. *If a body weighs* 2,000 *lbs. upon the surface of the earth, what would it weigh* 2,000 *miles above?*

$$(6000 \text{ mi.})^2 : (4000 \text{ mi.})^2 :: 2000 \text{ lbs.} : x = 888^8/_9 \text{ lbs.}$$

How much 500 *miles above?*

$$(4500 \text{ mi.})^2 : (4000 \text{ mi.})^2 :: 2000 \text{ lbs.} : x = 1580+\text{lbs.}$$

The weight of bodies below the surface of the earth decreases as the distance increases. *Ex.: What would the above body weigh if carried* 2,000 *miles below the surface?* 1,000 lbs. —1,000 *miles below?* 1,500 lbs. (See Physics, page 5, note.)

40. *At what distance above the surface of the earth will a body fall, the first second,* 21⅓ *inches?*

A body falls 16 ft.* (192 inches) at the surface of the earth. $21^1/_3$ inches are $^1/_9$ of 192 inches: Now as the attraction is inversely as the square of the distance, the distance must be $\sqrt{9}$, or 3 times that at the surface. Hence the body must be 12,000 miles from the centre, or 8,000 miles from the surface of the earth. The problem may be solved directly by proportion, thus:

$$x^2 : 4000^2 :: 192 \text{ inches} : 21^1/_3 \text{ inches.}$$

$$x = 12000 \text{ miles (distance from the centre)}$$

$$12000 \text{ miles} - 4000 \text{ miles} = 8000 \text{ miles.}$$

41. *How far will a body fall in* 8 *seconds?* 1,024 ft.—*In the* 8*th second?* 240 ft.—*In* 10 *seconds?* 1,600 ft.—*In the* 30*th second?* 944 ft.

---

* According to the best authorities the distance is more exactly $16^1/_{12}$ ft.

MOTION.

80. 1. *Can a rifle-ball be fired through a handkerchief suspended loosely from one corner?*

Yes. The wind of the ball will lift the handkerchief somewhat.

2. *A rifle-ball* thrown *against a board standing edgewise will knock it down; the same bullet* fired *at the board will pass through it without disturbing its position. Why is this?*

The ball which is thrown has time to impart its motion to the board; the one fired has not.

3. *Why can a boy skate safely over a piece of thin ice, when, if he should pause, it would break under him directly?*

In the former case there is time for the weight of his body to be communicated to the ice; in the latter, there is not.

4. *Why can a cannon-ball be fired through a door standing ajar, without moving it on its hinges?*

Because the cannon-ball is moving so quickly that its motion is not imparted to the door.

5. *Why can we drive on the head of a hammer by simply striking the end of the handle?*

This can only be done by a quick, sharp blow which will drive the wooden handle through the socket before the motion has time to overcome the inertia of the iron head. A slow, steady blow will be imparted to the head, and so fail of the desired effect.

6. *Suppose you were on a train of cars moving at the rate of* 30 *miles per hour: with what force would you be thrown forward if the train were stopped instantly?*

With the same velocity which the train had, or 44 feet per second. Your momentum would be your weight avoirdupois multiplied by this velocity.

7. *In what line does a stone fall from the mast-head of a vessel in motion?*

In a curved line, produced by the two forces—gravity and the forward motion of the vessel.

8. *If a ball be dropped from a high tower it will strike the earth a little east of a vertical line. Why is this?*

In the daily revolution of the earth on its axis, from west to east, the top of the tower moves faster than the bottom, because it passes through a larger circle. When, therefore, the ball falls, it retains that swifter easterly motion and so strikes east of the vertical.

9. *It is stated that a suit was once brought by the driver of a light-wagon against the owner of a coach for damages caused by a collision. The complaint was that the latter was driving so fast, that when the two carriages struck, the driver of the former was thrown forward over the dash-board. Show how his own testimony proved him to have been at fault.*

When the light-wagon was suddenly stopped, its driver went on by his inertia with the same speed at which the wagon was moving. That this threw him forward over the dash-board, proves his speed to have been unusual.

10. *Suppose a train moving at the rate of* 30 *miles per hour; on the rear platform is a cannon aimed parallel with the track and in a direction precisely opposite to the motion of the car. Let a ball be discharged with the exact speed of the train, where would it fall?*

In a vertical line to the track. The two equal, opposite motions would exactly destroy each other.

11. *Suppose a steamer in rapid motion and on its deck a man jumping. Can he jump further by leaping the way the boat is moving or in the opposite direction?*

It will make no difference as long as he jumps on the deck. Should he jump off the boat, then the effect would be different.

12. *Why is a running jump longer than a standing one?*

Because the motion gained in running is retained in the jump and adds to its distance.

13. *If a stone be dropped from the mast-head of a vessel in motion, will it strike the same spot on the deck that it would if the vessel were at rest?*

It will. It falls with the motion of the vessel, and goes just as far forward while falling as the vessel does.

14. *Could a party play ball on the deck of the Great Eastern when steaming along at the rate of* 20 *miles per hour, without making allowance for the motion of the ship?*

They could. The ball would have the motion of the ship, and would move with it in whatever direction they might throw it.

15. *Since "action is equal to reaction," why is it not as dangerous to receive the "kick" of a gun as the force of the bullet?*

The striking force is as the square of the velocity; and the velocity with which the gun moves backward is as much less than that with which the bullet moves forward, as the gun is heavier than the bullet. For this reason a heavy gun will kick much less than a light one.

16. *If you were to jump from a carriage in rapid motion, would you leap directly toward the spot on which you wished to alight?*

No; because as one jumps from the wagon he has its forward motion, and will go just as far ahead, while leaping, as he would if he had remained in the carriage. He should, therefore, aim a little back of the desired alighting-place.

17. *If you wished to shoot a bird in swift flight, would you aim directly at it?*

No. The bird will fly forward while the bullet is going to it. One should, therefore, aim a little in advance.

18. *At what parts of the earth is the centrifugal force the least?*

The poles. They simply turn around in 24 hours.

19. *What causes the mud to fly from the wheels of a carriage in rapid motion?*

The centrifugal force (the inertia of the mud).

20. *What proof have we that the earth was once a soft mass?*

It is flattened at the poles. This effect is produced upon a ball of soft clay by simply revolving it on a wire axis.

21. *On a curve in a railroad, why is one track always higher than the other?*

The outer track is raised that gravity may balance the centrifugal force.

22. *What is the principle of the sling?*

The sling is whirled until a strong centrifugal force is generated; the string, the centripetal force, is then released, when the stone flies off at a tangent.

23. *The mouth of the Mississippi river is about 2½ miles further from the centre of the earth than its source. What causes its water to thus "run up hill?"*

The centrifugal force produced by the revolution of the earth on its axis tends to drive the water from the poles toward the equator. Were the earth to stand still in its daily rotation, the Gulf of Mexico would empty its waters back through the Mississippi to the northern regions.

24. *Is it action or reaction that breaks an egg when I strike it against the table?*

The reaction of the table.

25. *Was the man philosophical who said "it was not the falling so far but the stopping so quick that hurt him?"*

He was.

26. *If one person runs against another, which receives the greater blow?*

Action is equal to reaction: hence the blows must be equal.

27. *Would it vary the effect if the two persons were running in opposite directions?*

The blow would then be the *sum* of both their momenta.

If they were running in the same direction?

The blow would be equal to the *difference* of their momenta.

28. *Why can you not fire a rifle-ball around a hill?*

Because a single force always produces motion in a straight line.

29. *Why does a heavy gun "kick" less than a light one?*

See problem 15.

30. *A man on the deck of a large steamer draws a small*

boat toward him. How much does the ship move to meet the boat?

The ship moves as much less distance than the boat, as it is heavier than the boat.

31. *Suppose a string, fastened at one end, will just support a weight of* 25 *lbs. at the other. Unfasten it, and let two persons pull upon it in opposite directions. How much can each pull without breaking it?*

25 lbs. The second person, in the latter case, can pull as much as the nail did in the former.

32. *Can a man standing on a platform-scale make himself lighter by lifting up on himself?*

He cannot; because action is equal to reaction, and in an opposite direction. As much as he lifts up, so much must he press down.

33. *Why cannot a man lift himself by pulling up on his boot-straps?*

See last problem.

34. *If from a gun placed vertically, a ball were fired into perfectly still air, where would it fall?*

It would return into the gun.

35. *With what momentum would a steamboat weighing* 1,000 *tons, and moving with a velocity of* 10 *feet per second, strike against a sunken rock?*

$$1000 \text{ tons} \times 10^2 = 100{,}000 \text{ tons.}$$

36. *With what momentum would a train of cars weighing* 100 *tons, and running* 10 *miles per hour, strike against an obstacle?*

The velocity per second is $14^2/_3$ ft. 100 tons $\times (14^2/_3)^2 = 21{,}511^1/_9$ tons.

37. *What would be the comparative striking-force of two hammers, one driven with a velocity of* 20 *feet per second, and the other* 10 *feet?*

$20^2 = 400$. $10^2 = 100$. $400 : 100 :: 1 : 4$. Hence one will strike four times as hard a blow as the other. This principle is of great importance in chopping wood, splitting rails, and in all cases where percussion is concerned. The highest attainable velocity is to be sought.

—There is a story told of a man who erected a huge pair of bellows in the stern of his pleasure-boat, that he might always have a fair wind. On trial the plan failed. In which direction should he have turned the bellows?

In the manner adopted at first, of turning the nozzle toward the sails, the action of the wind against the sails and the reaction of the bellows against the boat just balanced each other. If the man had turned the nozzle backward he could have saved the reaction of the bellows to move the boat. This would, however, have been a most costly and bungling way of navigation.

—If we whirl a pail of water swiftly around with our hand, why will the water all tend to leave the centre of the pail? Why will the foam all collect in the hollow at the centre?

THE MECHANICAL POWERS.

99. 1. *Describe the rudder of a boat as a lever.*

The water is the F, the boat the W, and the hand the P. As the W is between the F and the P, it is a lever of the second class.

2. *Show the change that occurs from the second to the third class of levers, when you take hold of a ladder at one end and raise it against a building.*

At first the ground is the F at one end, the hand the P at the other, and the ladder the W hanging between; hence this is a lever of the second class. After a little, the F remaining the same, the P is applied at one end, near the F, and the ladder is the W hanging at the other; hence this is now a lever of the third class.

3. *Why is a pinch from the tongs near the hinge more severe than one near the end?*

Because in the former case the tongs are a lever of the first class—in the latter, of the third. In the first class there is a gain of power, in the third a loss.

4. *Two persons are carrying a weight of* 250 *lbs., hanging*

between them from a pole 10 *feet in length. Where should it be suspended so that one will lift only* 50 *lbs.?*

One lifts 50 lbs.; the other 200 lbs. The proportionate length of the arms of the lever should be the same as the proportionate weights—*i. e.*, 1 to 4. $10 \div 5 = 2$, the unit of measure. Hence one arm is 2 feet long and the other 8 feet long. PROOF.—(See Prob. 7, p. 10.) $50 \times 8 = 200 \times 2$. This is the substance also of the equation $P \times Pd = W \times Wd$.

5. *In a lever of the first class,* 6 *feet long, where should the F be placed so that a P of* 1 *lb. will balance a W of* 23 *lbs.?*

6 feet = 72 inches. $72 \div 24 = 3$, the unit of distance. The W must be placed 3 in. and the P 69 in. from the F. PROOF. $23 \times 3 = 1 \times 69$ (Prob. 4).

6. *What P would be required to lift a barrel of pork with a windlass whose axle is one foot in diameter and handle* 3 *ft. long?*

$$P : W : \text{rad. of axle} :: \text{rad. of wheel.}$$

$$x : 200 \text{ lbs} :: {}^1/_2 \text{ ft.} : 3 \text{ ft.}$$

$$x = 33^1/_3 \text{ lbs.}$$

7. *What sized axle, with a wheel* 6 *feet in diameter, would be required to balance a W of* 1 *ton by a P of* 100 *lbs.?*

$$P : W :: \text{rad. of axle} : \text{rad. of wheel.}$$

$$100 \text{ lbs.} : 2000 \text{ lbs.} :: x : 3 \text{ ft.}$$

$$x = {}^3/_{20} \text{ ft.} = \text{the rad.; hence the diameter} = {}^3/_{10} \text{ ft.}$$

8. *What number of movable pulleys would be required to lift a W of* 200 *lbs. with a P of* 25 *lbs.?*

$$W = P \times \text{twice the no. of mov. pulleys; hence } \frac{W}{P} = \text{twice the no. of mov. pul's.}$$

$$200 \div 25 = 8. \quad 8 \div 2 = 4 = \text{the no. required.}$$

9. *How many lbs. could be lifted with a system of* 4 *movable pulleys, and one fixed pulley to change the direction of the force, by a P of* 100 *lbs.?*

$$W = P \times \text{twice the no. of mov. pulleys.}$$

$$100 \text{ lbs.} \times (4 \times 2) = 800 \text{ lbs.} = \text{the W.}$$

10. *What weight could be lifted with a single horse-power (*33,000 *lbs.) acting on the tackle-block?* (Fig. 62.)

This block has 3 movable pulleys, and using the equation of the pulleys given in the last two problems, we have, making no allowance for friction,

$$33{,}000 \text{ lbs.} \times (3 \times 2) = 198{,}000 \text{ lbs.}$$

11. *What distance should there be between the threads of a screw, that a P of 25 lbs., acting on a handle 3 ft. long, may lift 1 ton weight?*

P : W :: Interval : Circumference.

25 lbs. : 2000 lbs. :: x : 72 in. × 3.1416.

$x = 2.83 -$ in.

12. *How high could a P of 12 lbs., moving 16 ft. along an inclined plane, lift a W of 96 lbs.?*

P : W :: height : length.

12 lbs : 96 lbs. : : x : 16 ft.

$x = 2$ ft.

13. *I wish to roll a barrel of flour into a wagon, the box of which is 4 ft. from the ground. I can lift but 24 lbs. How long a plank should I get?*

P : W :: height : length.

24 lbs : 196 lbs. :: 4 ft. : $x = 32^2/_3$ ft.

14. *The "evener" of a pair of whiffletrees is 3 ft. 6 in. long, how much must the whiffletree be moved to give one horse the advantage of ⅓ over the other?*

For every 3 lbs. one horse pulls, the other must pull 4 lbs.: hence 7 represents the proportion in which the load is to be divided. 3 ft. 6 in. = 42 inches. 42 in. ÷ 7 = 6 inches, the unit of measure. Hence one arm of the evener must be 6 in. × 3 = 18 in. long, and the other 6 in. × 4 = 24 in. long. Or, if we prefer, we may say 21 in. — 3 in. = 18 in. long, and 21 in. + 3 in. = 24 in. long. PROOF.— (See Prob. 4, p. 20.) 18 × 4 = 24 × 3 = 72.

15. *In a set of three horse whiffletrees, having an "evener" 5 ft. long, at what point should the plough-clevis be attached that the single horse may draw the same as each one of the span of horses?*

For every lb. drawn by the single horse the span should draw 2 lbs.: hence 3 represents the proportion in which the load is to be divided. 60 in. ÷ 3 = 20 in., the unit of measure. 20 in. × 1 = 20 in., and 20 in. × 2 = 40 in. Hence one arm must be 20 in., and the other 40 in. long.

To give ¼ advantage?

The single horse should draw 3 lbs. and each of the others 4 lbs.: hence the span should draw 8 lbs. 60 in. ÷ 11 = $5^5/_{11}$ in., the unit of measure. $5^5/_{11}$ in. × 3 = $16^4/_{11}$ in., and $5^5/_{11}$ in. × 8 = $43^7/_{11}$ in.

16. *What W can be lifted with a P of 100 lbs. acting on a screw having threads ¼ of an inch apart and a lever handle 4 ft. long?*

P : W :: Interval : Circumference.

100 lbs. : x :: $^1/_4$ in. : 96 in. × 3.1416.

$x = 120{,}637+$ lbs.

17. *What is the object of the big balls cast on the ends of the handle of the screw used in copying-presses?*

By their inertia and centrifugal force they make the motion more uniform and continuous.

18. *In a steelyard* 2 *ft. long, the distance from the weight-hook to the fulcrum-hook is* 2 *in. How heavy a body can be weighed with a* 1 *lb. weight at the further end?*

24 in. — 2 in. = 22 in. 1 lb. × 22 = 22 lbs. = P. 22 lbs. ÷ 2 = 11 lbs. = W.

19. *Describe the change from the* 1*st to the* 3*d class of levers, in the different ways of using a spade.*

When digging, the ground at the back of the spade is the F; the ground lifted is the W; and the hand at the other end is the P. As the W is at one end, P at the other, and the F between, this is a lever of the 1st class. When throwing dirt, the left hand at one end of the spade is the F; the dirt at the other end is the W, and the right hand between the two is the P. As the P is between the F and the W, this is a lever of the 3d class.

20. *Why are not blacksmiths' and fire tongs constructed on the same principle?*

The former are of the 1st class, as power is required: the latter of the 3d class, as rapidity only is necessary.

21. *In a lever of the* 3*d class, what W will a P of* 50 *lbs. balance, if one arm is* 12 *ft. and the other* 3 *ft. long?*

P : W :: W*d* : P*d*.

50 lbs. : x :: 12 ft. : 3 ft.

$x = 12^1/_2$ lbs.

22. *In a lever of the* 2*d class, what W will a P of* 50 *lbs. balance, with a lever* 12 *feet long and W* 3 *feet from the F?*

50 lbs. : x :: 3 ft. : 12 ft.

$x = 200$ lbs.

23. *In a lever of the 1st class, what W will a P of 50 lbs. balance. with a lever 12 ft. long and the F 3 ft. from the W?*

$$50 \text{ lbs.} : x :: 3 \text{ ft.} : 9 \text{ ft.}$$

$$x = 150 \text{ lbs.}$$

24. *In a wheel and axle, the P = 40 lbs., W = 360 lbs., diameter of axle = 8 in. Required the circumference of the wheel.*

P : W :: diameter of axle : diam. of wheel

40 lbs. : 360 lbs. :: 8 in. : x = 72 in. = 6 ft., the diameter of wheel.

6 ft. × 3.1416 = 18.85 ft., the circumference of the wheel.

25. *In a wheel and axle the P = 20 lbs., the W = 240 lbs., and the diameter of wheel = 4 ft. Required the circumference of the axle.*

$$20 \text{ lbs} : 240 \text{ lbs} :: x : 48 \text{ in.}$$

x = 4 in. (diameter of axle).

4 in. × 3.1416 = 12.56 in. (circumference).

26. *Required, in a wheel and axle, the diameter of the wheel, the diameter of the axle being 10 inches, P = 100 lbs. and W = 1 ton.*

100 lbs. : 2000 lbs. :: 10 in. : x = 200 in. = $16^2/_3$ ft.

27. *What P would be necessary to sustain a weight of 3,780 lbs., with a system of 6 movable pulleys and one rope?*

W = P × twice the no. of mov. pulleys.

3,780 lbs. = P × (6 × 2). P = 315 lbs.

28. *How many movable pulleys would be required to sustain a W of 420 lbs. with a P of 210 lbs.?*—Ans. 1.

HYDROSTATICS.

121. 1. *Why do housekeepers test the strength of lye, by trying whether or not an egg will float on it?*

The potash dissolved in the water to form lye increases the density of the liquid. When enough has been dissolved to make its specific gravity greater than that of the egg, the egg will float. This becomes, therefore, a simple means of testing the amount of potash contained in the lye.

2. *How much water will it take to make a gallon of strong brine?*

A gallon. The salt does not increase the bulk of the liquid.

3. *Why can a fat man swim easier than a lean one?*

Because muscles and bones are heavier than fat. The specific gravity of a fat man is therefore less than that of a lean one.

4. *Why does the firing of a cannon over the water sometimes bring to the surface the body of a drowned person?*

One answer is given in the Philosophy. It is probable, also, that the firing of the gun produces a partial vacuum, or in some way takes off, for an instant, a part of the pressure of the air on the water. The gases in the body would then expand and bring it to the top.

6. *If we let bubbles of air pass up through a jar of water, why will they become larger as they ascend?*

The pressure of the water is less as they near the top, and so they expand.

7. *What is the pressure on a lock-gate* 14 *feet high and* 10 *feet wide, when the lock is full of water?*

$$14 \times 10 \times 7 \times 1000 \text{ oz.} = 980{,}000 \text{ oz.} = 61{,}250 \text{ lbs.}$$

8. *Will a pail of water weigh any more with a live fish in it than without?*

If the pail were full before the fish was put in, then it will make no difference, since the fish will displace its own weight of water, which will run over. If the pail is only partially filled, then, though the fish is upheld by the buoyancy of the water, since action is equal to reaction, it adds its own weight to that of the water.

—*If a man and a boy were riding in a wagon, and, on coming to the foot of a hill, the man should take up the boy in his arms, would not that help the horse?*

9. *If the water filtering down through a rock should collect in a crevice an inch square and* 250 *feet high, opening at the bottom into a closed fissure having* 20 *square feet of surface, what would be the total pressure tending to break the rock?*

The pressure is the same on every square inch of the twenty square feet of surface.

$$\frac{250 \times 1000 \text{ oz.} \times 20 \times 144}{144} = 312{,}500 \text{ lbs.}$$

10. *Why can stones in water be moved so much more easily than on land?*

Because the water buoys up about one-half of their weight.

11. *Why is it so difficult to wade in the water where there is any current?*

Because the buoyant force of the water makes us so light that we are easily carried away from our footing.

12. *Why is a mill-dam or a canal embankment small at the top and large at the bottom?*

Because the pressure of the water increases with the depth.

13. *In digging canals and building railroads, ought not the engineer to take into consideration the curvature of the earth?*

Certainly. If he should build on a true level he would find his embankment pointing up to the stars.

14. *Is the water at the bottom of the ocean denser than that at the surface?*

The immense pressure must condense it very much at great depths. There is a certain point beyond which divers cannot penetrate.

15. *Why does the bubble of air in a spirit-level move as the instrument is turned?*

Because the air is lighter than the alcohol and rises constantly to the highest point. For this reason, also, the tube is curved upward at the centre.

16. *Why can a swimmer tread on glass and other sharp substances at the bottom of the water with little harm?*

See problem 11.

17. *Will a vessel draw more water in salt or in fresh water?*

In fresh, because its specific gravity is less.

18. *Will iron sink in mercury?*

No. It will float, like a cork on water.

19. *The water in the reservoir in New York is about 80 feet*

above the fountain in the City Hall Park. What is the pressure on a single inch of the pipe at the latter point?

$$(1000 \text{ oz.} \times 80) \div 144 = 34.7 \text{ lbs.}$$

20. *Why does cream rise on milk?*

Because it is lighter than the milk.

21. *If a ship founders at sea, to what depth will it sink?*

Until its specific gravity becomes equal to that of the water?

22. *There is a story told of a Chinese boy who accidentally dropped his ball into a deep hole, where he could not reach it. He filled the hole with water, but the ball would not quite float. He finally bethought himself of a lucky expedient, which was successful. Can you guess it?*

He put salt in the water.

23. *Which has the greater buoyant force, oil or water?*

Water, because its density is greater.

24. *What is the weight of 4 cu. ft. of cork?*

1000 oz. = the weight of 1 cu. ft. of water.
.240 = the spec. grav. of cork.
240 oz. = the weight of 1 cu. ft. of cork.
4
960 oz. = " " 4 " "
= 60 lbs.

25. *How many oz. of iron will a cubic foot of cork float in water?*

1000 oz. = weight of a cubic foot of water.
.240 = spec. grav. of cork.
240 = weight of a cubic foot of cork.
1000 oz. — 240 oz. = 760 oz., the buoyant force of a cubic foot.

26. *What is the specific gravity of a body whose weight in air is 30 grs. and in water 20 grs.?*

$$30 \text{ grs.} - 20 \text{ grs.} = 10 \text{ grs.}$$

$$30 \text{ grs.} \div 10 \text{ grs.} = 3.$$

The body is three times as heavy as water.

27. *Which is heavier, a pail of fresh water or one of salt-water?*

A pail of salt-water is as much heavier than one of fresh-water as the weight of the salt added to make the brine.

28. *The weights of a piece of syenite-rock in air and in water were* 3941.8 *grs. and* 2607.5 *grs. Find its spec. grav.* --Ans. 2.954.

29. *A specimen of green sapphire from Siam weighed in air* 21.45 *grs., and in water* 16.33 *grs. Required its spec. grav.*—Ans. 4.189.

30. *A specimen of granite weighs in air* 534.8 *grs., and in water* 334.6 *grs. What is the spec. grav.?*—Ans. 2.671.

31. *What is the bulk of a ton of iron?*

1000 oz. = weight of 1 cu. ft. of water.
7.8 = spec. grav. of iron.

7800 oz. = weight of a cu. ft. of iron.

32,000 oz. (a ton of iron) ÷ 7,800 (weight of a cu. ft.) = $4^4/_{39}$ cu. ft.

A ton of gold?

1,000 oz. = weight of a cu. ft. of water.
19.34 = spec. grav. of gold.

19,340 oz.* = weight of a cu. ft. of gold.
32,000 oz.* ÷ 19,340 oz. = 1.6, the no. of cu. ft.

A ton of copper?

1000 oz. × 8.9 = 8900 oz.
32,000 oz. ÷ 8900 oz. = 3.6 (nearly) the no. of cu. ft.

32. *What is the weight of a cube of gold* 4 *feet on each side?*

4^3 = 64, the no. of cu. ft.
19,340 oz.* (no. of oz. in 1 cu. ft.) × 64 = 77,360 lbs.

33. *A cistern is* 12 *ft. long,* 6 *ft. wide, and* 10 *ft. deep When full of water, what is the pressure on each side?*

On one side, 12 × 10 × 5 × 1000 oz. = 600,000 oz. = 37,500 lbs.

On one end, 6 × 10 × 5 × 1000 oz. = 300,000 oz. = 18.750 lbs.

34. *Why does a dead fish always float on its back?*

It has its swimming-bladder located just under the spine; and this is the lightest part of its body, and, of course, comes to the top as soon as the fish dies.

---

* In these solutions the student should notice that avoirdupois weight is used in weighing the gold. To be exact, 1,000 oz., the weight of a cu. ft. of water, should be reduced to Troy weight, and the lb. gold taken as 12 oz. Troy, when the ans. would be about 1.36 cu. ft.

36. *A vessel holds* 10 *lbs. of water: how much mercury would it contain?*

Mercury is 13.5 times heavier than water. Hence the vessel would contain 10 lbs. × 13.5 = 135 lbs. of mercury.

37. *A stone weighs* 70 *lbs. in air and* 50 *in water. What is its bulk?*

70 — 50 = 20. 20 × 16 oz. = 320 oz., the weight of water displaced.
320 oz. is $^8/_{25}$ of a cu. ft.

38. *A hollow ball of iron weighs* 10 *lbs.: what must be its bulk, to float in water?*

10 lbs. = 160 oz. As a cubic ft. of water weighs 1,000 oz., the ball must displace such a part of a cu. ft. of water as 1,000 oz. is contained times in 160 oz which is .16 cu. ft.

HYDRAULICS.

121. 1. *How much more water can be drawn from a faucet* 8 *feet, than from one* 4 *feet below the surface of the water in a cistern?*

$$v = 2\sqrt{gd}\text{; hence } v = 2\sqrt{16 \times 8} = 22.6.$$
$$v = 2\sqrt{16 \times 4} = 16.$$

Hence 6.6 cu. ft. more would flow from one than from the other in each second.

2. *How much water would be discharged per second from a short pipe having a diameter of* 4 *inches and a depth of* 48 *feet below the surface of the water?*

$4^2 = 16$. $16 \times .7854 = 12.57$ sq. inches = .087 sq. ft. (area of the tube).
$$v = 2\sqrt{gd} = 2\sqrt{16 \times 48} = 55.4$$
$$.087 \times 55.4 = 4.8 \text{ cu. ft.}$$

3. *When we pour molasses from a jug, why is the stream so much larger near the nozzle than at some distance from it?*

Because, according to the law of falling bodies, the further the molasses falls the faster it falls. The stream, therefore, becomes smaller as it moves more swiftly, until, at last, it breaks up into drops.

4. *Ought a faucet to extend into a barrel beyona the staves?*

No; because cross currents would be produced, which would interfere with the free passage of the liquid.

5. *What would be the effect if both the openings in one of the arms in Barker's Mill were on the same side?*

It would cease revolving. The pressure in each direction would then be equal, and the arms would balance.

PNEUMATICS.

148. 1. *Why must we make two openings in a barrel of cider when we tap it?*

One to let out the cider, and one to admit the air.

2. *What is the weight of* 10 *cubic feet of air?*

100 cu. in. weigh 31 grs.; hence 10 cu. ft. will weigh 31 grs. × 172.8 = .7652 lbs. avoirdupois.

3. *What is the pressure of the air on one square rod of land?*

$$272^1/_4 \times 144 \times 15 \text{ lbs.} = 588{,}060 \text{ lbs.}$$

4. *What is the pressure on a pair of Magdeburg hemispheres* 4 *in. in diameter, when the air is entirely exhausted?*

$$3.1416 \times 4^2 \times 15 \text{ lbs.} = 753.9 \text{ lbs.}$$

5. *How high a column of water can the air sustain when the barometric column stands at* 28 *in.?*

$$28 \text{ in.} \times 13^1/_2 = 31^1/_2 \text{ feet.}$$

6. *If we should add a pressure of two atmospheres, what would be the bulk of* 100 *cu. in. of common air?*

The pressure is trebled, and according to Mariotte's law, the volume will be reduced in the same proportion; hence it will be 100 cu. in. ÷ 3 = $33^1/_3$ cu. in.

7. *If, while the water is running through the siphon, we quickly lift the long arm, what will be the effect on the water in the siphon?*

It will all run back through the short arm into the vessel.

8. *If we lift the entire siphon?*

The water will all run out the long arm. The reason of this difference is, that when we lift the long arm we make it in effect the short arm, and the other arm the long one.

8. *When the mercury stands at 29½ in. in the barometer, how high above the surface of the water can we place the lower pump-valve?*

In theory, 29½ in. $\times$ 13½ = 398¼ in.; in practice, the distance is much less than this.

9. *Why cannot we raise water, by means of a siphon, to a higher level?*

There is no power in a siphon; it is only a way of guiding the flow of water to a lower level.

10. *If the air in the chamber of a fire-engine be condensed to $\frac{1}{16}$ its former bulk, what will be the pressure due to the expansive force of the air on every square inch?*—Ans. 240 lbs.

11. *What causes the bubbles to rise to the surface, when we put a lump of loaf-sugar in hot tea?*

The bubbles of air contained in the pores of the sugar rise because they are lighter than the water.

12. *To what height can a balloon ascend?*

Until its specific gravity is the same as that of the air in which it floats.

—*What weight can it lift?*

A weight equal to the difference between its own weight and that of the air it displaces.

13. *Why is the air lighter in foul and heavier in fair weather?*

This question is answered in the Philosophy. Another reason may be, that the upward currents of air partly remove the pressure in foul weather.

14. *When smoke ascends in a straight line, is it a proof of the rarity or density of the air?*

Of its density, because it shows that the smoke is much lighter than the air, and so rises immediately to the top.

15. *Why do we not feel the heavy pressure of the air on our bodies?*

Because it is equally distributed within and without our bodies. The pressure on a person of ordinary size is about 16 tons.

16. *Is a bottle empty when filled with air?*

No; because we must empty the air out before we can fill the bottle with anything else.

18. *How does the variation in the pressure of the air affect those who ascend lofty mountains?*

The outward pressure is there partly removed, and the inner pressure remaining the same, the blood is often forced through the ears, nostrils, etc. When one descends into a deep mine the conditions are reversed: the outer pressure becomes in excess of the inner; severe pain is felt in the ear-drum, and ringing noises in the head become almost intolerable. These, however, disappear after a time, where the equilibrium between the internal and external pressure is restored. It is said that Humboldt ascended where the mercurial column fell to 14 inches, and descended in a diving-bell where it rose to 45 inches—thus making a variation of 31 inches, or a difference of 31,000 lbs. pressure on his body.

—*If the atmosphere in a diving-bell were of the same density as that at the surface of the earth, how deep in the water would it be necessary to sink the bell in order to reduce the volume of the air one-half, or, in other words, for the bell to half fill with water?*—Ans. 34 feet.

How near would the bell be filled at a depth of 1,020 *feet.*—Ans. $^{29}/_{30}$.

If the bell were then raised, would the water stay in till it reached the surface?

The elasticity of the air would cause it to gradually expand and drive out the water as it rose.

ACOUSTICS.

184. 1. *Why cannot the rear of a long column of soldiers keep time to the music?*

Because it takes time for the sound-wave to pass down the column, and hence those in the rear do not hear the music as soon as those in front.

2. *Three minutes elapse between the flash and the report of a thunderbolt: how far distant is it?*

If the air is at the freezing point, the distance is

$$1090 \text{ ft.} \times 60 \times 3 = 196{,}200 \text{ ft.}$$

3. *Five seconds expire between the flash and report of a gun: what is the distance?*

$$1090 \text{ ft.} \times 5 = 5450 \text{ ft.}$$

4. *Suppose a speaking-tube should connect two villages* 10 *miles apart. How long would it take a sound to pass that distance?*

$$52{,}800 \text{ ft.} \div 1090 \text{ ft.} = 48.4 \text{ (sec.)}$$

5. *The report of a pistol-shot was returned to the ear from the face of a cliff in* 4 *seconds. How far was it?*

$$1090 \text{ ft.} \times 2 = 2180 \text{ ft.}$$

6. *What is the cause of the difference in the voice of man and woman?*

It may be a difference in the length of the vocal chords, or in the power of lengthening and shortening them; but it is not yet fully understood. The difference between a bass and tenor, as between a contralto and soprano voice, is probably that of quality only, like that between different kinds of musical instruments.

7. *What is the number of vibrations per second necessary to produce the fifth tone ofthe scale of C?*

(p. 176.) $C_1 = 128$ vibrations. G of that scale = 192 vibrations per second.

8. *What is the length of each sound-wave in that tone when the temperature is zero?*

1090 ft.— 32 ft. =1058 ft. 1058 ft. ÷ 192 = 5 ft. 6 + in. (the length of each vibration).

9. *What is the number of vibrations in the fourth tone above middle C (C_2)?*

$C_2 = 256$ vibrations. $\frac{36}{24}$ = (the proportionate no. for the 5th of the scale).

$$256 \times \frac{36}{24} = 384 \text{ (the number of vibrations per second).}$$

10. *A meteor of Nov.* 13, 1868, *is said to have exploded at a height of* 60 *miles: what time would have been necessary for its sound to reach the earth?*

5280 ft. × 60 = 316,800 ft.

316,800 ft. ÷ 1090 ft. = 290 (sec.) = 4 min. 50 sec.

11. *A stone was let fall into a well, and in* 4 *seconds was heard to strike the bottom. How deep was the well?*

(See p. 48.) $d = 16 \times t^2$. $d = 16 \times 4^2 = 256$ ft.

12. *What time would it require for a sound to travel* 5 *miles in the still water of a lake?*

5280 ft. × 5 = 26,400 ft.

26,400 ft. ÷ 4700 ft. = 5.6 (sec.)

13. *How much louder will be the report of a gun to an observer at a distance of* 20 *rods than to one at half a mile?*

160 rods are 8 times 20 rods. The intensity of the sound is inversely as the square of the distance = $^1/_{64}$. Hence the sound is 64 times louder to the observer at 20 rods that to the one at half a mile.

14. *Does sound travel faster at the foot or at the top of a mountain?*

The density and elasticity of the air vary in the same proportion; hence if the temperature were the same on the top of a mountain that it is at the foot, the velocity of sound would be the same, but as it is always colder, the velocity is less.

15. *Why is an echo weaker than the original sound?*

Because the intensity of the sound-wave is weakened at each reflection.

16. *Why is it so fatiguing to talk through a speaking-trumpet?*

Because so much more air must be set in motion by the vocal chords. The column of air in the resonant cavity of the throat is re-enforced by all the air in the trumpet.

When we hear a goblet or a wine-glass struck with the blade of a knife, we can distinguish three sounds, the fundamental and two harmonics.*

* Is not the ear the most perfect sense? A needlewoman will distinguish by the sound, whether it is silk or cotton that is torn. Blind people recognize

OPTICS.

224. 1. *Why is a secondary bow fainter than the primary?*

The primary is produced by one reflection and two refractions; the secondary, by two reflections and two refractions. The additional reflection weakens the ray.

Why are the colors reversed?

We can understand this by looking at Fig. 159. In one bow we see that the rays enter the drops at the top, and are refracted at the *bottom* to the eye; in the other, that the rays enter at the bottom, and are refracted at the *top* to the eye.

2. *Why can we not see around a house or through a bent tube?*

The rays of light move in straight lines.

3. *What color would a painter use if he wished to represent an opening into a dark cellar?*

Black.

4. *Is black a color?*

No; it is the absence of color.

Is white?

Yes; it is the presence of all color—*i. e.*, it is the compound effect produced on the brain by seven different impressions.

5. *By holding an object nearer a light, will it increase or diminish the size of the shadow?*

It will increase it, because more rays are intercepted.

7. *Where do we see a rainbow in the morning?*

In the west.

---

the age of persons by their voices. An architect, comparing the length of two lines separated from each other, if he estimate within the 30th part, we deem very accurate; but a musician would not be considered very precise who only estimated within a quarter of a note. ($128 \div 30 = 4$, nearly.) In a large orchestra, the leader will distinguish each note of each instrument. We recognize an old-time friend by the sound of his voice, when the other senses utterly fail to recall him. The musician carries in his ear the idea of the musical key and every tune in the scale, though he is constantly hearing a multitude of sounds. A tune once learned will be remembered when the words of the song are forgotten. Prof. Pepper tells us that he tuned a fork which corresponded to 64,000 vibrations per second. The first harmonic is produced by one-half the whole cord, the second by one-third, &c.

8. *Can any two spectators see the same rainbow?*

They cannot, because no two persons can be at the right angle to get the same color from a drop.

9. *Why, when the drops of water are falling through the air, does the bow appear stationary?*

Because the drops succeed each other so rapidly that they keep a constant impression on the retina.

10. *Why can a cat see in the night?*

Because the pupils of its eyes are larger, and so admit more light.

Why cannot an owl see in daylight?

The pupils of its eyes are large enough to admit of clear vision in the night, but they cannot be contracted, and so in daylight the owl becomes dazzled with the excess of light received.

12. *Why are we blinded when we pass quickly from a dark into a brilliantly lighted room?*

The pupils of our eyes admit too much light, but they soon contract to the proper dimensions, and we can then see distinctly. When we pass out from a lighted room into the dark street, the conditions are reversed.

13. *If the light on a distant planet is only* $\frac{1}{100}$ *that which we receive, how does its distance from the sun compare with ours?*

As the light is inversely as the square of the distance, the distance is $\sqrt{100} = 10$ times greater than ours.

14. *If when I sit* 6 *feet from a candle I receive a certain amount of light, how much will I diminish it if I sit back* 6 *feet further?*

As my distance from the light is doubled, the light is inversely as 2^2, or only $\frac{1}{4}$ as bright.

15. *Why do drops of rain, in falling, appear like liquid threads?*

The impression the drop makes on the retina remains until the drop reaches the ground.

16. *Why does a towel turn darker when wet?*

More of the light is transmitted, and less reflected. We see this illustrated in greasing a bit of paper. It becomes semi-transparent because more light passes through it, but looks darker itself because less light is reflected to the eye.

17. *Does color exist in the object or in the mind of the observer?*

In the mind. Color in the object can be only a peculiar property whereby a body absorbs some colors, and reflects or transmits others.

18. *Why is lather opaque, while air and a solution of soap are each transparent?*

By repeated reflections and refractions in passing through the unhomogeneous mass of lather, the rays are weakened. The principle is the same as that of deadening floors with tan-bark. (Phil., p. 161.)

19. *Why does it whiten molasses candy to pull it?*

Water is given up both in cooking and pulling. This causes more light to be reflected (Q. 16), while the crystals formed, especially on the surface, hide the impurities.

20. *Why does plastering become lighter in color as it dries?*

Because, as the water evaporates, the mortar transmits less light, and reflects more light to the eye.

21. *Why does a photographer use a kerosene oil-lamp in the "dark-room?"*

Kerosene oil-flame emits only heat and color, but no actinic rays. Some "dark-rooms" are lighted with yellow glass windows.

22. *Is the common division of colors into "cold" and "warm" verified in philosophy?*

Yes; red contains more heat than violet.

23. *Why is the image on the camera, Fig. 167, inverted?*

The rays cross each other at the focus of the double convex lens

24. *Why is the second image seen in the mirror, Fig. 134, brighter than the first?*

The first is formed by reflection from the glass, and the second from the mercury. As the latter is a better reflector, the second image will be brighter. Each image after that will be weakened by the repeated reflection.

27. *Which can be heard at the greater distance, noise or music?*

Other things being equal, music will penetrate much further than noise. Boatmen call to each other, at a distance, in a musical tone. A band is heard above the noise of the rabble. It seems to be a wise arrangement of Providence that all harsh, discordant noises should perish as soon as possible, and only harmonious ones survive.

28. *Why are some bodies brilliant, and others dull?*

Some reflect the light better than others. A piece of stone coal lying in the sun's rays will shine so brilliantly that one will cease to see the coal at all, and will judge it to be a bright metal.

29. *Why can a carpenter looking along the edge of a board tell whether it is straight?*

If the edge is straight, the light will be reflected uniformly to his eye from the whole length. Any uneven places will make dark and light spots.

30. *Why can we not see out of the window after we have lighted the lamp in the evening?*

The glass reflects the light of the lamp back to our eyes, and they adapt themselves to the increased amount.

31. *Why does a ground-glass globe soften the light?*

It scatters the rays.

32. *Why can we not see through ground-glass or painted windows?*

They transmit the light irregularly to the eye, and not uniformly, like a transparent body.

33. *Why does the moon's surface appear flat?*

Because it is so distant that the eye cannot detect the difference between the distance of the centre and the circumference.

34. *Why can we see further with a telescope than with the naked eye?*

Because it furnishes us more light with which to see a distant object.

35. *Why is not snow transparent, like ice?*

Because it is unhomogeneous. See problem 18.

36. *Are there rays in the sunbeam which we cannot see?*

We cannot see the heat or the chemical rays.

37. (1) *Make two marks on a sheet of white paper, at a distance of about three inches from each other. Then closing one eye and looking steadily at one mark (though we can see both), move the paper toward the eye. A point will be reached where the eye can perceive only one of the marks; on coming nearer, both will be seen again.*

38. (2) *Prick with a pin, through a card-board, two holes closer together than the diameter of the pupil of the eye. Holding the card pretty near the eyes, look through these holes at the head of a pin. There will seem to be two pin-heads.*

39. (3) *Press the finger on one eyeball and we shall see objects double.*

Since an impression is made on the retina of each eye, it would seem that we ought always to see objects double. The nerves from both eyes are so joined, however, before they reach the brain, that this effect is avoided. If, now, we cause the image on the retina to be made on parts of the eye which do not correspond to each other, we shall obtain a double image.

40. *Why is a rainbow in the morning a sign of foul, and in the evening of fair weather?*

In the morning it indicates a formation of clouds when the temperature is rising, and therefore shows a determination to moisture. In the evening it indicates a clearing away when the temperature is falling, and hence shows a determination to dryness.

41. *Why is a red, lowering sky in the morning a sign of rain, and a brilliant red sky at night, of fair weather?*

42. *Why does a distant light, in the night, seem like a star?*

43. *Why does a bright light, in the night, seem so much nearer than it is?*

44. *Why does a ray of light, passed through a small hole, of any shape, in a card, make a round, bright spot?*

45. *Why are these spots crescent-shaped during an eclipse?*

46. *What color predominates in artificial lights?*

Yellow.

47. *Why does yellow seem white, and blue green, when seen by artificial light?*

Because the white takes on, in the yellow rays, a yellow hue, and the yellow added to the blue gives a green, hence there is no white for comparison. So, also, dark blue becomes purple, and red has a tawny hue. Magnesium light possesses all the colors of the spectrum, and hence all objects retain their natural appearance when illuminated by it.

48. *Why are we not sensible of darkness when we wink?*

Because the impression of the light is retained upon the retina during the brief interval of darkness.

HEAT.

258. 1. *Why will one's hand, on a frosty morning, freeze to a metallic door-knob sooner than to one of porcelain?*

Because the metal is a better conductor of heat than the porcelain, and hence conducts the heat from the hand faster.

2. *Why does a piece of bread toasting curl up on the side toward the fire?*

The water being expelled from the pores on that side causes the bread to shrink.

3. *Why do double windows protect from the cold?*

The non-conducting air enclosed between the window-panes keeps in the heat and keeps out the cold.

4. *Why do furnace-men wear flannel shirts in summer to keep cool, and in winter to keep warm?*

In summer the non-conducting flannel keeps out the furnace-heat, and in the winter keeps in the body-heat.

5. *Why do we blow our hands to make them warm, and our soup to make it cool?*

Our breath is warmer than our hands, but cooler than our soup.

6. *Why does snow protect the grass?*

The air enclosed between the flakes of snow is a non-conductor. No infant in its cradle is tucked in more tenderly than the coverlet of snow about the humble grass that nestles down for its winter's nap on the bosom of mother Earth.

7. *Why does water "boil away" more rapidly on some days than on others?*

Because the atmospheric pressure varies.

8. *What causes the crackling sound in a stove, when a fire is lighted?*

The expansion of the iron by the heat.

9. *Why is the tone of a piano higher in a cold room than in a warm one?*

The steel wires lengthen in a warm room, and so lower the tone.

10. *Ought an inkstand to have a large or a small mouth?*

A small mouth, to prevent evaporation.

11. *Why is there a space left between the ends of the rails on a railroad track?*

To allow room for the expansion and contraction of the rails with the changes in temperature.

12. *Why is a person liable to take cold when his clothes are damp?*

The water which evaporates from his clothes, in drying, absorbs heat from his body.

13. *What is the theory of corn-popping?*

The air in the cells of the corn expands by the heat and bursts the outer coating of the corn.

14. *Could vacuum-pans be employed in cooking?*

They could not, because the heat would not be sufficient to cook the food.

15. *Why does the air feel so chilly, in the spring, when snow and ice are melting?*

When the ice is passing into the liquid state, it absorbs heat from all surrounding objects.

16. *Why, in freezing ice-cream, do we put the ice in a wooden vessel, and the cream in a tin one?*

The non-conducting wooden vessel prevents the ice from absorbing heat from the external air, and the conducting tin vessel enables it to absorb the heat from the cream.

17. *Why does the temperature generally moderate when the snow falls?*

The vapor passing into the solid form gives off heat.

19. *Why does sprinkling a floor with water cool the air?*

The water turning to vapor absorbs heat.

20. *How low a degree of temperature can be reached with a mercurial thermometer?*

Nearly to the freezing point of mercury, $-39°$ F.

21. *If the temperature be 70° F., what is it C.?*

$$70° - 32° = 38°. \quad 38 \div 1.8 = 21.1° \text{ C.}$$

—*If the temperature be 70° C., what is it F.?*

$$70° \times 1.8 = 126°. \quad 126° + 32° = 158° \text{ F.}$$

22. *Will dew form on an iron bridge?*

Yes, because iron is a good radiator.

On a wooden bridge?

Not so readily, because wood is a poorer radiator.

23. *Why will not corn pop when very dry?*

The pores shrink, and the corn becomes compact; only porous, tender-celled corn will pop.

24. *The interior of the earth being a melted mass, why do we get the coldest water from a deep well?*

The well extends below the influence of the sun, and not deep enough to reach the internal heat of the earth.

25. *Ought the bottom of a tea-kettle to be polished?*

No, since a polished surface would reflect the heat. We need a black, rough, sooty surface to absorb the heat rapidly.

26. *Which boils the sooner, milk or water?*

Milk, because it is so adhesive that the bubbles of steam which are formed at the bottom of the dish cannot easily escape. They therefore pile up on top of each other, and the milk boils over readily.

27. *Is it economy to keep our stoves highly polished?*

The stove-blacking used is a good radiator, but the surface should not be highly polished, as that hinders radiation.

28. *If a thermometer be held in a running stream, will it indicate the same temperature that it would in a pailful of the same water?*

It will. For the same reason that a thermometer, in the wind, will indicate the same temperature as in the still air, although the former seems to us much colder.

29. *Which makes the better holder, woollen or cotton?*

Woollen, because it is so poor a conductor of heat.

30. *Which will give out the more heat, a plain stove or one with ornamental designs?*

The latter, since it has more radiating surface

31. *Does dew fall?*

No; it forms directly where it is found. The vapor merely collects on the cold surface.

32. *What causes the "sweating" of a pitcher?*

The vapor of the air condenses on the cold pitcher. It is often a sign of rain, since it shows that the air is full of vapor easily deposited.

33. *Why is evaporation hastened in a vacuum?*

Because the pressure of the air is removed.

34. *Does stirring the ground around plants aid in the deposition of dew?*

It does, since it facilitates radiation.

35. *Why does the snow at the foot of a tree melt sooner than that in the open field?*

The dark-colored tree absorbs the sun's heat, and then radiates it out in slow, dull waves, which are absorbed by the snow.

36. *Why is the opening in a chimney made to decrease in size from bottom to top?*

Because as the heated air rises it cools and shrinks. If the chimney did not diminish in size correspondingly, currents of cold air would set down from the top.

37. *Will tea keep hot longer in a bright or in a dull tea-pot?*

In a bright one, since a polished surface retards radiation.

39. *Why is one's breath visible on a cold day?*

The vapor in the breath is condensed by the cold air.

41. *Why is light-colored clothing cooler in summer and warmer in winter than dark-colored?*

It does not absorb the heat of the sun in summer, nor the heat of the body in winter; dark-colored clothing has neither of these desirable properties.

42. *How does the heat at two feet from the fire compare with that at four feet?*

$$2^2 : 4^2 :: 1 : 4.$$

Hence it is four times greater.

43. *Why does the frost remain later in the morning upon some objects than upon others?*

Those objects which are good absorbers of heat soon become warm enough to melt the frost upon them: poor absorbers heat more slowly, and so retain the frost longer.

44. *Is it economy to use green wood?*

It is not, since the sap must be changed to vapor, and water in turning to vapor renders latent over 900° of heat. This is, of course, entirely lost to the consumer.

45. *Why does not green wood snap?*

The pores are filled with water instead of air. The water does not expand rapidly enough to burst off the coverings of the cells, and so simply oozes out gradually and is vaporized.

46. *Why will a piece of metal dropped into a glass or porcelain dish of boiling water facilitate the ebullition?*

The rougher surface of the metal aids in the formation and disentanglement of the steam-bubbles. The bubbles cling longer to a smooth than to a rough surface. This is one cause of that bumping sound often noticed when liquids are boiling in glass dishes.

47. *Which can be ignited the more easily with a burning-glass, black or white paper?*

Black paper, since it is a much better absorber of heat.

48. *Why does the air feel colder on a windy day?*

Because fresh portions of cold air are brought constantly in contact with our bodies.

49. *In what did the miracle of Gideon's fleece consist?*

The hard threshing-floor was a better conductor of heat than the porous fleece; hence, naturally, the dew would collect on the latter more readily than on the former. In the miracle, the conditions remaining the same, the results in the two cases were reversed. (Judges, vi. 37-40.)

50. *Could a burning-lens be made of ice?*

Burning-lenses have been made of that material. The rays have no heating power until the waves of ether are stopped. They do not elevate the temperature of the medium through which they pass.

51. *Why is an iceberg frequently enveloped by a fog?*

The moisture of the air is condensed upon its cold surface.

52. *Would dew gather more freely on a rusty stove than on a bright kettle?*

It would, because the rusty iron surface is a good radiator.

53. *Why is a clear night colder than a cloudy one?*

On a cloudy night the clouds reflect the radiated heat of the earth back again, and thus act as a blanket to keep the earth warm. On such a night there can be no frost or dew. On a clear night, the heat which the earth radiates passes out freely into space, and thus the earth cools rapidly.

54. *Why is no dew formed on cloudy nights?*

See last question.

55. *Water boiled at a certain place at* 200° *F.: what was the height above the sea?*

56. *On Mont Blanc boiling water is only* 84° *C.: what is the height?*

57. *Why do we use a longer tube of mercury for a barometer than a thermometer?*

58. *Which is the hottest part of a room?*

59. *Why is it hotter above a flame than at the side?*

60. *What is the difference between dew and rain?*

61. *Why will ashes keep fire overnight?*

62. *If a pane of glass and a similar plate of polished steel were laid upon the ground, in the night, upon which would the dew form most abundantly?*

The glass is a poor conductor of heat, and so would absorb little heat from the earth, while the metal would absorb it freely; the glass is a better radiator than the polished metal, and thus would become drenched with dew, while the metallic surface would be scarcely dimmed.

63. *Why is there but little dew formed in cities?*

64. *Is an abundant dew a sign of rain?*

It is. See question 32.

65. *Is there any dew formed out at sea?*

66. *Why are gardens in a valley often touched with frost, while those on the hills escape unharmed?*

The cold air settles into the valley, while the warm air rises to the hills.

67. *How are hailstones formed?*

There are two separate currents of air, one hot and charged with moisture, the other cold. The former is displaced by the latter and driven up in the atmosphere. There its vapor is condensed at the centre of the cloud into snow, and at the extremities into ice-cold water. In this cloud there is a whirling motion which collects the snow into little balls, each of which is the nucleus of a hailstone. Each of these is carried, alternately, by the whirling currents, into the snow-cloud at the centre, and the ice-cold water outside. Both give it a coating, one of snow-like, spongy ice, and the other of transparent ice. This is done with great rapidity, until at last its weight overcomes the violent upward motion which sustains it in the air, and the hailstone falls to the ground. When a hailstone is carefully examined we can see this nucleus, and these concentric layers, like the coats of an onion.*

68. *Why do we have hailstorms in summer, and not in winter?*

The small spongy hail or sleet of winter has the same origin as hailstones in summer, but there is not enough vapor in the cold air to give them the size of summer hailstones.

69. *Is the sweating of a pitcher a sign of rain?*

See question 32.

70. *Where should ice be applied, to cool water?*

At the top, because cold water falls.

71. *Why is evaporation hastened in a vacuum?*

Because the pressure of the air is removed.

72. *Is a dusty boot hotter to the foot than a polished one?*

It is, because it is a better absorber of heat.

* The above theory is that advanced by Prof. Loomis, in his "Treatise on Meteorology." The teacher will find this work invaluable on all meteorological questions.

(Key, p. 34, Prob. 11.) The method adopted in solving this problem is merely the rough one in common use, and gives only an approximate result. If an exact answer is desired, we should take in account the time required for the sound to reach the ear. The following method may be employed:

$$x = \text{No. sec. for stone to fall.}$$
$$4 - x = \text{" " sound to reach the ear.}$$
$$16x^2 = (4 - x)1090.$$
$$16x^2 = 4360 - 1090x.$$

From this, by completing the square, we have

$$x = 3.7892 + \text{ seconds.}$$

Then the equation (2) $d = 16t^2$ gives the depth.

$$d = 16(3.7892+)^2 = 229 \text{ ft. and } 8.795 \text{ in.,}$$

which is the answer exact within a small fraction.

A second method (more exact)—

$$d = \text{depth of the well} = 16t^2.$$
$$t = \sqrt{\frac{d}{16}} = \frac{1}{4}\sqrt{d}.$$
$$4 - \tfrac{1}{4}\sqrt{d} = \text{No. of sec. for sound to reach the ear.}$$
$$(4 - \tfrac{1}{4}\sqrt{d})1090 = 4360 - \tfrac{1090}{4}\sqrt{d}.$$
$$4360 - \tfrac{1090}{4}\sqrt{d} = d.$$
$$\tfrac{1090}{4}\sqrt{d} = 4360 - d.$$
$$d^2 - \tfrac{331905}{4}d = -19009600.$$
$$d = 229.73 + \text{ feet.}$$

ANSWERS

TO THE PRACTICAL QUESTIONS,

AND SOLUTIONS OF THE PROBLEMS,

IN THE

FOURTEEN WEEKS COURSE

IN

CHEMISTRY.

[The bold-faced figures refer to the page of the Chemistry; the others to the number of the Practical Questions.]

1. *Is it likely that all the elements have been discovered?*

It is not, since several have been found lately by means of spectrum analysis. The ancients held that there are but four elements—earth, water, air, and fire; the first representing the solid form of matter, the second the liquid, the third the gaseous, and the fourth the force which changes matter from one form to another. Few of the sixty-five elements are common. Those italicised, in the table on page 14, are rare. The remarkable phenomena of allotropism would seem to indicate that, perhaps, what we now consider distinct elements may be only allotropic states of the same element. Indeed, it is possible to conceive that all substances are only allotropic forms of one universal essence. In the present state of chemistry this view cannot be proved, and is only a speculation as to what may be discovered in the future.

2. *What is the origin of the term "gas?"*

This word was first used in the 17th century. Explosions, strange noises, and lurid flames had been seen in mines, caves, &c. The alchemists, whose earthen vessels often exploded with terrific violence, commenced their experiments with prayer, and placed on their crucibles the sign of the cross—hence the name crucible from *crux* (gen. *crucis*), a cross. All these manifestations were supposed to be the work of invisible spirits, to whom the name *gahst* or *geist*, a ghost or spirit, was applied. The miners were in special danger from these unseen adversaries, and it is said that their church service contained the petition, "From geists, good Lord, deliver us!" The names—spirits of wine, nitre, &c., are a relic of the superstitions of that time.

3. *If the air were pure O, what bodies would escape combustion in a conflagration?*

The stones, mortar, &c., which being already combined with O and other elements, and having their chemical affinities satisfied, are hence termed "burnt bodies."

4. *Why will lime added to hard water often soften it?*

The lime will combine with the free carbonic acid absorbed by the water. This renders the water incapable of holding in solution as much carbonate of lime as before, which is then precipitated, and the water thus partly softened.

5. *Why will stirring a wood fire quicken the flame, but a coal fire, will deaden it?*

Stirring a fire lets in more O, which quickens a wood fire but reduces the temperature of a coal fire below the point of union between O and coal. It is really based on the fact that a higher temperature is requisite to burn coal than wood.

6. *Why does blowing on a fire quicken the flame, but on a lamp extinguishes it?*

The same principle applies as in the last question. In addition, the force of our breath often drives the flame off the wick mechanically.

7. *Why will oyster-shells placed on the grate of a coal fire prevent the formation of clinkers?*

The lime of the shells forms a flux with the silicates contained in the coal, and thus renders them more fusible.

8. *What alkali abounds in sea-weed?*

Soda.

9. *What alkali abounds in land-plants?*

Potash. The former salt is a constituent of sea-water, and the latter of rocks which decompose to form the soil.

10. *How is lime-water made from oyster-shells?*

The oyster-shells, in burning, lose their CO_2. This leaves the lime uncombined; hence it readily dissolves in water.

11. *What other tests of lead than HS?*

KI gives a yellow precipitate, NH_4S a black, and SO_3 a white one.

12. *Will not lime lose its beneficial effect upon soil after a time?*

Lime acts in various ways to improve the fertility of a soil. It corrects its acidity, aids in the decomposition of the rocky constituents, hastens the decay of the humus, and also makes the soil more porous. It does not, however, benefit the growing plant directly, but works up other materials in the soil. It therefore loses its effect after a time. The Belgian farmers have a proverb:

"Much lime and no manure
Make farm and farmer poorer."

13. *What is the derivation of the term zinc?*

The name is probably derived from the German *zinken*, signifying "nails," and is applied to this metal on account of its frequently forming pointed particles somewhat resembling nails, when melted and suddenly poured into water. (Griffiths.)

14. *What is the action of permanganate of potash* (chameleon mineral) *as a disinfectant?*

It gives up its O to oxydize the organic impurities of the water in which they collect.

15. *Do all fish die when taken out of the water?*

No. Some fish have an apparatus for moistening their gills. They can therefore crawl about in the grass, and even migrate from one stream to another.

16. *What proof have we that H is a metal?*

Besides that given in the Chemistry, the "sodium amalgam" is thought by some to be an additional proof. Heat moderately in a test-tube a little mercury with a grain or two of sodium. The two metals will combine, forming a pasty amalgam. When cold, pour over it a solution of sal-ammoniac. The amalgam will immediately swell up to eight or ten times its original bulk, *retaining, however, its metallic lustre.* It is thought that H is the metal which puffs out and combines with the mercury, since otherwise we would be compelled to suppose that NH_4 is a metallic element, instead of a compound radical, as is generally believed.

17. *Why does not frozen meat spoil?*

The cold protects from chemical change. The bodies of mammoths have been found in the frozen soil of Arctic regions so perfectly preserved that the dogs ate the flesh. How long the animals had been there we cannot tell, but certainly for ages. In 1861 the mangled remains of three guides were found at the foot of the Glacier de Boissons, in Switzerland. They had been lost in an avalanche on the grand plateau of Mont Blanc, forty-one years before.

18. *Give an illustration of the effect of food on the disposition of animals.*

Bears which feed on acorns are mild and tractable, while those of the polar regions, which live on flesh alone, are fierce and ungovernable.

19. *Compare the chemical action of the animal with that of the plant.*

The animal lives on *organized* materials, taking up O and evolving CO_2, and other oxydized products. The plant lives on *unorganized* materials, CO_2, HO, NH_3, and salts, organizing them and evolving O. The function of the animal is oxydation; that of the plant, reduction. The food of the plant serves merely to increase its bulk; that of the animal is employed to replace the material worn out by the active operations of life. The animal obtains the energy necessary for its existence from the oxydation of its own body; the plant obtains the energy necessary for the organization of its food directly from the sun.

20. *Show how man is made mainly of condensed air.*

Science has demonstrated that man is formed of condensed air; that he lives on condensed as well as uncondensed air, and clothes himself in condensed air, that he prepares his food by means of condensed air, and by means of the same agent moves the heaviest weights with the velocity of the wind. But the strangest part of the matter is, that thousands of these tabernacles formed of condensed air, and going on two legs, occasionally, and on account of the production and supply of these forms of condensed air which they require for food and clothing, or on account of their honor and power, destroy each other in pitched battles by means of condensed air.—LIEBIG.

19. 1. *In making O from chlorate of potash ($KO.ClO_5$), how much can be obtained from two pounds of the salt?*

6O=48=equivalent of constituent.
$KO.ClO_5$=122.5= " " compound.
x=weight of constituent.
2 lbs.= " " compound.

$$6O : KO.ClO_5 :: x : 2 \text{ lbs.}$$
$$48 : 122.5 :: x : 2 \text{ lbs.}$$
$$x=\frac{192}{245}=.78 \text{ lb. (O).}$$

2. *In making H, zinc is used. How much sulphate of zinc ($ZnO.SO_3+7HO$) will be formed from 2 lbs. of the metal?*

Zn = 32.5 = equivalent of the constituent.
$ZnO.SO_3+7HO$ = 143.6 = " " compound.
2 lbs. = weight of the constituent.
x = " " compound.

$$Zn : (ZnO.SO_3+7HO) :: 2 \text{ lbs.} : x.$$
$$32.5 : 143.6 :: 2 \text{ lb.} : x.$$
$$x=8.8 \text{ lbs. (white vitriol, sulp. zinc).}$$

3. *How much SO_3 will be required to make* 50 *lbs. sulphate of iron ($FeO.SO_3+7HO$)?*

$SO_3 = 40 =$ equivalent of the constituent.
$FeO.SO_3+7HO = 139 =$ " " compound.
$x =$ weight of the constituent.
50 lbs. = " " compound.
$SO_3 : (FeO.SO_3+7HO) :: x : 50$ lbs.
$40 : 139 :: x : 50$ lbs.
$x = 14\frac{54}{139}$ lbs. (SO_3.)

4. *The equivalent of the chloride of sodium (salt) is* 58.5. *In* 10 *lbs. there are* $6\frac{8}{117}$ *lbs. of chlorine: what is the equivalent of Cl?*

$x =$ equivalent of the given constituent.
$58.5 =$ " " " compound.
$6\frac{8}{117}$ lbs. = weight of the given constituent.
10 lbs. = " " " compound.
$x : 58.5 :: 6\frac{8}{117}$ lbs. : 10 lbs.
$x = 35.5$.

5. *In* 20 *grains of bromide of potassium there are* $6\frac{66}{119}$ *grains of potassium: the equivalent of potassium being* 39, *what is the equivalent of the bromide of potassium?*

$39 =$ equivalent of the given constituent.
$x =$ " " " compound.
$6\frac{66}{119}$ grs. = weight of the given constituent.
20 grs. = " " " compound.
$39 : x :: 6\frac{66}{119}$ grs. : 20 grs.
$x = 119$.

6. *In* 14 *lbs. of iron-rust* (Fe_2O_3) *how much O?*

$3O = 24 =$ equivalent of the given constituent.
$Fe_2O_3 = 80 =$ " " " compound.
$x =$ weight of the given constituent.
14 lbs. = " " " compound.
$24 : 80 :: x : 14$ lbs.
$x = 4\ {}^1/_5$ lbs. (O).

7. *In* 20 *lbs. of glass* ($NaO.SiO_2+CaO.SiO_2$) *how many lbs. of sand* (SiO_2)?

$2\ SiO_2 = 60 =$ equivalent of the given constituent.
$(NaO.SiO_2+CaO.SiO_2) = 119 =$ " " " compound.
$x =$ weight of the given constituent.
20 lbs. = " " " compound.
$60 : 119 :: x : 20$ lbs.
$x = 10\frac{10}{119}$ lbs. (SiO_2)

8. *In a* 25 *lb. sack of salt (NaCl) how many lbs. of the metal sodium?*

$Na = 23 =$ equivalent of the constituent.
$NaCl = 58.5 =$ " " compound.
$x =$ weight of the constituent.
25 lbs. $=$ " " compound.
$23 : 58.5 :: x : 25$ lbs.
$x = 9\frac{97}{117}$ lbs. (Na).

229. 5. *What weight of O is contained in* 60 *grs. of* $KO.ClO_5$*?*

$O = 48 =$ equivalent of constituent.
$KO.ClO_5 = 122^1/_2 =$ " " compound.
$x =$ weight of constituent.
60 grs. $=$ " " compound.
$48 : 122^1/_2 :: x : 60$ grs.
$x = 23\frac{25}{49}$ grs. (O).

6. *How much KCl will be formed in preparing* 80 *grs. of O?*

First find how much $KO.ClO_5$ will be required to make 80 grs. of O, and then subtract the 80 grs. of O from the amount, and the remainder will be the KCl. The constituent and compound are the same as in the last problem.

$48 : 122\,^1/_2 :: 80$ grs. $: x$
$x = 204.16$ grs.
204.16 grs. — 80 grs. = 124.16 grs. (KCl).

7. *How much H can be made from* 10 *lbs. of Zn?*

First find how much ZnO 10 lbs. of Zn will form; second, subtract the 10 lbs. of Zn, and the remainder is the O which came from the water. This O formed $\frac{8}{9}$ of the water, and the remaining $\frac{1}{9}$ is the H set free.

$Zn = 32.5 =$ equivalent of the constituent.
$ZnO = 40.5 =$ " " compound.
10 lbs. $=$ weight of the constituent.
$x =$ " " compound.
$35.5 : 40.5 :: 10$ lbs. $: x$.
$x = 12.461$ lbs. (ZnO). 12.461 lbs. ZnO — 10 lbs. Zn = 2.461 lbs. (O).
2.461 lbs. $\div$ 8 = .307 lbs. (H).

8. *How much H can be made from* 50 *lbs. of water?*

$$H = 1 = \text{equivalent of given constituent.}$$
$$HO = 9 = \text{" " compound.}$$
$$x = \text{weight of given constituent.}$$
$$50 \text{ lbs.} = \text{" " compound.}$$
$$1 : 9 :: x : 50 \text{ lbs.}$$
$$x = 5\,{}^5/_9 \text{ lbs. (H).}$$

More simply, $\frac{1}{9}$ of water is H; hence

$$50 \text{ lbs.} \div 9 = 5\,{}^5/_9 \text{ lbs. (H).}$$

9. *How much saltpetre will be required to make* 18 *lbs. of aquafortis?*

$$NO_5 = 54 = \text{equivalent of given constituent.}$$
$$KO.NO_5 = 101 = \text{" " compound.}$$
$$18 \text{ lbs.} = \text{weight of given constituent.}$$
$$x = \text{" " compound.}$$
$$54 : 101 :: 18 \text{ lbs.} : x.$$
$$x = 33\,{}^2/_3 \text{ lbs. (saltpetre).}$$

10. *How much oil of vitriol will be required to decompose* 6 *lbs. of saltpetre?*

First find how much KO in 6 lbs. of $KO.NO_5$, next how much $KO.SO_3$ that amount of KO will make, and lastly subtract the KO from the $KO.SO_3$, and the remainder will be the SO_3. In both cases we neglect the HO combined in the salts and the acid.

$$KO : KO.NO_5 :: x : 6 \text{ lbs.}$$
$$47 : 101 :: x : 6 \text{ lbs.}$$
$$x = 2.79 \text{ lbs. (KO).}$$
$$KO : KO.SO_3 :: 2.79 \text{ lbs} : x.$$
$$47 : 87 :: 2.79 \text{ lbs.} : x.$$
$$x = 5.16 \text{ lbs. } (KO.SO_3).$$
$$5.16 \text{ lbs. } (KO.\ SO_3) - 2.79 \text{ lbs. (KO)} = 2.37 \text{ lbs. } (SO_3).$$

11. *How much HO will be decomposed by one drachm of K, and how much KO will be formed?*

First find how much KO 1 dr. of K will form, then subtract from the KO the drachm of K, and the remainder is the O, which must be $\frac{8}{9}$ of the water from which it is obtained.

$$K : KO :: 1 \text{ dr.} : x.$$
$$39 : 47 :: 1 \text{ dr.} : x.$$
$$x = 1\tfrac{8}{39} \text{ drs. (KO).}$$
$$1\tfrac{8}{39} \text{ drs.} - 1 \text{ dr.} = \tfrac{8}{39} \text{ dr., the amount of O.}$$
$$\text{The HO is } {}^{9}/_{8} \text{ of } {}^{8}/_{39} \text{ dr.} = {}^{3}/_{13} \text{ dr. (HO).}$$

12. *What weight of nitrous oxyd will be formed from the decomposition of* 6 *oz. of nitrate of ammonia?*

$$2\,NO : NH_4O.NO_5 :: x : 6 \text{ oz.}$$
$$x = 3\,{}^{3}/_{10} \text{ oz. (NO).}$$

13. *How much sal-ammoniac would be required to make* 2 *lbs. of* NH_3*?*

$$NH_3 : NH_4Cl :: 2 \text{ lbs.} : x.$$
$$17 : 53.5 :: 2 \text{ lbs.} : x.$$
$$x = 6\,{}^{5}/_{17} \text{ lbs. (sal-ammoniac).}$$

14. *How much* CO_2 *will be formed in the combustion of* 30 *grs. of CO?*

$$CO : CO_2 :: 30 \text{ grs.} : x.$$
$$14 : 22 :: 30 \text{ grs.} : x.$$
$$x = 47\,{}^{1}/_{7} \text{ grs. } (CO_2).$$

15. *What weight of carbonate of soda* (sal-soda) *would be required to evolve* 12 *lbs. of* CO_2*?*

$$CO_2 : NaO.CO_2 :: 12 \text{ lbs.} : x.$$
$$22 : 53 :: 12 \text{ lbs.} : x.$$
$$x = 28\,{}^{10}/_{11} \text{ lbs. } (NaO.CO_2).$$

16. *What weight of bicarbonate of soda* ($NaO.2CO_2$*; " soda") would evolve* 12 *lbs. of* CO_2*?*

$$2CO_2 : NaO.2CO_2 :: 12 \text{ lbs.} : x.$$
$$44 : 75 :: 12 \text{ lbs.} : x.$$
$$x = 20\,{}^{5}/_{11} \text{ lbs. ("soda").}$$

17. *What weight of C is there in a ton of* CO_2*?*

$$C : CO_2 :: x : 2000 \text{ lbs.}$$
$$6 : 22 :: x : 2000 \text{ lbs.}$$
$$x = 545\,{}^{5}/_{11} \text{ lbs. (C).}$$

18. *How much O is consumed in burning a ton of C?*

$$C : CO_2 :: 2000 \text{ lbs.} : x.$$
$$6 : 22 :: 2000 \text{ lbs.} : x$$
$$x = 7333\,^1/_3 \text{ lbs. } (CO_2).$$
$$7333\,^1/_3 - 2000 \text{ lbs.} = 5333\,^1/_3 \text{ lbs. } (O).$$

More simply:—

$$C : 2O :: 2000 \text{ lbs.} : x.$$
$$x = 5333\,^1/_3 \text{ lbs.}$$

19. *In burning a charge of 10 lbs. of gunpowder, find the weight of the several products formed.*

(See page 107.)

$$(1.)\ KS : (KO.NO_5 + S + 3C) :: x : 10 \text{ lbs.}$$
$$55 : 135 :: x : 10 \text{ lbs.}$$
$$x = 4\,^2/_{27} \text{ lbs. } (KS).$$
$$(2.)\ N : (KO.NO_5 + S + 3C) :: x : 10 \text{ lbs.}$$
$$14 : 135 :: x : 10 \text{ lbs.}$$
$$x = 1\,^1/_{27} \text{ lbs. } (N).$$
$$(3.)\ 3CO_2 : (KO.NO_5 + S + 3C) :: x : 10 \text{ lbs.}$$
$$66 : 135 :: x : 10 \text{ lbs.}$$
$$x = 4\,^{24}/_{27} \text{ lbs. } (CO_2).$$

20. *What weight of common salt would be required to form 25 lbs. of muriatic acid (HCl)?*

$$Cl : HCl :: x : 25 \text{ lbs.}$$
$$35.5 : 36.5 :: x : 25 \text{ lbs.}$$
$$x = 24.3 \text{ lbs. } (Cl).$$
$$Cl : NaCl :: 24.3 \text{ lbs.} : x.$$
$$35.5 : 58.5 :: 24.3 \text{ lbs.} : x.$$
$$x = 40.044 \text{ lbs. } (NaCl).$$

21. *HCl of a specific gravity of 1.2 contains about 40 per cent. of the acid. This is very strong commercial acid. What weight of this acid could be formed by the HCl acid gas produced in the reaction named in the preceding problem?*

If 25 lbs. = 40 per cent., then 100 per cent. = 2.5 times 25 lbs. = $62\,^1/_2$ lbs.

22. *What weight of hydriodic acid (HI) is formed from a drachm of iodine?*

$$I : HI :: 1 \text{ dr.} : x.$$
$$126.8 : 128.8 :: 1 \text{ dr.} : x.$$
$$x = 1\tfrac{5}{634} \text{ drs. } (HI).$$

23. *What weight of Glauber salt can be formed from* 100 *lbs. of oil of vitriol?* *

$$SO_3 : NaO.SO_3 :: 100 \text{ lbs.} : x.$$
$$40 : 71 :: 100 \text{ lbs.} : x.$$
$$x = 177.5 \text{ lbs.} (NaO.SO_3).$$

24. *What weight of S is there in* 10 *grs. of sulphide of hydrogen?*

$$S : HS :: x : 10 \text{ grs.}$$
$$16 : 17 :: x : 10 \text{ grs.}$$
$$x = 9\,{}^{7}/_{17} \text{ grs.} (S).$$

25. *How much O is required to change a lb. of SO_2 to SO_3?*

$$SO_2 : SO_3 :: 1 \text{ lb.} : x.$$
$$32 : 40 :: 1 \text{ lb.} : x.$$
$$x = 1\,{}^{1}/_{4} \text{ lb.} (SO_3).$$
$$1\,{}^{1}/_{4} \text{ lb.} - 1 \text{ lb.} = {}^{1}/_{4} \text{ lb.} (O).$$

26. *How much phosphorus in* 40 *lbs. of phosphate of lime?*

(See page 245.)

$$P : 3CaO.PO_5 :: x : 40 \text{ lbs.}$$
$$31 : 155 :: x : 40 \text{ lbs.}$$
$$x = 8 \text{ lbs.} (P).$$

27. *How much P in* 40 *lbs. of the superphosphate of lime?*

$$P : CaO.PO_5 :: x : 40 \text{ lbs.}$$
$$31 : 99 :: x : 40 \text{ lbs.}$$
$$x = 12\,{}^{52}/_{99} \text{ lbs.} (P).$$

28. *How much phosphate of lime will an oz. of P make?*

$$P : 3CaO.PO_5 :: 1 \text{ oz.} : x.$$
$$31 : 155 :: 1 \text{ oz.} : x.$$
$$x = 5 \text{ oz.} (3CaO.PO_5).$$

29. *How many lbs. of HO in* 186 *lbs. of $SO_3.3HO$?*

$$3HO : SO_3.3HO :: x : 186 \text{ lbs.}$$
$$27 : 67 :: x : 186 \text{ lbs.}$$
$$x = 74\,{}^{64}/_{67} \text{ lbs.} (HO).$$

---

* In this, as in the other problems, the HO contained in the acid and in the salt is neglected, since it is a variable quantity, and the examples are merely for practice.

30. *How much CO_2 is formed in the combustion of* 1 *ton of C?*

$$C : CO_2 :: 2000 \text{ lbs.} : x.$$
$$C : 22 :: 2000 \text{ lbs.} : x.$$
$$x = 7333\,{}^1/_3 \text{ lbs. } (CO_2).$$

31. *What weight of S is there in a ton of iron pyrites?*

$$2S : FeS_2 :: x : 2000 \text{ lbs.}$$
$$32 : 60 :: x : 2000 \text{ lbs.}$$
$$x = 1066\,{}^2/_3 \text{ lbs. (S).}$$

32. *What weight of copperas could be made from* 500 *lbs. of iron pyrites?*

In forming $FeO.SO_3$ from FeS_2 only one atom of S is required; hence the 500 lbs. of iron pyrites really contain but $366\,{}^2/_3$ lbs. of FeS, which will, at a single reaction, form copperas; by oxydation from the air, the remaining atom of S would doubtless be used afterward. The problem might be solved as well, perhaps, by taking either the Fe or the S alone as the constituent.

$$FeS : (FeO.SO_3 + 7HO) :: 366\,{}^2/_3 \text{ lbs. (FeS)} : x.$$
$$44 : 139 :: 366\,{}^2/_3 \text{ lbs.} : x.$$
$$x = 1158.3 \text{ lbs. } (FeO.SO_3 + 7HO).$$

33. *What weight of H is there in a pound of heavy carburetted hydrogen?*

$$4H : C_4H_4 :: x : 1 \text{ lb.}$$
$$4 : 28 :: x :: 1 \text{ lb.}$$
$$x = {}^1/_7 \text{ lb. (H).}$$

34. *How much O would be required to oxydize the metallic copper which could be reduced from its oxyd by passing over it, when white-hot,* 20 *grs. of H gas?*

The same amount of O would be required to oxydize the copper that was taken from it when it was reduced from its oxyd. The H passing over it when white-hot takes out its O and forms HO. H is always $\frac{1}{9}$ of the HO. The H = 20 grs.; hence the HO = 9 times 20 grs. = 180 grs. 180 grs. (HO) — 20 grs. (H) = 160 grs. (O).

35. *How much O would be required to oxydize the metallic iron which could be reduced in the same manner by* 10 *grs. of H gas?*

Following the same reasoning as in the last problem, we have

$$H = 10 \text{ grs.}; \text{ hence the } HO = 9 \text{ times } 10 \text{ grs.} = 90 \text{ grs.}$$
$$90 \text{ grs. } (HO) - 10 \text{ grs. } (H) = 80 \text{ grs. } (O).$$

36. *What weight of N is there in* 10 *lbs. of* $NH_3.HO$*?*

$$N : NH_3.HO :: x : 10 \text{ lbs.}$$
$$14 : 26 :: x : 10 \text{ lbs.}$$
$$x = 5\,{}^{5}/_{13} \text{ lbs. } (N).$$

37. *How much* $KO.ClO_5$ *would be required to evolve sufficient O to burn the H produced by the decomposition of* 2 *lbs. of HO?*

$\frac{8}{9}$ of HO is O; hence 2 lbs. of HO will produce, when decomposed, $1\frac{7}{9}$ lbs. O. The problem is, then, how much $KO.ClO_5$ would be required to furnish $1\frac{7}{9}$ lbs. O?

$$6O : KO.ClO_5 : 1.77 \text{ lbs.} : x.$$
$$48 : 122.5 :: 1.77 \text{ lbs.} : x.$$
$$x = 4.51 \text{ lbs. } (KO.ClO_5).$$

(If the common fractions are used in solving this problem, the answer is $4\frac{29}{54}$ lbs.)

38. *How much H must be burned to produce a ton of water?*

$$H : HO : x : 2000 \text{ lbs.}$$
$$1 : 9 :: x : 2000 \text{ lbs.}$$
$$x = 222{}^{2}/_{9} \text{ lbs. } (H).$$

39. *How much S is there in a lb. of* SO_2*?*

$$S : SO_2 :: x : 1 \text{ lb.}$$
$$16 : 32 :: x : 1 \text{ lb.}$$
$$x = {}^{1}/_{2} \text{ lb. } (S).$$

40. *Find how much "soda" is formed from* 500 *lbs. of salt.*

41. *Find the amount of Glauber salt produced in the first step, with the charge just named.*

42. *Find the amount of HCl produced.*

43. *Find how much sulphuret of sodium is formed in the second step.*

44. *Find how much sulphuret of calcium is made*

45. *Find how much sulphur could be saved (if none were lost) from the CaS.*

The following reactions show the chemical changes which take place in the various stages:

$$(1)\quad NaCl + SO_3HO = NaO.SO_3 + HCl.$$

$$(2)\quad \begin{cases} NaO.SO_3 + 2C = NaS + 2CO_2. \\ NaS + CaO.CO_2 = CaS + NaO.CO_2. \end{cases}$$

From the (1) reaction we find how much Glauber salt will be made from 500 lbs. of common salt. To do this we first find how much Na there is in 500 lbs. NaCl; and, secondly, how much $NaO.SO_3$ that amount of Na will make.

$$Na : NaCl :: x : 500 \text{ lbs.}$$
$$23 : 58.5 :: x : 500 \text{ lbs.}$$
$$x = 196\tfrac{68}{117} \text{ lbs. (Na).}$$
$$Na : NaO.SO_3 :: 196\tfrac{68}{117} \text{ lbs.} : x.$$
$$23 : 71 :: 196\tfrac{68}{117} : x.$$
$$= 606\tfrac{98}{117} \text{ lbs. } (NaO.SO_3). \quad \textit{Ans. to 41st prob.}$$

$$Na : NaO.CO_2 :: 196\tfrac{68}{117} \text{ lbs. (Na)} : x.$$
$$23 : 53 : 196\tfrac{68}{117} \text{ lbs.} : x.$$
$$x = 452\tfrac{116}{117} \text{ lbs. } (NaO.CO_2, \text{ "Soda"}). \quad \textit{Ans. to 40th prob.}$$

$$Cl : NaCl :: x : 500 \text{ lbs.}$$
$$35.5 : 58.5 :: x : 500 \text{ lbs.}$$
$$x = 303\tfrac{49}{117} \text{ lbs. (Cl).}$$
$$Cl : HCl :: 303\tfrac{49}{117} \text{ lbs.} : x.$$
$$35.5 : 36.5 :: 303\tfrac{49}{117} \text{ lbs.} : x.$$
$$x = 311\tfrac{113}{117} \text{ lbs. (HCl).} \quad \textit{Ans. to 42d prob.}$$

$$Na : NaS :: 196\tfrac{68}{117} \text{ lbs. (Na)} : x.$$
$$23 : 39 :: 196\tfrac{68}{117} \text{ lbs.} : x.$$
$$x = 333\,{}^1/_3 \text{ lbs. (NaS).} \quad \textit{Ans. to 43d prob.}$$

$$333\,{}^1/_3 \text{ lbs. (NaS)} - 196\tfrac{68}{117} \text{ lbs. (Na)} = 136\tfrac{88}{117} \text{ lbs. (S).} \quad \textit{Ans. to prob. 45.}$$

$$S : CaS :: 136\tfrac{88}{117} \text{ lbs. (S)} : x.$$
$$x = 307\,{}^9/_{13} \text{ lbs. (CaS).} \quad \textit{Ans. to 44th prob.}$$

46. *How many lbs. of HCl would be required to neutralize sufficient carbonate of ammonia to form a 30 lb. cake of sal-ammoniac ($NH_4.Cl$)?*

First find how much Cl there is in a 30 lb. cake of sal-ammoniac; second, how much HCl would contain that amount of Cl.

$$Cl : NH_4Cl :: x : 30 \text{ lbs.}$$
$$35.5 : 53.5 :: x : 30 \text{ lbs.}$$
$$x = 19.9 \text{ lbs. (Cl).}$$
$$Cl : HCl :: 19.9 \text{ lbs.} : x.$$
$$35.5 : 36.5 :: 19.9 \text{ lbs.} : x.$$
$$x = 20.4 \text{ lbs. (HCl).}$$

47. *How much S is there in a ton of plaster (gypsum)?*

$$S : CaO.SO_3 :: x : 2000 \text{ lbs.}$$
$$16 : 68 :: x : 2000 \text{ lbs.}$$
$$x = 470.58 \text{ lbs. (S).}$$

48. *How much aluminum is there in a ton of clay?*

$$2Al : Al_2O_3.SiO_2 :: x : 2000 \text{ lbs.}$$
$$27.4 : 81.4 :: x : 2000 \text{ lbs.}$$
$$x = 673.2 \text{ lbs. (Al).}$$

49. *How much K is there in 10 lbs. of alum?*

$$K : (KO.SO_3 + Al_2O_3.3SO_3 + 24HO) : x : 10 \text{ lbs.}$$
$$39 : 474.4 :: x : 10 \text{ lbs.}$$
$$x = .82 \text{ lb. (K).}$$

50. *How much white-lead ($PbO.CO_2$) could be made from 1 lb. of litharge?*

$$Pb : PbO :: x : 1 \text{ lb.}$$
$$103 : 111.6 :: x : 1 \text{ lb.}$$
$$x = .92 \text{ lb. (Pb) in 1 lb. of litharge.}$$
$$Pb : PbO.CO_2 :: .92 \text{ lb.} : x.$$
$$103 : 133 :: .92 : x.$$
$$x = 1.1 \text{ lb. } (PbO.CO_2).$$

51. *How many lbs. of C would be required to reduce 40 tons of brown hematite ($2Fe_2O_3.3HO$)?*

In the intense heat of the furnace the .3HO would be decomposed, and so only sufficient C would be required to burn the 6 atoms of O in the $2Fe_2O_3$. In 40 tons of brown hematite there are 34.22 of the base.

$$6O : 2Fe_2O_3 :: x : 34.22 \text{ tons.}$$
$$48 : 160 :: x : 34.22 \text{ tons.}$$
$$x = 10.26 \text{ tons (O).}$$

Eight-elevenths of CO_2 is O; if 10.26 tons is $\frac{8}{11}$, it would require 3.84 tons of C to burn 10.26 tons of O, and thus reduce 40 tons of hematite.

52. *In* 60 *lbs. of heavy spar (sulphate of baryta) how much S is there?*

$$S : BaO.SO_3 :: x : 60 \text{ lbs.}$$
$$16 : 116.5 :: x : 60 \text{ lbs.}$$
$$x = 8.2 \text{ lbs. (S).}$$

53. *How much alum can be made from* 1 *cwt. of potash?*

$$KO : (KO.SO_3 + Al_2O_3.3SO_3 + 24HO) : 100 \text{ lb.} : x.$$
$$47 : 474.4 :: 100 \text{ lbs.} : x.$$
$$x = 1009.3 + \text{ lbs. (alum).}$$

ANSWERS

TO THE PRACTICAL QUESTIONS

IN THE

FOURTEEN WEEKS COURSE

IN

DESCRIPTIVE ASTRONOMY.

---

1. *Did Tycho Brahe have a telescope?*

No. Galileo invented the telescope.

2. *Suppose one should watch the sky, on a winter's evening, from* 6 P. M. *to* 6 A. M., *what portion of the celestial sphere would he see?*

All that is ever seen in his latitude.

3. *How do we find what proportion of the sun's heat reaches the earth?*

Calculate the surface of a sphere whose radius is the distance of the earth from the sun, and then estimate what proportion of that area the earth occupies.

4. *How many real motions has the sun?*

Two. One around its axis, and one with the solar system around the Pleiades.

5. *How many apparent motions has the sun?*

Three. One along the ecliptic,—its yearly motion; one through the heavens,—its daily motion; and one N. and S.

6. *How many real motions has the earth?*

Three. One on its axis; one around the sun; and a third its "wabbling motion," which causes Precession.

7. *Can any inferior planet have an elongation of* 90°*?*

No. Venus recedes only 48° from the sun.

8. *How do we know the heat of the sun's rays at any planet?*

The intensity of the heat and light vary inversely as the square of the distance.

9. *Can you give any other proof than that named in the book, of the rotundity of the earth?*

Aeronauts, when at a proper height, can distinctly see the curving form of the earth's surface.

10. *In what way is the force which acts on a spinning-top opposite to that which produces precession* (p. 125)?

Gravity, acting on the top, tends to draw C P (Fig. 34) *from* the perpendicular. The attraction of the sun, acting on the bulging mass of the earth's equator, tends to draw C P *toward* the perpendicular.

11. *Why is the Tropic of Cancer placed where it is?*

Because it is the farthest place north where the sun is ever seen directly overhead.

12. *Why is the Tropic of Cancer so called?*

When named, the sun was probably in that constellation at the time of the summer solstice. Now, owing to the precession of the equinoxes, the sun is in the constellation Gemini, and to be exact, it should be called the Tropic of Gemini. It is still, however, the sign Cancer, as before. The same reasoning applies to the Tropic of Capricorn, which is now in the constellation Sagittarius.

13. *In Greenland, at what part of the year will the midnight sun be seen due north?*

At the summer solstice.

14. *How do we know that the moon has little if any atmosphere?*

Because when the moon occults a star, there is no refraction of the star's true place.

15. *When is the moon seen high in the eastern sky in the afternoon, long before the sun sets?*

During the second quarter before it comes into opposition.

16. *Why is the Ecliptic so called?*

Because eclipses always occur within it.

17. *Why is it that the sun in summer shines on the north side of some houses both at rising and setting, but in winter never does?*

Since at the summer solstice the sun rises and sets north of the E. and W. points, it will rise and set on the north side of a house which stands exactly N. and S. At the winter solstice the sun rises and sets S. of the E. and W. points

TABLE OF THE MINOR PLANETS.

No.	*Name.*	*Date of Discovery.*	*Discoverer.*	*Sidereal Revolution (Days.)*
1	Ceres	1801, January 1	Piazzi	1680
2	Pallas	1802, March 28	Olbers	1682
3	Juno	1804, Sept. 1	Harding	1596
4	Vesta	1807, March 29	Olbers	1326
5	Astræa	1845, December 8	Hencke	1512
6	Hebe	1847, July 1	Hencke	1379
7	Iris	1847, August 13	Hind	1346
8	Flora	1847, October 18	Hind	1193
9	Metis	1848, April 25	Graham	1346
10	Hygieia	1849, April 12	Gasparis	2043
11	Parthenope	1850, May 11	Luther	1403
12	Victoria	1850, Sept. 13	Hind	1303
13	Egeria	1850, Nov. 2	Gasparis	1511
14	Irene	1851, May 19	Hind	1519
15	Eunomia	1851, July 29	Gasparis	1570
16	Psyche	1852, March 17	Gasparis	1828
17	Thetis	1852, April 17	Luther	1421
18	Melpomene	1852, June 24	Hind	1271
19	Fortuna	1852, August 22	Hind	1393
20	Massalia	1852, Sept. 19	Gasparis	1365
21	Lutetia	1852, Nov. 15	Goldschmidt	1388
22	Calliope	1852, Nov. 16	Hind	1813
23	Thalia	1852, Dec. 15	Hind	1556
24	Themis	1853, April 5	Gasparis	2036
25	Phocæa	1853, April 7	Chacornac	1358
26	Proserpina	1853, May 5	Luther	1580
27	Euterpe	1853, Nov. 8	Hind	1313
28	Bellona	1854, March 1	Luther	1692
29	Amphitrite	1854, March 1	Marth	1492
30	Urania	1854, July 22	Hind	1329
31	Euphrosyne	1854, Sept. 1	Ferguson	2048
32	Pomona	1854, October 26	Goldschmidt	1521
33	Polyhymnia	1854, October 28	Chacornac	1778
34	Circe	1855, April 6	Chacornac	1609
35	Leucothea	1855, April 19	Luther	1903
36	Atalanta	1855, October 5	Goldschmidt	1664
37	Fides	1855, October 5	Luther	1569
38	Leda	1856, January 12	Chacornac	1657
39	Lætitia	1856, February 8	Chacornac	1684
40	Harmonia	1856, March 31	Goldschmidt	1247
41	Daphne	1856, May 22	Goldschmidt	1681
42	Isis	1856, May 23	Pogson	1392
43	Ariadne	1857, April 15	Pogson	1195
44	Nysa	1857, May 27	Goldschmidt	1379
45	Eugenia	1857, June 27	Goldschmidt	1638
46	Hestia	1857, August 16	Pogson	1470
47	Aglaia	1857, Sept. 15	Luther	1788
48	Doris	1857, Sept. 19	Goldschmidt	2003
49	Pales	1857, Sept. 19	Goldschmidt	1975
50	Virginia	1857, October 4	Ferguson	1576
51	Nemausa	1858, January 22	Laurent	1338
52	Europa	1858, February 4	Goldschmidt	1993
53	Calypso	1858, April 4	Luther	1548
54	Alexandra	1858, Sept. 10	Goldschmidt	1634
55	Pandora	1858, Sept. 10	Searle	1674

No.	*Name.*	*Date of Discovery.*			*Discoverer.*	*Sidereal Revolution (Days.)*
56	Melete*..........	1857,	Sept.	9	Goldschmidt.......	1526
57	Mnemosyne	1859,	Sept.	22	Luther.............	2049
58	Concordia........	1860,	March	24	Luther.............	1615
59	Elpis	1860,	Sept.	12	Chacornac	1634
60	Echo	1860,	Sept.	15	Ferguson....... ...	1352
61	Danaë	1860,	Sept.	9	Goldschmidt..	1902
62	Erato	1860,	Sept.	14	Förster and Lesser.	2023
63	Ausonia..........	1861,	February	10	Gasparis	1355
64	Angelina.........	1861,	March	4	Tempel	1601
65	Cybele	1861,	March	8	Tempel	2311
66	Maia	1861,	April	9	Tuttle..............	1588
67	Asia	1861,	April	17	Pogson	1375
68	Leto..............	1861,	April	29	Luther.............	1695
69	Hesperia.........	1861,	April	29	Schiaparelli........	1893
70	Panopea	1861,	May	5	Goldschmidt.......	1542
71	Niobe............	1861,	August	13	Luther....	1671
72	Feronia..........	1861,	May	29	Peters and Safford.	1245
73	Clytie............	1862,	April	7	Tuttle	1590
74	Galatea	1862,	August	29	Tempel.............	1691
75	Eurydice.........	1862,	Sept.	22	Peters	1594
76	Freia	1862,	October	21	d'Arrest.	2080
77	Frigga...........	1862,	Nov.	12	Peters	1596
78	Diana............	1863,	March	15	Luther.............	1554
79	Eurynome	1863,	Sept.	14	Watson............	1399
80	Sappho	1864,	May	2	Pogson	1270
81	Terpsichore	1864,	Sept.	30	Tempel.............	1693
82	Alcmene	1864,	Nov.	27	Luther.............	1659
83	Beatrix..........	1865,	April	26	Gasparis	1381
84	Clio	1865,	August	26	Luther.............	1330
85	Io	1865,	Sept.	19	Peters	1583
86	Semele..........	1866,	January	4	Tietjen	1983
87	Sylvia...........	1866,	May	16	Pogson	2384
88	Thisbe...........	1866,	June	15	Peters	1675
89	Julia.............	1866,	August	6	Stephan	1472
90	Antiope	1866,	October	11	Luther.............	2031
91	Ægina	1866,	Nov.	4	Stephan	1495
92	Undina	1867,	July	7	Peters..........	2086
93	Minerva	1867,	August	24	Watson	1669
94	Aurora...........	1867,	Sept.	6	Watson............	2050
95	Arethusa.........	1867,	Nov.	23	Luther.............	1964
96	Ægle.............	1868,	February	17	Coggia.............	1950
97	Clotho	1868,	February	17	Tempel	1592
98	Ianthe.	1868,	April	18	Peters	1607
99	Dike..	1868,	May	28	Borelly	....
100	Hecate....... ...	1868,	July	11	Watson............	1892
101	Helena...........	1868,	August	15	Watson............	1508
102	Miriam	1868,	August	22	Peters	1587
103	Hera	1868,	Sept.	7	Watson............	1622
104	Clymene.........	1868,	Sept.	13	Watson............	2071
105	Artemis..........	1868,	Sept.	16	Watson..	1341
106	Dione............	1868,	October	10	Watson	2092
107	Camilla	1868,	Nov.	17	Pogson	....
108	Hecuba	1869,	April	2	Luther.............	2104
109	Felicitas.........	1869,	Oct.	9	Peters.....	1615

* Goldschmidt at first believed it to be *Daphne* (41), but Schubert finding its period different, called it *Pseudo-Daphne.* It was not seen from 1857 to 1861, when *Luther* rediscovered it, and named it *Melete.*

The numerical order is that adopted by the authority of the Berlin Ephemeris.

No.	*Name.*	*Date of Discovery.*			*Discoverer.*	*Log. a.**
110	Lydia............	1870,	April	19	Borelly............	0.437126
111	Ate.............	1870,	August	14	Peters.............	0.413183
112	Iphigenia.......	1870,	Sept.	19	Peters.	0.386324
113	Amalthea........	1871,	March	12	Luther............	0.375971
114	Cassandra.......	1871,	July	23	Peters.............	0.427422
115	....	1871,	August	6	Watson...........	0.376540
116	Sirona..........	1871,	Sept.	8	Peters.............	0.441912
117	Lomia..........	1871,	Sept.	12	Borelly.....	0.475643
118	Peitho..........	1872,	March	15	Luther............	0.386977
119	....	1872,	April	3	Watson...........	0.410364
120	Lachesis........	1872,	April	10	Borelly............	0.495810
121	....	1872,	May	12	Watson...........	0.538967
122	Gerda...........	1872,	July	31	Peters.............	0.508118
123	Brunhilda.......	1872,	July	31	Peters.......... ...	0.430151
124	Alceste.........	1872,	August	23	Peters.............	0.419063
125	....	1872,	Sept.	11	Prosper Henry.....	0.48219
126	....	1872,	Nov.	5	Paul Henry........	0.386778
127	....	1872,	Nov.	5	Prosper Henry.....	0.44377
128	....	1872,	Nov.	25	Watson...........	....
129	Antigone........	1873,	Feb.	5	Peters.	0.457822
130	Electra..........	1873,	Feb.	17	Peters.............	....

* Log. a = logarithm of major semiaxis of orbit, taking the earth's distance from the sun as unit.

SIMPLE DIRECTIONS

TO A BEGINNER

FOR

PERFORMING THE EXPERIMENTS

IN THE

FOURTEEN WEEKS COURSE

IN

CHEMISTRY.

(OLD NOMENCLATURE.)

[The large figures refer to the page of the Chemistry, and the small ones to the number of the experiment. Read for additional directions, Chemistry, pp. 235-248, and new edition, pp. 245-267.]

---

11. I. Put as much chlorate of potash (potassic chlorate) as will lie upon the point of a knife-blade, and half as much sulphur, into the mortar. Grind them slowly with the pestle until the ingredients are thoroughly mixed and distributed over the bottom of the mortar. Hold the mortar so that the loose particles cannot fly into your eyes, nor the flame burn your clothes, and then grind heavily with the pestle, when rapid detonations will ensue. The mixture will last for days. After use, clean out the mortar carefully for other experiments. The powder can be wrapped with paper into a hard pellet and exploded on an anvil by a sharp blow from a hammer. Sometimes small bits of phosphorus are used instead of sulphur. Great care is then necessary, as the particles of burning phosphorus are apt to fly to some distance.

12. I. Two teaspoonfuls of common carbonate of soda and one of tartaric acid should be dissolved separately in a wine-glass of water. On being poured together in a larger glass, they will violently effervesce. Use a glass large enough to prevent any running over upon the table. Neatness in experiments is essential to perfection, and often to success.

15. I. The cabbage solution is made by steeping purple cabbage leaves in water. A little lemon-juice or vinegar will turn it to a bright red, and a little of the potash solution to a deep green. Add a little alcohol to the red solution, to keep it from freezing, and bottle it for use. Dissolve a little of the dry litmus in water, filter and bottle it. These are to be used in testing the alkalies and acids. Dissolve also a stick of the potash in water, filter and bottle. Fill two test-tubes nearly full of water; color one with the cabbage and the other with the litmus solution. Add a few drops of the potash solution and of the sulphuric acid alternately to each. The color can be changed at pleasure.

Take a small bit of tubing, and heating the ends in the flame of the spirit-lamp (the greatest heat is near the tip of the flame), seal up the opening. This will be useful to dip into the acid or alkali, as it will remove a drop more readily than by dropping from the bottle.

20. Pulverize an ounce of the potassic chlorate very carefully; stir in it one-fourth of its weight of the black oxyd of manganese and place the mixture in the copper retort, attach the tubing and gas-bag as shown in the figure of p. 234; or in the Florence flask, attaching a delivery tube, as shown in figure on p. 20. The glass tubing may be heated in the flame of the alcohol-lamp and bent to the desired shape, or it can be broken into short lengths by simply starting the break in the tube by a mere scratch with a three-cornered file and then connecting the pieces of glass tubing with a short bit of the small rubber tubing, as in the figure on p. 20. The gas may be passed off from the gas-bag, or directly from the retort into the pneumatic cistern, C, across which is placed a shelf perforated, to permit the gas to bubble up into the receiver, J. The pneumatic cistern may consist of a tub of water. The bottles for collecting the gas are sunk into the water until filled, inverted, and then lifted up on the shelf, carefully keeping the lower edge of the bottle beneath the water. A large tin pan, without any shelf, may be used as a cistern by filling the bottles full of water in a deep pail, and then slipping a plate underneath each one, as shown in the second figure on p. 22, leaving enough water on the plate to cover the edge of the bottle; it may then be lifted out and placed in the cistern. In the same way the bottles, when filled with gas, may be removed and kept for use. Gas may be passed from one bottle to another by inverting one over the other beneath the water in the pneumatic cistern, or in a large pail, when the gas will bubble up from the lower one into the upper one.

Apply the heat to the glass retort very carefully at first, holding the lamp in the hand and moving it around so that the flame may strike all the lower part of the flask, and thus expand it uniformly. Be careful also that there is no draft of cold air to strike against the heated retort. With the copper retort no care of this kind is necessary. When the gas ceases to come off, remove the stopper or lift the end of the tube out of the water; otherwise, as the retort cools and a vacuum is formed, the water in the cistern will set back into the flask, and, if of glass, will break it. An ounce of the salt will make over six quarts of oxygen gas. When the retort is partly cooled, pour in some *warm* water to dissolve the residuum, which may then be poured out and the retort drained and set away for future use. In order to test the purity of the materials, and thus avoid any danger of an explosion, place a little of the mixture for making oxygen in an iron spoon and heat it over the spirit-lamp. If the gas passes off quietly, no danger need be apprehended.

22. 1. The experiment with the candle can be performed most strikingly by filling a common fruit-jar with nitrogen (see page 32) and another with oxygen. The covers will preserve the gases until wanted for use. The covers may then be laid loosely on top of the jars, and the lighted candle passed quickly from one jar to the other. It will be extinguished in one and relighted in the other. With care, it may be passed and repassed a dozen times. This strikingly illustrates the difference between oxygen and nitrogen. Test the carbonic acid, in this as in all similar experiments, with the blue litmus and the green cabbage, or a slip of blotting-paper wet with the litmus solution. A few drops of the solution may be poured into the jar, and then the jar shaken, so as to permit the water to absorb the gas. The candle may be simply stuck upon the end of a bent wire, but it is much neater to have the tinsmith fit a little cup for its reception, as shown in the figure.

2. The worn-out watch-springs which can be obtained gratis of any jeweller, may be easily straightened by drawing them between the fingers. If the end of each spring be heated and then pounded with a hammer on any smooth hard surface, the temper may be thoroughly drawn and the edge sharpened. Make a slit with a knife in the side of a match, into which insert the edge of the spring. Take a piece of zinc or tin large enough to cover the mouth of the jar containing the oxygen, and make a hole through it with a nail. Pass the other end of the spring through this hole, and then through a thin cork. The spring is now ready for burning. The metal cover will prevent the flame from coming out of the jar and burning one's hand, and the cork will hold the spring in its place. When the match is ignited, and then lowered into the jar of oxygen, the spring should not reach more than half-way to the bottom, and should be pushed down as it burns. If a specie-jar be used, do not fill it quite full of gas, as a little water left in the bottom will prevent the melted globules of iron from breaking the glass.

23. 1. If brimstone be used in this experiment, and it fails to light readily, pour upon it a few drops of alcohol, and then ignite it.

2. If you have not a deflagrating spoon to contain the phosphorus, one may be readily extemporized. Hollow a small piece of chalk and attach it to a wire, which may then be secured to a metal top, as in the case of the watch-spring. This need *not* be pushed down into the jar as the burning progresses. At the close of the experiment, test for the acid formed in the combustion. The fumes are very disagreeable, and should not be inhaled or allowed to escape into the room.

3. If a piece of *bark* charcoal be ignited, and then lowered into a jar of oxygen, it will deflagrate with bright scintillations.

31. 1. Put in an evaporating-dish a little starch; cover it with water in which a few crystals of iodide of potassium have been dissolved, and heat. Stir the liquid, to prevent lumps. When cooked, immerse in the paste slips of blotting-paper. Use while moist. Be careful not to heat the glass tube too hot, lest the ether vapor may ignite. Keep the jar well filled with vapor by frequently shaking it. Lower into the ozone a bit of silver-leaf moistened with water; it will quickly crumble into dust, the oxyd of silver.

34. 1. To make the iodide of nitrogen, cover a few scales of iodine with strong aqua ammonia. After standing for a half-hour, pour off the liquid and place the brown sediment in small pieces on bits of broken earthenware to dry. This will require several hours. They may then be taken to the class-room very carefully and exploded by a slight touch of a rod, or even a feather.

37. 1. For making NO_5 a special apparatus is necessary for complete success. The Florence flask may, however, be used, and the heat of the spirit-lamp will be sufficient. The fumes may be caught in the evolution flask, which is kept cool by a towel frequently wet. When the retort is partially cooled, at the conclusion of the process, pour in a little warm water, to dissolve the sulphate of potash, otherwise the retort may break by the crystallization of the salt.

2. Mix equal parts of nitric acid and oil of vitriol (perhaps a teaspoonful of each), and pour the mixture on hot finely-powdered charcoal, or on a little oil of turpentine. It will be oxydized with almost explosive violence. This should be performed out of doors.

3. Bits of tin may be obtained of any tinsmith. Put them in a tumbler and nearly cover them with the NO_5. In using copper, the apparatus shown on page 39 is excellent. The acid may be turned in gradually through the funnel tube. Before putting in the acid pour into the flask warm water to cover the lower end of the funnel tube, which should nearly reach the bottom of the flask. When a jar is filled with the NO_2 it may be lifted out of the water and inverted, when the NO_4 will pass off in blood-red clouds. If the jar be left in the cistern and one edge be lifted so as to admit a bubble of air, red fumes will fill the jar. By standing a moment the

water will absorb the red vapor. This process can be repeated several times with the remaining gas.

40. 1. The finely-powdered sal-ammoniac and lime may be mixed in an evaporating-dish. The escaping ammonia should be tested with a glass rod or tube wet with hydrochloric acid.

2. Heat a little aqua ammonia in the Florence flask. Collect the vapor in an inverted bottle, to which is fitted a cork and tube, with the inner extremity drawn to a fine point over the spirit-lamp. Insert the cork, and then plunge the bottle into a vessel of water. The water which passes in first will absorb the gas so quickly as to make a partial vacuum, into which the water will rush so violently as to produce a miniature fountain.

42. 1. In making H, the directions given on pages 236–7 should be carefully observed. For purifying the gas a solution of potash should be placed in the flask *d* (page 42). If a junk bottle be used the acid should be added slowly, as the heat generated is liable to break the bottle. Pour the water into the flask *a* until the lower end of the funnel is covered, before adding the acid. The flow of gas may be regulated by additions of acid, as may be wanted. One part of acid to ten or twelve of water will liberate the gas very rapidly. If it comes off very fast, the liquid is liable to froth over. The philosopher's lamp, page 237, is very interesting. The jet may be a straight glass tube drawn to a fine point over the spirit-lamp. Large glass tubes or the beaks of broken retorts, held over this flame, will produce the singing tones, though not as well as the apparatus figured in the book. The tone may be regulated by the size of the flame, *i. e.* the rapidity with which the gas comes off, the size of the jet as well as the length and size of the tubes. The H can be collected over the pneumatic cistern, or, since it is lighter than air, in inverted bottles. As soon as the bottles are turned right side up the gas will escape. To measure the H and O for the "mixed gases," a receiver, with a stop-cock on top, which may be connected by rubber tubing with the gas-bag, is very useful. The oxygen may be passed directly into the gas-bag, however, as on page 234, until it is about one-third full, when the bag may be removed and attached to the hydrogen apparatus to be filled.

50. 1. In lieu of a small crucible, fill a common tobacco-pipe with crystals of blue vitriol, and heat them over the lamp or in a common fire until the water of crystallization is expelled. Alum may be rendered anhydrous in the same manner.

56. 1. Small paste-diamonds may be obtained of a jeweller, to illustrate the forms of cutting the diamond.

60. 1. Place a filtering paper in the glass funnel, and in it a couple of ounces of bone-black or finely-powdered charcoal. Filter through it water colored with ink, litmus, or any other impurities. In pouring the liquid into the filter hold a glass rod against the edge of the pouring vessel, so as to direct the stream into the funnel. The funnel may be placed in the nozzle of a bottle, but must not fit closely. A bit of wood or a thread inserted between the stem of the funnel and the nozzle will leave an opening sufficient for the egress of the air.

64. 1. Break some marble into small bits; place them carefully in the evolution-flask, and, inserting the cork and tube, pour in HCl slowly. The gas, on account of its weight, may be passed directly into a bottle or jar.

2. Lower a lighted candle into a jar of the gas, or, lowering the candle into an empty jar, pour the gas into the jar, as if it were water. Test the acid with litmus paper.

3. Place a piece of lime as large as an egg in a pint of water; let it stand overnight; pour off the clear liquid—it is lime-water. Place a little in a tumbler and breathe through it by means of a tube, or pass a current of CO_2 from the evolution-flask until the liquid, at first milky, clears.

4. Breathe through a tube into an empty bottle. Lower into it a lighted candle—it will be immediately extinguished. Pour in some lime-water, shake it thoroughly and it will become milky.

5. Twist a wire around the neck of a small wide-mouthed vial, to answer as a bucket. Lower it by the wire into a jar of CO_2, our ideal well foul with the gas. Raise it again, and test for the CO_2 by means of a lighted match. The bucket will be found to be full of the gas.

6. Fill a jar with hydrogen, and in a similar way dip the gas *downward* and burn it over a lamp. This shows in a very striking manner the difference between H and CO_2 in respect to specific gravity. The one, we see, is dipped upward, the other downward.

7. Balance a large paper bag or box on a delicate pair of scales, or in any simple manner one's ingenuity may suggest. Empty into the box a large jar of CO_2, and the box will quickly descend.

8. Arrange little wax-tapers in a wooden or pasteboard trough, as on page 65. Light them, and then pour in at the top a bottle of carbonic acid gas. If the proper slant is given to the trough, all the candles will be extinguished.

72. 1. Olefiant gas may be made by heating in the flask one part, by measure, of alcohol and two parts of sulphuric acid. Pass it through a solution of potash, as shown on page 88, and then collect in the gas-bag. Fit a piece of glass tubing, drawn to a fine point at one end, to the stop-cock of the gas-bag by means of a bit of the rubber tubing. On turning the stop-cock and forcing out the gas it may be ignited, when it will burn with a clear white light.

2. Fill a tall jar one-third full of olefiant gas, and the remainder with chlorine gas. On lighting, the mixture will burn with a dense cloud of smoke. HCl is the product of the combustion.

3. Mix with oxygen and explode in soap-bubbles. It produces a greater noise even than the "mixed gases." Great care must be taken not to let the light approach the gas-bag containing the mixture.

4. Fit a large test-tube with a cork and a piece of glass tubing, drawn to a fine point at the outer end. Fill the tub with fine dry pine-shavings. On heating, the gases from the wood will pass off, and can be ignited at the jet-tube. The test-tube can be held by a strip of twisted paper or wire.

5. At the close of the 1st exp. perform the one figured on page 79. A small piece of wire-gauze, 4 or 6 inches square, for this purpose can be purchased of any tinsmith. If you do not force the gas out too rapidly, you will be able to burn it on either side of the gauze at pleasure.

79. Place on top of the gauze a bit of camphor-gum. Ignite it, and the flame will not pass through to the lower side. Then ignite on the lower side, and extinguish the flame on the upper side.

77. The carbonic acid of a burning candle may be passed through lime-water in the following manner. Take a bottle arranged with tubes, as in the middle one shown in the figure on page 87. From the tall tube at the left suspend a glass funnel with the stem coupled to the tube by means of a piece of rubber tubing. Place under this funnel a burning candle. Partly fill the bottle with lime-water. Then placing the mouth to the right-hand tube, draw out the air from the bottle. This makes a draft over the candle, and draws its invisible smoke through the funnel, down the long tube, and up through the lime-water, which soon becomes milky.

80. The compound blow-pipe with gasometers, as shown on page 238, is the most serviceable. If gas-bags are used, the one for hydrogen should be twice the size of the one for oxygen. A board should be laid on each bag, upon which weights may be placed, when ready for use, so as to force out the gas steadily. Turn the stop-cock so that the H will pass out twice as fast as the O. Always ignite the H first, and then turn on the O slowly until the best effect is produced. If gasometers are used, press the inner receivers down to the bottom, and then pour in water till it reaches nearly the top. The rubber pipes may then be attached to the hydrogen or oxygen apparatus, and the gases passed directly into the gasometers. Proper pressure is produced, when the jet is to be ignited, by unloosing the strings from the inner receivers, and thus taking off the "lift" of the weights which equipoise them. Additional pressure is secured by bearing down upon the receivers. All the metals burn in the blow-pipe flame with their characteristic colors. Narrow slips should be prepared for this purpose. A mirror, and a cup for holding the chalk, are necessary to show the lime-light. A piece of hard chalk or lime, whittled to about the size of a pencil, may be held in the flame to illustrate the principle.

87. Put in the flask two ounces of common salt and an ounce and a half of black oxyd of manganese. Pour on enough water to reduce the mixture to a thin liquid. Shake the flask until the whole interior is moistened. Insert the cork and delivery-tube; the middle bottle shown in the figure is not necessary. Fill the pneumatic cistern with *warm water, using just as small a quantity as possible,* since water absorbs the gas. Pour in an ounce of the oil of vitriol through the funnel-tube, or directly at the nozzle, by removing the ground stopper, if a kind of flask be used which has one. The gas will come off at once, even before the heat is applied. Collect the gas in bottles and use directly, if convenient, otherwise put corks in them and rub the nozzles well with tallow. Pass the gas through cold water, as shown on page 88, or more simply, through a tumbler of water. This will form chlorine water, which should be bottled and kept in a dark place.

2. Fill a test-tube nearly full of pure rain or snow water, and let fall into it a drop or two of the nitrate of silver solution. A drop of HCl will form a cloudy white precipitate.

91. 1. Place on a clean white dish a few scales of iodine and a bit of phosphorus as large as a pea. It will soon ignite.

2. Fill three test-tubes nearly full of soft water. Pour in one a few drops of a solution of bichloride of mercury, into the second of sugar of lead, into the third of subnitrate of mercury (formed by pouring NO_5 on mercury). Add to each of these a few drops of the solution of iodide of potassium. The first especially will produce a brilliant color (iodide of mercury); the rapid change from yellow to red is very marked. On continuing to add the iodide of potassium, the red precipitate will be dissolved and disappear.

3. Make an additional quantity of the iodide of mercury, as in the 2d exp. Let it settle. Pour off the liquid, and then spread the sediment on a piece of heavy card-board, making a red spot as large as a silver dollar. Dry it carefully. Then heat very strongly, when it will turn yellow. Rub over the yellow spot the point of a knife several times, bearing on very firmly, and a red mark can be seen. Lay away the paper for a day or two, and the red color will spread over the whole spot.

4. Dissolve a few scales of iodine in fifteen or twenty times its bulk of alcohol. Pour a few drops of this solution on a

freshly-cut potato or apple. Blue specks will show the presence of starch.

96. 1. Melt a quantity of sulphur, either the flowers or brimstone, in a test-tube. It is at first thick and dark-colored, but after continued heating becomes thin and dark-colored. Pour it now into water and it will form an elastic gum, which can be moulded into any desired form.

2. Heat a piece of brimstone in a test-tube. After a little the sulphur will sublime and collect in the upper part of the tube as flowers of sulphur.

3. Fill a cup with brimstone and melt it with a gentle heat. Set it aside to cool. When a crust has formed on top, break it and pour out the liquid contents. If the cup be broken, the bottom will be found covered with crystals of sulphur.

100. Place in the evolution-flask half an ounce of sulphuret of iron. Cover this with water, and then pour in oil of vitriol through the funnel until the gas comes off freely. It may be passed through a glass of cold water. This solution must be bottled and closely corked. The gas may be tested directly; see page 137.

102. 1. Cover a stick of phosphorus with dry, fine-powdered charcoal. It will soon ignite.

2. Put in a vial half an ounce of sulphuric ether and a half-dozen pieces of phosphorus not larger than grains of wheat. Thoroughly shake and then set away. Repeat the shaking often. When the phosphorus is dissolved, pour a little of the solution on the hands, and when briskly rubbed together in a dark place they will glow with a ghostly light.

3. Pour some of the solution on a lump of loaf-sugar. Drop this in hot water, when the ether will catch fire.

4. Place in a wine-glass a few crystals of chlorate of potash and a small bit of phosphorus. Fill the glass nearly full of water. By means of a funnel-tube, pour a little oil of vitriol to the bottom of the glass. A violent deflagration will immediately take place, and, in a dark room, flashes of green light will be seen.

119. Cut off three or four inches of magnesium ribbon, and holding one end with a pair of pincers, thrust the other into the flame of the spirit-lamp. The metal will almost instantly ignite, when it may be removed and held up to the view of the class until the Mg is consumed.

124. To make a saturated solution of alum, drop crystals of the salt into boiling water, until a drop of the liquid taken out on the end of a glass rod and put on a bit of glass will crystallize as soon as it cools.

134. Fill a test-tube nearly full of water. Pour in it a few drops of the solution of sulphate of copper. Add ammonia, and a blue precipitate will be formed. Notice the change from green to blue. The sulphate of copper may be readily made for this experiment by covering a copper cent with dilute oil of vitriol. This experiment may be made to show the divisibility of matter by weighing the cent, then seeing what proportion of the whole solution you use, and then experiment to find what quantity of water can be taken and yet have the blue color perceptible in the ammonia test.

185. Fill a test-tube one-sixth full of sweet oil, add a little ammonia, and nearly fill with water. The constituents remain separate. Shake thoroughly, and they will combine, forming a thin, soapy liquid. Add an acid, and they will dissolve partnership at once.

SUGGESTIONS.

Melted snow, or very clear rain-water, will answer the place of distilled water in making solutions, &c., for experiments. Whenever corks leak gas they may be wrapped with thin strips of wet paper to make them fit more tightly, or the entire nozzle may be smeared with tallow, or covered with sealing-wax, if heat is not used. In that case a little plaster of paris may be wet up and quickly applied. The experimenter will find a retort-stand for holding the retorts, a test-tube holder, a set of tin cork-borers, several Florence flasks of different sizes, the copper retort for making oxygen, and the gas-bag, with its tubing and connectors, almost indispensable. After these, the compound blow-pipe is of the greatest value. A few drops of a solution of magenta (¼ dr. in a gill of HO) will color the water beautifully, and add to the effect of certain experiments.

KEY

TO

CHEMISTRY AND PHYSIOLOGY.

ANSWERS

TO THE

PRACTICAL QUESTIONS AND PROBLEMS

IN THE

FOURTEEN WEEKS IN CHEMISTRY,

REVISED EDITION,

WITH NEW NOMENCLATURE.

[*The large figures refer to the page of the Chemistry, and the small ones to the number of the Question.*]

24.—1. *In a 25-lb. sack of common salt, how many pounds of the metal sodium?*

$Na = 23$ = atomic weight of the given element.
$NaCl = 58.5$ = molecular weight of the compound.
x = weight of the given element.
25 lbs. = " " compound.

$$Na : NaCl :: x : 25 \text{ lbs.}$$
$$23 : 58.5 :: x : 25 \text{ lbs.}$$
$$58.5\,x = 575 \text{ lbs.}$$
$$x = 9\tfrac{97}{117} \text{ lbs. (Na).}$$

2. *In* 14 *lbs. of iron rust* (Fe_2O_3), *how much* O?

$O_3 = 48$ = atomic weight of the given element.
$Fe_2O_3 = 160$ = molecular weight of the compound.
x = weight of the given element.
14 lbs. = " " compound.

$$O_3 : Fe_2O_3 :: x : 14 \text{ lbs.}$$
$$48 : 160 :: x : 14 \text{ lbs.}$$
$$160\,x = 672 \text{ lbs.}$$
$$x = 4\tfrac{1}{5} \text{ lbs. (O).}$$

3. *How much* S *is there in* 2 *lbs. of* SO_2?

$S = 32 =$ atomic weight of the given element.
$SO_2 = 64 =$ molecular weight of the compound.
$x =$ weight of the given element.
2 lbs. = " " compound.
$S : SO_2 :: x : 2$ lbs.
$32 : 64 :: x : 2$ lbs.
$644 = 64$ lbs.
$x = 1$ lb. (S).

4. *How much* S *is there in* 2 *lbs. of* H_2SO_4?

$S : H_2SO_4 :: x : 2$ lbs.
$32 : 98 :: x : 2$ lbs.
$98\,x = 64$ lbs.
$x = \frac{32}{49}$ lb. (S).

5. *How much* O *is there in* 5 *lbs. of* HNO_3?

$O_3 = 48 =$ atomic weight of the given element.
$HNO_3 = 63 =$ molecular weight of the compound.
$x =$ weight of the given element.
5 lbs. = " " compound.
$O_3 : HNO_3 :: x : 5$ lbs.
$48 : 63 :: x : 5$ lbs.
$63\,x = 240$ lbs.
$x = 3\frac{17}{21}$ lbs. (O).

6. *How much* H *is there in* 6 *lbs. of* HCl?

$H : HCl :: x : 6$ lbs.
$1 : 36.5 :: x : 6$ lbs.
$36.5\,x = 6$ lbs.
$x = \frac{60}{365} = \frac{12}{73}$ lb. (H).

7. *How much* K_2O *could be made from* 3 *lbs. of* K?

$K_2 : K_2O :: 3$ lbs. $: x$.
$78 : 94 :: 3$ lbs. $: x$.
$78\,x = 282$ lbs.
$x = 3\frac{8}{13}$ lbs. (K_2O).

40.—1. *Are all acids sour?*

(See *Chemistry*, page 22, note, and also page 110.)

2. *What is the difference between an* -ate, *an* -ite, *and an* -ide *compound?*

An *-ate* compound is a union of an *-ic* acid with a base; an *-ite* compound is a union of an *-ous* acid with a base; and an *-ide* compound is a union of two elements, a binary compound. EXAMPLES.—Iron sulphate, $FeSO_4$; calcium sulphite, $CaSO_3$; potassium chloride, KCl.

3. *Why does not canned fruit decay?*

Because the O of the air is excluded.

4. *Where is the higher oxide formed, at the forge or in the pantry?*

(See *Chemistry*, page 33, note.)

5. *Why is the blood red in the arteries and dark in the veins?*

When specimens of venous and of arterial blood are subjected to chemical examination, the differences presented by their solid and fluid constituents are found to be very small and inconstant. As a rule, there is rather more water in arterial blood, and rather more fatty matter. But the gaseous contents of the two kinds of blood differ widely in the proportion which the carbonic acid gas bears to the oxygen; there being a smaller quantity of oxygen and a greater quantity of carbonic acid, in venous than in arterial blood. And it may be experimentally demonstrated that this difference in their gaseous contents is the only essential difference between venous and arterial blood. For if arterial blood be shaken up with carbonic acid, so as to be thoroughly saturated with that gas, it loses oxygen, gains carbonic acid, and acquires the hue and properties of venous blood; while, if venous blood be similarly treated with oxygen, it gains oxygen, loses carbonic acid, and takes on the color and properties of arterial blood.—HUXLEY'S *Lessons in Physiology.*

6. *Why do we need more oxygen in winter than in summer?*

Because there is a brisker fire going on in our corporeal stoves.

7. *Which would starve sooner, a fat man or a lean one?*

(See *Chemistry*, page 35, note.)

A superabundance of flesh, in a time of scarcity, is taken up by the absorbents and thrown into the circulation, thus supplying the place of food in nourishing the body.

8. *How do teamsters warm themselves by slapping their hands together?*

To produce the motion, additional O is supplied, and increased oxidation is the result. This liberates heat to warm the body. Besides, the blood sets to the arms and the general circulation becomes more rapid. This extra supply, both by its presence and the friction of the swiftly moving currents, furnishes heat, and thus raises the temperature of the body.

9. *Could a person commit suicide by holding his breath?*

Respiration is entirely independent of consciousness, as is seen in sleep, coma, etc. It may be interrupted for a few minutes, but no effort of the will can enable one to hold his breath until life is extinct. The desire for O, the *besoin de respirer*, or the respiratory sense, as it is called, becomes at last so great that the strongest resolution yields the struggle.

10. *Why do we die when our breath is stopped?*

"In asphyxia it is difficult to say which destroys life, the absence of oxygen or the presence of carbonic acid."—FLINT. There is an absence of oxygen, so essential to every vital operation, and also an accumulation of carbonic acid * in the system.

11. *Why do we breathe so slowly when we sleep?*

(See *Chemistry*, page 35.)

Because so little muscular action is going on in the body.

12. *How does a cold-blooded animal differ from a warm-blooded one?*

In the imperfection with which the blood is oxygenated. The lungs are often of small capacity, and loose texture, and are sometimes wanting entirely. In reptiles a portion of the blood is not sent to the heart, and hence in the vessels there is a mixture of arterial and venous blood. The breathing is therefore slow, the motions are languid, and there is little heat.

13. *Why does not the body burn out like a candle?*

Because it is renewed by the processes of assimilation and nutrition as rapidly as it is destroyed by the waste of oxidation. Whenever the former are in excess we gain flesh, when the latter, we grow poor.

14. *Do all parts of the body change alike?*

* This gas remains fixed in the blood-corpuscles, and renders them incapable of furnishing any oxygen to the system. CO is a deadly poison, because it clings to the disks more tenaciously.

The rate of change varies with the amount of oxidation, and that depends on the use of the organ. The right arm of the blacksmith must be transformed much more rapidly than the left.

15. *What objects would escape combustion?*

Burnt bodies, *i. e.*, those which are already combined with oxygen.

16. *How much oxygen can be obtained from* 6 *oz. of* $KClO_3$?

$$O_3 : KClO_3 :: x : 6 \text{ oz.}$$
$$48 : 122.5 :: x : 6 \text{ oz.}$$
$$122.5\, x = 288 \text{ oz.}$$
$$x = 2.35 \text{ oz. (O).}$$

Or (see *Chemistry*, page 28), $\frac{96}{245} \times 6$ oz. $= 2\frac{86}{245}$ oz. (O).

17. *How much* $KClO_3$ *would be needed to produce* 2 *lbs. of* O?

$$O_3 : KClO_3 :: 2 \text{ lbs.} : x.$$
$$48 : 122.5 :: 2 \text{ lbs.} : x.$$
$$48\, x = 245 \text{ lbs.}$$
$$x = 5\tfrac{5}{48} \text{ lbs. } (KClO_3).$$

18. *How much* KCl *would be formed in preparing* 1 *lb. of* O

(See *Chemistry*, page 28, diagram.)

If 1 lb. is $\frac{96}{245}$ of a compound, what are $\frac{149}{245}$?

Ans. $\frac{149}{96}$ lbs. $= 1\frac{53}{96}$ lbs. (KCl).

19. *Name a substance from which the* O *can be set free by the stroke of a hammer.*

Potassium chlorate.

20. *Name one from which it is liberated with great difficulty.*

Sand, carbonic anhydride. (See *Chem.*, p. 98, note.)

21. *Is it probable that all the elements have been discovered?*

(See *Key*, page 49, Question 1.)

22. *Is heat* PRODUCED *by oxidation?*

(See *Chemistry*, pages 36 and 100.)

All forms of force—electricity, heat, muscular energy, chemical attraction, gravitation, etc., are now considered as movements of molecules; the particles being in continuous, undulatory motion, the swiftness and width of the vibrations determining the character of the force. These forces are interchangeable, but cannot be created or annihilated, increased or diminished.

23. *What is the difference between dynamic and potential force?*

A potential force is one that is latent; a dynamic, one that is sensible. The former is hidden; the latter is in full action. Potential force is a weight wound up, a loaded gun, a river trembling on the brink of a precipice, a giant waiting the word, an engine with the valve closed. Dynamic force is the weight falling, the river tumbling, the giant striking, the engine flying along the track.

24. *Why does running cause panting?*

As soon as we begin to perform any unusual exercise, we commence breathing more rapidly—showing that, in order to do the work, we need more O to unite with the food and muscles. In very violent labor, as in running, we are compelled to open our mouths, and take in deep inspirations of oxygen.

25. *How does O give us strength?*

(See *Chemistry*, page 35.)

Our muscles, as well as the food from which they are formed, consist of complex molecules, and the tension of the forces is very great. When they oxidize, the potential force becomes a dynamic one.

26. *Does the plant* PRODUCE *force?*

(See *Chemistry*, page 100.)

It only gathers up the solar force.

27. *If we burn an organic body in a stove, it gives off heat; in the body it produces also motion. Explain.*

The force set free by the oxidation of the muscles, and food within the body is, by the principle of the correlation of forces, converted into muscular energy.

28. *In preparing* N *a thin, white cloud remains in the jar for a long time. What is it?*

Probably an antozone cloud.

49.—1. *How could you detect any free* O *in a jar of* N?

By passing into the jar a bubble of NO, and watching for the production of the red fumes of NO_2.

2. *How would you remove the product of the test?*

By letting the jar stand over water.

3. *In the experiment shown in Fig.* 11, *why is the gas red in the flask, but colorless when it bubbles up into the jar?*

Because the NO_2 formed by the air present in the flask is absorbed by the H_2O in the pneumatic tub.

4. *How much* H_3N *can be obtained from* 3 *lbs. of sal-ammoniac?*

$$\begin{aligned}
(1).\quad H_3N : H_4N,Cl &:: x : 3 \text{ lbs.} \\
17 : 53.5 &:: x : 3 \text{ lbs.} \\
53.5\, x &= 51 \text{ lbs.} \\
x &= \tfrac{102}{107} \text{ lb. } (H_3N).
\end{aligned}$$

(2). From the formulæ it is seen that any amount of sal-ammoniac will yield $\frac{170}{535}$ its weight of ammonia: hence, 3 lbs. will give 3 lbs. $\times \frac{170}{535} = \frac{102}{107}$ lb. (H_3N).

5. *How much* H_2O *will be formed in the process?*

By examining the reaction given in the *Chemistry*, page 48, it will be seen that $\frac{1}{4}$ of the H in each molecule of H_4N,Cl goes to form H_2O. Hence, find (1) how much H there is in 3 lbs. of sal-ammoniac, and (2) how much H_2O would be formed by $\frac{1}{4}$ that amount of H.

$$\begin{aligned}
(1)\quad H_4 : H_4N,Cl &:: x : 3 \text{ lbs.} \\
4 : 53.5 &:: x : 3 \text{ lbs.} \\
53.5\, x &= 12 \text{ lbs.} \\
x &= \tfrac{24}{107} \text{ lb. (H).}
\end{aligned}$$

(2) $\frac{24}{107}$ lb. $\div 4 = \frac{6}{107}$ lb. $\frac{6}{107}$ lb. $\times 9^{*} = \frac{54}{107}$ lb. (H_2O).

6. *How much* CaO *will be needed?*

Find (1) how much O there is in $\frac{54}{107}$ lb. of H_2O; and (2) how much CaO would be needed to furnish that amount of O.

(1) $\frac{54}{107}$ lb. $\times \frac{8}{9}{}^{*} = \frac{48}{107}$ lb.; hence, there are $\frac{48}{107}$ lb. of O in the water produced.

$$\begin{aligned}
(2)\quad O : CaO &:: \tfrac{48}{107} \text{ lb.} : x. \\
16 : 56 &:: \tfrac{48}{107} \text{ lb.} : x. \\
16\, x &= \tfrac{2688}{107}. \\
x &= 1.57 + \text{ lbs. (CaO).}
\end{aligned}$$

7. *In separating* N, *how much air will be needed to furnish a gallon of the gas?*

About $\frac{4}{5}$ of the atmosphere is N: hence, $\frac{5}{4}$ of a gallon of common air would be required to furnish one gallon of N.

* See *Chemistry*, page 24.

8. *How much* N_2O *can be made from* 1 *lb. of ammonium nitrate?*

$$N_2O : H_4N,NO_3 :: x : 1 \text{ lb.}$$
$$44 : 80 :: x : 1 \text{ lb.}$$
$$80\,x = 44 \text{ lbs.}$$
$$x = \tfrac{11}{20} \text{ lb. } (N_2O).$$

9. *How much nitric acid can be formed from* 50 *lbs. of sodium nitrate* ($NaNO_3$)?

Find (1) how much N there is in 50 lbs. of sodium nitrate (Chili saltpetre), and (2) how much HNO_3 could be made from that amount of N.

$$(1)\quad N : NaNO_3 :: x : 50 \text{ lbs.}$$
$$14 : 85 :: x : 50 \text{ lbs.}$$
$$85\,x = 700 \text{ lbs.}$$
$$x = 8\tfrac{4}{17} \text{ lbs. (N).}$$

$$(2)\quad N : HNO_3 :: 8\tfrac{4}{17} \text{ lbs.} : x.$$
$$14 : 63 :: 8\tfrac{4}{17} \text{ lbs.} : x.$$
$$14\,x = 518\tfrac{14}{17} \text{ lbs.}$$
$$x = 37\tfrac{1}{17} \text{ lbs. } (HNO_3).$$

10. *What causes flesh to decompose so much more easily than wood?*

It is partly owing to the greater complexity of its molecule, and partly to the presence of the fickle N.

11. *If a tuft of hair be heated in a test tube, the liquid formed will turn red litmus-paper blue. Explain.*

Ammonia is formed by the decomposition of the hair, and this acting on the red litmus-paper turns it blue.

12. *Why should care be used in opening a bottle of strong* H_3N *in a warm room?*

The volatile gas sometimes drives out the liquor ammoniæ with great force.

13. *What weight of* N *is there in* 10 *lbs. of* HNO_3?

$$N : HNO_3 :: x : 10 \text{ lbs.}$$
$$14 : 63 :: x : 10 \text{ lbs.}$$
$$63\,x = 140 \text{ lbs.}$$
$$x = 2\tfrac{2}{9} \text{ lbs. (N).}$$

14. *How much sal-ammoniac would be required to make* 2 *lbs. of* H_3N?

$$H_3N : H_4N,Cl :: 2 \text{ lbs.} : x.$$
$$17 : 53.5 :: 2 \text{ lbs.} : x.$$
$$17\,x = 107 \text{ lbs}$$
$$x = 6\tfrac{5}{17} \text{ lbs. } (H_4N,Cl).$$

15. *Give illustrations of the replacement of the* H *in an acid by a metal.*

(See *Chemistry*, page 44, note; page 51, reaction; and page 128, note.)

16. *What is the difference between liquid ammonia and liquor ammoniæ?*

Liquid ammonia is the gas condensed into a liquid by cold: liquor ammoniæ is a solution of the gas in H_2O.

63.—1. *Why, in filling the hydrogen gun, do we use* 5 *parts of common air to* 2 *of* H, *and only one part of* O *to* 2 *of* H?

Because the air is only $\frac{1}{5}$ oxygen, and hence 5 parts of common air are equivalent to 1 part oxygen.

2. *Why are coal cinders often moistened with* H_2O *before using?* (See *Chemistry*, page 57, note.)

The H_2O being decomposed by the heat of the fire increases the combustion.

3. *What injury may be done by throwing a small quantity of* H_2O *on a fire?*

"No more heat is produced by the action of the H_2O, but it is in a more available form for communicating heat. The steam in contact with incandescent charcoal is decomposed—the O going to the C to form CO_2, and the H being set free. If the C is abundant, and the heat high, the CO_2 is also decomposed, and double its volume of CO formed. The inflammable gases, H and CO, mingled with the hydrocarbons always produced, are ignited, making the billows of flame which sweep over a burning building."—S. P. SHARPLES.

4. *Why does the hardness of water vary in different localities?*

The hardness of the water will necessarily vary with the *solubility* of the minerals in different localities.

5. *What causes the variety of minerals in the ocean? Is the quantity increasing?*

The ocean contains the washings of the land. Every mineral soluble in water is borne to the sea. The quantity of mineral matter in the ocean would therefore seem to be increasing, yet there is a compensation in the return to the soil, of guano, marine plants, and fish, which are driven on shore by winds and waves, or carried by the industry of man.

Analysis of sea-water (Schweitzer):

Water	963.74
Sodium chloride	28.05
Potassium chloride	.76
Magnesium chloride	3.66
Magnesium bromide	.02
Magnesium sulphate	2.29
Calcium sulphate	1.40
Calcium carbonate	.03
Iodine	traces
Ammonia	traces
	1000.00

6. *Is there not a compensation in the sea-plants, fish, etc., which are washed back on the land?*

(See Answer to Question 5.)

7. *Since "all the rivers flow to the sea," why is it not full?*

Because of the constant evaporation from its surface.

8. *What is the cause of the tonic influence of the sea breeze?*

There are traces of certain minerals which probably give to the sea breeze a bracing influence. The air from the ocean is also, doubtless, highly ozonized. Persons with delicate lungs, therefore, find the sea breeze tóo corrosive. In England, rheumatic and other inflammatory diseases are more abundant near the coast than inland.

9. *When fish are taken out of the water, and thus brought into a more abundant atmosphere, why do they die?*

Fish inhale O through the fine silky filaments of their gills. When a fish is drawn out of H_2O, these dry up, and it is unable to breathe, although it is in a more plentiful atmosphere than it is accustomed to enjoy.

10. *Do all fish die when brought on land?*

(See *Key*, page 51, Question 15.)

11. *What weight of water is there in* 100 *lbs. of sodium sulphate* ($Na_2SO_4,10H_2O$), *or Glauber's salt?*

$$10H_2O : Na_2SO_4,10H_2O :: x : 100 \text{ lbs.}$$
$$180 : 322 :: x : 100 \text{ lbs.}$$
$$322\,x = 18000 \text{ lbs.}$$
$$x = 55.9 \text{ lbs. } (H_2O).$$

12. *What weight of water in a ton of alum* ($KAl,2SO_4, 12H_2O$)?

$$12H_2O : KAl,2SO_4, 12H_2O :: x : 2000 \text{ lbs.}$$
$$216 : 474.5 :: x : 2000 \text{ lbs.}$$
$$474.5\, x = 432000 \text{ lbs.}$$
$$x = 910.4 \text{ lbs. } (H_2O).$$

13. *How much water would it require to furnish enough* H *to change* 5 *lbs. of nitric anhydride to nitric acid?*

Find (1) how much HNO_3 could be made from 5 lbs. of N_2O_5 (see *Chemistry*, page 44, note); (2) how much H_2O is contained in that amount of HNO_3. The difference between the weight of the nitric anhydride and that of the nitric acid will show the amount of water required to furnish the H.

$$(1).\quad N_2O_5 : 2(HNO_3) :: 5 \text{ lbs.} : x.$$
$$108 : 126 :: 5 \text{ lbs.} : x.$$
$$108\, x = 630 \text{ lbs.}$$
$$x = 5.833 \text{ lbs. } (HNO_3).$$

$$(2).\quad 5.833 \text{ lbs. } (HNO_3) - 5 \text{ lbs. } (N_2O_5) = .833 \text{ lb. } (H_2O).$$

14. *How does the air purify running water?*

The O contained in the air absorbed by the H_2O oxidizes the organic substances, which are the most dangerous impurities.

15. *What is the action of potassium permanganate as a disinfectant?*

It gives up its O to oxidize the organic impurities.

16. *Why does lime sometimes soften hard water when added to it?*

(See *Key*, page 50, Question 4.)

17. *What weight of* H *can be obtained from a gallon of water?*

The standard gallon of the United States weighs 8.3389 lbs. of distilled water.

$$H_2 : H_2O :: x : 8.3389 \text{ lbs.}$$
$$2 : 18 :: x : 8.3389 \text{ lbs.}$$
$$9x = 8.3389 \text{ lbs.}$$
$$x = .9265 \text{ lb. (H).}$$

18. *In decomposing* H_2O, 65 *parts by weight of* Zn *yield* 2 *parts by weight of* H. *How much* Zn *must be employed to obtain* 100 *lbs. of* H ?

If we look at the equation

$$H_2SO_4 + Zn = ZnSO_4 + H_2,$$

we see that

H_2	signifies	2	parts	by	weight	of	hydrogen,
H_2O	"	18	"	"	"	"	water,
S	"	32	"	"	"	"	sulphur,
O_4	"	64	"	"	"	"	oxygen,
H_2SO_4	"	98	"	"	"	"	sulphuric acid,
Zn	"	65	"	"	"	"	zinc,
$ZnSO_4$	"	161	"	"	"	"	zinc sulphate.

The equation, therefore, shows that 98 parts by weight of sulphuric acid added to 65 parts of zinc will form 161 parts of zinc sulphate, and, decomposing 18 parts of water, liberate 2 parts of hydrogen. For every part of H we must have $\frac{65}{2}$ parts of Zn: hence, to obtain 100 lbs. of H we should need 100 lbs. $\times \frac{65}{2} = 3250$ lbs. Zn. In a similar way we can find the amount of each of the other constituents needed.

19. *How much* $KClO_3$ *would be required to evolve sufficient* O *to burn the* H *produced by the decomposition of* 2 *lbs. of* H_2O ?

(See *Key*, page 61, Question 37.)

20. *How much* O *would be required to oxidize the metallic* Cu *which could be reduced from its oxide by passing over it, when white-hot,* 20 *gr. of* H *gas?*

(See *Key*, page 60, Question 34.)

21. *How much* O *would be required to oxidize the metallic* Fe *which could be reduced in the same manner by* 10 *grs. of* H *gas?*

(See *Key*, page 61, Question 35.)

22. *Why are rose-balloons so buoyant?*

They are filled with hydrogen or coal-gas, which is lighter than common air.

23. *How much* H *must be burned to produce a ton of water?*

Find how much H is contained in 2000 lbs. of water.

$$
\begin{aligned}
(1).\quad H_2 : H_2O &:: x : 2000 \text{ lbs.} \\
2 : 18 &:: x : 2000 \text{ lbs.} \\
18\,x &= 4000 \text{ lbs.} \\
x &= 222\tfrac{2}{9} \text{ lbs. (H).}
\end{aligned}
$$

2d Method.—One-ninth of any weight of water is hydrogen; hence,

$$2000 \text{ lbs.} \div 9 = 222\tfrac{2}{9} \text{ lbs. (H).}$$

94.—1. *Why does not blowing cold air on a fire with a bellows extinguish it?*

More heat is liberated by the O which combines with the fuel than is withdrawn from the fire by the current of cold air. Yet the temperature of the fire must be sufficient to elevate that of the O to the point of union with C and H, else the fire will be extinguished.

3. *Why is fire-damp more dangerous than choke-damp?*

Fire-damp, or marsh-gas, is inflammable, while choke-damp, or "carbonic acid," is not.

4. *Represent the reaction in making* CO_2, *showing the atomic weights, as in the preparation of* O *on page* 28.

In this experiment the acid exchanges its hydrogen for the calcium, producing calcium chloride ($CaCl_2$) on the one hand, and carbonic acid (H_2CO_3) on the other. But the carbonic acid is so unstable that it immediately becomes decomposed into water, which remains behind, and into carbonic anhydride, which comes off as a gas with brisk effervescence. The decomposition may be represented as follows:

$$CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2.$$

$$\begin{array}{ccccccccc} \left.\begin{array}{c}\text{(Calcium Car-}\\ \text{bonate)}\end{array}\right\} & + & \left\{\begin{array}{c}\text{(Hydrochlo-}\\ \text{ric Acid)}\end{array}\right\} & = & \left\{\begin{array}{c}\text{(Calcium}\\ \text{Chloride)}\end{array}\right\} & + & \text{(Water)} & + & \left\{\begin{array}{c}\text{(Carbonic}\\ \text{Anhydride)}\end{array}\right. \\ Ca\ C\ O_3 & & 2(H\ Cl) & & Ca\ \ Cl_2 & + & H_2\,O & + & C\ \ O_2 \\ \underbrace{40+12+3\times16}_{100} & & \underbrace{2(1+35.5)}_{73} & & \underbrace{40+2(35.5)}_{111} & & \underbrace{2+16}_{18} & & \underbrace{12+2\times16}_{44} \\ \multicolumn{3}{c}{\underbrace{\qquad\qquad\qquad\qquad}_{173}} & & \multicolumn{5}{c}{\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad}_{173}} \end{array}$$

The CO liberated = $\frac{44}{173}$ of the materials used; the $H_2O = \frac{18}{173}$, and the $CaCl_2 = \frac{111}{173}$.

5. *Should one take a light into a room where the gas is escaping?*

Great care should be used, since coal-gas is combustible, and when mixed with O in the proper proportion explodes with great violence. Severe accidents frequently occur from a neglect of this precaution.

6. *What causes the difference between a No.* 1 *and a No.* 4 *pencil?*

(See *Chemistry*, page 67.)

7. *Why does it dull a knife to sharpen a pencil?*

(See *Chemistry*, page 67.)

8. *Why is slate found between seams of coal?*

(See *Geology*, page 150.)

The coal represents a period of vegetation, and the slate, one of convulsion. During the former, a deposit of the leaves, branches, trunks of trees, etc., was made; during the latter, one of gravel, sand, etc., accumulated.

9. *Why was the coal hidden in the earth?*

It is natural to think that one object was to protect it from accidental combustion.

10. *Where was the* C, *now contained in the coal, before the Carboniferous age?*

(See *Geology*, pages 150–1.)

In the atmosphere, which was then so full of CO_2 that, according to certain authorities, it contained 7 to 8 parts in 100.

11. *Must the air have then contained more plant food?*

(See *Chemistry*, page 71, and *Geology*, page 150.)

12. *What is the principle of the aquarium?*

The inter-dependence of animals and plants, whereby each supplies the wants of the other. The aquarium is a microcosm—a world in miniature.

* I have read somewhere a beautiful Persian fable in which a nightingale and a rose are represented as being confined in a cage together, and being dependent upon each other for life. The fable is truth symbolized. The idea has now become more practical, but not less beautiful. In the modern aquarium, or drawing-room fish-pond, we see the world in miniature. It is a self-regulating, self-subsisting establishment, and is constructed on the most perfect principles of chemical economy.

"Before this truth of compensation between animals and plants was discovered, many attempts were made to keep fish in small glass globes. As

13. *What test should be employed before going down in an old well or cellar?*

A lighted candle should be lowered. If that is dimmed or extinguished it is not safe for one to descend.

14. *What causes the sparkle of wine and the foam of beer?*

The CO_2 formed in the process of fermentation.

15. *What causes the cork to fly out of a catsup bottle?*

The CO_2 which is produced when the catsup ferments.

they soon exhausted the oxygen, and impregnated the water with carbonic acid, it was necessary to change it daily. In this operation they suffered the most intense fear. For a few weeks they would drag out a dubious existence, seemingly anxious only to find out before they died where they were and how they got there. Finally, but a few years since, it was discovered that plants evolve oxygen and consume carbonic acid in the water as well as in the air. Starting out with this idea, about the year 1850, a Mr. Warrington, an Englishman, set about breeding fish and mollusks in tanks by the aid of marine plants. He succeeded admirably for a few days, but after a time, a change came over his little world. Without apparent reason, the water became suddenly impure and the fish died. Here was a new agency at work. With the aid of a microscope, Mr. Warrington explored his tank for the poison that was evidently latent there. He soon discovered that some of his plants had reached maturity and, in obedience to the law of nature, had died. The decaying matter was the poison of which he was in search. How was this to be counteracted? In nature's tanks—seas, rivers, and ponds—reflected Mr. Warrington, plants must die and decay, yet this does not destroy animal life. We must see how nature remedies the evil. He hastened to a pond in the vicinity and examined its bottom with care. He found, as he had anticipated, an abundance of vegetable matter decayed. He likewise found swarms of water-snails doing duty as scavengers, and devouring the putrefying substances before they had time to taint the water. Here was the secret; so beautiful a contrivance that it is said Mr. Warrington, with the emotion of a true man of science, burst into tears when it flashed upon him like a revelation.

"He, however, quickly dried his eyes, gathered a quantity of snails, and threw a handful into his little tank at home. In a single day the water was clear and pure again. The fish throve and gamboled, grew and multiplied; the plants resumed their bright colors, and the snails not only rollicked in an abundance of decaying branches, but laid a profusion of eggs, on which the fish dined sumptuously every day."

16. *What philosophical principle does the solidification of* CO_2 *illustrate?*

(See *Philosophy*, page 242.)

That evaporation is a cooling process. A portion of the liquid CO_2 turns to vapor, and thus abstracts so much heat from the remainder as to freeze it.

17. *Why does the division in the chimney shown in Fig.* 28 *produce two currents?*

For a few moments there is an uncertainty—a condition of unstable equilibrium. The heated air is endeavoring to rise, and the cold air trying to come in to supply its place. The situation of the candle in the jar determines the length of time before the currents start. If the candle be placed on one side of the jar they will be established almost instantly.

18. *What causes the unpleasant odor of coal-gas? Is it useful?*

Impurities which it contains. Olefiant gas has a faint sweetish odor, while carbonic oxide and hydrogen, when pure, are inodorous. The disagreeable smell is due in part to acetylene (C_2H_2). The unpleasant odor warns us of the presence of coal-gas.

19. *What causes the sparkling often seen in a gas-light?*

Particles of lime taken up mechanically in the process of purification.

20. *Why does* H *in burning give out more heat than* C?

1 lb. of H burned in O emits heat sufficient to melt 315.2 lbs. of ice; and 12 lbs. of carbon converted into CO_2 enough to melt 700 lbs. of ice. (This subject is

quite fully treated in Miller's Chemical Physics, page 294, *et seq.*) The cause is not as yet fully determined, although it is perhaps safe to say that in ordinary combustion the heat depends on the amount of O which enters into combination with the fuel. "Thus hydrogen in burning takes up three times as much O as C does, and hence gives off three times as much heat."—YOUMANS.

21. *Why does blowing on a fire kindle it, and on a lighted lamp extinguish it?*

(See *Key*, page 50, Question 6.)

22. *Why can we not ignite hard coal with a match?*

Because it is a good conductor of heat.

23. *What causes the dripping of a stove-pipe?*

The condensation of the water formed in the combustion of the fuel.

24. *Why will an excess of coal put out a fire?*

Because it will absorb the heat, and thus reduce the temperature of the fire below the combining point of C and O.

25. *Why do not stones burn as well as wood?*

Because they are already burned, i. e., combined with O.

26. *Why does not hemlock make good coals?*

Because (1) of its lack of C, and (2) its porous structure.

27. *What adaptation of chemical affinities is shown in a light?*

If O had the same affinity for C that it has for H, they would be consumed at once, with little light. The fact that the H burns first, and thus heats up to the luminous point the particles of C as they float outward to the air, causes the illuminating power of the hydrocarbons.

28. *Is there a gain or a loss of weight by combustion?*

The products of combustion weigh as much as the fuel and the O which enters into combination with it.

29. *Why does snuffing a candle brighten the flame?*

Because it removes the charred wick, which diminishes the heat of the flame both by conduction and radiation.

30. *Why is the flame of a candle red or yellow, and that of a kerosene oil-lamp white?*

(See *Philosophy*, page 225.)

The heat of a candle-flame is much less than that of kerosene, and thus the colors characteristic of a lower temperature are produced.

31. *Why does blowing on a light extinguish it?*

Because it lowers the temperature of the flame below the point of union between O and C.

32. *Why will water put out a fire?*

(See *Chemistry*, page 93.)

Partly by absorbing the heat of the fire, and partly by shutting out the O.

33. *What should we do if a person's clothes take fire?*

The best course is to wrap the person in a blanket, carpet, coat, or even in his own garments. This smothers the fire by shutting out the O.

34. *Ought we to leave open the doors or windows of a burning house?*

(See *Chemistry*, page 93.)

No. Open doors or windows will make draughts of air to feed the flame.

35. *Why does a street gas-light burn blue on a windy night? Is the light then as intense? The heat?*

O is mingled with the flame in sufficient quantities to burn the H and C simultaneously. Thereby the heat is increased, but the light diminished. The principle is that of Bunsen's burner.

36. *Why does not the lime burn in a calcium-light?*

Lime is a burned body; its symbol is CaO.

37. *Why is a candle-flame tapering?*

(See *Chemistry*, page 88.)

The currents of air rushing toward the flame from all sides give it the conical form.

38. *Why does a draught of air cause a lamp to smoke?*

It lowers the heat of the flame below the point of union between C and O, and thus the C is precipitated.

39. *What makes the coal at the end of a candle-wick?*

The wick at the edge of the flame comes in contact with the O of the air, and therefore burns.

40. *Which is the hottest part of a flame?*

Toward the point of the cone, where the gaseous envelopes meet and make a solid flame.

41. *Why does not a candle-wick burn?*

There is no O at the centre of the flame.

42. *How does a chimney enable us to burn highly carboniferous substances like oil without smoke?*

(See *Chemistry*, page 88.)

It keeps out the cold air, and elevates the temperature of the O, which supplies the flame. Thus more C can be consumed.

43. *How much* CO_2 *in* 200 *lbs. of chalk?*

$$CO_2 : CaCO_3 :: x : 200 \text{ lbs.}$$
$$44 : 100 :: x : 200 \text{ lbs.}$$
$$100\,x = 8800 \text{ lbs.}$$
$$x = 88 \text{ lbs. } (CO_2).$$

44. *What weight of* CO_2 *in a ton of marble?*

$$CO_2 : CaCO_3 :: x : 2000 \text{ lbs.}$$
$$44 : 100 :: x : 2000 \text{ lbs.}$$
$$100\,x = 88{,}000 \text{ lbs.}$$
$$x = 880 \text{ lbs. } (CO_2).$$

45. *What is the difference between marble and chalk?*

Marble is a compact, crystallized carbonate of lime, while chalk is a porous kind of limestone.

46. *Why does not a cold saucer held over an alcohol flame blacken, as it does over a candle or gas-light?*

There is less C in alcohol than in tallow or in coal-gas.

47. *Could a light be frozen out, i. e., extinguished, by merely lowering the temperature?*

It is said to have been done in Arctic regions.

48. *How much* CO_2 *is formed in the combustion of one ton of* C?

$$C : CO_2 :: 2000 \text{ lbs.} : x.$$
$$12 : 44 :: 2000 \text{ lbs.} : x.$$
$$12\,x = 88{,}000 \text{ lbs.}$$
$$x = 7333.33 + \text{ lbs. } (CO_2).$$

49. *What weight of* C *is there in a ton of* CO_2?

$$C : CO_2 :: x : 2000 \text{ lbs.}$$
$$12 : 44 :: x : 2000 \text{ lbs.}$$
$$44\,x = 24{,}000 \text{ lbs.}$$
$$x = 545.45 + \text{ lbs. } (C).$$

50. *How much* O *is consumed in burning a ton of* C?

In any quantity of CO_2, $\frac{8}{11}$ of the compound is O, and $\frac{3}{11}$ C. If $\frac{3}{11} = 2000$ lbs. (CO_2), then $\frac{8}{11} = \frac{8}{3}$ of 2000 lbs. $= 5333.33 +$ lbs. (O).

51. *What weight of sodium carbonate* ($Na_2CO_3, 10H_2O$, "*carbonate of soda*") *would be required to evolve* 12 *lbs. of* CO_2?

$$CO_2 : Na_2CO_3, 10H_2O :: 12 \text{ lbs.} : x.$$
$$44 : 286 :: 12 \text{ lbs.} : x.$$
$$44\,x = 2432 \text{ lbs.}$$
$$x = 50.72 \text{ lbs. } (Na_2CO_3, 10H_2O).$$

52. *How much* CO_2 *will be formed in the combustion of* 30 *grs. of* CO?

$$CO : CO_2 :: 30 \text{ grs.} : x.$$
$$28 : 44 :: 30 \text{ grs.} : x.$$
$$28\,x = 1320 \text{ grs.}$$
$$x = 47.14 \text{ grs. } (CO_2).$$

53. *What weight of hydrogen sodium carbonate* ($HNaCO_3$, "*bi-carbonate of soda*") *would be required to evolve* 12 *lbs. of* CO_2?

$$CO_2 : HNaCO_3 :: 12 \text{ lbs.} : x.$$
$$44 : 84 :: 12 \text{ lbs.} : x.$$
$$44\,x = 1008 \text{ lbs.}$$
$$x = 22.9 \text{ lbs. } (HNaCO_3).$$

54. *Write in double columns the different properties of carbonic anhydride and carbonic oxide.*

1. CO_2.	1. CO.
2. Atomic weight—44.	2. Atomic weight—28.
3. Specific gravity—1.529.	3. Specific gravity—.967.
4. Will not burn.	4. Burns with a blue flame.
5. A negative poison.	5. A direct poison.
6. Liquefies at 32°, and a pressure of 38.5 atmospheres.	6. Has never been liquefied.
7. Freely soluble in H_2O.	7. Sparingly soluble in water.
8. Forms salts.	&c., &c.
&c., &c.	

118.—1. *If chlorine water stands in the sunlight for a time, it will only redden a litmus-solution. Why does it not bleach it?*

Hydrochloric acid is formed, which reddens the litmus.

2. *Why do tinsmiths moisten with* HCl, *or sal-ammoniac, the surface of metals to be soldered?*

It dissolves the coating of oxide and leaves the surface of the metal free for the action of the solder.

3. *How much* HCl *can be made from* 25 *lbs. of common salt?*

Find (1) how much Cl there is in 25 lbs. of NaCl, and (2) how much HCl that amount of Cl would make.

$$(1).\quad Cl : NaCl :: x : 25 \text{ lbs.}$$
$$35.5 : 58.5 :: x : 25 \text{ lbs.}$$
$$58.5\,x = 887.5 \text{ lbs.}$$
$$x = 15.17094 \text{ lbs. (Cl).}$$

$$(2).\quad Cl : HCl :: 15.17094 \text{ lbs.} : x.$$
$$35.5 : 36.5 :: 15.17094 \text{ lbs.} : x.$$
$$35.5\,x = 553.73931 \text{ lbs.}$$
$$x = 15.5980056+ \text{ lbs. (HCl).}$$

4. *What weight of* NaCl *would be required to form* 25 *lbs. of muriatic acid?*

(See *Key*, page 58, Question 20.)

5. HCl *of a specific gravity of* 1.2 *contains about* 40 *per cent. of the gas. This is very strong commercial acid. What weight could be formed by the* HCl *acid gas produced in the reaction named in the preceding problem?*

(See *Key*, page 58, Question 21.)

6. *What is the difference between sublimation and distillation?*

A body is said to *sublime* when it rises as vapor and condenses in the solid form; when it condenses as a liquid it is said to *distil.*

7. *Why do eggs discolor silver spoons?*

The sulphur of the egg combines with the Ag, forming silver sulphide—the black sulphuret of silver.

8. *Explain the principle of hair-dyes.*

The two principal chemicals used for dyeing the hair are lead and silver nitrate. The S in the hair combining with the Ag makes silver sulphide, or with the Pb, lead sulphide, either of which stains the hair: the former colors the skin as well as the hair, while the latter is absorbed through the skin, causing colics and other diseases such as are common among painters. The "golden yellow color" lately in fashion is produced by a solution of arsenic with the hydrosulphate of ammonia. In order to dye the lighter tints, it is necessary to bleach the hair with an alkaline solution. See *Fireside Science*, page 77.

9. *Why is new flannel apt to turn yellow when washed?*

New flannels, washed in strong soap, turn yellow, because the alkali of the soap unites with the SO_2 used in bleaching the cloth, and thus sets free the original color.

10. *Is it safe to mix oil of vitriol and water in a glass bottle?*

The heat produced by the combination of the two will be liable to break the glass.

11. *What is the color of a sulphuric acid stain on cloth? How would you remove it?*

It is generally red, especially on black cloth. The color may be restored by a few drops of a solution of common "soda."

12. *What causes the milky look when oil of vitriol and water are mixed?*

Pb from the stills in which the acid is condensed, and which is soluble in strong H_2SO_4, is precipitated when the acid is diluted with H_2O.

13. *What is the relation between animals and plants? Which perform the office of reduction, and which that of oxidation?*

(See *Key*, page 52, Question 19.)

14. *How many pounds of* S *are contained in* 100 *lbs. of* H_2SO_4?

$$S : H_2SO_4 :: x : 100 \text{ lbs.}$$
$$32 : 98 :: x : 100 \text{ lbs.}$$
$$98\,x = 3200 \text{ lbs.}$$
$$x = 32\tfrac{32}{49} \text{ lbs. (S).}$$

15. *How much* O *and* H_2O *are needed to change a ton of* SO_2 *to* H_2SO_4?

One ton of SO_2 will make $1\frac{17}{32}$ tons of H_2SO_4: of which $\frac{1}{49}$ is H, $\frac{16}{49}$ is S, and $\frac{32}{49}$ is O. $\frac{1}{4}$ of this O, or $\frac{8}{49}$, comes from the air, and $\frac{1}{4}=\frac{8}{49}$ from the water. (See process of manufacture, *Chemistry*, p. 116.) Hence $\frac{8}{49}$ (O) and $\frac{1}{49}$ (H) $=\frac{9}{49}$ of the acid was furnished by the water—$\frac{9}{49}$ of $1\frac{17}{32}$ tons $=\frac{9}{32}$ ton (H_2O). The process of reasoning may be seen more clearly, perhaps, by preparing the formulæ as in Question 18, page 99, of this Key.

16. *How much* O *in a lb. of* H_2SO_4?

$\frac{32}{49}$ of any quantity of sulphuric acid are O; $\frac{1}{49}$ is H; and $\frac{16}{49}$ are S. Hence in 1 lb. of H_2SO_2 there are $\frac{32}{49}$ lb. (O).

17. *State the analogy between the compounds of* O *and* S.

O	S
H_2O	H_2S
H_2O_2 (hydrogen dioxide)	H_2S_2
CO_2	CS_2

The corresponding compounds possess not only an analogous composition, but also similar chemical properties.

146.—1. *In the experiment with* Na_2SO_4, *on page* 133, *an accurate thermometer will show that in making the solution, the temperature of the liquid will fall, and in its solidification, will rise. Explain.*

(See *Philosophy*, page 233.)

The solid salt passing into a liquid takes up heat, and, in returning from a liquid to a solid again, gives up heat. The latter is illustrated in next question.

2. *If, in making a solution of* Na_2SO_4, *we use the salt which has effloresced, and so become anhydrous, the temperature will rise instead of falling as before. Explain.*

This is because a solid hydrate is formed before the salt dissolves in the H_2O. The same holds true of other anhydrous bodies, as the chlorides of Zn, Fe, and Cu.

3. *Why is* KNO_3 *used instead of* $NaNO_3$ *for making gunpowder?*

Sodium nitrate is imported from Chili in large quantities, and attempts have been made to use it for making gunpowder,* but its tendency to attract moisture has frustrated the plan. It is now extensively used as a fertilizer, and is said to be the cheapest form in which N can be furnished the soil.

4. *Why is a potassium salt preferable to a sodium one in glass-making?*

Sodium salts give a greenish tint to the glass.

* Gunpowder is an intimate mechanical mixture of about 1 part nitre, 1 part sulphur, and 3 parts charcoal. These proportions, however, vary somewhat in different countries, as well as in different sorts of powder. More charcoal adds to its power, but also causes it to attract moisture from the air, which of course injures its quality. For blasting rocks, where a sustained force, rather than an instantaneous one, is required, the powder contains more sulphur, and is even then often mixed with sawdust to retard the explosion. The nitre, sulphur, and charcoal, having been ground and sifted separately, are thoroughly mixed and then made into a thick paste with water. This is ground for some hours under edge-stones, after which it is subjected to immense pressure between gun-metal plates, forming what is known as *press-cake.* These cakes are then submitted to the action of toothed rollers, whereby the granulation of the powder is effected. The grains thus formed are sorted into different sizes by means of a series of sieves, and thoroughly dried at a steam heat. The last operation, that of polishing, is accomplished in revolving barrels, after which the powder is ready for market. The heavier the powder, the greater is its explosive power. Good powder should resist pressure between the fingers, giving no dust when rubbed, and have a slightly glossy aspect.—YOUMANS.

5. *What is the glassy slag so plentiful about a furnace?**

A silicate of lime or some other base contained in the ore.

Ordinary Slag from Blast Furnace (Bloxam).

Silica	43.07
Alumina	14.85
Lime	28.92
Magnesia	5.87
Oxide of iron	2.53
Oxide of manganese	1.37
Potash	1.84
Sulphide of calcium	1.90
Phosphoric acid	trace
	100.35

6. *State the formulæ of nitre, saleratus, carbonate and bicarbonate of soda, plaster, pearlash, saltpetre, plaster of Paris, gypsum, carbonate and bicarbonate of potash, sal-soda, and soda.*

Nitre, saltpetre	KNO_3.
Saleratus, pearlash	$HKCO_3$.
Carbonate of soda, sal-soda	Na_2CO_3.
Bicarbonate of soda, "soda"	$HNaCO_3$.
Plaster, gypsum	$CaSO_4,2H_2O$.
Plaster of Paris	$CaSO_4$.

7. *Explain how ammonium carbonate is formed in the process of making coal-gas.*

Nitrogen exists in small quantities in coal, and when that is distilled at a high temperature, the elements in their nascent state combine to form this compound.

* The slag is commonly employed for road-making in the neighborhood of the iron-works. Some attempts have been made to turn the slag to account by employing it as a manure for soils deficient in potash, of which it will be seen that the above slag contains nearly $\frac{1}{50}$th of its weight, in a form which would be easily rendered available for plants by the combined action of air and moisture. When the slag is run into water, or blown into a frothy condition by the blast, it resembles pumice-stone, and is easily ground to a powder fit for applying to the soil.

8. *Upon what fact depends the formation of stalactites?*

Water containing carbonic acid in solution will dissolve carbonate of lime freely, but when, on exposure to the air, the gas escapes, the carbonate is deposited.

9. *Why is* HF *kept in gutta-percha bottles?*

Because it will dissolve silica, and so destroy a glass bottle.

10. *Explain the use of borax in softening hard water?*

It softens hard water by uniting with the soluble salts of lime or magnesia, and making insoluble ones which settle and form a thin sediment in the bottom of pitchers in which it is placed.

11. *How are petrifactions formed?*

Certain springs contain large quantities of some alkaline carbonate; their waters, therefore, dissolve silica abundantly. If we place a bit of wood in them, as fast as it decays, particles of silica will take its place—atom by atom—and thus petrify the wood. The wood has not been *changed to* stone, but has been *replaced by* stone.

12. *In what part of the body, and in what forms, is phosphorus found?*

As a phosphate it is the principal earthy constituent of the bones. It is also a never-failing ingredient of the brain and nervous system. The susceptibility of phosphorus to oxidation especially adapts it to the rapid changes incident to the structure and offices of the brain.*

* Phosphorus is an element which can imperceptibly and quickly pass from a condition of great chemical activity to one of equal chemical inertness. In

13. *Why are matches poisonous? What is the antidote?*

(See *Physiology*, page 209.)

Because of the phosphorus in the match.

virtue of this character, it "may follow the blood in its changes, may oxidize in the one great set of capillaries, and be indifferent to oxygen in the other; may occur in the brain, in the vitreous form, changing as quickly as the intellect or imagination demands, and literally flaming that thoughts may breathe and words may burn; and may be present in the bones in its amorphous form, content like an impassive caryatid, to sustain upon its unwearied shoulders the mere dead weight of stones of flesh. And what is here said of the brain as contrasted with the bones, will apply with equal or similar force to many other organs of the body. All throughout the living system, we may believe that phosphorus is found at the centres of vital action in the active condition, and at its outlying points in the passive condition. In the one case it is like the soldier with his loaded musket pressed to his shoulder and his finger on the trigger, almost anticipating the command to fire; in the other it is like the same soldier with his unloaded weapon at his side standing at ease."

"Further, phosphorus forms with oxygen a powerful acid, capable even of abstracting water from sulphuric acid, and yet perfectly unirritating to the organic textures. Taking up varying quantities of water, phosphoric acid assumes no fewer than three distinct forms, which will unite with one, two, or three atoms of alkali respectively, giving an acid, neutral or alkaline reaction. Thus it is available for the most varied uses in the body. A child is beginning to walk, and the bones of its limbs must be strengthened and hardened; phosphoric acid, accordingly, carries with it three units of lime to them, and renders them solid and firm. But the bones of its skull must remain comparatively soft and yielding, for it has many a fall, and the more elastic these bones are, the less will it suffer when its head strikes a hard object; so that in them we may suppose the phosphoric acid to retain but two units of lime, and to form a softer, less consistent solid. And the cartilages of the ribs must be still more supple and elastic, so that in them the phosphoric acid may be supposed to be combined with but one unit of base. On the other hand, its teeth must be harder than its hardest bones, and a new demand is made on the lime-phosphates to associate themselves with other lime-salts (especially fluoride of calcium), to form the cutting edges and grinding faces of the incisors and molars. All the while, also, the blood must be kept alkaline, that oxidation of the tissues may be promoted, and albumen retained in solution; and yet it must not be too alkaline, or tissues and albumen will both be destroyed, and the carbonic acid developed at the systemic capillaries will not be exchanged for oxygen when the blood is exposed to that gas at the lungs. So phosphoric acid provides a salt containing two

14. *Will the burning phosphorus ignite the wood of the match?*

It does not give off enough heat in its oxidation to raise the temperature of the wood to the igniting point. Many, however, claim the true reason to be that, in burning, it produces an ash (P_2O_5) which covers the wood as with a varnish and so protects it from oxidation.

15. *What philosophical principle is illustrated in the ignition of a match by friction?*

(See *Philosophy*, page 230.)

The conversion of motion into heat.

16. *How much* H_2O *would be required to dissolve a pound of* KNO_3?

3½ lbs. of cold water and ⅓ lb. of hot water.

17. *What causes the bad odor after the discharge of a gun?*

The potassium sulphide gradually gives up its S to form H_2S.

18. *Write in parallel columns the properties of common and of red phosphorus.*

units of soda and one of water, which is sufficiently alkaline to promote oxidation, dissolve albumen, and absorb carbonic acid, and yet holds the latter so loosely, that it instantly exchanges it for oxygen when it encounters that gas in the pulmonary capillaries. Again, the flesh juice must be kept acid (perhaps in opposition to the alkaline blood, as affecting the transmission of the electric currents which traverse the tissues), and phosphoric acid provides a salt, containing two units of water and one of potash, which secures the requisite acidity."—Dr. G. Wilson, *Edinburgh Essays*, 1856.

Common phosphorus.	Amorphous phosphorus.
1. Specific gravity—1.83.	1. Specific gravity—2.14.
2. Burns at 111°.	2. Burns at 500°.
3. Odor of garlic.	3. Odorless.
4. Soluble in CS_2.	4. Insoluble in CS_2.
5. Colorless, or straw-yellow.	5. Red often rivalling vermilion.
6. A deadly poison.	6. Harmless.

19. *What causes the difference between fine and coarse salt?*

(See *Chemistry*, page 132.)

The rapidity of evaporation in the process of manufacture.

20. *Why do the figures in a glass paper-weight look larger when seen from the top than from the bottom?*

The form of the glass acts like a convex lens to magnify the apparent size of the figures.

21. *What is the difference between water-slacked and air-slacked lime?*

The former is simply calcium hydrate, CaO, H_2O, while the latter is hydrated calcium carbonate, CaO, CO_2, H_2O (?).

22. *Why do oyster-shells on the grate of a coal-stove prevent the formation of clinkers?*

The lime of the shells acts as a flux with the iron in the coal; thus dissolving the clinkers, if any form.

23. *How is lime-water made from oyster-shells?*

The shells are burned, driving off the CO_2 combined with the CaO in the $CaCO_3$, and the lime thus formed is slightly soluble in water.

24. *Why do newly plastered walls remain damp so long?*

The plaster or mortar in drying gives off the water the lime took up in slacking.

25. *Will lime lose its beneficial effect upon a soil after frequent applications?*

(See *Key*, page 51, Question 12.)

26. *What causes plaster of Paris to harden again after being moistened?*

(See *Chemistry*, page 139.)

It recombines with the water which was driven off in the process of its manufacture.

27. *What is the difference between sulphate and sulphite of lime?*

The former is a compound of sulphuric acid; the latter of sulphurous acid.

28. *What two classes of rays are contained in the magnesium light?*

(See *Philosophy*, page 206.)

The actinic or chemical, and the colorific or luminous rays.

29. *What rare metals would become useful in the arts, if the process of manufacture were cheapened?*

Magnesium, aluminum, sodium, etc.

30. *What is the rational formula for calcium carbonate? Calcium sulphite? Calcium sulphate?*

1. $CaCO_3 = CaO,CO_2$.
2. $CaSO_3 = CaO,SO_2$.
3. $CaSO_4 = CaO,SO_3$.

31. *Why is lime placed in the bottom of a leach-tub?*

The potash of the ashes is generally in the form of a carbonate, the acid neutralizing in part the strength of the alkali. The lime combines with the CO_2.

32. *Is saleratus a salt of* K *or of* Na?

It should be a carbonate of K, but, on account of its cheapness, the corresponding salt of Na is often sold instead.

33. *Why will* Na *burst into a blaze when thrown on hot water?*

The heat of the water raises the hydrogen to the igniting point. This catches fire, and the volatilized Na colors the flame.

34. *Why are certain kinds of brick white?*

They contain no iron, this being the substance which by its oxidation gives the color to common brick.

35. *Illustrate the force of chemical affinity.*

The tremendous force of chemical affinity forms with O half the crust of the earth. Yet when the chemist sets the O free from its prison-house, it comes before him a *transparent, invisible gas*, and he cannot condense it to a solid or liquid state by any mechanical process.

176.—1. Pb *is softer than* Fe; *why is it not more malleable?*

The facility with which a mass of metal can be hammered or rolled into a thin sheet without being torn, must depend partly upon its softness, and partly upon its tenacity. If it depended upon softness alone, lead should be the most malleable of ordinary metals; but, although it is easy to hammer a mass of lead into a flat plate, or to squeeze it between rollers, any attempt to reduce it to an extremely thin sheet fails from its want of tenacity, which causes it to be worn into holes by percussion or friction. On the other hand, if malleability were entirely regulated by tenacity, iron would occupy the first place, whereas, on account of its hardness, it is the least malleable of metals in ordinary use; whilst gold, occupying an intermediate position with respect to tenacity, is the most malleable, which appears surprising to those who are only acquainted with gold in its ordinary forms of coin and ornament, in which it is hardened and rendered much less malleable by the presence of copper and silver.

I.—*Relative Malleability of the Metals.*

1. Gold.	4. Tin.	7. Zinc.
2. Silver.	5. Platinum.	8. Iron.
3. Copper.	6. Lead.	

II.—*Relative Tenacity of the Metals.*

Lead	1	Silver	$12\frac{1}{2}$
Tin	$1\frac{1}{3}$	Platinum	15
Zinc	2	Copper	18
Palladium	$11\frac{1}{2}$	Iron	$27\frac{1}{2}$
Gold	12	Steel	42

III.—*Relative Ductility of the Metals.*

1. Gold.	5. Copper.	8. Zinc.
2. Silver.	6. Palladium.	9. Tin.
3. Platinum.	7. Aluminum.	10. Lead.
4. Iron.		

—Bloxam.

2. *What is the cause of the changing color often seen in the scum on standing water?*

(See "Interference of Light," *Philosophy*, page 209.)

The thin pellicles of iron-rust on standing H_2O produce a beautiful iridescent appearance, the color changing with the thickness of the oxide. A soap-bubble exhibits in the same way a play of variegated colors according to the thickness of the film in different parts.

3. *How can the spectra of the metals be obtained?*

(See *Astronomy*, page 285.)

By looking through a prism at a flame containing minute portions of the volatilized metal.

4. *Ought cannon, car-axles, etc., to be used until they break or wear out?*

Cannon are condemned and recast after being fired a certain number of times, even though they show no flaw, as the jarring to which they are exposed causes the iron to take on a crystalline form and become less fibrous and tough. A cast-iron gun of 10-inch bore or less, ought to stand 1000 rounds; larger calibres, a smaller number.

5. *Why is "chilled iron" used for safes?*

The iron being cooled so instantaneously, the crystals are exceedingly small, and the metal is correspondingly harder than when cast in the ordinary way.

6. *Does a blacksmith plunge his work into water merely to cool it?*

The metal is harder when cooled quickly and therefore resists wear longer.

7. *What causes the white coating made when we spill water on zinc?*

The oxide of zinc which is formed on the surface of the metal through the favoring influence of the water.

8. *Is it well to scald pickles, make sweetmeats, or fry cakes in a brass kettle?*

(See *Chemistry*, page 159.)

9. *What danger is there in the use of lead pipes? Is a lining of* Zn *or* Sn *a protection?*

(See *Chemistry*, pages 156 and 160, and *Fireside Science*, page 149.)

Zinc and tin are corroded by oxygen, though less readily than Pb, and, while their salts are poisonous, the lead is soon laid bare, and this also oxidizes.

10. *Is water which has stood in a metal-lined ice-pitcher healthful?*

(See *Chemistry*, page 157.)

The dissimilar metals fastened with solder which corrodes in the presence of water, develop a galvanic current which hastens the oxidation. The salts thus formed are very dangerous.

11. *If you ask for "cobalt" at a drug-store, what will you get? If for "arsenic?"*

Impure metallic arsenic is sold as "cobalt," while arsenious anhydride is called "arsenic."

12. *What two elements are fluid at ordinary temperatures?*

Bromine and mercury.

13. *Should we touch a gold ring to mercury?*

The mercury will form with the gold an amalgam.

14. *Why does silver blacken if handled?*

The perspiration of the body contains S, which combining with the metal forms silver sulphide—the black sulphuret of silver.

15. *Why does silver tarnish rapidly where coal is used for fires?*

S, which is present in coal, is set free by combustion and forms a silver sulphide.

16. *Why is a solution of a coin blue?*

From the Cu which is contained in silver coin.

17. *Why will a solution of silver nitrate curdle brine?*

A white, curdy precipitate of silver chloride is formed.

18. *Why does writing with indelible ink turn black when exposed to the sun, or to a hot iron?*

By the decomposition of the silver salt contained in the ink, and consequent production of Ag_2O, which stains organic matter black.

19. *What alloys resemble gold?*

Oreide, aluminum-bronze, etc.

20. *Why does a fish-hook "rust out" the line to which it is fastened?*

Ferric oxide and ferric hydrate act as conveyers of O, absorbing it from the air and giving it up to organic bodies with which they are in contact.

21. *Why do the nails in clap-boards loosen?*

(See Question 20.)

22. *Show that the earth's crust is mainly composed of burnt metals.*

(See Cooke's *Religion and Chemistry.*)

It consists largely of potassium, magnesium, calcium, aluminum, sodium, etc., in combination with O. These compounds are the products of combustion.

The elements O, Si, Al, Mg, Ca, K, Na, Fe, C, S, H, Cl and N—13 in all—probably make up $\frac{99}{100}$ of the earth's crust.

23. *What kind of iron is used for a magnet? For a magnetic needle?*

Steel.

24. *Why does a tin pail so quickly rust out when once the tin is worn through?*

The iron rusts rapidly in the presence of water, which favors oxidation.

25. *Why is the zinc oxide found in New Jersey red, when zinc rust is white?*

The oxide in New Jersey is colored by compounds of iron and manganese.

26. *Should we filter a solution of permanganate of potash through paper?*

(See *Chemistry*, page 155, note.)

No. The salt will give up O and corrode the filter.

27. *Why is wood, cordage, etc., sometimes soaked in a solution of corrosive sublimate?*

This salt possesses strong antiseptic properties.

28. *Why does the white paint around a sink turn black?*

H_2S is set free, which, acting on the paint, forms lead sulphide—the black sulphuret of lead.

29. *Why is aluminum, rather than platinum, used for making the smallest weights?*

Because of its bulk as compared with that of platinum.

30. *How would you detect the presence of iron particles in black sand?*

By a magnet.

31. *Which metals can be welded?*

(See *Philosophy*, page 37.)

Iron and platinum.

32. *When the glassy slag from a blast-furnace has a dark color, what does it show?*

It might be anticipated that the appearance of the slag would convey to the experienced eye some useful information with respect to the character of the ore and the general progress of the smelting operation. A good slag is liquid, nearly transparent, of a light grey color, and has a fracture somewhat resembling that of limestone. A dark slag shows that much of the oxide of iron is escaping unreduced. Streaks of blue are commonly found when ores containing sulphur are being smelted, possibly from the presence of a substance similar to ultramarine, the constituents of which are all present in the slag. Again, the slags obtained in smelting ores containing titanium generally present a peculiar blistered appearance.—Bloxam.

33. *In welding iron the surfaces to be joined are sometimes sprinkled with sand. Explain.*

The silica acts as a flux with the oxide upon the surface and lays bare the metal for welding.

34. *What is the difference between an alloy and an amalgam?*

An amalgam is composed of mercury and some other metal. An alloy consists of any metals whatever.

35. *Steel articles are blued to protect from rusting, by heating in a sand-bath. Explain.*

A thin coating of oxide is formed on the surface of the metal.

36. *Give the rational formulæ for copperas and white lead.*

1. $FeSO_4 = FeO,SO_3$.
2. $PbCO_3 = PbO,CO_2$.

37. *Why is* Hg *used for filling thermometers?*

(See *Philosophy*, page 235.)

Because it is fluid at all ordinary temperatures.

38. *What oxide is formed by the combustion of* Na, K, Zn, S, Fe, Pb, Cu, P, *etc.? Which are bases? Acids? Give the common name of each.*

(1). Na_2O is formed when Na oxidizes in dry air, or oxygen at a low temperature. This takes up water with great avidity, forming HNaO (NaHO), sodium hydroxide. Na_2O_2 is made when Na is heated to 200° C. HNaO is the caustic soda of commerce, and is an alkaline base.

(2). K in a similar manner, depending upon the temperature, forms K_2O, K_2O_2, and K_2O_4. The first, with water, forms the ordinary caustic potash, HKO, of commerce. It is an alkaline base.

(3). ZnO is the only known oxide of zinc. It forms salts.

(4). Seven compounds of S and O are known, but only two are of interest—the familiar anhydrides, SO_2 and SO_3.

(5). The oxides of iron are four in number: (1) the monoxide, or ferrous oxide, FeO, from which the green ferrous salts are derived; (2) the sesquioxide, or ferric oxide, Fe_2O_3, yielding the yellow ferric salts; (3) the magnetic or black oxide, Fe_3O_4, which does not form any definite salts; (4) ferric acid, H_2FeO_4, a weak acid, forming colored salts with potassium.

(6). Pb forms two oxides, the monoxide and the dioxide. The former is the well known litharge, which is the base of the lead salts.

(7). Cu has two oxides—the cuprous (Cu_2O) and cupric (CuO), both of which form salts, thus giving rise to two series, the cuprous and the cupric salts. The two oxides are commonly known as the red and the black.

(8). Phosphorus forms two oxides, phosphorous anhydride (P_2O_3) and phosphoric anhydride (P_2O_5).

39. *Is charcoal lighter than* H_2O?

Charcoal appears at first sight to be lighter than water, as a piece of it floats on the surface of this liquid; this is, however, due to the porous nature of the charcoal, for if it be finely powdered it sinks to the bottom of the water.—ROSCOE.

40. *Name the vitriols.*

The compounds of sulphuric acid and oil of vitriol, commonly called "the vitriols," are as follows:

1.	Sulphate of iron,	Green vitriol.
2.	Sulphate of copper,	Blue vitriol.
3.	Sulphate of zinc,	White vitriol.

41. *Is* Mg *a monad or a dyad?* Zn?

Mg belongs to the zinc class of metals which comprises magnesium, zinc, cadmium, and indium. These are all dyads.

42. *Name some dibasic acid.*

Sulphuric acid, carbonic acid, etc.

43. *Name a neutral salt. An acid salt.*

(See *Chemistry*, page 128, note.)

44. *Calculate the percentage of water contained in crystallized copper sulphate. Sodium sulphate. Calcium sulphate. Alum.*

(1). $CuSO_4, 5H_2O = 249.5.$

$5H_2O = 90.$

Hence, $\frac{90}{249.5} = .36 = 36\%$ of copper sulphate is water.

(2). $Na_2SO_4, 10H_2O = 322.$

$10H_2O = 180.$

Hence, $\frac{180}{322} = .55 = 55\%$ of sodium sulphate is water.

(3). $CaSO_4, 2H_2O = 172.$

$2H_2O = 36.$

Hence, $\frac{36}{172} = .20 = 20\%$ of gypsum is water.

(4). $Al_2K_2, 4SO_4 + 24H_2O = 949.$

$24H_2O = 432.$

Hence, $\frac{432}{949} = .45 = 45\%$ of potash alum is water.

45. *What is the test for* Ag? Cu?

Ag can be easily detected when in solution by the precipitation of the white curdy chloride, insoluble in H_2O and HNO_3, and soluble in H_3N: the metal can be obtained in malleable globules before the blowpipe, and is reduced from its solutions by Fe, Cu, P, and Hg. Ag is estimated quantitatively either as the chloride or as the metal.

Copper may be tested (1) by the black insoluble sulphide; (2) by the blue hydrate turning black on heating; (3) by the deep blue coloration with ammonia; (4) by the deposition of red metallic copper upon a bright surface of iron placed in the solution.

46. *What weight of crystallized "tin salts"* ($SnCl_2$, $2H_2O$) *can be prepared from one ton of metallic tin?*

$$Sn : SnCl_2, 2H_2O :: 2000 \text{ lbs.} : x.$$
$$118 : 225 :: 2000 \text{ lbs.} : x.$$
$$118\,x = 450000 \text{ lbs.}$$
$$x = 3813.56 \text{ lbs.} (SnCl_2, 2H_2O).$$

47. 100 *parts by weight of silver yield* 132.8+ *parts of silver chloride. Given the combining weight of chlorine, required that of silver.*

$$x : 35.5 :: 100 : 32.8+.$$
$$328\,x = 3550.$$
$$x = 108+.$$

48. *What is the composition of slacked lime?*

(See *Chemistry*, page 137.)

CaO,H_2O.

49. *How is ferrous sulphate obtained? How many tons of crystals can be obtained by the slow oxidation of* 230 *tons of iron pyrites containing* 37.5 *per cent. of sulphur?*

(See *Chemistry*, page 155, and *Key*, page 60; Question 32.)

Find (1) how much S there is in the given weight of iron pyrites; (2) how much ferrous sulphate could be made from that amount of S, if it were all oxidized.

(1). 230 tons × .375 = 86.25 tons (S).

$$\begin{aligned}&(2).\ S : FeSO_4, 7H_2O :: 86.25 \text{ tons} : x.\\ &32 : 278 :: 86.25 \text{ tons} : x.\\ &32\,x = 23977.5 \text{ tons.}\\ &x = 749.296 \text{ tons } (FeSO_4, 7H_2O).\end{aligned}$$

50. *Required* 500 *tons of soda crystals; what will be the weight of salt and pure sulphuric acid needed?*

Find (1) how much Na there is in 500 tons of "soda," and (2) how much NaCl would be needed to furnish that amount of the metal in case all were utilized.

$$\begin{aligned}&(1).\ Na_2 : Na_2CO_3,10H_2O :: x : 500 \text{ tons.}\\ &46 : 286 :: x : 500 \text{ tons.}\\ &286\,x = 23{,}000 \text{ tons.}\\ &x = 80.42- \text{ tons (Na).}\end{aligned}$$

(2). $\frac{230}{585}$ of any amount of NaCl is Na; hence, to furnish 80.42 tons of Na would require $\frac{585}{230}$ × 80.42 tons = 204.546 tons (NaCl).

(3). By comparing the atomic weights of the substances it will be seen that for 46 parts of Na there must be 98 of pure H_2SO_4. $\frac{98}{46}$ × 204.546 tons = 435.771 tons (H_2SO_4).

51. *Describe the uses of lime in agriculture.*

(See *Key*, page 51, Question 12.)

52. *How many tons of oil of vitriol, containing* 70 *per cent. of pure acid* (H_2SO_4), *can be prepared from* 250 *tons of iron pyrites, containing* 42 *per cent. of sulphur?*

(1). (See Question 49.) 250 tons × .42 = 105 tons (S).

$$\begin{aligned}&(2).\ S : H_2SO_4 :: 105 \text{ tons} : x.\\ &32 : 98 :: 105 \text{ tons} : x.\\ &32\,x = 10290 \text{ tons.}\\ &x = 321.56 \text{ tons } (H_2SO_4).\end{aligned}$$

(3). If 321.56 tons (H_2SO_4) is 70% of the given oil of vitriol, the entire amount would be 321.56 tons × $\frac{100}{70}$ = 459.28 tons (oil of vitriol).

1. *How would you prove the presence of tannin in tea?*

By adding a few drops of a solution of ferrous sulphate. This would form a dark precipitate of iron tannate.

2. *How would you test for* Fe *in a solution?*

(See Miller's *Inorganic Chemistry*, page 525.)

A solution of nutgalls will give a bluish-black, inky precipitate. The ferrous- or proto-salts are distinguished by their light green color, and by their solutions giving (1) a white precipitate, with caustic alkalies; (2) a light blue precipitate, with potassium ferrocyanide, which rapidly becomes dark: whilst the ferric- or per-salts are yellow-colored, and their solutions yield (1) a deep reddish-brown precipitate, with the caustic alkalies; and (2) a deep blue precipitate (Prussian blue), with potassium ferrocyanide.

3. *Why can we settle coffee with an egg?*

The albumen of the egg coagulates by heat, and entangling the particles of coffee, mechanically carries them to the bottom.

4. *How would you show the presence of starch in a potato?*

A solution of iodine will form the blue iodide of starch.

5. *Why is starch stored in the seed of a plant?*

For the growth of the young plant.

6. *Why are unbleached cotton goods dark-colored?*

Because of the dirt gathered in the process of manufacture. The cotton balls are snowy white.

7. *Why do beans, rice, etc., swell when cooked?*

By the bursting of the starch granules.

8. *Why does decaying wood darken?*

By the formation of humus which contains carbon in excess.

9. *Why does smoke cure hams?*

The creosote of the smoke has powerful antiseptic properties.

10. *How would you show that* C *exists in sugar?*

By the experiments described in the *Chemistry* on page 117, note; page 190, note; and page 191 in the formation of caramel.

11. *Why do fruits lose their sweetness when over-ripe?*

(See Miller's *Organic Chemistry*, page 875.)

The vegetable acid contained in the fruit when green, oxidizes as the ripening process continues, O being absorbed and CO_2 evolved. If this continues too long, the sugar itself becomes oxidized.

12. *Why does maple-sap lose its sweetness when the leaf starts?*

The sugar of the sap is applied to the wants of the growing tree.

13. *Should yeast-cakes be allowed to freeze?*

A cold of 32° will kill the ferment.

14. *Why will wine sour if the bottle be not well corked?*

The presence of air will cause the continuation of the oxidizing process into the second or acetic stage.

15. *Why can vinegar be made from sweetened water and brown paper?*

The paper acts as a ferment, while the sugar or molasses is oxidized into alcohol and thence into acetic acid.

16. *Why should the vinegar-barrel be kept in a warm place?*

Heat promotes chemical change.

17. *Why does "scalding" check the "working" of preserves?*

The ferment which causes the fermentation is killed by the heat.

18. *Is the oxalic acid in the pie-plant poisonous?*

It is neutralized by the alkaline base, with which it is combined in the plant.

19. *How may ink-stains be removed?*

By a solution of oxalic acid, forming an iron oxalate which is soluble in water, and hence may be washed out.

20. *Why is leather black on only one side?*

(See *Chemistry*, page 211.)

The solution of copperas, which blackens the leather, is applied on only one side.

21. *Why do drops of tea stain a knife-blade?*

(See *Chemistry*, page 211.)

The tannic acid of the tea combines with the iron, forming an iron tannate.*

22. *Why will not coffee stain it in the same way?*

(See Miller's *Organic Chemistry*, page 549.)

The modification of tannin contained in coffee, unlike that in tea, turns a solution of ferrous sulphate green, and will not precipitate one of gelatin.

23. *Why does writing-fluid darken on exposure to the air?*

(See *Chemistry*, page 262.)

It absorbs O, the iron changing to ferric oxide.

24. *What causes the disagreeable smell of a smoldering wick?*

A volatile substance, termed acrolein, is produced in the decomposition of the oil.

25. *Why does ink corrode steel pens?*

The free sulphuric acid of the ink combines with the iron of the pen.

26. *How does a bird obtain the* $CaCO_3$ *for its egg shells?*

(See chemistry of a hen's egg in *Fireside Science.*)

A common hen's egg is 95 per cent. carbonate of lime,

* The tannic acid of the tea tans the albumen of the milk used in seasoning the tea, forming flakes of real leather. It has been calculated that an average tea-drinker, in this way, makes and drinks enough leather each year to make a pair of shoes. The albumen of milk uniting with the tannic acid of tea, softens its flavor. This is generally preferred to the harsh, clear beverage.

one per cent. phosphate of lime and magnesia, and two per cent. animal matter. The shell would weigh over 100 grains, so that a hen laying 100 eggs in a season would require nearly 1½ lbs. of $CaCO_3$. The hen must in part secrete this from her food, and in part gather it from the sand, pebbles, etc., she picks up amid her incessant scratching and searching.

27. *Why will tallow make a harder soap than lard?*

Tallow contains more palmitin, and less olein, than lard.

28. *Why does new soap act on the hands more than old?*

The spent lye, which contains the excess of alkali, gradually separates from the soap, leaving only the salts in which the alkali is neutralized by the fatty acids. Also a more complete combination takes place, whereby some free alkali is taken up by the acids, perhaps before uncombined. The former statement is especially true in the case of soft or home-made soap.

29. *What is the shiny coat on certain leaves and fruits?*

A species of wax secreted by the plant.

30. *Why does turpentine burn with so much smoke?*

Because it contains an excess of carbon.

31. *Why is the nozzle of a turpentine bottle so sticky?*

The turpentine on exposure to the air oxidizes, turning to rosin.

32. *Why does kerosene give more light than alcohol?*

It contains more carbon, which, when heated in the flame of the burning H, gives out a white light.

33. *What is the antidote to oxalic acid? Why?*

Magnesia or chalk, forming an insoluble oxalate.

34. *Would you weaken camphor spirits with water?*

(See *Chemistry*, page 117.)

No; since camphor is insoluble in dilute alcohol. The principle is the same as that of the precipitation of lead from dilute oil of vitriol.

35. *What is the difference between rosin and resin?*

Rosin is an oxidized resin. Rosin is a species, and resin a genus.

36. *Why does skim-milk look blue and new milk white?*

The globules of butter contained in new milk reflect the light, and so make it look white; but when they are removed, by the separation of the cream, more light is transmitted, and only the blue is reflected to the eye.

37. *Why does an ink-spot turn yellow after washing with soap?*

The free alkali of the soap combines with the tannic acid of the ink, leaving the oxide of iron (ferric oxide), which stains the cloth yellow.

Name	Symbol	Atomic Weight	Molecular Weight	Specific Gravity	Specific Heat	Quantivalence	Electrical Character	Color	Fusing Point	Solvent
Aluminum	Al	27.5	$Al_2=55$	2.67	.2143	II or IV	+ 12	white	1292 F.	HCl
Antimony (Stibium)	Sb	122	$Sb_4=488$	6.71	.05077	III or V	— 16	bluish-white	812° F.	$HCl+HNO_3$
Arsenic	As	75	$As_4=300$	5.95	.08140	III or V	— 9	steel-gray	774° F.	HNO_3
Barium	Ba	137	$Ba_2=274$	1.85	......	II	+ 5	yellow	....	....
Bismuth	Bi	210	$Bi_4=840$	9.799	.03084	III or V	+ 28	reddish-white	507° F.	HNO_3
Boron	B	11	....	2.680	.2500	III	— 14	brown	....	K_2CO_3 hot
Bromine	Br	80	$Br_2=160$	3.187	.1060	I	— 5	brownish-red	45° F.	Ether
Cadmium	Cd	112	$Cd_2=224$	8.604	.05669	II	+ 24	bluish-white	4420° F.	H_2SO_4
Cæsium	Cs	133	$Cs_2=266$	unknown	......	I	+	....	....	....
Calcium	Ca	40	$Ca_2=80$	1.578	......	II	+ 7	light-yellow	....	HCl dil.
Carbon	C	12	$C_2=24$?	2.35	.02411	IV	— 15	black	infus.	insol.
Cerium	Ce	92	....	....	......	II	+ 15	....	....	....
Chlorine	Cl	35.5	$Cl_2=71$	2.435	.1214	I	— 4	green	....	H_2O
Chromium	Cr	52.5	$Cr_2=105$	6.810	......	II or IV	— 10	gray	....	HCl
Cobalt	Co	59	$Co_2=118$	8.95	.10696	II	+ 22	steel-gray	2000° F.	HCl
Copper (Cuprum)	Cu	63.5	$Cu_2=127$	8.90	.09515	II	+ 30	red	1994° F.	H_2SO_4
Didymium	D	96	$D_2=192$	....	......	II	+ 16	....	....	....
Erbium	E	112	$E_2=224$	....	......	II	+ 11	....	....	....
Fluorine	F	19	$F_2=38$	1.31	......	I	— 3	....	....	....
Glucinum	G	9.5	$G_2=19$	2.10	......	II	+ 9	....	....	....
Gold (Aurum)	Au	197	$Au_2=394$	19.34	.03244	III	— 23	yellow	2015° F. (?)	$HCl+HNO_3$
Hydrogen	H	1	$H_2=2$	.069 ‡	3.4046	I	— 22	colorless	....	....
Indium	In	76	....	7.20	......	II	+ 26	white	349° F.	....
Iodine	I	127	$I_2=254$	4.94	.05412	I	— 6	bluish-black	225° F.	Ether
Iridium	Ir	197	....	21.80	.03259	II or IV	— 25	white	O-H	insol.
Iron (Ferrum)	Fe	56	....	7.80	.11379	II or IV	+ 20	gray-white	1900 to 2900	Acids
Lanthanum	La	92	....	....	......	II	+ 17	....	....	....
Lead (Plumbum)	Pb	207	....	11.36	.0314	II	+ 25	bluish-white	620° F.	HNO_3
Lithium	L	7	$L_2=14$	0.59	.9408	I	+ 4	white	324° F.	....
Magnesium	Mg	24	....	1.70	.2499	II	+ 8	white	446° F.	Acids
Manganese	Mn	55	....	8.00	.1217	II or IV	+ 18	gray-white	....	HCl
Mercury (Hydrargyrum)	Hg	200	....	13.596	.03332	II	— 30	white	—39° F.	HNO_3
Molybdenum	Mo	96	....	8.64	......	VI	— 12	gray	....	HNO_3

Nickel	Ni	59	....	8.90	.10863	II	+ 21	white	2732°	HCl
Niobium	Nb	94	....	....	......	V	— 19	....	....	....
Nitrogen	N	14	$N_2=28$	.971	.2440	III or V	— 2	colorless	... .	....
Osmium...........	Os	199	....	21.400	.03063	II or IV	— 24	bluish-white	infus.	....
Oxygen	O	16	$O_2=32$	1.1056	.2182	II	—	colorless	....	....
Palladium..........	Pd	106	....	11—12	.05927	II or IV	— 29	white	4000° (?)	HNO_3
Phosphorus.........	P	31	....	1.83	.1887	III or V	— 8	colorless	110°	CS_2
Platinum	Pt	197	....	21.53	.03243	II or IV	— 26	white	4591° F. (?)	$HCl+HNO_3$
Potassium (Kalium)	K	39	$K_2=78$	.865	.16956	I	+ 2	bluish-white	136°	....
Rhodium	Ro	104	....	11.00	.05803	II or IV	— 27	....	....	....
Rubidium..........	Rb	85	$Rb_2=170$	1.52	......	I	+ 1	white	101°	....
Ruthenium........	Ru	104	....	11—12	......	II or IV	— 28	....	....	....
Selenium..........	Se	79.5	$Se_2=159$	4.80	.0837	II or VI	— 7	brown	423°	CS_2
Silicon.............	Si	28	....	2.49	......	IV	— 21	brown	....	HNO_3+HF
Silver (Argentum)..	Ag	108	$Ag_2=216$	10.50	.05701	I	+ 31	white	1873° F.	HNO_3
Sodium (Natrium)..	Na	23	$Na_2=46$	.972	.2934	I	+ 3	white	195°	....
Strontium.........	Sr	87.5	....	2.54	......	II	+ 6	pale-yellow	....	dil. HNO_3
Sulphur...........	S	32	$S_2=64$	2.00	.1776	II or VI	— 1	yellow	228°	CS_2
Tantalum...	Ta	182	....	10.78	......	V	— 18	....	....	....
Tellurium..........	Te	129	$Te_2=258$	6.65	.04737	II or VI	— 17	reddish-white	716°	H_2SO_4
Thallium	Tl	204	....	11.86	.03355	I or III	+ 23	white	554°	HNO_3
Thorium	Th	238	....	....	......	IV	+ 14	....	....	....
Tin (Stannum).....	Sn	118	....	7.3	.05623	II or IV	+ 27	white	442° F.	HCl
Titanium...........	Ti	50	....	5.3	......	II or IV	— 20	gray	....	HCl
Tungsten (Wolframium).......	W	184	....	17.50	.03342	VI	— 13	steel-gray	....	HNO_3
Uranium	U	120	....	18.40	......	III or V	+ 29	gray	....	....
Vanadium..........	V	51	....	3.64	......	III or V	— 11	....	....	....
Yttrium	Y	62	....	....	.....	II	+ 10	....	....	....
Zinc	Zn	65	....	7.15	.9555	II	+ 19	bluish-white	773° F.	H_2SO_4
Zirconium	Zr	89	....	4.15	......	IV	+ 13	black	.. ..	HF

NOTE.—The names of metals are printed in Roman, non-metals in *italics*.

The electrical character of an element is relative; although aluminum is positive towards a majority of the elements, it is negative towards 12 elements. Oxygen is the most electro-negative of all; sulphur is the most negative with one exception, hence marked —1. Cæsium is the most electro-positive of all and takes a plus sign. Silver is in middle numerically, there being 31 elements more strongly negative and 31 more strongly positive. Temperatures above 2000° F. are only approximate.

ANSWERS

TO THE

PRACTICAL QUESTIONS

IN THE

FOURTEEN WEEKS IN HUMAN PHYSIOLOGY.

38.—1. *Why does not a fall hurt a child as much as it does a grown person?*

The bones of a child are largely cartilaginous, and so do not transmit a shock, or readily yield to a blow. They are also well padded with fat.

2. *Should a young child ever be urged to stand or walk?*

No; bow-legs are often caused by the premature use of the lower limbs in standing or walking. Nature is the best guide in such matters.

3. *What is meant by "breaking one's neck?"*

The dislocation of the vertebræ and consequent injury of the spinal cord.

4. *Ought chairs or benches to have straight backs?*

The backs should conform to the natural shape of the spine. This tends to prevent curvatures and other distortions of the vertebral column.

5. *Ought a child's feet to dangle from a high chair?*

The position is as unnatural and painful for a child as for a grown person.

6. *Why can we tell whether a fowl is young by pressing on the point of the breast-bone?*

Because that part of the breast-bone is not ossified in a young fowl.

7. *What is the use of the marrow in the bones?*

It contains the blood-vessels carrying material for the growth of the bone, and also diffuses any shock which the bone may receive.

8. *Why is the shoulder so often put out of joint?*

Because of the shallowness of the socket in the scapula.

9. *How can you tie a knot in a bone?*

By removing the mineral matter and thus softening a rib-bone, a knot can be easily tied in it.

10. *Why are high pillows injurious?*

They elevate the head, and so give an unnatural position to the spine. For the pads between the vertebræ to assume their proper shape during the night they should be relieved of all pressure.

11. *Is the "Grecian bend" a healthy position?*

The natural position is the only healthy one. The distortion known as the "Grecian bend" contracts the chest, changes the outline of the spine, and diminishes the vitality of the system.

12. *Ought a boot to have a heel-piece?*

A low and broad heel-piece probably aids in walking: a narrow or high one weakens and enlarges the ankle, produces bunions, corns, etc., by throwing the weight forward upon the toes, and makes the gait exceedingly ungraceful.

13. *Why should one always sit and walk erect?*

Because then all the organs are in their natural position.

14. *Why does a young child creep rather than walk?*

(See *Physiology*, page 50.)

Its bones not yet being fully ossified, nature teaches it not to bear its weight upon them. Besides, it has not yet learned the difficult art of balancing itself.

56.—1. *What class of lever is the foot when we lift a weight on the toes?*

The third class. The ankle-joint is the fulcrum, the weight is at the toes, and the power is in front of the ankle, where the muscle which lifts the toes (the extensor digitorium) is attached to the foot.

2. *Explain the movement of the body backward and forward, when resting upon the thigh-bone as a fulcrum.*

The weight is at the center of gravity of the head and trunk, high above the hip-joints, where the fulcrum is situated. The flexor muscles of the thigh are the power, and act close to the fulcrum. The weight is sometimes directly over the fulcrum, and may be on any side of it.

This seems to the author to be an example of the first or second class of lever. Huxley gives it as an illustration of the third class.

3. *What class of lever do we use when we lift the foot while sitting down?*

The third class. The fulcrum is the knee-joint; the weight is at the center of gravity of the foot and leg, and the power is applied by the ligament which passes over the patella.

4. *Explain the swing of the arm from the shoulder.*

(See *Physiology*, page 48.)

The third class. The fulcrum is the shoulder-joint; the weight is at the center of gravity of the arm and hand, and the power is applied by the biceps or triceps muscle at its attachment near the elbow.

5. *What class of lever is used in bending our fingers?*

The fulcrum is at the junction of the finger with the palm; the weight is at the center of gravity of the finger, and may play about the fulcrum as stated in second question. It is the third class of lever, especially when force is exerted at the extremity of the fingers.

6. *What class of lever is our foot when we tap the ground with our toes?*

(See *Physiology*, Fig. 14, *k*.)

The first class. The weight is at the toe when the force is exerted; the fulcrum is at the ankle; and the power is applied by the gastrocnemius muscle at its attachment to the heel.

7. *What class of lever do we use when we raise ourselves from a stooping position?*

The third class. See second question. If we are attempting to lift a heavy burden, the bones act on the principle of the toggle-joint. "When one stoops to take a heavy weight upon his back or shoulder, he puts both the knee and the hip-joints into the condition that the toggle-joint is when it is bent; and then as he straightens up, the weight is raised by an action of the joints precisely similar to that of the toggle-joint in machinery. In the case of the knee, the straightening of the joints is done by the muscles on the front part of the thigh, that draw up the knee-pan with the tendon attached to it. This is using the principle of the toggle-joint in pressing *upward*. It is also sometimes used in pressing *downward*. In crushing anything with the heel, we give great force to the blow on the principle of the toggle-joint, by flexing the knee and straightening the limb as we bring down the heel upon the thing to be crushed. In pushing anything before us, we bend the elbow as preparatory to the act, and then thrust the arm out straight, thus exemplifying the toggle-joint. The horse gives great force to his kick in the same way. The great power exerted by beasts of draught and burden is to be referred very much to the principle of the toggle-joint. When a horse is to draw a heavy load, he bends all his limbs, especially the hinder ones, and then as he straightens them, he starts the load. In this case the ground is the fixed block of the mechanism, the body of the horse to which the load is attached is the movable one, and his limbs are so many toggle-joints. By this application of the principle, we see draught horses move very heavy loads."—HOOKER'S *Physi-*

ology. "So (admitting fable to be fact), when the farmer, in answer to his petition for assistance, was commanded by Hercules to exert himself to raise his wagon from the pit, he placed his shoulder against the wheel, and drawing his body up into a crouching attitude, whereby all his joints were flexed, and making his feet the fixed points, by a powerful muscular effort, he straightened the toggle-joints of his limbs, and the wheel was raised from its bed of miry clay. His horses at the same moment extending their joints, the heavily laden wagon was carried beyond the reach of further detention."—GRISCOM.

8. *What class of lever is the foot when we walk?*

In the first stage it is clearly the second class. (See *Physiology*, page 47, Fig. 18.) The fulcrum is the ground on which the toes rest; the power is applied by the gastrocnemius muscle (see Fig. 14, *k*) to the heel; the resistance is so much of the weight of the body as is borne by the ankle-joint of the foot, which of course lies between the heel and the toes.

9. *Why can we raise a heavier weight with our hand when lifting with the elbow than from the shoulder?*

Because we bring the fulcrum nearer the power. In the former case it is at the elbow; in the latter, at the shoulder.

10. *What class of lever do we employ when we are hopping, the thigh-bone being bend up toward the body and not used?*

In this case the fulcrum is at the hip-joint. The power (which may be assumed to be furnished by the *rectus* muscle* of the front of the thigh) acts upon the knee-cap; and the position of the weight is represented by that of the center of gravity of the thigh and leg, which will lie somewhere between the end of the knee and the hip.—HUXLEY.

11. *Describe the motions of the bones when we are using a gimlet.*

The radius rolls on the ulna at the elbow, while the ulna rolls on the radius at the wrist. The two combined produce a free, rotary motion.

12. *Why do we tire when we stand erect?*

(See *Physiology*, page 49.)

Because so large a number of muscles must be in constant action to maintain this position.

13. *Why does it rest us to change our work?*

We thereby bring into use a new set of muscles.

14. *Why and when is dancing a beneficial exercise?*

When dancing is performed out-of-doors, or in a well-ventilated room and at proper hours, it is doubtless a beneficial exercise, since it employs the muscles and pleasantly occupies the mind. Late at night, in a heated room, with thin clothing and exciting surroundings, it is simply a dangerous dissipation, ruinous to the health, alike of body and soul.

* This muscle is attached above to the haunch-bone or *ileum*, and below to the knee-cap. The latter bone is connected by a strong ligament with the *tibia*.

15. *Why can we exert greater force with the back teeth than with the front ones?*

(See *Physiology*, page 49.)

The lower jaw is a lever of the second class. In the former case the resistance to be overcome, *i. e.*, the weight, is situated much nearer the power.

16. *Why do we lean forward when we wish to rise from a chair?*

(See *Philosophy*, pages 57–8.)

In order to bring the center of gravity over the feet.

17. *Why does the projection of the heel-bone make walking easier?*

(See Frontispiece, and also Fig. 18 in *Physiology*.)

It brings the power further from the fulcrum or weight.

18. *Does a horse travel easier over a flat than a hilly country?*

No. The variety of travel in a hilly country, other things being equal, tends to rest the horse, and enable him to better endure the fatigue of the journey.

19. *Can you move your upper jaw?*

All the bones of the face, except the lower jaw, are firmly and immovably articulated with one another and with the cranium.—LEIDY.

20. *Are people naturally right or left-handed?*

Many persons are naturally either right or left-handed; but most can and should learn to use either hand with equal facility.

21. *Why can so few persons move their ears by the muscles?*

Perhaps, because of lack of practice; more probably, however, the muscles (see *Physiology*, p. 65 and Fig. 14) are developed in few persons.

22. *Is the blacksmith's right arm healthier than the left?*

By no means. Strength is not essential to health. The right arm may be stronger, but the functions of the left may be as active and well-performed.

23. *Boys often, though foolishly, thrust a pin into the flesh just above the knee. Why is it not painful?*

The muscles of the leg there end in tendons, which are insensible.

24. *Will ten minutes practice in a gymnasium answer for a day's exercise?*

Spasmodic or violent exercise is not beneficial. It should be comparatively quiet, gentle, and continuous to produce the best effect. Moreover, the vitalizing influences of the sun and pure air demand that we should exercise out-of-doors.

25. *Why would an elastic tendon be unfitted to transmit the motion of a muscle?*

Force would be lost by its transmission through an elastic medium.

26. *When one is struck violently on the head, why does he instantly fall?*

The body is kept erect only by the constant exercise of many muscles. These perform their functions through the unconscious action of the brain and spinal cord. A blow paralyzes the nervous system, the muscles at once cease to act, and the body falls by its weight.

27. *What is the cause of the difference between light and dark meat in a fowl?*

The amount of blood which circulates through different parts of the body. The organs of a fowl which are used the most become the darkest.

79. 1. *If a hair be plucked out, will it grow again?*

Yes. A new hair will always grow out so long as the papilla at the bottom of the follicle remains uninjured.

2. *What causes the hair to "stand on end" when we are frightened?*

(See *Physiology*, page 65.)

"Many of the unstriated muscular fibres from the true skin pass obliquely down from the surface of the dermis to the under side of the slanting hair-follicles. The contraction of these fibres erects the hairs, and by drawing the follicles to the surface and drawing in a little point of the skin, produces that roughness of the integument called "goose-skin," or *Cutis Anserina.* The standing on end of the hair of the head, as the result of extreme fright, may be partly due to the contraction of such fibres, as well as to the action of the occipito-frontalis muscle."—CUTTER.

3. *Why is the skin roughened by riding in the cold?*

(See *Physiology*, page 65; also Answer to Question 2.)

4. *Why is the back of a washer-woman's hand less water-soaked than the palm?*

The difference depends upon the relative abundance of the oil-glands in different parts of the body.

5. *What would be the length of the perspiratory tubes in a single square inch of the palm, if placed end to end?*

(See *Physiology*, page 72. $2{,}800 \times \frac{1}{16}$ in. $= \frac{2800}{16}$ in. $=$ 14 ft. 7 in.—Answer.)

6. *What colored clothing is best adapted to all seasons?*

Light-colored clothing is cooler in summer and warmer in winter.

(See *Physiology*, page 77; *Natural Philosophy*, page 246.)

7. *What is the effect of paint and powder on the skin?*

They fill the pores of the skin, and thus prevent the passage of the perspiration. Moreover, they often contain substances which are poisonous, and being carried in by the absorbents cause disease.

(See *Physiology*, page 73.)

8. *Is water-proof clothing healthful for constant wear?*

No. It retains the insensible perspiration by which waste matter is being constantly thrown off from the system.

9. *Why are rubbers cold to the feet?*

They retain the insensible perspiration. The moisture which gathers absorbs the heat of the feet, and readily conducts it from the body.

10. *Why does the heat seem oppressive when the air is moist?*

In the moisture-laden atmosphere, the evaporation of the insensible perspiration from the surface of the body goes on slowly. The heat, which would otherwise pass off through the pores, is retained in the system.

11. *Why is friction of the skin invigorating after a cold bath?*

The friction produces heat, expands the veins, etc., on the surface, and, calling the blood in that direction, produces a vigorous circulation. In other words, it causes a reaction.*

(See *Physiology*, page 75.)

12. *Why does the hair of domestic animals become roughened in winter?*

(See Question 2.)

The effect is beneficial, since more air—a non-conductor of heat—is retained by the hair, and thus the rough

* "Strength in the living body is maintained by the full but natural exercise of each organ; and as we have seen, the actions of these portions of the nervous system is made dependent upon influences conveyed to them by the sensitive nerves distributed over the various parts of the body. And among these the nerves passing to the skin are the chief. The full access of all healthful stimuli to the surface, and its freedom from all that irritates or impedes its functions, are the first external conditions of the normal vigor of this nervous circle. Among these stimuli, fresh air and pure water hold the first place. Sufficient warmth is second. The great, and even wonderful advantages of cleanliness are partly referable to the direct influence of a skin healthily active, open to all the natural stimuli, and free from morbid irritation, upon the nerve-centres of which it is the appointed excitant. This influence is altogether distinct from those cleansing functions which the healthy skin performs for the blood; and in any just estimate of its value is far too important to be overlooked."—HINTON.

winter-coat of an animal is warmer than its smooth summer-coat.

13. *Why do fowls shake out their feathers erect before they perch for the night?*

(See Question 12.)

This is a wise provision of Nature to protect the fowl against the chilliness of the night. More air is confined by the roughened feathers, and thus the internal heat of the bird is prevented from radiating.

14. *How can an extensive burn cause death by congestion of the lungs?*

The insensible perspiration is stopped upon the burned surface, and the excretions are sent to the lungs, which are overworked and overloaded by the excess.

(See *Physiology*, page 74.)

15. *Why do we perspire so profusely after drinking cold water?*

The vital organs being chilled for an instant, the blood is sent to the surface, a reaction is produced, the skin acts more vigorously as an excretory organ, and the insensible perspiration is thrown off more rapidly.

16. *What are the best means of preventing skin diseases, colds, and rheumatism?*

The skin should be kept in a healthy state by bathing, rubbing, etc. Exposure to sudden changes of temperature should be avoided as far as possible. Flannel worn next the skin, in all seasons of the year, is an excellent precaution against unavoidable exposure.

17. *What causes the difference between the hard hand of a blacksmith and the soft hand of a woman?*

The varying thickness of the cuticle.

(See *Physiology*, page 62.)

18. *Why should a painter avoid getting paint on the palm of his hand?*

(See *Physiology*, page 73.)

19. *Why should we not use the soap or soiled towel at a hotel?*

Because of the danger of contracting disease through the absorbents of the skin. (See *Physiology*, p. 73.) There is a similar danger in using a hair-brush or a comb at a barber shop.

20. *Which teeth cut like a pair of scissors?*

The "back-teeth," as we commonly call them, when moved laterally, cut somewhat in this way. In chewing the food all the "front teeth" act like scissors, as may be readily seen by noticing their movements.

21. *Which like a chisel?*

The incisors, or four front teeth of each jaw, have knife edges; the canine teeth have wedge-shaped edges; the bicuspids and molars have broader crowns. We can work the jaws so as to make the front-teeth either pierce like wedges or cut like scissors.

22. *Which should be clothed the warmer, a merchant or a farmer?*

The merchant is liable to more sudden and violent changes of temperature, and his body is less likely to be hardened by exposure and habit to resist them.

23. *Why should we not crack nuts with our teeth?*

The brittle enamel is very liable to crack, and once broken can never be restored.

24. *Do the edges of the upper and lower teeth meet?*

(See Question 21.)

25. *When fatigued, would you take a cold bath?*

Certainly not. The system is not vigorous enough to produce a reaction, and the effect might be dangerous.

26. *Why is the outer surface of a kid glove finer than the inner?*

This illustrates the difference in texture between the cutis and cuticle; the dermis and epidermis.

27. *Why will a brunette endure the sun's rays better than a blonde?*

(See *Physiology*, page 63.)

The skin is perhaps of a coarser texture, and not so sensitive to heat. May it not be also that the black pigment absorbs the heat and radiates it again rather than transmits it directly to the internal organs? It has also been suggested that there is an increased flow of blood in the darker skin, and hence increased perspiration.

28. *Does patent-leather form a healthful covering for the feet?*

No. The pores of the leather are partly filled, and hence the insensible perspiration is largely restrained.

29. *Why are men more frequently bald than women?*

This is the effect of the close, unventilated head-covering commonly worn by men.

30. *On what part of the head does baldness commonly occur?*

On that part most fully covered by the hat or cap.

31. *What does the combination in our teeth of canines and grinders suggest as to the character of our food?*

That we are to eat a mixed diet of vegetable and animal food.*

* "The question of the use of animal or vegetable food may well be remitted to the arbitrament of nature, as expressed in the desires; by which it would be victoriously decided, in all such climates as ours, in favor of the flesh-eater. But the sufficiency of vegetable food, if widely varied, to maintain health and even strength, is not to be questioned, for those who like it. When we hear that the ancient Persians lived a good deal on water-cress, we naturally connect in our minds their physical inferiority with the poverty of their diet; but finding, on the other hand, that the Romans, in the best period of the Republic, largely sustained themselves on turnips, and that degeneracy came in as turnips went out, we are compelled to reconsider our opinion. In brief, an exclusively vegetable food may be best suited to those by whom it really is preferred. Children in this respect exhibit the greatest difference; some, with manifest advantage, eat meat in large quantity—others can hardly be prevailed on to taste it, and yet retain perfect vigor. Similar differences, in all probability, exist among adults; but a vegetarianism self-imposed against the promptings of desire, would tend, as a vigorous writer says, to make us 'not the children, but the abortions of Paradise.' "—HINTON.

32. *Is a staid, formal promenade suitable exercise?*

No. There is an intimate relation between the brain and the muscles. The mind should be pleasantly employed to obtain the full effect of any exercise. The sports of children are often the very perfection of healthful gymnastic exercises? *

33. *Is there any danger in changing the warm clothing of our daily wear for the thin one of a party?*

Very great. The body is not as well protected as usual against a sudden change of temperature, as in going from a heated-room to the carriage, and a cold is often the consequence. This may lay the foundation of, or prepare the way for, fatal disease.

34. *Should we retain our overcoat, shawl, or furs, when we come into a warm room?*

No. The body will become over-heated, the pores be opened, and the skin be rendered susceptible to the change of temperature when we return into the open air.

35. *Which should bathe the oftener, students or out-door laborers?*

* "The mental operations, like all others, are connected with changes in the material of the body. In all our consciousness the chemical tendencies of the substance of the brain come into play, and thus a chain of action is set up which extends throughout the system. The influence of these brain-changes is felt wherever a nerve travels, and modifies, invigorates, or depraves the action of every part. Experience gives ample proof of this fact to every one, as in the sudden loss of appetite a piece of bad news will cause, or in the watering of the mouth excited by the thought of food. And the history of disease abounds in evidence of a similar kind: hair becoming gray in a single night from sorrow, milk poisoning an infant from an attack of passion in the nurse, permanent discoloration of the skin from terror, are among the instances on record."—Hinton.

This depends entirely on circumstances—the amount of exercise, freedom and character of perspiration, state of the system, etc. Each case must be decided by itself.

36. *Is abundant perspiration injurious?*

No. It removes impure matter from the system, and hence may be beneficial. It may, however, weaken the body, and frequent hot baths should therefore be taken only on suitable medical advice.

99.—1. *What is the philosophy of the "change of voice" in a boy?*

Up to the age of fourteen or fifteen, there is little or no difference in point of size between the larynx of a boy and that of a girl; but subsequently the former grows proportionately larger, so that at last, in the adult male, the vibrating parts or vocal cords are necessarily longer than in the female. They are also undoubtedly thicker, perhaps even coarser in structure. From all these circumstances the adult male voice is stronger, louder, and of lower pitch than the weaker and higher vocal range accomplished by the female larynx.

The cause of the difference in quality of the voice, known as its *timbre*, is not well known; but it must undoubtedly be dependent on physical, that is to say, structural peculiarities in some part of the laryngeal apparatus.

The production of the different *notes* within the compass of any one individual depends upon alterations in the length and state of tension of the vocal cords, and on their degree of proximity or separation from one another.

The higher notes require the vocal cords to be comparatively shorter, tighter, and more closely approximated together; whilst the lower notes demand opposite conditions. A high note, furthermore, implies greater rapidity in the movement of the air through the glottis; but the quantity of air passing is larger during the production of a low note.

The volume or *loudness* of the voice depends mainly on the combination of quantity of air with greater force of expulsion. Loudness, with clearness, also demands a peculiar resonance up in the nasal cavities and sinuses. Lastly, the unnatural or *falsetto* voice seems also to be produced by some tensive change effected in the upper part of the pharynx at the back of the nose: hence it is called by singers the *head voice*, in contradistinction to the ordinary, or *chest voice*.—MARSHALL.

2. *Why can we see our breath on a frosty morning?*

The vapor of the breath is condensed by the cold air.

3. *When a law of health and a law of fashion conflict, which should we obey?*

It depends, of course, whether we prefer to be fashionable or to be healthy, to obey man or God. With too many people the former is of far greater importance, and in selecting an article of dress, few ask or think about the latter. The consequence is seen in the weakened frame, the prevalence of disease, and the shortened life. God's laws written in our bodies cannot be violated with impunity.

4. *If we use a "bunk" bed, should we pack away the clothes when we first rise in the morning?*

No. They should first be thoroughly aired.

5. *Why should a clothes-press be well ventilated?*

The clothes naturally contain the products of the insensible perspiration, which passing off, pollute the air of the closet.

6. *Should the weight of our clothing hang from the waist or the shoulder?*

From the shoulder, so as to avoid the constriction of the compressible organs in the abdomen.

7. *Describe the effects of living in an over-heated room.*

(1). The body becomes more sensitive to change, and the susceptibility to colds is greatly increased: (2) the dry, heated air abstracts the moisture from the skin, rendering it dry, hard, and incapable of performing its normal functions.

8. *What habits impair the power of the lungs?*

Above all others, those of a leaning posture, tight-lacing, and ill-ventilation.

9. *For full, easy breathing in singing, should we use the diaphragm and lower ribs or the upper ribs alone?*

Nearly all the inspirations are effected by the movements of the diaphragm and the inferior ribs only. From time to time a deeper and more complete inspiration causes the thorax to rise, not simultaneously, but successively at the base, then at the apex. In the first case the respiration is *diaphragmatic;* when the lower and middle ribs are raised, it is termed *lateral;* and lastly, when the first rib and clavicle take part in the movement, it is costo-superior or *clavicular*. In diaphragmatic respiration, as M. Mandl has observed, the larynx is immovable, the inspiration is easy, without effort, and permits exertion in singing or in gymnastics for a long time and without fatigue. On the contrary, persons who respire principally by the upper ribs are easily fatigued, and very soon out of breath. This is seen in women when the corset compresses the base of the chest, and in singers who adopt, on erroneous principles, the bad habit of clavicular respiration. In this last method of inspiration the larynx is drawn down by the contraction of the external muscles, and its action becomes painful. The effort of the inspiratory muscles rapidly induces fatigue, and the inspiration, always incomplete, becomes also more frequent. Diaphragmatic respiration is practised by mountaineers, gymnasts, and skilful singers—a habit induced either by instinct, or a well-directed education.—*Wonders of the Human Body.*

10. *Why is it better to breathe through the nose than the mouth?*

The air passing through the nostrils becomes filtered of its coarse impurities, and the chill is taken off before it strikes against the tender, mucous surfaces of the larynx.

11. *Why should not a speaker talk while returning home on a cold night after a lecture?*

The cold air will strike against the vocal apparatus when inflamed and peculiarly sensitive.

12. *What part of the body needs the loosest clothing?*

The abdomen; because of the delicate organs within, unprotected by a bony covering.

13. *What part needs the warmest?*

The feet, because they are furthest from the center of heat and motion and most exposed to cold and wet: and the neck and shoulders, since here are located the delicate organs of voice and respiration.

14. *Why is a "spare bed" generally unhealthy?*

Because it is apt to be damp and unventilated.

15. *Is there any good in sighing?*

(See *Physiology*, page 91.)

It probably brings up the "arrears" of respiration.

16. *Ought a hat to be thoroughly ventilated? How?*

Certainly, as the heated, foul air is injurious. A single hole at the top is quite insufficient for ventilation. Several openings should be made on the sides near the band.

17. *Why do the lungs of people who live in cities become of a gray color.*

Probably because of the deposition of carbonaceous particles which penetrate the substance of the tissues. The coloring is permanent, like tattooing, where india-ink is pricked beneath the skin.

18. *How would you convince a person that a bed-room should be aired?*

Take him from the fresh, pure, invigorating out-door atmosphere into the close, depressing air of the bed-room, when first vacated in the morning, and his sense of smell will satisfy him of the need of ventilation.

19. *What persons are most liable to scrofula, consumption, etc.*

(See *Physiology*, pages 94–98.)

The victims of lung-starvation.

20. *If a person is plunged under water, will any enter his lungs?*

No. The epiglottis will close involuntarily and prevent the admission of water.

21. *Are bed-curtains healthy?*

No. They prevent the free circulation of the air and confine the waste products thrown off from the body.

22. *Why do some persons take "short breaths" after a meal?*

The distention of the stomach prevents the free action of the lungs. If such persons are not given to gluttony, the lungs are small or the other organs misplaced.

23. *What is the special value of public parks?*

They bring fresh air, sunshine, green grass and trees within the reach of all. They are truly the "breathing-holes of a city." They are thus of incalculable benefit both on account of their sanitary and moral influence.

24. *Can a person become used to bad air, so that it will not injure him?*

The system may come to endure without complaint, but never fails to inflict full punishment for the infraction of nature's laws.

25. *Why do we gape when we are sleepy?*

(See Question 15.)

The stretching of the nerves may perhaps serve to restore the equilibrium of the nervous influence, disturbed by the attention being fixed during the day upon some absorbing occupation.

26. *Is a fashionable waist a model of art in sculpture or painting?*

The Venus of Milo, in the Louvre at Paris, is the beau-ideal of symmetry and beauty, yet the form indicates not a "wasp-waist," but the full, free, flowing outlines of nature. The sculptor and painter in copying the human figure can make no improvement on its Divine maker.

27. *Should a fire-place be closed?*

(See *Physiology*, page 100.)

No. It is a most efficient means of ventilation.

28. *Why does embarrassment or fright cause a stammerer to stutter still more painfully?*

Stuttering is mainly a nervous disorder, and hence any excitement tends to increase the impediment of the speech.

29. *In the organs of voice, what parts have somewhat the same office as the case of a violin and the sounding-board of a piano?*

(See *Philosophy*, page 176.)

The pharynx, the mouth, and the nasal passages all act by resonance to modify the voice.

129.—1. *Why does a dry, cold atmosphere favorably affect catarrh?*

It tends to diminish inflammation in the mucous membrane lining the nose and nasal passages.

2. *Why should we put on extra covering when we lie down to sleep?*

The respiration and the circulation are then less active. The fire in our corporeal stoves being low, we need extra covering to preserve the warmth of the body.

3. *Is it well to throw off our coats or shawls when we come in heated from a long walk?*

No. We rather need to put on extra clothing at such times to keep the body from cooling too rapidly. The best hygienic teachers commend the throwing of a shawl about the shoulders whenever we sit down to rest after fatiguing labor.

4. *Why are close-fitting collars or neck-ties injurious?*

They impede both respiration and circulation.

5. *Which side of the heart is the more liable to inflammation?*

The left; since that contains the red blood just oxygenated in the lungs.

6. *What gives the toper his red nose?*

(See *Physiology*, pages 125 and 173.)

The congested state of the capillaries.

7. *Why does not the arm die when the surgeon ties the principal artery leading to it?*

The anastomoses of the arteries enable a collateral circulation to be established, whereby blood is supplied to the arm.

8. *When a fowl is angry, why does its comb redden?*

Because an extra quantity of blood is thrown into that part of the body.

9. *Why does a fat man endure cold better than a lean one?*

Fat is a good non-conductor of heat, and helps to preserve the uniform temperature of the body.

10. *Why does one become thin during a long sickness?*

By absorption, the fat of the body is taken up and used to supply the wants of the system. The old flesh being renewed with new, vigorous material, after such a wasting sickness, a person often has better health than previous to it.

11. *What would you do if you should come home "wet to the skin?"*

One should (1) go into a warm room; (2) remove all wet garments; (3) if chilled, take a hot, full- or foot-bath, and by gentle friction restore the circulation; (4) put on dry clothing.

12. *When the cold air strikes the face, why does it first blanch and then flush?*

The muscles and blood-vessels of the surface are contracted by the cold, and the blood is driven back toward the heart. The reaction which ensues forces the blood again toward the skin, and this flushes with the incoming tide. The face is therefore first whitened and then reddened.

13. *What must be the effect of tight lacing upon the circulation of the blood?*

It must, by contracting the blood-vessels, impede the flow of the blood, and by decreasing the quantity furnished the various organs, injure their action. Thus, finally, it will impair the quality of the blood.

14. *Do you know the position of the large arteries in the limbs, so that in case of accident you could stop the flow of blood?*

These can be located by examining the cut in *Physiology*, page 104, or any good chart of the circulation.

15. *When a person is said to be "good-hearted," is it a physical truth?*

The expressions, large-hearted, good-hearted, etc., are remains of the old idea that the affections are located in the heart rather than in the brain—the seat of the mind and all its attributes.

16. *Why does a hot foot-bath often relieve the headache?*

(See *Physiology*, pages 127–8.)

It withdraws blood from the head, and so relieves the congested state of that organ.

17. *Why does the body of a drowned or strangled person turn blue?*

The blood is not purified in the lungs, and so blue or venous blood fills the vessels.

18. *What are the little "kernels" in the arm-pits?*

(See *Physiology*, page 123.)

They are the lymphatic glands which sometimes become swollen.

19. *When we are excessively warm, would the thermometer show any rise of temperature in the body?*

(See *Physiology*, page 119, note.)

Probably not. In health, the average temperature of the body does not vary more than 2°.

20. *What forces besides that of the heart aid in propelling the blood?*

(See Flint's *Physiology*—The Circulation; Cutler's *Analytic Anatomy*, etc., page 166, *et seq.*)

The elasticity of the arteries and the veins, the force of capillary attraction in the capillaries, etc.

21. *Why can the pulse be felt best in the wrist?*

It is, in general, a mere matter of convenience. We can feel it not only in the radial artery at the wrist, but in the carotid of the neck, the temporal of the forehead, the popliteal * in the inner side of the knee, etc.

* If the hollow of the knee of one leg be allowed to rest upon the knee of the other one, it may be remarked that the point of the suspended foot moves visibly up and down at each beat of the pulse.

22. *Why are starving people exceedingly sensitive to any jar?*

The marrow of the bones is absorbed, and hence the shock of a jar is unbroken. The nervous system is also weakened by the general prostration.

23. *Why will friction, an application of horse-radish leaves, or a blister relieve internal congestion?*

They bring the blood to the surface of the body, and so relieve the internal organ.

24. *Why are students very liable to cold feet?*

Because the tendency of the blood is toward the head to supply the waste in that part of the body.

25. *Is the proverb that "blood is thicker than water" literally true?*

(See Draper's *Human Physiology*, page 112.)

The specific gravity of the blood varies from 1.050 to 1.059.

26. *What is the effect upon the circulation of "holding the breath?"*

The blood is not oxygenated, the products of waste accumulate in the system, the circulation is impeded, the blood-vessels become distended and are liable to burst, while all the delicate organs, especially the brain, are oppressed by congestion.

27. *Which side of the heart is the stronger?*

The left, which drives the blood to the extremities.

28. *How is the heart itself nourished?*

The coronary arteries springing from the aorta just after its origin, carry blood to the muscular walls of the heart: the venous blood comes back through the coronary veins, and empties directly into the right auricle.

29. *Does any venous blood reach the heart without coming through the venæ cavæ?*

(See Question 28.)

155.—1. *How do clothing and shelter economize food?*

The force which would be converted into heat to preserve the temperature of the body, is saved. The food needed to supply this amount of force may be reserved or changed into flesh, or into other forms of force.

2. *Is it well to take a long walk before breakfast?*

(See *Physiology*, page 53.)

A vigorous person in good health and in a healthy region may do so, but one in ill health, or a malarious district, needs to be braced with food before taking any except very light exercise.

3. *Why is warm food easier to digest than cold?*

Heat favors the chemical change whereby the food is prepared for assimilation.

4. *Why is salt beef less nutritious than fresh?*

(See *Physiology*, page 155, note.)

The salts and juices of the meat are extracted by the brine.

5. *What should be the food of a man recovering from a fever?*

It should be that which is nutritious, easily digested, and not over-stimulating. Beef-tea or essence* is generally commended. As soon as the patient will bear it, beefsteak, tender, broiled, and not over-done, is most beneficial.

6. *Is a cup of black coffee a healthy close to a hearty dinner?*

The tannic acid contained in tea and coffee (see *Chemistry*, pp. 211, 215) is neutralized by the milk generally used with these beverages. In *café noir*, black or clear coffee, the tannic acid acts unfavorably on the mucous membrane lining the stomach. Besides, the coffee, like a dessert, is superfluous, the appetite being already satisfied. It therefore, both actively and negatively, tends to delay the digestion of the meal. The glass of wine sometimes taken to aid digestion merely deadens the sensibility of the stomach, so that the food is hurried, half-digested, out into the intestines.†

7. *Should ice-water be used at a meal?*

Only a person in robust health can endure the shock

* Dr. Martindale gives the following recipe for making this essence: Cut a quantity of lean beef into small pieces, put it into a strong bottle, without water, cork it loosely so that the steam can escape, and immerse the bottle to its neck in a vessel of cold water. Place on the fire and boil for two hours; then pour off the essence.

† Mix some bread and meat with gastric juice; place them in a phial, and keep that phial in a sand-bath at the slow heat of 98 degrees, occasionally shaking briskly the contents to imitate the motion of the stomach; you will find, after six or eight hours, the whole contents blended into one pultaceous mass. If to another phial of food and gastric juice, treated in the same way, you add a glass of pale ale or a quantity of alcohol, at the end of seven or eight hours, or even some days, the food is scarcely acted upon at all.

of drinking ice-water at a meal. Indeed, drinking of ice-water under any circumstances is dangerous and hurtful. If used at all, it should be carefully and *slowly sipped*, a little at a time.

8. *Why is strong tea or coffee injurious?*

The tannic acid acts unfavorably on the coatings of the stomach.* The nervous system is over-stimulated, and, when the reaction occurs, becomes correspondingly depressed and weakened. The constant decay of the body, so essential to its highest activity, is greatly retarded. Wakefulness is often induced, and thus the organs are deprived of that rest which is absolutely essential.

9. *Should food or drink be taken hot?*

The pepsine of the gastric juice, in order to produce its effect, must have a moderately warm temperature, neither too hot nor too cold. The gastric juice will not act upon the food when near the freezing point of water, neither will it have any effect if raised to the neighborhood of a boiling temperature. It must be intermediate between the two; and its greatest activity is about 100 degrees Fahrenheit, which is exactly the temperature of the interior of the living stomach.—DALTON'S *Physiology*, p. 103.

10. *Are fruit-cakes, rich pastry, and puddings healthful?*

(See BLACK'S *Ten Laws of Health*, p. 83, *et seq.*)

They are too concentrated. They are not easily penetrated by the juices of the system, and hence are not quickly digested. They stimulate the appetite, and so

* Tea contains from 14 to 16 per cent. of this astringent substance, and coffee not over 6 per cent.—YOUMANS.

lead to gluttony. They supply the system with an over-abundance of nutrition, for which the blood has no use, and so lead to biliousness and other diseases of the blood and digestive organs.

11. *Why are warm biscuit and bread hard of digestion?*

They form a pasty mass, which the juices of the digestive organs penetrate very slowly.

12. *Should any stimulants be used in youth?*

No. The system is then vigorous, and all its functions promptly performed. If stimulants are ever used, it should be when the body needs forcing, as when recovering from disease, or languid with the decay of the natural powers in old age.

13. *Why should bread be made spongy?*

(See Question 11.)

14. *Which should remain longer in the mouth, bread or meat?*

Bread, since the pepsin is essential to the conversion of starch into sugar?

15. *Why should cold water be used in making soup, and hot in boiling meat?*

In the former case, we desire to extract the juices of the meat; in the latter, to retain this by quickly coagulating the albumen on the surface of the meat.

16. *Name the injurious effects of over-eating.*

(See *Physiology*, page 151.)

17. *Why do not buckwheat cakes, with syrup and butter, taste as well in July as in January?*

In the winter, the system craves highly carbonaceous food; in the summer, it relishes cooling, acid drinks, and an unstimulating diet.

18. *Why is a late supper injurious?*

The system is wearied with the day's labor, and the stomach is unfitted to undertake the task of digesting a meal as much as the body is to begin a new day's task unrefreshed by sleep.*

* "Being allowed for once to speak, I would take the opportunity to set forth how ill, in all respects, we stomachs are used. From the beginning to the end of life, we are either afflicted with too little or too much, or not the right thing, or things which are horribly disagreeable to us; or are otherwise thrown into a state of discomfort. I do not think it proper to take up a moment in bewailing the Too Little, for that is an evil which is never the fault of our masters, but rather the result of their misfortunes; and, indeed, we would sometimes feel as if it were a relief from other kinds of distress if we were put upon short allowance for a few days. But we conceive ourselves to have matter for serious complaint against mankind in respect of the Too Much, which is always an evil voluntarily incurred. What a pity that in the progress of discovery we cannot establish some means of a good understanding between mankind and their stomachs; for really the effects of their non-acquaintance are most vexatious. Human beings seem to be, to this day, completely in the dark as to what they ought to take at any time, and err almost as often from ignorance as from depraved appetite. Sometimes, for instance, when we of the inner house are rather weakly, they will send us down an article that we could deal with when only in a state of robust health. Sometimes, when we would require a mild vegetable diet, they will persist in the most stimulating and irritating of viands.

"What sputtering we poor stomachs have when mistakes of that kind occur! What remarks we indulge in regarding our masters! "What's this, now?" will one of us say; "ah, detestable stuff! What a ridiculous fellow that man is! Will he never learn? Just the very thing I did not want. If he would only send down a bowl of fresh leek soup or barley broth, there would be some sense in it:" and so on. If we had only been allowed to give the slightest hint now and then, like faithful servants as we are, from how many miseries might we have saved both our masters and ourselves!

"I have been a stomach for about forty years, during all of which time I have endeavored to do my duty faithfully and punctually. My master, however, is so reckless, that I would defy any stomach of ordinary ability and capacity to get along pleasantly with him. The fact is, like almost all other men, he, in his eating and drinking, considers his own pleasure only, and never once reflects on the poor wretch who has to be responsible for the disposal of everything down stairs. Scarcely on any day does he fail to exceed the strict

19. *What makes a man "bilious?"*

(See Hall's *Health by Good Living*, p. 111, *et seq.*)

The liver strains the bile out of the blood. This waste matter is not withdrawn when the liver is inactive, and hence the face and eyes become yellow—the color of bile, and the functions all become torpid.

rule of temperance; nay, there is scarcely a single meal which is altogether what it ought to be. My life is therefore one of continual worry and fret; I am never allowed to rest from morning till night, and have not a moment in the four-and-twenty hours that I can safely call my own. My greatest trial takes place in the evening, when my master has dined. If you only saw what a mess this said dinner is—soup, fish, flesh, fowl, ham, rice, potatoes, table-beer, sherry, tart, pudding, cheese, bread, all mixed up together. I am accustomed to the thing, so don't feel much shocked; but my master himself would faint at the sight. The slave of duty in all circumstances, I call in my friend Gastric Juice, and we set to work with as much good-will as if we had the most agreeable task in the world before us. But, unluckily, my master has an impression very firmly fixed upon him that our business is apt to be vastly promoted by an hour or two's drinking; so he continues at table among his friends, and pours down some bottle and a half of wine, perhaps of various sorts, that bothers Gastric Juice and me to a degree which no one can have any idea of. In fact, this said wine undoes our work almost as fast as we do it, besides blinding and poisoning us poor servants into the bargain. On many occasions I am obliged to give up my task for the time altogether; for while this vinous shower is going on I would defy the most vigorous stomach in the world to make any advance in its business worth speaking of. Sometimes things go to a much greater length than at others; and my master will paralyze us in this manner for hours, not always, indeed, with wine, but occasionally with punch, one ingredient of which—the lemon—is particularly odious to us. All this time I can hear him jollifying away at a great rate, drinking healths to his neighbors, and ruining his own.

"I am a lover of early hours, as are my brethren generally. To this we are very much disposed by the extremely hard work which we usually undergo during the day. About ten o'clock, having, perhaps, at that time got all our labors past, and feeling fatigued and exhausted, we like to sink into repose, not to be again disturbed till next morning at breakfast-time. Well, how it may be with others I can't tell; but so it is, that my master never scruples to rouse me up from my first sleep, and give me charge of an entirely new meal, after I thought I was to be my own master for the night. This is a hardship of the most grievous kind. Only imagine me, after having gathered in my coal, drawn on my night-cap, and gone to bed, called up and made to take charge of a quantity of stuff which I know I shall not be able to get off my hands all night! Such, O mankind, are the woes which befall our tribe in

20. *What is the best remedy?*

Diet to give the organs rest, and active exercise to arouse the secretions and the circulation.

21. *What is the practical use of hunger?*

To prompt us to furnish the body with sufficient food.

22. *How can jugglers drink when standing on their heads?*

Because water does not fall into the stomach by its own weight, but is conveyed thither from the mouth by the contraction of the muscular bands of the œsophagus.

consequence of your occasionally yielding to the temptations of "a little supper." I see turkey and tongue in grief and terror. Macaroni fills me with frantic alarm. I behold jelly and trifle follow in mute despair. O that I had the power of standing beside my master, and holding his unreflecting hand, as he thus prepares for my torment and his own! Here, too, the old mistaken notion about the need of something stimulating besets him, and down comes a deluge of hot spirits and water, that causes me to writhe in agony, and almost sends Gastric Juice off in the sulks to bed. Nor does the infatuated man rest here. If the company be agreeable, one glass follows another, while I am kept standing, as it were, with my sleeves tucked up, ready to begin, but unable to perform a single stroke of work.

"I feel that the strength which I ought to have at my present time of life has passed from me. I am getting weak, and peevish, and evil-disposed. A comparatively small trouble sits long and sore upon me. Bile, from being my servant, is becoming my master; and a bad one he makes, as all good servants ever do. I see nothing before me but a premature old age of pains and groans, and gripes and grumblings, which will, of course, not last over long; and thus I shall be cut short in my career, when I should have been enjoying life's tranquil evening, without a single vexation of any kind to trouble me. Were I of a revengeful temper, it might be a consolation to think that my master—the cause of all my woes—must suffer and sink with me; but I don't see how this can mend my own case; and, from old acquaintance, I am rather disposed to feel sorry for him, as one who has been more ignorant and imprudent than ill-meaning. In the same spirit let me hope that this true and unaffected account of my case may prove a warning to other persons how they use their stomachs; for, they may depend upon it, whatever injustice they do to *us*, in their days of health and pride, will be repaid to *themselves* in the long-run—our friend Madame Nature being a remarkably accurate accountant, who makes no allowance for ignorance or mistakes."—CHAMBERS' *Memoir of a Stomach*.

23. *Why do we relish butter on bread?*

Butter supplies the carbonaceous element in which bread is lacking.

24. *Is chewing tobacco more injurious than smoking?*

(See Cutler's *Physiology*, pages 242-4.)

It is not only more filthy, but also more detrimental to the health, as thereby a greater proportion of the poisonous alkaloids of the tobacco is carried into the system. Among the too frequent evil effects of this powerful narcotic are an impaired nutrition, a poisoned circulation, a stupefied mind and conscience—evils which end not with the parent but are transmitted many-fold to the child.

25. *Why should ham and sausage be thoroughly cooked?*

The trichina, which frequents pork, is only destroyed at a high temperature.

26. *Why do we wish butter on fish, eggs with tapioca, oil on salad, and milk with rice?*

To supply the elements of food lacking in the composition of fish, tapioca, etc.

27. *Explain the relation of food to exercise.*

Their relation is exceedingly intimate. If we eat much we should take more exercise, and if, on the contrary, we labor more, we desire additional food. Violent exercise, directly after a hearty meal, is injurious; but a gentle, quiet half-hour's saunter will greatly benefit the digestion.

28. *How do you explain the difference in the manner of eating between carnivorous and herbivorous animals?*

Meat requires less saliva to aid in its digestion, and hence it is mainly digested in the stomach; while vegetable food needs to be thoroughly masticated and incorporated with the salivary mucus.

29. *Why is a child's face plump and an old man's wrinkled?*

In the child the processes of nutrition are more active than those of waste. The reverse is the case in old age.

30. *Show how life depends on repair and waste.*

(See *Chemistry*, page 34, *et seq.*; and *Physiology*, page 120.)

31. *What is the difference between the decay of the teeth and the constant decay of the body?*

The particles of the teeth lost by decay are not renewed, while in the body they are replaced as fast as worn out.

32. *Should biscuit and cake containing yellow spots of soda be eaten?*

Certainly not. The alkali neutralizes the acids of the alimentary juices, and thus impairs their functions, while it corrodes and irritates the delicate mucous lining of the digestive organs.

33. *Tell how the body is composed of organs, organs are made up of tissues, and tissues of cells.*

(See *Physiology*, page 154, note.)

34. *Why do we not need to drink three pints of water per day?*

(See *Physiology*, page 133.)

The amount of water one needs depends upon the character of his food, the nature of his labor, and the activity of the three eliminating organs—the skin, the kidneys, and the lungs. One perspiring freely, or eating dry food, needs more drink than one whose skin is inactive, or whose food consists, in part, of soups or watery vegetables.

35. *Why, during a pestilence, are those who use liquors as a beverage the first, and often the only victims?*

The nervous system becomes impaired, the digestion weakened, and the blood impoverished: hence, the functions of the body being disturbed, its ability to resist disease is greatly impaired. It is said that the alcohol hardens the albuminous matter of the brain and the membranous lining of the lungs, and hence clogs the action of these organs.

36. *What two secretions seem to have the same general use?*

The saliva and the pancreatic juice both change starch into sugar. They have other important uses, however, in the process of digestion. The former softens the food and aids in the work of mastication, while the latter emulsifies the fats.

37. *How may the digestive organs be strengthened?*

The digestive organs, like the other organs, are strengthened by judicious labor. The stomach is a muscle, and like muscle, generally grows strong by use and weak by disuse. The same laws should govern one in his daily exercise of every organ—brain, hand, and stomach.

175.—1. *Why is the pain of incipient hip-disease frequently felt in the knee?*

The sensation of pain is located by the mind, at the part of the body where the injured nerve takes it rise.

2. *Why does a child require more sleep than an aged person?*

The processes of nutrition are going on rapidly, and, in youth, much rest is required to repair the losses of each day; in age, waste predominates, and the repairs made are of a temporary character. The building is soon to be torn down, and little effort is taken to beautify or strengthen that which is to be used for so short a time.

3. *When you put your finger in the palm of a sleeping child, why will he grasp it?*

The unconscious action of the near nervous centers produces a contraction of the muscles.

4. *How may we strengthen the brain?*

By judicious, habitual, but not exhaustive employment. The life of the brain is in change. Monotony is stagnation, and stagnation is decay.

5. *What is the object of pain?*

Pain is monitory in its character. It guards against danger and warns us of the presence of *dis*ease, *i. e.*, the want of ease. Were it not for this, we should lose the use of the more delicate organs. A child might gaze at the sun until its eyesight was ruined. The author knew of a man who had lost the sense of feeling in one leg because of the sensory nerve being severed. He was constantly bruising and burning that limb until he ruined it entirely.

6. *Why will a blow on the stomach sometimes stop the heart?*

By sympathy. The pneumogastric or tenth pair of nerves supply the stomach and the heart.

7. *How long will it take for the brain of a man six feet high to receive news of an injury to his foot, and to reply?*

The nervous force has been estimated to travel at the rate of 100 feet per second, although authorities vary much. Taking this figure, it would require about one-eighth of a second.*

8. *How can we grow beautiful?*

If one is penurious, selfish, or hard-hearted, his face will betray the fact to every passer by. Purity of thought and nobleness of soul, the simple habit of cherishing high and generous purposes, refine and spiritualize the countenance, making, at last, the homeliest features to glow with a beauty that will be a true "joy forever."

9. *Why do intestinal worms ever affect a child's sight?*

Through the action of the sympathetic system of nerves.

10. *Is there any indication of character in physiognomy?*

(See Question 8; also *Physiology*, page 171.)

* A bare-footed boy steps on a thorn. If he had to wait for news of the injury to be sent to his brain, and an order to be telegraphed back to remove the foot, much time would be lost. As it is, with the first prick, the nearer nerve-centers act and order the foot off almost before the brain has heard of the accident.

11. *When one's finger is burned, where is the ache?*

All pain is in the brain. It is located, however, by the mind, at the place of the injury.

12. *Is a parlor generally a healthy room?*

No. It is generally ill-ventilated, and, to preserve the furniture, kept dark, and hence damp.

13. *Why can an idle scholar read his lesson and at the same time count the marbles in his pocket?*

The duality of the brain may, perhaps, account for this.

(See *Physiology*, page 162, note.)

14. *In amputating a limb, what part, when divided, will cause the keenest pain?*

When a surgical operation is performed, the most painful part of it is the incision through the skin; the muscles, cartilage, and bone being comparatively without sensation. Hence, if we could benumb the surface, certain of the lesser operations might be undergone without great inconvenience. This is, in fact, very successfully accomplished by means of the cold produced by throwing a spray of ether, or of some other rapidly evaporating liquid, upon the part to be cut.

15. *What is the effect of bad air on nervous people?*

The nerves connect all the organs of the body. They are therefore especially sensitive to a derangement in the function of any organ. Bad air causes impure blood, deranged nutrition, and hence a disturbance of the entire economy.

16. *Is there any truth in the proverb that "he who sleeps, dines?"*

The proverb expresses the fact that the nourishment of the brain and other parts goes on actively during sleep, they being controlled by the sympathetic nerves.

17. *What does a high, wide forehead indicate?*

It suggests a large brain and a high intellectual power.

18. *How does indigestion frequently cause a headache?*

Through the action of the sympathetic system.

19. *What is the cause of the foot's being "asleep?"*

(See *Physiology*, page 176, note.)

20. *When an injury to the nose has been remedied by transplanting skin from the forehead, why is a touch to the former felt in the latter?*

The mind refers the sensation to the place where the nerve naturally had its origin—*i. e.*, the part over which its tiny fibres were originally distributed.

21. *Are closely-curtained windows healthy?*

No. They keep out the sun and the fresh air.

22. *Why, in falling from a height, do the limbs instinctively take a position to defend the important organs?*

The reflex action of the spinal cord moves the limbs into a position of defence, the brain having no time to act.

23. *What causes the pylorus to open and close at the right time?*

The reflex action of the nerves which preside over that organ. In a similar way, a tickling in the throat excites coughing.

24. *Why is pleasant exercise most beneficial?*

A chief condition of keeping the brain healthy is to keep the unconscious nervous functions in full vigor, and in natural alternations of activity and repose. Thus it is that (besides its effect in increasing the breathing and the general vigor of the vital processes) muscular exercise has so manifest a beneficial influence on a depressed or irritable state of mind. The bodily movement, by affording an outlet to the activity of the spinal cord, withdraws a source of irritation from the brain; or it may relieve excitement of that organ by carrying off its energy into a safe channel.—HINTON.

25. *Why does grief cause one to lose his appetite?*

Through the action of the sympathetic system.

26. *Why should we never study directly after dinner?*

The blood then sets toward the stomach, and the whole strength of the system is needed to properly digest the food.

27. *What produces the peristaltic movement of the stomach?*

The presence of the food which, through the sympathetic system, acting involuntarily, sets in motion the complicated apparatus of digestion.

28. *Why is a healthy child so restless and full of mischief?*

Nature prompts it to exercise all the muscles in its body in order to their proper development.

29. *Why is a slight blow on the back of a rabbit's neck fatal?*

The medulla oblongata is not defended with thick muscles as in man.

30. *Why can one walk and carry on a conversation at the same time?*

(See Question 13, page 176.)

31. *What are the dangers of over-study?*

(See Hinton's *Health and its Conditions*, page 193, *et seq.*, and Cutler's *Analytical Anatomy*, page 248.)

Exhaustive mental labor overstrains the delicate nerve-cells of the brain, and the condition of the blood-vessels of the entire body, especially of the vital organs, is regulated, moment by moment, by its changing moods. Even the supply furnished the brain is subject to the same influence. Hence results deranged nutrition, impaired circulation, and weakened brain and body. Whenever we consume vital energy faster than it can be replaced, we encroach upon the capital, and thus cause an irreparable injury.

32. *What is the influence of idleness upon the brain?*

If we would have healthy bodies we must have active brains, that the streams of force may flow into every organ from a full, fresh, energizing source. "The perfect health of a man is not that of an ox or a horse." The proper exercise of the brain is an essential element of real life.

33. *State the close relation which exists between physical and mental health and disease.*

"A partial cultivation of the mental faculties is incompatible not only with the highest order of thought, but with the highest degree of health and efficiency. The result of professional experience fairly warrants the statement that in persons of a high grade of intellectual endowment and cultivation, other things being equal, the force of moral shocks is more easily broken, tedious and harassing exercise of particular powers more safely borne, than in those of an opposite description, and disease, when it comes, is more readily controlled and cured. The kind of management which consists in awakening a new order of emotion, in exciting new trains of thought, in turning attention to some new matter of study or speculation, must be far less efficacious, because less applicable, in one whose mind has always had a limited range than in one of larger resources and capacities. In endeavoring to restore the disordered mind of the clodhopper who has scarcely an idea beyond that of his manual employment, the great difficulty is to find some available point from which conservative influences may be projected. He dislikes reading, he never learned amusements, he feels no interest in the affairs of the world; and unless the circumstances allow of some kind of bodily labor, his mind must remain in a state of solitary isolation, brooding over its morbid fancies, and utterly incompetent to initiate any recuperative movement."—Dr. Ray.

34. *In what consists the value of the power of habit?*

It saves the "wear and tear" of our principles. We can perform an act a few times, though with difficulty, and then ever after it becomes a habit. We resist evil once, and thenceforth it is easier. We can become accustomed to do good, so that the chances will all be in favor of our well-being in any emergency. By as much as the power of habit is thus pregnant with good, by so much is it susceptible of terrible evil.

35. *How many pairs of nerves supply the eye?*

(See *Physiology*, page 167.)

Three; the motores oculi.

36. *Describe the reflex actions in reading aloud.*

The body is kept erect, the hand holds the book, the eyes are directed to the page, the vocal organs pronounce the words, the features express the sentiments, and the other hand makes corresponding gestures—yet all the time the mind is intent only upon the thought conveyed.

37. *Under what circumstances does paralysis occur?*

When the nerve leading to any part of the body is injured or fails to keep up communications between that portion and the mind.

38. *If the eyelids of a profound sleeper were raised, and a candle brought near, would the iris contract?*

It would, by reflex action.

39. *How does one cough in his sleep?*

By the reflex action of the near nervous centers. A tickling in the throat, or some other cause, acts as the stimulus to excite their action.

40. *Give illustrations of the unconscious action of the brain.*

(See *Physiology*, page 225.)

194.—1. *Why does a laundress test the temperature of her flat-iron by holding it near her cheek?*

The sense of warmth is very keen in the palms of the hand, the cheek, etc. This sensation is much less delicate in the lips and the back of the hand.

2. *When we are cold, why do we spread the palms of our hands before the fire?*

(See Question 1.)

3. *What is meant by a "furred tongue?"*

In health, the tongue has hardly a discernible lining, but in disease, the epithelium, or scarf skin, accumulates, and gives a white, coated appearance. This covering is likely to be of a yellowish shade when the liver is disturbed, and brown or dark in blood diseases. One's occupation often colors it. Thus it is said the tongue of a tea-taster has a curious orange-tint.

4. *Why has sand or sulphur no taste?*

They are insoluble in the saliva.

5. *What was the origin of the word palatable?*

The mistaken notion that the palate, or roof of the mouth, is the seat of the taste.

6. *Why does a cold in the head injure the flavor of our coffee?*

Because the sense of taste is so dependent on that of smell.

7. *Name some so-called flavors which are really sensations of touch.*

Taste is not a simple sense. Certain other sensations, as those of touch, temperature, smell, and pain, are blended and confused with it; and certain so-called tastes are really sensations of another kind. Thus an astringent taste, like that of alum, is more properly an astringent feeling, and results from an impression made upon the nerves of touch, that ramify in the tongue. In like manner, the qualities known as smooth, oily, watery, and mealy tastes, are dependent upon these same nerves of touch. A burning or pungent taste is a sensation of pain, having its seat in the tongue and throat. A cooling taste, like that of mint, pertains to that modification of touch called the sense of temperature.—HUTCHISON'S *Physiology*, p. 190–1.

8. *What is the object of the hairs in the nostrils?*

They prevent the entrance of dust and other impurities. They are also exceedingly delicate in all sensations of touch.

9. *What use does the nose subserve in the process of respiration?*

It warns us of noxious gases, sifts out impurities, and tempers the air before it enters the delicate respiratory organs.

10. *Why do we sometimes hold the nose when we take unpleasant medicine?*

(See Question 6.)

11. *Why is the nose placed over the mouth?*

As a sentinel at the gateway to the stomach and the lungs.

12. *Describe how the hand is adapted to be the instrument of touch.*

Its isolation at the extremity of the movable arm, the mobility of its different parts, and the delicacy of the sensation at the tips of the fingers, exquisitely adapt the hand to be the instrument of touch.

13. *Besides being the organ of taste, what use does the tongue subserve?*

It aids in the mastication of the food and in speech.

14. *Why is not the act of tasting complete until we swallow?*

Because the organ of taste is located especially in the back part of the tongue and the soft palate.

15. *Why do all things have the same flavor when one's tongue is "furred" by fever?*

They are really tasteless. The tongue is then dry, and there is no saliva to dissolve and carry particles of the food into the cells covering the nerves of taste.

16. *Which sense is the more useful—hearing or sight?*

(See *Wonders of the Human Body*, page 201.)

"The sight speaks more directly to the intelligence; it enlarges the field of thought, it gives birth to precise notions of light, of form, of extent; and it permits the communication of thought by conventional signs. Hearing is a necessary condition of articulate language; without it man lives alone, affection and confidence lose their most precious forms of expression, and friendship cannot exist. Auditory sensations act upon the nervous system with more force than visual sensations. We are carried away by rhythm, or it adapts itself to our ideas and our passions; music plunges us into an ideal world, and holds us by an indefinable charm; in a word, if sight speaks more especially to the intellect, hearing addresses itself to the affections. Sight is certainly more necessary to man than hearing, but still the blind are generally gay and communicative, while the deaf seem inclined to melancholy. As to the relative influence of these two senses on the development of the intellect, we know that the education of the deaf is slow, but may be complete, while that of the blind is, on the contrary, rather rapid, but is almost always very limited; many ideas cannot be acquired by them, and, as has been remarked by M. Longet, their minds rarely attain maturity."

17. *Which coat is the white of the eye?*

The sclerotic.

18. *What makes the difference in the color of eyes?*

The varying shade of the pigment deposited in the iris of the eye.

19. *Why do we snuff the air when we wish to obtain a distinct smell?*

As muscular actions are called into play to aid the sense of taste, as in smacking the tongue and lips, so the act of "sniffing," which is a mixed respiratory and nasal muscular effort, is used to bring odorous substances more surely and extensively into contact with the upper and proper olfactory region of the nose, besides causing a larger amount of them to pass over the mucous surface in a given time.—MARSHALL.

20. *Why do red-hot iron and frozen mercury* (—40°) *produce the same sensation?*

The sensation in both cases is that of pain, not that of touch.

21. *Why can an elderly person drink tea which to a child would be unbearably hot?*

The sensation of touch has become impaired, and is much less delicate.

22. *Why does an old man hold his paper so far from his eyes?*

"Far sight" is common among elderly people, and is remedied by convex glasses. In old age the power of adjusting the crystalline lens is lost.

23. *Would you rather be punished on the tips of your fingers than on the palm of your hand?*

The sense of touch is much keener in the tips of the fingers than in the palm of the hand.

24. *What is the object of the eyebrows? Are the hairs straight?*

They serve to prevent the perspiration of the forehead from running down into the eye. They act, in a measure, with the eyelashes, also to screen the eye from the dust and glaring light. The hairs of the eyebrows overlap each other and are set obliquely outward.

25. *What is the use of winking?*

It serves to wash the eyeballs, and thus keep the "windows of the soul" clean. The necessity for winking is shown by the great effort required to restrain it even for a short time. First discomfort, then congestion of the mucous membrane, and then a profuse watering of the eye follow any attempt at stopping this necessary act. It is an obscure sense of discomfort, not usually noticed by the consciousness, that excites this movement, the objects of which are periodically to cleanse the exposed part of the eyeball, to moisten and lubricate it with the secretions from the neighboring glands, and probably in this way to aid in the preservation of the polish and translucency of the epithelial layer on the transparent portion of the globe. At the same time it carries towards the inner corner all foreign bodies, and directs the residual secretions towards the lachrymal ducts. Finally it allows a brief but periodical rest to the levator muscle of the upper eyelid.—MARSHALL.

26. *When you wink, do the eyelids touch at once along their whole length? Why?*

In winking, both lids move, but the upper one much the more extensively. Moreover, they do not come in contact all along their margins at the same instant of time, but meet first at the outer corner and then rapidly inwards as far as the lachrymal papillæ on which the lachrymal ducts are situated. By this sweeping movement, all foreign bodies are carried to the lachrymal lake.—MARSHALL.

27. *How many rows of hairs are there in the eyebrows?*

The *eyelashes*, or *cilia*, consist of two, and opposite the middle of the eyelid, of three rows of finely-curved hairs —those of the upper lid being more numerous, thicker, and longer than those of the lower lid. "Those of the upper lid are curved upward, those of the lower lid are curved downward; and when the lids are brought near together, these two ranges of hairs stand like so many crossed sabres, or a kind of chevaux-de-frise, guarding the entrance to the eye."—DALTON'S *Physiology*, p. 330.

28. *Do all nations have eyes of the same shape?*

No. Witness the almond-shaped eyes of the Chinese. "The greater or less extent of the opening of the lids makes the eye appear larger or smaller; the conformation of the palpebral muscles and the tarsal cartilages gives to the eye an elongated and languishing form as in the East, or round and bold as among the Occidentals; but the dimensions and form of the globe are the same in all countries and in all individuals."—*Wonders of the Human Body.*

29. *Why does snuff-taking cause a flow of tears?*

Because of the action of the sympathetic system.

30. *Why does a fall cause one to "see stars?"* *

Whenever a nerve is excited in any way, it gives rise to the sensation peculiar to the organ with which it com-

* "On the occasion of a remarkable trial in Germany, it was claimed by a person who had been severely assaulted on a very dark night, that the flashes of light caused by repeated blows upon the head enabled him to see with sufficient distinctness to recognize his assailant. But the evidence of scientific men entirely refuted this claim, by pronouncing that the eye, under the circumstances named, was incapacitated for vision."—HUTCHISON.

municates. Thus, an electric shock sent through the eye gives rise to the appearance of a flash of light; and pressure on any part of the retina produces a luminous image, which lasts as long as the pressure, and is called a *phosphene.* If the point of the finger be pressed upon the outer side of the ball of the eye, a luminous image—which, in my own case, is dark in the centre, with a bright ring at the circumference (or, as Newton described it, like the "eye" in a peacock's tail)—is seen; and this image lasts as long as the pressure is continued.—HUXLEY.

31. *Why can we not see with the nose, or smell with the eyes?*

Each set of nerves is adapted to transmit to the brain a peculiar class of sensations alone.

32. *What causes the roughness of a cat's tongue?*

The sharpness and strength of the papillæ upon its tongue. This is a peculiarity of the lion tribe.

33. *Is the cuticle essential to touch?*

Yes. If the cuticle be removed, as in case of a blister, contact with the exposed surface produces pain rather than a sense of touch.

34. *Can one tickle himself?*

It is said not; but the author has found persons who averred that they could produce this sensation upon themselves. The sense, it is noticeable, is present only in those parts where that of touch is feeble.

35. *Why does a bitter taste often produce vomiting?*

The 5th pair of nerves, which supplies the lip and sides of the tongue, and perceives especially sweet and sour substances, ramifies over the face, and hence an acid will "pucker" the features; while the 9th pair, at the base of the tongue, which is sensitive to salt and bitter tastes, is distributed also to the throat, and is in sympathy with the internal organs, since it seems to be "a common nerve of feeling for the mucous membrane generally."

36. *Is there any danger of looking "cross-eyed" for fun?*

The muscles used thus in sport may become permanently distorted.

37. *Should school-room desks face a window?*

No. The light should be admitted so as to fall over the shoulder upon the book. Many school-rooms are arranged to accommodate the teacher only, while a blinding flood of light pours directly into the faces of the pupils.

38. *Why do we look at a person to whom we are listening attentively?*

One sense instinctively aids another.

39. *Do we really feel with our fingers?*

No. All sensation is in the mind.

40. *Is the eye a perfect sphere?*

No. The front projects somewhat, while, at the back, the optic nerve is attached like the stem to a fruit.

41. *How often do we wink?*

Five or six times a minute.

42. *Why is the interior of a telescope or microscope often painted black?*

To absorb the scattered rays of light which would confuse the vision. For the same reason, the posterior surface of the iris, the ciliary processes and the choroid are covered with a layer of dark pigment.

43. *What is "the apple of the eye?"*

The pupil.

44. *What form of glasses do old people require?*

(See Question 22.)

45. *Should we ever wash our ears with cold water?*

Rarely, if ever, lest we chill this sensitive organ.

46. *What is the object of the winding passages in the nose?*

To furnish additional surface on which to expand the olfactory nerve.

47. *Can a smoker tell in the dark, whether or not his cigar is lighted?*

Sight often seems to be essential to perfect what we call a sensation of taste.

48. *Will a nerve re-unite after it has been cut?*

Nerve-fibre seems to re-unite as readily as muscle-fibre.

49. *Will the sight give us an idea of solidity?*

(See *Physiology*, page 196, note.)

50. *Why can a skillful surgeon determine the condition of the brain and other internal organs by examining the interior of the eye?*

(See *Physiology*, page 196, note.)

51. *Is there any truth in the idea that the image of the murderer can be seen in the eye of the dead victim?*

When the flame of a taper is held near, and a little on one side of, a person's eye, any one looking into the eye from a proper point of view will see three images of the flame, two upright and one inverted. One upright figure is reflected from the front of the cornea, which acts as a convex mirror. The second proceeds from the front of the crystalline lens, which has the same effect; while the inverted image proceeds from the posterior face of the lens, which, being convex backwards, is, of course, concave forwards, and acts as a concave mirror.—HUXLEY. The images formed upon the retina are as fleeting as light itself, from the nature of the case, and disappear as soon as the object is removed.

ANSWERS

TO THE

PRACTICAL QUESTIONS AND PROBLEMS

IN THE

FOURTEEN WEEKS COURSE IN PHYSICS.

MOTION AND FORCE.

37.—1–37. (See pp. 15–19 of this Key for Answers to these Questions.)

38. *If a* 100 *horse-power engine can propel a steamer* 5 *miles per hour, will one of* 200 *horse-power double its speed?*

By no means. Resistance is proportional to v^2. (See *Physics*, p. 26.) To double the velocity would require over 400 horse-power. (See note, p. 27.)

39. *Why is a bullet flattened if fired obliquely against the surface of water?*

"Because the particles of the ball which strike the water are impeded in their course by the particles of water with which they come in contact, and are driven back upon those lying next to them, before the motion of the ball can be imparted to the water"—*A. B. Watkins.*

40. *Why are ships becalmed at sea often floated by strong currents into dangerous localities without the knowledge of the crew?*

As there are no fixed objects with which to compare their motion, the officers are not sensible of any movement, and so are often drifted far out of their course.

41. *A man in a wagon holds a* 50-*lb. weight in his hand. Suddenly the wagon falls over a precipice. Will he, while dropping, bear the strain of the weight?*

No. While on solid ground, his hand resisted the tendency of the weight to fall toward the earth's centre of gravity; but all are now descending freely under the influence of gravity, and he no longer feels the pressure.

42. *Why are we not sensible of the rapid motion of the earth?*

Because all the objects around us are moving in the same direction with the earth, and there is nothing at hand with which to compare.

43. *A feather is dropped from a balloon which is immersed in and swept along by a swift current of air. Will the feather be blown away, or will it appear to a person in the balloon to drop directly down?*

It will seem to drop directly downward, as if in a dead calm. Its fall is vertical, however, only as regards the balloon, and not as regards the earth.

(See Stewart's *Physics*, p. 18.)

44. *Suppose a bomb-shell, flying through the air at the rate of* 500 *feet per second, explodes into two parts of equal weight, driving one-half forward in the same direction as*

before, but with double its former velocity. What would become of the other half?

One half will go forward with a double velocity (=1000 feet per sec.), and the other half will be checked and will fall directly to the ground.

(See Stewart's *Physics*, p. 37.)

45. *Which would have the greater penetrating power, a small cannon-ball with a high velocity, or a large one with a low velocity?*

The former would penetrate, while the latter would crush an obstacle.

46. *There is a story told of a man who erected a huge pair of bellows in the stern of his pleasure-boat, that he might always have a fair wind. On trial, the plan failed. In which direction should he have turned the bellows?*

(See *Key*, p. 20.)

47. *If a man and a boy were riding in a wagon, and, on coming to the foot of a hill, the man should take up the boy in his arms, would that help the horse?*

No change would be produced in the weight of the entire establishment drawn by the horse, as no readjustment of the load would modify the attraction of gravity which produces the weight. Also, action = reaction; so the man would press down on the wagon an amount equal to the weight of the boy.

48. *Why does a bird, as it begins to fly, always, if possible, turn toward the wind?*

For the same reason that a boy, wishing to raise a kite, runs against the wind. The greater the velocity of the wind, within certain limits, the greater the lifting force.

(See note, p. 32.)

49. *If we whirl a pail of water swiftly around with our hands, why will the water tend to leave the centre of the pail?*

This is generally attributed to the action of the centrifugal force. More correctly, the inertia of the water, *i.e.*, its tendency to continue to move in the straight line in which it is at each moment passing, overcomes the weak force of cohesion, and the molecules fly off from the centre of motion and collect against the outside of the pail.

50. *Why will the foam collect at the hollow in the centre?*

The foam, being lighter than the water, has less momentum, and is forced back by the heavier particles.

51. *If two cannon-balls, one weighing* 8 *lbs. and the other* 2 *lbs., be fired with the same velocity, which will go the further?*

The former has much less surface in proportion to its weight and consequent momentum. It will therefore go much further against the resistance of the air.

52. *Resolve the force of the wind which turns a common wind-mill, and show how one part acts to push the wheel against its support, and one to turn it around.*

(See Arnott's *Physics*, p. 226.)

The toy-mill shown in Fig. 14, p. 32, illustrates the principle perfectly. The vanes turn in a direction contrary to that in which they are inclined. Let GH, in Fig. 10, p. 31, represent the face of the vane, and the description in the text will then apply.

53. *Why is a gun firing blank cartridges more quickly heated than one firing balls?*

In the one case, the energy of the burning powder is changed to heat; in the other, largely to the motion of the ball.

54. *When an animal is jumping or falling, can any exertion made in mid-air change the motion of its centre of gravity?*

The centre of gravity falls steadily 16.08 feet (see p. 54), whatever other force may act on the body.

(See Second Law of Motion.)

55–60. (See Answers under Questions 1 to 7, on pages 5 and 6 of this Key.)

61. *Why is a "running jump" longer than a "standing jump"?*

This is generally spoken of as an illustration of inertia. It is really an example under the first law of motion. The momentum of the person when running ($m \times v$) is added to the force with which he finally springs from the ground for the jump.

62. *Why, after the sails of a vessel are furled, does it still continue to move? and why, after the sails are spread, does it require some time to get it under full headway?*

This illustrates the tendency of matter to continue in its present state, whether of rest or of motion, *i.e.*, its inertia. For the former part of the question, apply the first law of motion, and for the latter, the first paragraph on p. 28 of the *Physics*. If, on starting with a heavy load, the horses leap suddenly forward, they will break the harness; but, by a steady, constantly-increased draught, they will overcome the inertia of the mass.

63. *Why can a tallow candle be fired through a board?*

Because it pierces the board so quickly that the particles have no time to yield. Its slight cohesion, multiplied by its velocity, is greater than the cohesion of the board.

COHESION.

46.—1–10. (See Answers to these Questions under Cohesion, pp. 6 and 7 of this Key.)

11. *Why can glass be welded?*

Because, like iron, it becomes viscous before melting.

ADHESION.

51.—1–17. (See Answers to these Questions under Adhesion, pp. 7 to 9 of this Key.)

18. *Why does the water in Fig. 22 stand higher inside of the tube than next the glass on the outside?*

There is the influence of a larger surface of glass in proportion to the quantity of water to be lifted.

19. *Why will clothes-lines tighten and sometimes break during a shower?*

The rope absorbs water and expands transversely. This shortens it with so much force as often to break it. The shrinking of new cloth when wet illustrates the same principle.

20. *Show that the law of the diffusion of gases aids in preserving the purity of the atmosphere.*

(See *New Chemistry*, p. 96.)

Foul gases do not remain for any length of time in one place, but tend to spread through the adjacent atmosphere. Fresh air also seeks to creep into noisome localities.

21. *In casting large cannon, the gun is cooled by a stream of cold water. Why?*

The object of this is to cause the iron to cool more quickly and so not give the molecules time to arrange themselves in crystals.

(See p. 45.)

22. *Why does paint adhere to wood? Chalk to the blackboard?*

These are illustrations of the force of adhesion.

23. *Why does a towel dry one's face after washing?*

The capillary pores of the cloth absorb the water on the face.

24. *Why will a greased needle float on water?*

The repulsion between the grease and the water is sufficient to support the slight weight of the needle.

25. *Why is the point of a pen slit?*

The ink rises in the capillary space of the slit, and is there held for use. When the pen is pressed on the paper, the space is widened and the ink descends.

26. *Why is a thin layer of glue stronger than a thick one?*

The adhesion between the glue and the wood is stronger than the cohesion between the particles of glue; hence the thinner the layer of glue the fewer the particles acted upon only by the latter or weaker force.

GRAVITATION.

62.—1–41. (See the Answers to these Queries on pp. 9 to 14 of this Key.)

42. *How long would it take for a pendulum one mile in length to make a vibration?*

(See Key, p. 13, Problem 37.)

According to the second law of pendulums (*Physics*, p. 59),

$$1 \text{ sec.} : x :: \sqrt{39} : \sqrt{5280 \times 12 \text{ in.}}$$
$$x = 40 + \text{ sec.}$$

43. *How long would it take for a pendulum reaching from the earth to the moon to make a vibration?*

$$1 \text{ sec.} : x :: \sqrt{39.1 \text{ in.}} : \sqrt{240,000 \times 5280 \times 12 \text{ in.}}$$
$$x = 5 \text{ hrs. } 28 + \text{ minutes.}$$

44. *Required the length of a pendulum that would vibrate centuries.*

$$(1 \text{ sec.})^2 : (100 \times 365.25 \times 24 \times 60 \times 60)^2 :: 39.1 \text{ in.} : x.$$
$$x = 6,145,674,053,727,272 + \text{ miles.}$$

—SOLOMON SIAS.

45. *What would be the time of vibration of a pendulum 64 metres long?*

$$(1 \text{ sec.})^2 : x^2 :: 1 \text{ metre (nearly)} : 64 \text{ metres.}$$
$$x = 8 \text{ seconds (nearly).}$$

46. *A ball is dropped from a height of* 64 *feet. At the same moment a second ball is thrown upward with sufficient velocity to reach the same point. Where will the two balls pass each other?*

At the end of one second. The first ball would fall 64 feet in 2 seconds; the second would rise for 2 seconds, and they would pass in 1 sec.

47. *Two bodies are successively dropped from the same point with an interval of* $\frac{1}{5}$ *of a second. When will the distance between them be one metre?*

$$\text{Let } t = \text{time of descent of 2d body.}$$
$$\text{Then } t + .2 = \text{time of descent of 1st body.}$$

Since the space passed over equals 4.9 m. (16 ft.) multiplied by the square of the time, we have

$$4.9\,t^2 = \text{space passed over by 2d body.}$$
$$4.9(t + .2)^2 = 4.9t^2 + 1.96t + .196$$
$$= \text{space passed over by 1st body.}$$

The difference between the 2 spaces being 1 m., we have

$$4.9t^2 + 1.96t + .196 - 4.9t^2 = 1 \text{ m.}$$
$$1.96t = .804.$$
$$t = .4102 \text{ sec.} = \text{time of descent of 2d body.}$$
$$.6102 \text{ sec.} = \text{time of descent of 1st body.}$$

Therefore they will be 1 m. apart when the 1st body has fallen for .6102 sec., or the 2d body for .4102 sec.

PROOF.—$4.9 \times .6102^2 - 4.9 \times .4102^2 = 1$ (nearly).

—WM. H. TAYLOR.

48. *Explain the following fact: A straight stick loaded with lead at one end, can be more easily balanced vertically*

on the finger when the loaded end is upward than when it is downward.

When the loaded end is upward a slighter motion is needed to bring the line of direction within the base. The principle is similar to that of the balancing pole of the gymnast.

49. *What effect would the fall of a heavy body to the earth have upon the motion of the earth in its orbit?*

If its line of fall was exactly opposed to the direction of the earth's motion, it would, by its momentum, tend to retard the earth. If its line of fall was exactly in the direction of the earth's motion, it would increase the earth's velocity. If its line of fall was transverse to the direction of the earth's motion, it would deflect the earth from its orbit. All of these changes would, of course, be infinitesimal in amount.

50. *If a body weighing* 1 *lb. on the earth were carried to the sun, it would weigh* 27 *lbs. How much would it attract the sun?*

Ans. 27 lbs.

51. *Why does watery vapor float and rain fall?*

(See *Physics*, p. 116, Question 13.)

The vapor of water is lighter than water itself, as the particles are pushed so far apart by the repellent force—heat.

52. *If a body weighs* 10 *kilos. on the surface of the earth, what will it weigh* 1,000 *km. above?*

$$x : 10 \text{ kilos.} :: (6{,}366\,*)^2 : (7.366)^2$$
$$x = 7.5 \text{ kilograms.}$$

* The radius, or semi-diameter of the earth, is given by French astronomers at 6,366 km.

53. *A body is thrown vertically upward with a velocity of* 100 *metres. How long before it will return to its original position?*

Ans. 20.4 seconds.

54. *How long will be required for a body to fall a distance of* 2,000 *metres?*

Equation (6) $d = \frac{1}{2} g t^2$. $2{,}000 = \frac{9.8}{2} t^2$.

$\therefore\ t = 20.2$ seconds.

55. *If two bodies weighing respectively* 1 *kilo. and* 1 *demi-kilo. are connected by a rod* 9 *decimetres long, where is the centre of gravity?*

Ans. 6 dm. from one body and 3 dm. from the other.

(See Key, p. 10, Question 7.)

ELEMENTS OF MACHINES.

79.—1–26. (See Answers on pp. 20 to 24 of this Key.)

27. *Why is the rim of a fly-wheel made so heavy?*

The heavier the wheel, the greater its inertia; and the further the weight is from the centre of motion (or axle), the greater its inertia or centrifugal force.

(See *Physics*, p. 78.)

28. *Describe the hammer, when used in drawing a nail, as a bent lever, i. e., one in which the bar is not straight.*

If a lever is bent, or if, when it is straight, the bar is not at right angles to the lines of action of the P and the W, it is necessary to distinguish between the arms of a lever and the arms of the P and the W, regarded as forces which have moments around the F. In the latter sense, the arms are the perpendiculars, dropped from the F to the lines of action of the P and the W.

(See Everett's *Text-book of Physics*, p. 23; and Todhunter's *Natural Philosophy for Beginners*, Vol. I, p. 78, where there is an excellent diagram.)

HYDROSTATICS.

96.—1–38. (See pp. 24–29 of this Key.)

39. *Suppose that Hiero's crown was an alloy of silver and gold, and weighed 22 ozs. in air and $20\frac{1}{2}$ ozs. in water. What was the proportion of each metal?*

"Multiply the specific gravity of each ingredient by the difference between it and the specific gravity of the compound. As the sum of the products is to the respective products, so is the specific gravity of the body to the proportions of the ingredients. Then, as the specific gravity of the compound is to the weight of the compound, so is each of the proportions to the weight of its material."—*American Cyclopædia.*

Second method:

Let A = mass of crown = 22
" B = sp. gr. " = 14.66
" x = mass of gold
" x' = sp. gr. " = 19.26
" y = mass of silver
" y' = sp. gr. " = 10.5

then

$$A = x + y;$$

and since

$$\text{volume} = \frac{\text{mass}}{\text{specific gravity}},$$

we have

$$\frac{A}{B} = \frac{x}{x'} + \frac{y}{y'};$$

whence we find (approximately),

Gold = 13.95

Silver = 8.05

40. *Why will oil, which floats on water, sink in alcohol?*

The specific gravity of absolute alcohol is only .79; hence even the dilute alcohol of commerce is lighter than water.

41. *A specific-gravity bottle holds* 100 *gms. of water and* 180 *gms. of sulphuric acid. Required the density of the acid.*

Ans. 1.8.

42. *What is the density of a body which weighs* 58 *gms. in air and* 46 *gms. in water?*

Ans. $4\frac{5}{6}$.

43. *What is the density of a body which weighs* 63 *gms. in air and* 35 *gms. in a liquid of a density of* .85?

Ans. 1.9125.

HYDRAULICS OR HYDRODYNAMICS.

103.—1–5. (See Key, pp. 29, 30.)

PNEUMATICS.

116.—1–18. (See Key, pp. 30–32.)

19. *Explain the theory of "sucking cider" through a straw.*

The air in the straw being exhausted, the pressure of the air on the cider in the vessel forces the liquid through the straw.

20. *Would it make any difference in the action of the siphon if the arms were of unequal diameter?*

It would change the relative weight of the columns of liquid in the two arms, and so increase or diminish the difference of pressure which forces the liquid through the long arm. Now, the heavier *cd* and the lighter *ab*, in Fig. 105, the faster the flow.

21. *If the receiver of an air-pump is 5 times as large as the barrel, how many strokes of the piston will be needed to diminish the air nearly one-half?*

One-fifth of the air in the receiver is removed at each stroke. After the third stroke there would remain in the receiver $\frac{64}{125}$ of the original atmosphere.

22. *What would be the effect of making a small hole in the top of a diving-bell while in use?*

The air would escape at the top, and the water would ascend and fill the bell.

ACOUSTICS.

144.—1–16. (See Key, pp. 32–34.)

17. *Why will the report of a cannon fired in a valley be heard on the top of a neighboring mountain, better than one fired on the top of a mountain will be heard in the valley?*

A sound always has the intensity given it by the density of the atmosphere where it originated, and not of that where it is heard.

(See Tyndall's *Lectures on Sound*, p. 40.)

18. *Why do our footsteps in unfurnished dwellings sound so startlingly distinct?*

In furnished rooms, the chairs, carpets, pictures, etc. break up the echoes. Then, also, our footsteps are louder on an uncarpeted floor.

19. *Why do the echoes of an empty church disappear when the audience assemble?*

The audience break up the echoes which interfere with the original sound. Wires strung across a lofty room often serve the same purpose.

20. *What is the object of the sounding-board of a piano?*

By its vibrations and those of the body of air which it encloses, it reinforces the sound of the wires.

21. *During some experiments, Tyndall found that a certain sound would pass through twelve folds of a dry silk handkerchief, but would be stopped by a single fold of a wet one. Explain.*

(See Tyndall's *Lectures on Light*, p. 325, for a series of experiments showing the action of moisture in propagating the sound-waves.)

22. *What is the cause of the musical murmur often heard near telegraph lines?*

It is produced by the vibration of the wires. These are thrown into motion by the wind and other causes.

23. *Why will a variation in the quantity of water in the goblet, when caused to sound as in the experiment described on page* 123, *make a difference in the tone?*

It changes the length of the vibrating portion of the glass.

24. *At what rate (in metres) will sound move through air at* 20° *C.?*

Sound moves at the rate of 1,090 feet at 0° C. The difference is nearly 2 feet for each degree C.

$$1090 \text{ feet} + 40 \text{ feet} = 1130 \text{ feet.}$$

OPTICS.

177.—1–25. (See Key, pp. 35–39.)

26. *What is the principle of the kaleidoscope?*

27. *Which will be seen at the greater distance, a yellow or a gray body?*

The yellow, since it is brighter.

28. *Look down into the glass of water shown in Fig.* 145, *and at a certain angle you will see two spoons, one small and having the real handle of the spoon, though apparently bent, and the real spoon with no handle. Explain.*

In trying the experiments here alluded to, the glass should be looked into at all possible angles, and the spoon be turned about in the goblet. The glass of water acts as a convex lens to magnify objects; the concave upper surface of the water, when one looks down into it, as a concave lens to minify objects; and the upper surface of the water, when one looks up at it, as a total reflector of the light. These facts, together with the phenomenon of refraction, as shown in the apparent breaking of the handle where it enters the water, will account for all the curious modifications which may be noticed. The experiment is worth hours of examination.

29. *When a star is near the horizon, does it seem higher or lower than its true place?*

It seems higher, since the rays of light are bent downward to the eye, and the object is seen in the line of the ray as it enters that organ.

30. *Why can we not see a rainbow at midday?*

Because the sun is not in the right position. To produce the ordinary rainbow it must be toward the eastern or western horizon.

31. *What conclusion do we draw from the fact that moonlight shows the same dark lines as sunlight?*

That its light has the same source as that of the sun, and is, indeed, sunlight.

32. *Why does the bottom of a ship seen under water appear flatter than it really is?*

Because, by refraction, the bottom of the ship is apparently elevated above its true place.

33. *Of what shape does a round body appear in water?*

It appears to be flattened; and hence a round body looks like an oval one.

34. *Why is rough glass translucent while smooth glass is transparent?*

The minute protuberances scatter the rays of light and do not allow them to pass freely to the eye of the observer.

35–42. (See Key, pp. 38, 39; Questions 28–35.)

43. *Are there rays in the sunbeam which we cannot perceive with the eye?*

(See *Physics*, pp. 163, 164.)

The calorific and actinic rays are invisible.

44. *Why, when we press the finger on one eyeball, do we see objects double?*

"Each retina possesses regions of symmetry with the other, and on this fact singleness of vision depends; each point of the outer portion of the retina of the right eye has its point of symmetry in an inner portion of the left, and when from a distant object rays fall on these symmetrical points, that object will be seen single; but if, by the pressure of the finger or otherwise, we compel the image in one of the eyes to fall upon another and non-symmetrical point, the object at once becomes double."

(See Draper's *Human Physiology*, p. 395.)

45. *Why does a distant light, in the night, seem like a star?*

The light radiating in every direction produces the star-like effect, and we cannot see the surrounding objects by which to correct the impression. Hence one often mistakes a fire on a distant hill for a star rising.

46. *Why does a bright light, in the night, seem so much nearer than it is?*

We judge of the distance of an object by its magnitude, by its distinctness of outline, and by the size, etc., of intervening objects with which we compare it. In the night, the brightness of a light confuses us by its vividness, seeming to be near at hand. Moreover, we cannot see the neighboring objects, whose distance we know or could estimate in the daylight. Our error is therefore one of judgment. A fire at night thus seems near at hand, and persons often run toward it for great distances, expecting every moment to reach it.

(See Question 54.)

48, 49. (See Key, p. 40; Questions 47, 48.)

50. *Why is the lens of a fish's eye (seen in the eye-socket of a boiled fish) so convex?*

The difference of density between the water and the eye is not so great as that between the air and the eye. Hence, to refract the light sufficiently to bring it to a focus on the retina requires a more convex lens.

(See Dudgeon, on the *Human Eye;* and *Physics*, p. 268, note.)

51. *When do the eyes of a portrait seem to follow a spectator to all parts of a room?*

This is noticed only in a full-face portrait. In that case the spectator, when he goes to either side, fails to see the side of the eyeballs, and hence the effect is that of looking directly into the eye. "A rifleman, portrayed as if taking aim directly in front of the picture, appears to every observer to be pointing at him specially."

52. *Why does the dome of the sky seem flattened?*

"Because the light from above, having to pass through a less amount of air, is less obstructed than that which comes horizontally. It is therefore more vivid."

53. *Why do the two parallel tracks of a railroad appear to approach in the distance?*

This depends upon what is known in painting as the *vanishing point.* "Suppose two long rows of pillars, 100 feet apart, and an observer standing at one end looking down the rows. Evidently, for the same reason as the space between the top and bottom of the pillars, that is to say their height, becomes apparently less and less as their distance from the eye increases, so will the space between each pillar and its opposite in the other row become apparently less, and the lines of pillars will, at a certain distance (viz., where 200 feet are apparently reduced to a point), seem to join. Beyond that spot, known as the vanishing point, none of the pillars can be seen."

(Read Arnott's *Physics*, pp. 616-622.)

54. *Why does a fog magnify objects?*

The fog diminishes the intensity of the light. The visual angle, however, remains the same. "An object at two miles, subtending the same angle as an object at one mile, is twice as broad, and the conclusion is drawn that the dim object is large. Thus, a person in a fog may believe that he is approaching a great tree fifty yards distant, when the next instant throws him into a low bush that has deceived him. A boy on the stage, with a thin gauze screen before him, will look to the audience like a man in the distance."

(See Arnott's *Physics*, p. 628.)

It is not the refraction of the rays of light, as is commonly supposed, which makes an object seem larger when seen through a mist. It really appears to us in its proper size. The mist, however, dims the color and the outline, giving it the indistinctness belonging to a mile in distance, while it has the magnitude of half a mile. Dr. Wayland relates that, as he was sailing through Newport harbor early one morning, in a dense fog, he observed on the apparently distant wharf some very tall men. While he was remarking upon their extraordinary size, he was astonished to see them jumping about like children, and otherwise behaving in a most unaccountable manner. Presently, as the sun dispersed the fog, he found that he was close to the wharf, and that the gigantic men were really a party of small boys amusing themselves with play.

The opposite mistake is made when the atmosphere is more transparent than that to which we are accustomed. Foreign travellers in Switzerland, who have started on foot to visit a glacier or a mountain-peak which seemed within easy distance, have often been surprised to find, after two or three hours of brisk walking, that the object of their desire seemed as far away as at first. So in looking across a sheet of water, where there are no intervening objects, distance is always underrated.

When we throw a stone at an object in the water we find that our eye has deceived us, and the stone falls far short of the mark. For the same reason, objects seen on the shore from the water seem much less than their natural size. The fact is, they appear of the magnitude which belongs to the distance, but we suppose the distance less than it is; and, associating this magnitude with diminished distance, they appear to us less than they really are.

In order to form these judgments correctly, one of these elements must be fixed. From this we learn to institute a comparison, and thus form an accurate opinion. If we know the magnitude of an object, the change in its color and outline will teach us its distance. If we know its distance, we can judge of its magnitude. Hence, painters, in order to give us a correct idea of an object which they represent, always place in its vicinity something with whose real magnitude we are familiar. Thus, to show the size of a pyramid, an Arab with his camel may be drawn at its foot. If the pyramid were represented by itself, its intended size might be mistaken; but every one knows the size of a camel, and from this he would judge of the magnitude of a pyramid.—*Wayland's Intellectual Philosophy*, p. 78, *et seq.*

55. *If you sit where you cannot see another person's image, why cannot that person see yours?*

The angle of incidence is equal to the angle of reflection under all circumstances. If a ray from the other person is not reflected at the right angle to reach your eye, then a ray from you is not reflected at the right angle to reach the other person's eye.

56. *Why can we see the multiple images in a mirror better if we look into it very obliquely?*

More light is then reflected to the eye.

(See *Physics*, p. 151, 2d note.)

57. *Why is an image seen in water inverted?*

(Examine Fig. 140, in *Physics*.)

58. *Why is the sun's light fainter at sunset than at mid-day?*

(See *Physics*, p. 149, note.)

59. *Why can we not see the fence-posts when we are riding rapidly?*

There is not time for the rays of light to produce a distinct impression on the retina.

(See *Physics*, p. 177, line 13.)

60. *Ought a red flower to be placed in a bouquet by an orange one? A pink or blue with a violet one?*

(See *Physics*, p. 167.)

These are not complementary colors, and so weaken rather than strengthen each other.

61. *Why are the clouds white while the clear sky is blue?*

Prof. Tyndall has shown that the larger particles of vapor scatter light of all colors, *i. e.*, white light; while the smallest particles, only the blue rays. In accordance with this fact the clouds are white and the sky is blue. If the air were absolutely pure and free from all foreign matter, it is thought that the azure of the sky would not be seen and the heavens would appear black: the illumination of objects would be strong and glaring on one side, and on the opposite side the shadows would be deep and unrelieved by the diffused light to which we are accustomed. The minute particles of vapor in the air serve to scatter the direct rays of the sun and to turn them around corners and into places not in the direct line of the sunlight.

(See a full and interesting discussion in Tyndall's *Lecture on Light*, page 152, *et seq.*)

62. *Why does skim-milk look blue and new milk white?*

The fatty globules of the new milk reflect all the colors of the spectrum to the eye; but when deprived of the cream the milk reflects the blue light in excess of the others.

63. *What would be the effect of filling the basin, in the experiment shown in Fig.* 147, *with salt water?*

The water would be made denser and its refractive power would be correspondingly increased.

(Compare *Physics*, p. 268, note.)

64. *Why is not the image of the sun in water at mid-day so bright as near sunset?*

(See *Physics*, p. 151, 2d note.)

65. *Why is the rainbow always opposite the sun?*

(See *Physics*, p. 166.)

HEAT.

203.—1–54. (See Key, pp. 40–47.) With regard to Question 23 there is much difference of opinion. Many authorities think that *temperature*, and not *moisture*, is the chief factor in producing barometric changes.

(See Müller, *Komische Physik*, 637.)

55. *Why will "fanning" cool the face?*

It brings in contact with the face a current of fresh and generally cooler air.

(See *Physics*, p. 191.)

56. *How are safes made fire-proof?*

By filling the space between the inner and the outer iron-plates with a non-conducting material, as plaster, etc., the safe is rendered nearly fire-proof. In one form of safe, pipes of water are used, which absorb the heat and render it latent.

57. *Why can you heat water quicker in a tin than a china cup?*

Because the metal is a better conductor of heat than the china.

58. *Why will a woollen blanket keep ice from melting?*

The woollen is a non-conductor of heat.

59. *Does dew form under trees?*

The trees reflect back the heat radiated by the earth, grass, etc., and so prevent the temperature, in general, from sinking to the dew-point.

60. *What is the principle of heating by steam?*

(See *Physics*, p. 206.)

61. *Why is a gun firing blank cartridges more heated than one firing balls?*

(See Key, p. 207, Question 53.)

62. *What is the cause of "cloud-capped" mountains?*

(See *Physics*, p. 197.)

63. *Show how the glass in a hot-house acts as a trap to catch the sunbeam.*

(See *Physics*, p. 194.)

64. *Does the heat of the sun come in through our windows?*

(See *Physics*, p. 194.)

65. *Does the heat of our stoves pass out in the same way?*

(See *Physics*, p. 194.)

67. *Is a dusty boot hotter to the foot than a polished one?*

(See *Physics*, p. 194.)

68. *The top of a mountain is nearer the sun; why is it not warmer?*

(See Question 62.)

72. *Can we find frost on the windows and on the stone-flagging the same morning?*

It requires a much intenser cold to produce the former effect than the latter, as glass is a poorer conductor of heat than stone. We frequently find frost on the flagging early in the fall, but frost on the window is a sign of very severe winter weather.

73. *Why will not snow "pack" into balls except in mild weather?*

The snow must be very near the melting-point for the pressure of the hand to be sufficient to melt enough of it to produce the phenomena of regelation. (*Physics*, p. 202, 1st note; also Tait's *Recent Advances in Physical Science*, p. 129, and Tyndall's *Forms of Water*, p. 163.) This principle involves the theory of Glaciers. "The masses of snow cannot rest on the steep slopes of Alpine summits. The pressure upon the under layers is too great to allow them to remain upon their sloping beds, and they are forced to descend. This descent is accomplished in two forms: that of an avalanche, one of the most awful and imposing spectacles to witness; or of a glacier, which is really an avalanche of ice of extremely slow motion. But the glacier differs from the ordinary avalanche not only in that its motion is so slow, but in that it consists of ice, thick, firm, and hard. The principles involved in this transition of the loose, flaky snow which first falls upon the mountain-top into the solid ice of the glacier, are very well illustrated, as Helmholtz has remarked, in the manufacture of the schoolboy's snow-ball or snow-man. Very cold snow is always light and flaky, and cannot be made by the pressure of the hands into a cohesive mass; in order to succeed in that operation, snow is always employed which is already at the melting-point, or only so far below this temperature that the warmth of the hand suffices to bring it to the required temperature, and then, by dint of pressure and moulding, an icy ball may be easily produced. So with the formation of the glacier ice. A process of almost simultaneous melting and freezing goes on among the under layers of snow, and under an immense and ever-constant pressure from the weight of the snow above; thus solid ice is formed. That this ice conforms itself to the various windings, constrictions, and dilatations of its rocky channel during its downward march is a fact not less familiar than wonderful."

74. *Why is the sheet of zinc under a stove so apt to become puckered?*

When zinc cools after expansion it does not return quite to its former dimensions, and so becomes "puckered," as it is called.

75. *Why does a mist gather in the receiver of the air-pump as the air becomes rarefied?*

"The remaining air, cooled by rarefaction, absorbs heat from the invisible vapor in combination with it, and renders the water visible. The mist may be removed by continued action of the machine, or by readmitting the normal quantity of air."

(See Arnott's *Physics*, p. 448.)

76. *Why are the tops of high mountains in the tropics covered with perpetual snow?*

(See Question 62.)

MISCELLANEOUS QUESTIONS AND PROBLEMS FOR REVIEW.

1. *Does a plumb-line point to the earth's centre of figure or centre of gravity?*

2. *In a dark room, let the light of a candle pass through a small hole in a card, and the image of the candle on the opposite wall will be inverted. Explain.*

3. *Why does drift on the Mississippi accumulate for the most part on the west bank?*

4. *How many times heavier is the earth than an equally large globe of water?*

5. *Why does the arc of a rainbow seem a part of an ellipse instead of a circle?*

6. *Why does a rocket ascend into the air?*

7. *Is the water at the foot of Niagara Falls warmer than that in the river above?*

8. *What causes wheel fire-works to rotate?*

9. *A brass-rod covered tightly with thin paper may be held some time in a flame without the paper being scorched; while, if the rod be of wood, the paper will scorch at once. Why is this difference?*

10. *How would it affect the action of a siphon if it were carried up a mountain?*

11. *If a vessel of water containing a floating body be placed under the receiver of an air-pump, and the air gradually exhausted, what will be the effect on the floating body?*

12. *How will it change the height of the column of mercury in a barometer to incline the tube?*

13. *In the image of a written page seen in a mirror, why does the writing seem to slope to the left?*

14. *Why does a coin placed in a tumbler look larger when the glass is full of water than when it is empty?*

15. *Two bodies of different bulks weigh the same in water; which will weigh the more in mercury, the larger or the smaller?*

16. *How does the wind drift sand, snow, etc.?*

17. *Why does oil "still troubled waters"?*

18. *Why does crouching down at the highest points in a swing, and standing up at the lowest point, increase the velocity?*

19. *What difference would it make in the guinea-and-feather experiment to force into the tube additional air, instead of exhausting it, as ordinarily done?*

EXPLAINING MIRRORS AND LENSES.

The author has met with the best success in explaining mirrors and lenses to his pupils, by using the following method.

A Concave Mirror.—Holding up before his eye the forefinger of each hand, he represents to the pupil how the rays of light enter his eye *converging;* how he then sees the object on *diverging* rays: thus the visual angle being *increased*, the apparent size of the object is correspondingly increased. By crossing his two forefingers before his eye he represents the focus, and shows how *diverging* rays then enter the eye; the object is seen on *converging* rays, the visual angle is *decreased*, and the apparent size of the object correspondingly decreased.

A Convex Mirror.—Using the fingers in the same way, he illustrates how *diverging* rays enter the eye, the object is seen on *converging* rays, the visual angle is *diminished*, and the apparent size of the object correspondingly diminished. The rays of light are not brought to a focus, hence the second effect of a concave mirror cannot be seen.

The same illustration can be used in explaining lenses, remembering that the effect of a convex lens is like that of a concave mirror, and of a concave lens that of a convex mirror.

At the close of the explanation and illustration with the fingers, the following formula is put on the blackboard, and the pupil applies it to each class of mirrors and lenses:

CONVERGING (diverging) RAYS ENTER THE EYE, THE OBJECT IS SEEN ON DIVERGING (converging) RAYS; HENCE THE VISUAL ANGLE IS INCREASED (decreased), AND THE IMAGE IS LARGER (smaller) THAN LIFE.

PARKER & WATSON'S NATIONAL READERS.

The salient features of these works which have combined to render them so popular may be briefly recapitulated as follows:

1. THE WORD-BUILDING SYSTEM.—This famous progressive method for young children originated and was copyrighted with these books. It constitutes process with which the beginner with *words* of one letter is gradually introduced to additional lists formed by prefixing or affixing single letters, and is thus led almost insensibly to the mastery of the more difficult constructions. This is one of the most striking modern improvements in methods of teaching.

2. TREATMENT OF PRONUNCIATION.—The wants of the youngest scholars in this department are not overlooked. It may be said that from the first lesson the student by this method need never be at a loss for a prompt and accurate rendering of every word encountered.

3. ARTICULATION AND ORTHOEPY are considered of primary importance.

4. PUNCTUATION is inculcated by a series of interesting *reading lessons*, the simple perusal of which suffices to fix its principles indelibly upon the mind.

5. ELOCUTION. Each of the higher Readers (3d, 4th and 5th) contains elaborate, scholarly, and thoroughly practical treatises on elocution. This feature alone has secured for the series many of its warmest friends.

6. THE SELECTIONS are the crowning glory of the series. Without exception it may be said that no volumes of the same size and character contain a collection so diversified, judicious, and artistic as this. It embraces the choicest gems of English literature, so arranged as to afford the reader ample exercise in every department of style. So acceptable has the taste of the authors in this department proved, not only to the educational public but to the reading community at large, that thousands of copies of the Fourth and Fifth Readers have found their way into public and private libraries throughout the country, where they are in constant use as manuals of literature, for reference as well as perusal.

7. ARRANGEMENT. The exercises are so arranged as to present constantly alternating practice in the different styles of composition, while observing a definite plan of progression or gradation throughout the whole. In the higher books the articles are placed in formal sections and classified topically, thus concentrating the interest and inculcating a principle of association likely to prove valuable in subsequent general reading.

8. NOTES AND BIOGRAPHICAL SKETCHES. These are full and adequate to every want. The biographical sketches present in pleasing style the history of every author laid under contribution.

9. ILLUSTRATIONS. These are plentiful, almost profuse, and of the highest character of art. They are found in every volume of the series as far as and including the Third Reader.

10. THE GRADATION is perfect. Each volume overlaps its companion preceding or following in the series, so that the scholar, in passing from one to another, is only conscious, by the presence of the new book, of the transition.

11. THE PRICE is reasonable. The National Readers contain more matter than any other series in the same number of volumes published. Considering their completeness and thoroughness they are much the cheapest in the market.

12. BINDING. By the use of a material and process known only to themselves, in common with all the publications of this house, the National Readers are warranted to outlast any with which they may be compared—the ratio of relative durability being in their favor as two to one.

WATSON'S INDEPENDENT READERS.

This Series is designed to meet a general demand for smaller and cheaper books than the National Series proper, and to serve as well for intermediate volumes of the National Readers in large graded schools requiring more books than one ordinary series will supply.

Beauty. The most casual observer is at once impressed with the unparalleled mechanical beauty of the Independent Readers. The Publishers believe that the æsthetic tastes of children may receive no small degree of cultivation from their very earliest school books, to say nothing of the importance of making study attractive by all such artificial aids that are legitimate. In accordance with this view, not less than $25,000 was expended in their preparation before publishing, with a result which entitles them to be considered "The Perfection of Common School Books."

Selections. They contain, of course, none but entirely new selections. These are arranged according to a strictly progressive and novel method of developing the elementary sounds in order in the lower numbers, and in all, with a view to topics and general literary style. The mind is thus led in fixed channels to proficiency in every branch of good reading, and the evil results of 'scattering' as practised by most school-book authors, avoided.

The Illustrations, as may be inferred from what has been said, are elegant beyond comparison. They are profuse in every number of the series from the lowest to the highest. This is the only series published of which this is true.

The Type is semi-phonetic, the invention of Prof. Watson. By it every letter having more than one sound is clearly distinguished in all its variations without in any way mutilating or disguising the normal form of the letter.

Elocution is taught by prefatory treatises of constantly advancing grade and completeness in each volume, which are illustrated by wood-cuts in the lower books, and by black-board diagrams in the higher. Prof. Watson is the first to introduce Practical Illustrations and Black-board Diagrams for teaching this branch.

Foot Notes on every page afford all the incidental instruction which the teacher is usually required to impart. Indices of words refer the pupil to the place of their first use and definition. The Biographies of Authors and others are in every sense excellent.

Economy. Although the number of pages in each volume is fixed at the minimum, for the purpose recited above, the utmost amount of matter available without overcrowding is obtained in the space. The pages are much wider and larger than those of any competitor and contain *twenty per cent* more matter than any other series of the same type and number of pages.

All the Great Features. Besides the above all the popular features of the National Readers are retained except the Word-Building system. The latter gives place to an entirely new method of progressive development, based upon some of the best features of the Word System, Phonetics and Object Lessons.

NATIONAL READERS.

ORIGINAL AND "INDEPENDENT" SERIES

SPECIMEN TESTIMONIALS.

From D. H. Harris, *Supt. Public Schools*, *Hannibal*, *Mo.*

The National Series of Readers are now in use in our public schools, and I regar them *the best* that I have ever examined or used.

From Hon. J. K. Jillson, *Supt. of Education*, *State of South Carolina.*

I have carefully examined your new and beautiful Series of Readers known as "The Independent Readers," and do not hesitate to recommend it as the finest and most excellent ever presented to the public.

From D. N. Rook, *Sec. of School Board*, *Williamsport*, *Pa.*

I would say that Parker & Watson's Series of Readers and Spellers give the best satisfaction in our schools of any Series of Readers and Spellers that have ever been used. There is nothing published for which we would exchange them

From Prof. H. Seele, *New Braunfels Academy*, *Texas.*

I recommend the National Readers for four good reasons: (1.) The printing, engraving, and binding is excellent. (2.) They contain choice selections from English Literature. (3.) They inculcate good morals without any sectarian bias. (4.) They are truly *National*, because they teach pure patriotism and not sectional prejudice.

From S. Findley, *Supt. Akron Schools*, *Ohio.*

We use no others, and have no desire to. They give entire satisfaction. We like the freshness and excellence of the selections. We like the biographical notes and the definitions at the foot of the page. We also like the white paper and clear and beautiful type. In short, we do not know where to look for books which would be so satisfactory both to teachers and pupils.

From Pres. Robert Allyn, *McKendree College*, *Ill.*

Since my connection with this college, we have used in our preparatory department the Series of Readers known as the "National Readers," compiled by Parker & Watson, and published by Messrs. A. S. Barnes & Co. They are *excellent;* afford choice selections; contain the right system of elocutionary instruction, and are well printed and bound so as to be serviceable as well as interesting. I can commend them as among the excellent means used by teachers to make their pupils proficient in that noblest of school arts, Good Reading.

From W. T. Harris, *Supt. Public Schools*, *St. Louis*, *Mo.*

I have to admire these excellent selections in prose and verse, and the careful arrangement which places first what is easy of comprehension, and proceeds gradually to what is difficult. I find the lessons so arranged as to bring together different treatments of the same topic, thereby throwing much light on the pupil's path, and I doubt not adding greatly to his progress. The proper variety of subjects chosen, the concise treatise on elocution, the beautiful typography and substantial binding—all these I find still more admirable than in the former series of National Readers, which I considered *models* in these respects.

From H. T. Phillips, Esq., *of the Board of Education*, *Atlanta*, *Ga.*

The Board of Education of this city have selected for use in the public schools of Atlanta the entire series of your Independent Readers, together with Steele's Chemistry and Philosophy. As a member of the Board, and of the Committee on Text-books, the subject of Readers was referred to me for examination. I gave a pretty thorough examination to ten (10) different series of Readers, and in endeavoring to arrive at a decision upon the sole question of merit, and entirely independent of any extraneous influence, I very cordially recommended the Independent Series. This verdict was approved by the Committee and adopted by the Board.

From Report of Rev. W. T. Brantly, D.D., *late Professor of Belles Lettres*, *University of Georgia*, *on "Text-Books in Reading," before the Teachers' Convention of Georgia*, *May 4, 1870.*

The *National Series*, by Parker & Watson, is deserving of its high reputation. The Primary Books are suited to the weakest capacity; whilst those more advanced supply instructive illustration on all that is needed to be known in connection with the art.

WATSON'S CHILD'S SPELLER.

THE INDEPENDENT CHILD'S SPELLER.

This unique book, published in 1872, is the first to be consistently printed a imitation of writing; that is, it teaches orthography as we use it. It is for th smallest class of learners, who soon become familiarized with words by their forms, and learn to read writing while they spell.

EXTRACT FROM THE PREFACE.

Success in teaching English orthography is still exceptional, and it must so continue until the principles involved are recognized in practice. Form is foremost: the eye and the hand must be trained to the formation of words; and since spelling is a part of writing, the written form only should be used. The laws of mental association, also—especially those of resemblance, contrast, and contiguity in time and place—should receive such recognition in the construction of the text-book as shall insure, whether consciously or not, their appropriate use and legitimate results. Hence, the spelling-book, properly arranged, is a necessity from the first; and, though primers, readers, and dictionaries may serve as aids, it can have no competent substitute.

Consistently with these views, the words used in the Independent Child's Speller have such original classifications and arrangements in columns—in reference to location, number of letters, vowel sounds, alphabetic equivalents, and consonant terminations—as exhibit most effectively their formation and pronunciation. The vocabulary is strictly confined to the simple and significant monosyllables in common use. He who has mastered these may easily learn how to spell and pronounce words of more than one syllable.

The introduction is an illustrated alphabet in script, containing twenty-six pictures of objects, and their names, commencing both with capitals and small letters. Part First embraces the words of one, two, and three letters; Part Second, the words of four letters; and Part Third, other monosyllables. They are divided into short lists and arranged in columns, the vowels usually in line, so as to exhibit individual characteristics and similarity of formation. The division of words into paragraphs is shown by figures in the columns. Each list is immediately followed by sentences for reading and writing, in which the same words are again presented with irregularities of form and sound. Association is thus employed, memory tested, and definition most satisfactorily taught.

Among the novel and valuable features of the lessons and exercises, probably the most prominent are their adaptedness for young children and their being printed in exact imitation of writing. The author believes that hands large enough to spin a top, drive a hoop, or catch a ball, are not too small to use a crayon, or a slate and pencil; that the child's natural desire to draw and write should not be thwarted, but gratified, encouraged, and wisely directed; and that since the written form is the one actually used in connection with spelling in after-life, the eye and the hand of the child should be trained to that form from the first. He hopes that this little work, designed to precede all other spelling-books and conflict with none, may satisfy the need so universally recognized of a fit introduction to orthography, penmanship, and English composition.

The National Readers and Spellers.

THEIR RECORD.

These books have been adopted by the School Boards, or official authority, of the following important States, cities, and towns—in most cases for exclusive use

The State of Missouri. **The State of Kentucky.**
The State of Alabama.
The State of Florida. **The State of North Carolina.**
The State of Delaware. **The State of Louisiana.**

New York.
New York City.
Brooklyn.
Buffalo.
Albany.
Rochester.
Troy.
Syracuse.
Elmira.
&c., &c.

Pennsylvania.
Reading.
Lancaster.
Erie.
Scranton.
Carlisle.
Carbondale.
Westchester.
Schuylkill Haven.
Williamsport.
Norristown.
Bellefonte.
Wilkesbarre.
&c., &c.

New Jersey.
Newark.
Jersey City.
Paterson.
Trenton.
Camden.
Elizabeth.
New Brunswick.
Phillipsburg.
Orange.
&c., &c.

Delaware.
Wilmington.

D. C.
Washington.

Illinois.
Chicago.
Peoria.
Alton.
Springfield.
Aurora.
Galesburg.
Rockford.
Rock Island.
&c., &c.

Wisconsin.
Milwaukee.
Fond du Lac.
Oshkosh.
Janesville.
Racine.
Watertown.
Sheboygan.
La Crosse.
Waukesha.
Kenosha.
&c., &c.

Michigan.
Grand Rapids.
Kalamazoo.
Adrian.
Jackson.
Monroe.
Lansing.
&c., &c.

Ohio.
Toledo.
Sandusky.
Conneaut.
Chardon.
Hudson.
Canton.
Salem.
&c., &c.

Indiana.
New Albany.
Fort Wayne.
Lafayette.
Madison.
Logansport.
Indianapolis.

Iowa.
Davenport.
Burlington.
Muscatine.
Mount Pleasant.
&c.

Nebraska.
Brownsville.
Lincoln.
&c.

Oregon.
Portland.
Salem.
&c.

Virginia.
Richmond.
Norfolk.
Petersburg.
Lynchburg.
&c.

South Carolina
Columbia.
Charleston.

Georgia.
Savannah.

Louisiana.
New Orleans.

Tennessee
Memphis

The *Educational Bulletin* records periodically all new points gained

SCHOOL-ROOM CARDS.

Baade's Reading Case,

A frame containing movable cards, with arrangement for showing one sentence at a time, capable of 28,000 transpositions.

Eureka Alphabet Tablet

Presents the alphabet upon the Word Method System, by which the child will learn the alphabet in nine days, and make no small progress in reading and spelling in the same time.

National School Tablets, 10 Nos.

Embrace reading and conversational exercises, object and moral lessons, form, color, &c. A complete set of these large and elegantly illustrated Cards will embellish the school-room more than any other article of furniture.

READING.

Fowle's Bible Reader

The narrative portions of the Bible, chronologically and topically arranged, judiciously combined with selections from the Psalms, Proverbs, and other portions which inculcate important moral lessons or the great truths of Christianity. The embarrassment and difficulty of reading the Bible itself, by course, as a class exercise, are obviated, and its use made feasible, by this means.

North Carolina First Reader
North Carolina Second Reader
North Carolina Third Reader

Prepared expressly for the schools of this State, by C. H. Wiley, Superintendent of Common Schools, and F. M. Hubbard, Professor of Literature in the State University.

Parker's Rhetorical Reader

Designed to familiarize Readers with the pauses and other marks in general use, and lead them to the practice of modulation and inflection of the voice.

Introductory Lessons in Reading and Elocution

Of similar character to the foregoing, for less advanced classes.

High School Literature

Admirable selections from a long list of the world's best writers, for exercise in reading, oratory, and composition. Speeches, dialogues, and model letters represent the latter department.

ORTHOGRAPHY.

SMITH'S SERIES

Supplies a speller for every class in graded schools, and comprises the most complete and excellent treatise on English Orthography and its companion branches extant.

1. Smith's Little Speller .

First Round in the Ladder of Learning.

2. Smith's Juvenile Definer

Lessons composed of familiar words grouped with reference to similar signification or use, and correctly spelled, accented, and defined.

3. Smith's Grammar-School Speller

Familiar words, grouped with reference to the sameness of sound of syllables differently spelled. Also definitions, complete rules for spelling and formation of derivatives, and exercises in false orthography.

4. Smith's Speller and Definer's Manual

A complete *School Dictionary* containing 14,000 words, with various other useful matter in the way of Rules and Exercises.

5. Smith's Etymology—Small, and Complete Ed's.

The first and only Etymology to recognize the *Anglo-Saxon* our *mother tongue;* containing also full lists of derivatives from the Latin, Greek, Gaelic, Swedish, Norman, &c., &c ; being, in fact, a complete etymology of the language for schools.

Sherwood's Writing Speller
Sherwood's Speller and Definer
Sherwood's Speller and Pronouncer

The Writing Speller consists of properly ruled and numbered blanks to receive the words dictated by the teacher, with space for remarks and corrections. The other volumes may be used for the dictation or ordinary class exercises.

Price's English Speller

A complete spelling-book for all grades, containing more matter than "Webster," manufactured in superior style, and sold at a lower price—consequently the cheapest speller extant.

Northend's Dictation Exercises

Embracing valuable information on a thousand topics, communicated in such a manner as at once to relieve the exercise of spelling of its usual tedium, and combine it with instruction of a general character calculated to profit and amuse.

Wright's Analytical Orthography

This standard work is popular, because it teaches the elementary sounds in a plain and philosophical manner, and presents orthography and orthoepy in an easy, uniform system of analysis or parsing.

Fowle's False Orthography

Exercises for correction.

Page's Normal Chart

The elementary sounds of the language for the school-room walls.

ORTHOGRAPHY—Continued.

Barber's Complete Writing Speller

"The Student's Own Hand-Book of Orthography, Definitions, and Sentences, consisting of Written Exercises in the Proper Spelling, Meaning, and Use of Words." (Published 1873.) This differs from Sherwood's and other Writing Spellers in its more comprehensive character. Its blanks are adapted to writing whole sentences instead of detached words, with the proper divisions for numbering, corrections, etc. Such aids as this, like Watson's Child's Speller and Sherwood's Writing Speller, find their *raison d'être* in the postulate that the art of correct spelling is dependent upon written, and not upon spoken language, for its utility, if not for its very existence. Hence the indirectness of purely oral instruction.

Pooler's Test Speller

The best collection of "hard words" yet made. The more uncommon ones are fully defined, and the whole are *arranged alphabetically* for convenient reference. The book is designed for Teachers' Institutes and "Spelling Schools," and is prepared by an experienced and well-known conductor of Institutes.

ETYMOLOGY.

Smith's Complete Etymology,
Smith's Condensed Etymology,

Containing the Anglo-Saxon, French, Dutch, German, Welsh, Danish, Gothic, Swedish, Gaelic, Italian, Latin, and Greek Roots, and the English words derived therefrom accurately spelled, accented, and defined.

From Hon. Jno. G. McMynn, *late State Superintendent of Wisconsin.*

I wish every teacher in the country had a copy of this work.

From Prin. Wm. F. Phelps, *Minn. State Normal.*

The book is superb—just what is needed in the department of etymology and spelling.

From Prof. C. H. Verrill, *Pa. State Normal School.*

The Etymology (Smith's) which we procured of you we like much. It is the best work for the class-room we have seen.

From Hon. Edward Ballard, *Supt. of Common Schools, State of Maine.*

The author has furnished a manual of singular utility for its purpose.

DICTIONARY.

The Topical Lexicon,

This work is a School Dictionary, an Etymology, a compilation of synonyms, and a manual of general information. It differs from the ordinary lexicon in being arranged by topics instead of the letters of the alphabet, thus realizing the apparent paradox of a "Readable Dictionary." An unusually valuable school book.

ENGLISH GRAMMAR.

CLARK'S DIAGRAM SYSTEM.

Clark's Easy Lessons in Language,

Published 1874. Contains illustrated object-lessons of the most attractive character, and is couched in language freed as much as possible from the dry technicalities of the science.

Clark's Brief English Grammar,

Published 1872. Part I. is adapted to youngest learners, and the whole forms a complete "brief course" in one volume, adequate to the wants of the common school.

Clark's Normal Grammar,

Published 1870, and designed to take the place of Prof. Clark's veteran "Practical" Grammar, though the latter is still furnished upon order. The Normal is an entirely new treatise. It is a full exposition of the system as described below, with all the most recent improvements. Some of its peculiarities are—A happy blending of SYNTHESES with ANALYSES; thorough Criticisms of common errors in the use of our Language; and important improvements in the Syntax of Sentences and of Phrases.

Clark's Key to the Diagrams,

Clark's Analysis of the English Language,

Clark's Grammatical Chart,

The theory and practice of teaching grammar in American schools is meeting with a thorough revolution from the use of this system. While the old methods offer proficiency to the pupil only after much weary plodding and dull memorizing, this affords from the inception the advantage of *practical Object Teaching*, addressing the eye by means of illustrative figures; furnishes association to the memory, its most powerful aid, and diverts the pupil by taxing his ingenuity. Teachers who are using Clark's Grammar uniformly testify that they and their pupils find it the most interesting study of the school course.

Like all great and radical improvements, the system naturally met at first with much unreasonable opposition. It has not only outlived the greater part of this opposition, but finds many of its warmest admirers among those who could not at first tolerate so radical an innovation. All it wants is an impartial trial to convince the most skeptical of its merit. No one who has fairly and intelligently tested it in the school-room has ever been known to go back to the old method. A great success is already established, and it is easy to prophecy that the day is not far distant when it will be the *only system of teaching English Grammar.* As the SYSTEM is copyrighted, no other text-books can appropriate this obvious and great improvement.

Welch's Analysis of the English Sentence,

Remarkable for its new and simple classification, its method of treating connectives, its explanations of the idioms and constructive laws of the language, etc.

Clark's Diagram English Grammar.

TESTIMONIALS.

From J. A. T. DURNIN, *Principal Dubuque R. C. Academy, Iowa.*

In my opinion, it is well calculated by its system of analysis to develop those rational faculties which in the old systems were rather left to develop themselves, while the memory was overtaxed, and the pupils discouraged.

From B. A. COX, *School Commissioner, Warren County, Illinois.*

I have examined 150 teachers in the last year, and those having studied or taught Clark's System have universally stood fifty per cent. better examinations than those having studied other authors.

From M. H. B. BURKET, *Principal Masonic Institute, Georgetown, Tennessee.*

I traveled two years amusing myself in instructing (exclusively) Grammar classes with Clark's system. The first class I instructed fifty days, but found that this was more time than was required to impart a theoretical knowledge of the science. During the two years thereafter I instructed classes only *thirty* days each. Invariably I proposed that unless I prepared my classes for a more thorough, minute, and accurate knowledge of English Grammar than that obtained from the ordinary books and in the ordinary way in from one to two years, I would make no charge. I never failed in a solitary case to far exceed the hopes of my classes, and made money and character rapidly as an instructor.

From A. B. DOUGLASS, *School Commissioner, Delaware County, New York.*

I have never known a class pursue the study of it under a *live* teacher, that has not succeeded; I have never known it to have an opponent in an educated teacher who had *thoroughly* investigated it; I have never known an *ignorant* teacher to examine it; I have never known a teacher who has used it, to try any other.

From J. A. DODGE, *Teacher and Lecturer on English Grammar, Kentucky.*

We are tempted to assert that it foretells the dawn of a brighter age to our mother-tongue. Both pupil and teacher can fare sumptuously upon its contents, however highly they may have prized the manuals into which they may have been initiated, and by which their expressions have been moulded.

From W. T. CHAPMAN, *Superintendent Public Schools, Wellington, Ohio.*

I regard Clark's System of Grammar the best published. For teaching the analysis of the English Language, it surpasses any I ever used.

From F. S. LYON, *Principal South Norwalk Union School, Connecticut.*

During ten years' experience in teaching, I have used six different authors on the subject of English Grammar. I am fully convinced that Clark's Grammar is better calculated to make thorough grammarians than any other that I have seen.

From CATALOGUE OF ROHRER'S COMMERCIAL COLLEGE, *St. Louis, Missouri.*

We do not hesitate to assert, without fear of successful contradiction, that a better knowledge of the English language can be obtained by this system in six weeks than by the old methods in as many months.

From A. PICKETT, *President of the State Teachers' Association, Wisconsin.*

A thorough experiment in the use of many approved authors upon the subject of English Grammar has convinced me of the superiority of Clark. When the pupil has completed the course, he is left upon a foundation of *principle*, and not upon the *dic-tum* of the author.

From GEO. F. MCFARLAND, *Prin. McAllisterville Academy, Juniata Co., Penn.*

At the first examination of public-school teachers by the county superintendent, when one of our student teachers commenced analyzing a sentence according to Clark, the superintendent listened in mute astonishment until he had finished, then asked what that meant, and finally, with a very knowing look, said such work wouldn't do here, and asked the applicant to parse the sentence right, and gave the lowest certificates to all who barely mentioned Clark. Afterwards, I presented him with a copy, and the next fall he permitted it to be partially used, while the third or last fall, he openly commended the system, and appointed three of my best teachers to explain it at the two Institutes and one County Convention held since September.

☞ For further testimony of equal force, see the Publishers' Special Circular, or current numbers of the Educational Bulletin.

GEOGRAPHY.

NATIONAL GEOGRAPHICAL SYSTEM.

THE SERIES.

1. Monteith's First Lessons in Geography,
2. Monteith's New Manual of Geography,
3. McNally's System of Geography,

INTERMEDIATE OR ALTERNATE VOLUMES.

1*. Monteith's Introduction to Geography,
2*. Monteith's Physical and Political Geography,

ACCESSORIES.

Monteith's Wall Maps 2 sets (see page 15),
Monteith's Manual of Map-Drawing (Allen's System)
Monteith's Map-Drawing and Object-Lessons,
Monteith's Map-Drawing Scale,

1. PRACTICAL OBJECT TEACHING. The infant scholar is first introduced to *a picture* whence he may derive notions of the shape of the earth, the phenomena of day and night, the distribution of land and water, and the great natural divisions, which mere words would fail entirely to convey to the untutored mind. Other pictures follow on the same plan, and the child's mind is called upon to grasp no idea without the aid of a pictorial illustration. Carried on to the higher books, this system culminates in Physical Geography, where such matters as climates, ocean currents, the winds, peculiarities of the earth's crust, clouds and rain, are pictorially explained and rendered apparent to the most obtuse. The illustrations used for this purpose belong to the highest grade of art.

2. CLEAR, BEAUTIFUL, AND CORRECT MAPS. In the lower numbers the maps avoid unnecessary detail, while respectively progressive, and affording the pupil new matter for acquisition each time he approaches in the constantly enlarging circle the point of coincidence with previous lessons in the more elementary books. In the Physical and Political Geography the maps embrace many new and striking features. One of the most effective of these is the new plan for displaying on each map the relative sizes of countries not represented, thus obviating much confusion which has arisen from the necessity of presenting maps in the same atlas drawn on different scales. The maps of "McNally" have long been celebrated for their superior beauty and completeness. This is the only school-book in which the attempt to make a *complete* atlas *also clear and distinct*, has been successful. The map *coloring* throughout the series is also noticeable. Delicate and subdued tints take the place of the startling glare of inharmonious colors which too frequently in such treatises dazzle the eyes, distract the attention, and serve to overwhelm the names of towns and the natural features of the landscape.

GEOGRAPHY—Continued.

3. THE VARIETY OF MAP-EXERCISE. Starting each time from a different basis, the pupil in many instances approaches the same fact no less than *six times*, thus indelibly impressing it upon his memory. At the same time, this system is not allowed to become wearisome—the extent of exercise on each subject being graduated by its relative importance or difficulty of acquisition.

4. THE CHARACTER AND ARRANGEMENT OF THE DESCRIPTIVE TEXT. The cream of the science has been carefully culled, unimportant matter rejected, elaboration avoided, and a brief and concise manner of presentation cultivated. The orderly consideration of topics has contributed greatly to simplicity. Due attention is paid to the facts in history and astronomy which are inseparably connected with, and important to the proper understanding of geography—and *such only* are admitted on any terms. In a word, the National System teaches geography as a science, pure, simple, and exhaustive.

5. ALWAYS UP TO THE TIMES. The authors of these books, editorially speaking, never sleep. No change occurs in the boundaries of countries, or of counties, no new discovery is made, or railroad built, that is not at once noted and recorded, and the next edition of each volume carries to every school-room the new order of things.

6. SUPERIOR GRADATION. This is the only series which furnishes an available volume for every possible class in graded schools. It is not contemplated that a pupil must necessarily go through every volume in succession to attain proficiency. On the contrary, *two* will suffice, but *three* are advised; and, if the course will admit, the whole series should be pursued. At all events, the books are at hand for selection, and every teacher, of every grade, can find among them one *exactly suited* to his class. The best combination for those who wish to abridge the course consists of Nos. 1, 2, and 3, or where children are somewhat advanced in other studies when they commence geography, Nos. 1*, 2, and 3. Where but *two* books are admissible, Nos. 1* and 2*, or Nos. 2 and 3, are recommended.

7. FORM OF THE VOLUMES AND MECHANICAL EXECUTION. The maps and text are no longer unnaturally divorced in accordance with the time-honored practice of making text-books on this subject as inconvenient and expensive as possible. On the contrary, all map questions are to be found on the page opposite the map itself, and each book is complete in one volume. The mechanical execution is unrivalled. Paper and printing are everything that could be desired, and the binding is—A. S. Barnes & Company's.

8. MAP-DRAWING. In 1869 the system of Map-Drawing devised by Professor Jerome Allen was secured *exclusively* for this series. It derives its claim to originality and usefulness from the introduction of a *fixed unit of measurement* applicable to every Map. The principles being so few, simple and comprehensive, the subject of Map-Drawing is relieved of all practical difficulty. (In Nos. 2, 2*, and 3, and published separately.)

9. ANALOGOUS OUTLINES. At the same time with Map-Drawing was also introduced (in No. 2) a new and ingenious variety of Object Lessons, consisting of a comparison of the outlines of countries with familiar objects pictorially represented.

GEOGRAPHY—Continued.

MONTEITH'S INDEPENDENT COURSE.

Elementary Geography

Comprehensive Geography (with 103 Maps)

☞ These volumes are not revisions of old works—not an addition to any series—but are entirely new productions—each by itself complete, independent, comprehensive, yet simple, brief, cheap, and popular; or, taken together, the most admirable "series" ever offered for a common-school course. They present the following features, skillfully interwoven—the student learning all about one country at a time.

LOCAL GEOGRAPHY, or the Use of Maps. Important features of the Maps are the coloring of States as objects, and the ingenious system for laying down a much larger number of names for reference than are found on any other Maps of same size—and without crowding.

PHYSICAL GEOGRAPHY, or the Natural Features of the Earth, illustrated by the original and striking ***Relief Maps,*** being bird's-eye views or photographic pictures of the Earth's surface.

DESCRIPTIVE GEOGRAPHY, including the Physical; with some account of Governments, and Races, Animals, etc.

HISTORICAL GEOGRAPHY, or a brief summary of the salient points of history, explaining the present distribution of nations, origin of geographical names, etc.

MATHEMATICAL GEOGRAPHY, including ASTRONOMICAL, which describes the Earth's position and character among planets; also the Zones, Parallels, etc.

COMPARATIVE GEOGRAPHY, or a system of analogy, connecting new lessons with the previous ones. Comparative sizes and latitudes are shown on the margin of each Map, and all countries are measured in the "*frame of Kansas.*"

TOPICAL GEOGRAPHY, consisting of questions for review, and testing the student's general and specific knowledge of the subject, with suggestions for *Geographical Compositions.*

ANCIENT GEOGRAPHY. A section devoted to this subject, with Maps, will be appreciated by teachers. It is seldom taught in our common schools, because it has heretofore required the purchase of a separate book.

GRAPHIC GEOGRAPHY, or MAP-DRAWING by Allen's "Unit of Measurement" system (now almost universally recognized as without a rival) is introduced throughout the lessons, and not as an appendix.

CONSTRUCTIVE GEOGRAPHY, or GLOBE-MAKING. With each book a set of Map Segments is furnished, with which each student may make his own Globe by following the directions given.

RAILROAD GEOGRAPHY, with a grand Map illustrating routes of travel in the United States. Also, a "Tour in Europe."

MAP DRAWING.

Monteith's Map-Drawing Made Easy.

A neat little book of outlines and instructions, giving the "corners of States" in suitable blanks, so that Maps can be drawn by unskillful hands from any atlas; with instructions for written exercises or compositions on geographical subjects, and Comparative Geography.

Monteith's Manual of Map-Drawing (Allen's System).

The only consistent plan, by which all Maps are drawn on one scale. By its use much time may be saved, and much interest and accurate knowledge gained.

Monteith's Map-Drawing and Object Lessons.

The last-named treatise, bound with Mr. Monteith's ingenious system for committing outlines to memory by means of pictures of living creatures and familiar objects. Thus, South America resembles a dog's head; Cuba, a lizard; Italy, a boot; France, a coffee-pot; Turkey, a turkey, etc., etc.

Monteith's Map-Drawing Scale.

A ruler of wood, graduated to the "Allen fixed unit of measurement."

WALL MAPS.

Monteith's Pictorial Chart of Geography.

The original drawing for this beautiful and instructive chart was greatly admired in the publisher's "exhibit" at the Centennial Exhibition of 1876. It is *a picture* of the Earth's surface with every natural feature displayed, teaching also physical geography, and especially the mutations of water. The uses to which man puts the earth and its treasures and forces, as Agriculture, Mining, Manufacturing, Commerce, and Transportation are also graphically portrayed so that the young learner gets a realistic idea of "the world we live in," which weeks of book-study might fail to convey.

Monteith's School Maps, 8 Numbers.

The "School Series" includes the Hemispheres (2 Maps), United States, North America, South America, Europe, Asia, Africa.—Price, $2.50 each.

Each map is 28 × 34 inches, beautifully colored, has the names all laid down, and is substantially mounted on canvas with rollers.

Monteith's Grand Maps, 8 Numbers.

The "Grand Series" includes the Hemispheres (1 Map), North America, United States, South America, Europe, Asia, Africa, The World on Mercator's Projection, and Physical Map of the World.—Price, $5.00 each. Size 42 × 52 inches, names laid down, colored, mounted, &c.

Monteith's Sunday School Maps,

Including a Map of Paul's Travels ($5.00), one of Ancient Canaan ($3.00), and Modern Palestine ($3.00), or Palestine and Canaan together ($5.00).

MONTEITH'S GEOGRAPHIES

Have been adopted, by official authority, for the schools of the following States and Cities—in most cases for *exclusive* and uniform use.

California,	Tennessee,	Iowa,	Arkansas,	North Carolina,
Missouri,	Texas,	Louisiana,	Florida,	Kansas,
Alabama,	Vermont,	Oregon,	Minnesota,	Mississippi.

Cities.—New York City, Brooklyn, Chicago, New Orleans, Buffalo, Richmond, Jersey City, Hartford, Worcester, San Francisco, Louisville, Newark, Milwaukee, Charleston, Rochester, Mobile, Syracuse, Memphis, Salt Lake City, Nashville, Utica, Wilmington, Trenton, Norfolk, Norwich, Lockport, Dubuque, Galveston, Portland, Savannah, Indianapolis, Springfield, Wheeling, Toledo, Bridgeport, St. Paul, Vicksburg, &c.

Monteith & McNally's National Geographies.

CRITICAL OPINIONS.

From R. A ADAMS, *Member of Board of Education, New York.*

I have found, by examination of the Book of Supply of our Board, that considerably the largest number of any series now used in our public schools is the National, by Monteith and McNally.

From BRO. PATRICK, *Chief Provincial of the Vast Educational Society of the* CHRISTIAN BROTHERS *in the United States.*

Having been convinced for some time past that the series of Geographies in use in our schools were not giving satisfaction, and came far short of meeting our most reasonable expectations, I have felt it my imperative duty to examine into this matter, and see if a remedy could not be found.

Copies of the different Geographies published in this country have been placed at our command for examination. On account of other pressing duties we have not been able to give as much time to the investigation of all these different series as we could have desired; yet we have found enough to convince us that there are many others better than those we are now using; but we cheerfully give our most decided preference, above all others, to the National Series, by Monteith & McNally.

Their easy gradation, their thoroughly practical and independent character, their comprehensive completeness as a full and accurate system, the wise discrimination shown in the selection of the subject matter, the beautiful and copious illustrations, the neat cut type, the general execution of the works, and *other excellencies*, will commend them to the friends of education everywhere.

From the "HOME MONTHLY," *Nashville, Tenn.*

MONTEITH'S AND MCNALLY'S GEOGRAPHIES.—Geography is so closely connected with Astronomy, History, Ethnology, and Geology, that it is difficult to define its limits in the construction of a text-book. If the author confines himself strictly to a description of the earth's surface, his book will be dry, meager, and unintelligible to a child. If, on the other hand, he attempts to give information on the cognate sciences, he enters a boundless field, and may wander too far. It seems to us that the authors of the series before us have hit on the happy medium between too much and too little. *The First Lessons*, by applying the system of object-teaching, renders the subject so attractive that a child, just able to read, may become deeply interested in it. The second book of the course enlarges the view, but still keeps to the maps and simple descriptions. Then, in the third book, we have Geography combined with History and Astronomy. A general view of the solar system is presented, so that the pupil may understand the earth's position on the map of the heavens. The first part of the fourth book treats of Physical Geography, and contains a vast amount of knowledge compressed into a small space. It is made bright and attractive by beautiful pictures and suggestive illustrations, on the principle of object-teaching. The maps in the second part of this volume are remarkably clear, and the map exercises are copious and judicious. In the fifth and last volume of the series, the whole subject is reviewed and systematized. This is strictly a Geography. Its maps are beautifully engraved and clearly printed. The map exercises are full and comprehensive. In all these books the maps, questions and descriptions are given in the same volume. In most geographies there are too many details and minute descriptions—more than any child out of purgatory ought to be required to learn. The power of memory is overstrained; there is confusion—no clearly defined idea is formed in the child's mind. But in these books, in brief, pointed descriptions, and constant use of bright, accurate maps, the whole subject is photographed on the mind.

MATHEMATICS.

DAVIES' NATIONAL COURSE.

ARITHMETIC.

1. Davies' Primary Arithmetic,
2. Davies' Intellectual Arithmetic,
3. Davies' Elements of Written Arithmetic,.
4. Davies' Practical Arithmetic,
5. Davies' University Arithmetic.

TWO BOOK SERIES.

1. First Book in Arithmetic, Primary and Mental.
2. Complete Arithmetic.

ALGEBRA.

1. Davies' New Elementary Algebra.
2. Davies' University Algebra,
3. Davies' New Bourdon's Algebra.

GEOMETRY.

1. Davies' Elementary Geometry and Trigonometry,
2. Davies' Legendre's Geometry,
3. Davies' Analytical Geometry and Calculus,
4. Davies' Descriptive Geometry,
5. Davies' New Calculus,

MENSURATION.

1. Davies' Practical Mathematics and Mensuration,
2. Davies' Elements of Surveying,
3. Davies' Shades, Shadows, and Perspective,

MATHEMATICAL SCIENCE

Davies' Grammar of Arithmetic,
Davies' Outlines of Mathematical Science,
Davies' Nature and Utility of Mathematics,
Davies' Metric System,
Davies & Peck's Dictionary of Mathematics,

DAVIES' NATIONAL COURSE of MATHEMATICS.

ITS RECORD.

In claiming for this series the first place among American text-books, of what ever class, the Publishers appeal to the magnificent record which its volumes have earned during the *thirty-five years* of Dr. Charles Davies' mathematical labors. The unremitting exertions of a life-time have placed *the modern series* on the same proud eminence among competitors that each of its predecessors has successively enjoyed in a course of constantly improved editions, now rounded to their perfect fruition—for it seems almost that this science is susceptible of no further demonstration.

During the period alluded to, many authors and editors in this department have started into public notice, and by borrowing ideas and processes original with Dr. Davies, have enjoyed a brief popularity, but are now almost unknown. Many of the series of to-day, built upon a similar basis, and described as "modern books," are destined to a similar fate; while the most far-seeing eye will find it difficult to fix the time, on the basis of any data afforded by their past history, when these books will cease to increase and prosper, and fix a still firmer hold on the affection of every educated American.

One cause of this unparalleled popularity is found in the fact that the enterprise of the author did not cease with the original completion of his books. Always a practical teacher, he has incorporated in his text-books from time to time the advantages of every improvement in methods of teaching, and every advance in science. During all the years in which he has been laboring, he constantly submitted his own theories and those of others to the practical test of the class-room—approving, rejecting, or modifying them as the experience thus obtained might suggest. In this way he has been able to produce an almost perfect series of class-books, in which every department of mathematics has received minute and exhaustive attention.

Upon the death of Dr. Davies, which took place in 1876; his work was immediately taken up by his former pupil and mathematical associate of many years, Prof. W. G. Peck, LL.D., of Columbia College. By him the original Series is kept carefully revised and not allowed in any way to fall behind the times.

Davies' System is the acknowledged National Standard for the United States, for the following reasons:—

1st. It is the basis of instruction in the great national schools at West Point and Annapolis.

2d. It has received the *quasi* endorsement of the National Congress.

3d. It is exclusively used in the public schools of the National Capital.

4th. The officials of the Government use it as authority in all cases involving mathematical questions.

5th. Our great soldiers and sailors commanding the national armies and navies were educated in this system. So have been a majority of eminent scientists in this country. All these refer to "Davies" as authority.

6th. A larger number of American citizens have received their education from this than from any other series.

7th. The series has a larger circulation throughout the whole country than any other, being *extensively used in every State in the Union.*

Davies' National Course of Mathematics.

TESTIMONIALS.

From L. VAN BOKKELEN, *State Superintendent Public Instruction, Maryland.*

The series of Arithmetics edited by Prof. Davies, and published by your firm, have been used for many years in the schools of several counties, and the city of Baltimore, and have been approved by teachers and commissioners.

Under the law of 1865, establishing a uniform system of Free Public Schools, these Arithmetics were unanimously adopted by the State Board of Education, after a careful examination, and are now used in all the Public Schools of Maryland.

These facts evidence the high opinion entertained by the School Authorities of the value of the series theoretically and practically.

From HORACE WEBSTER, *President of the College of New York.*

The undersigned has examined, with care and thought, several volumes of Davies' Mathematics, and is of the opinion that, as a whole, it is the most complete and best course for Academic and Collegiate instruction, with which he is acquainted.

From DAVID N. CAMP, *State Superintendent of Common Schools, Connecticut.*

I have examined Davies' Series of Arithmetics with some care. The language is clear and precise; each principle is thoroughly analyzed, and the whole so arranged as to facilitate the work of instruction. Having observed the satisfaction and success with which the different books have been used by eminent teachers, it gives me pleasure to commend them to others.

From J. O. WILSON, *Chairman Committee on Text-Books, Washington, D. C.*

I consider Davies' Arithmetics decidedly superior to any other series, and in this opinion I am sustained, I believe, by the entire Board of Education and Corps of Teachers in this city, where they have been used for several years past.

From JOHN L. CAMPBELL, *Professor of Mathematics, Wabash College, Indiana.*

A proper combination of abstract reasoning and practical illustration is the chief excellence in Prof. Davies' Mathematical works. I prefer his Arithmetics, Algebras, Geometry and Trigonometry to all others now in use, and cordially recommend them to all who desire the advancement of sound learning.

From MAJOR J. H. WHITTLESEY, *Government Inspector of Military Schools.*

Be assured, I regard the works of Prof. Davies, with which I am acquainted, as by far the best text-books in print on the subjects which they treat. I shall certainly encourage their adoption wherever a word from me may be of any avail.

From T. McC. BALLANTINE, *Prof. Mathematics Cumberland College, Kentucky.*

I have long taught Prof. Davies' Course of Mathematics, and I continue to like their working.

From JOHN McLEAN BELL, B. A., *Prin. of Lower Canada College.*

I have used Davies' Arithmetical and Mathematical Series as text-books in the schools under my charge for the last six years. These I have found of great efficacy in exciting, invigorating, and concentrating the intellectual faculties of the young.

Each treatise serves as an introduction to the next higher, by the similarity of its reasonings and methods; and the student is carried forward, by easy and gradual steps, over the whole field of mathematical inquiry, and that, too, in a *shorter* time than is usually occupied in mastering a single department. I sincerely and heartily recommend them to the attention of my fellow-teachers in Canada

From D. W. STEELE, *Prin. Philekoian Academy, Cold Springs, Texas.*

I have used Davies' Arithmetics till I know them nearly by heart. A better series of school-books never were published. I have recommended them until they are now used in all this region of country.

A large mass of similar "Opinions" may be obtained by addressing the publishers for special circular for Davies' Mathematics. New recommendations are published in current numbers of the *Educational Bulletin.*

DAVIES AND PECK'S

CONDENSED COURSE OF MATHEMATICS.

CONCISE, CONSECUTIVE, AND COMPLETE.

Elementary Section.

1. Brief Arithmetic, . . $0.60 2. Complete Arithmetic, $0.90

Intermediate Section.

1. Manual of Algebra, . $1.10 2. Manual of Geometry, $1.10

Advanced Section.

1. Analytical Geometry, $1.25 2. Practical Calculus, . $1.25

(Resumé.)

DAVIES & PECK'S ARITHMETICS.

OPTIONAL OR CONSECUTIVE.

The best thoughts of these two illustrious mathematicians are combined in the following beautiful works which are now for the first time offered to the public, sumptuously printed, and bound in crimson, green, and gold.

Davies and Peck's Brief Arithmetic, ... $0.60

Also called the "Elementary Arithmetic." It is the shortest presentation of the subject, and is *adequate* for all grades in common schools, being a thorough introduction to practical life, except for the specialist.

At first the authors play with the little learner for a few lessons, by object teaching and kindred allurements; but he soon begins to realize that study is earnest, as he becomes familiar with the simpler operations, and is delighted to find himself master of important results.

The second part reviews the Fundamental Operations on a scale proportioned to the enlarged intelligence of the learner. It establishes the General Principles and Properties of Numbers, and then proceeds to Fractions. Currency and the Metric System are fully treated in connection with Decimals. Compound Numbers and Reduction follow, and finally Percentage with all its varied applications.

An Index of words and principles concludes the book, for which every scholar and most teachers will be grateful. How much time has been spent in searching for a half forgotten definition or principle in a former lesson!

Davies and Peck's Complete Arithmetic, ... $0.90

This work certainly deserves its name in the best sense. Though complete, it is not, like most others which bear the same title, *cumbersome*. These authors excel in clear, lucid demonstrations, teaching the science pure and simple, yet not ignoring convenient methods and practical applications.

For turning out a thorough business man no other work is so well adapted. He will have a clear comprehension of the science as a whole, and a working acquaintance with details which must serve him well in all emergencies. Distinguishing features of the book are the logical progression of the subjects and the great variety of practical problems, not *puzzles*, which are beneath the dignity of educational science. A clear-minded critic has said of Dr. PECK's work that it is free from that juggling with numbers which some authors falsely call "Analysis." A series of Tables for converting ordinary weights and measures into the Metric System appear in the later editions.

MATHEMATICS—Continued.

PECK'S HIGHER COURSE.

Peck's Manual of Algebra,

Bringing the methods of Bourdon within the range of the Academic Course.

Peck's Manual of Geometry,

By a method purely practical, and unembarrassed by the details which rather confuse than simplify science.

Peck's Practical Calculus,

Peck's Analytical Geometry,

Peck's Elementary Mechanics,

Peck's Mechanics, with Calculus,

The briefest treatises on these subjects now published. Adopted by the great Universities; Yale, Harvard, Columbia, Princeton, Cornell, &c.

ARITHMETICAL EXAMPLES.

Reuck's Examples in Denominate Numbers,

Reuck's Examples in Arithmetic,

These volumes differ from the ordinary arithmetic in their peculiarly *practical* character. They are composed mainly of examples, and afford the most severe and thorough discipline for the mind. While a book which should contain a complete treatise of theory and practice would be too cumbersome for every-day use, the insufficiency of *practical* examples has been a source of complaint.

HIGHER MATHEMATICS.

Macnie's Algebraical Equations,

Serving as a complement to the more advanced treatises on Algebra, giving special attention to the analysis and solution of equations with numerical coefficients.

Church's Elements of Calculus,

Church's Analytical Geometry,

Church's Descriptive Geometry, 2 vols.,

These volumes constitute the "West Point Course" in their several departments.

Courtenay's Elements of Calculus,

A standard work of the very highest grade.

Hackley's Trigonometry,

With applications to navigation and surveying, nautical and practical geometry and geodesy.

PENMANSHIP.

Beers' System of Progressive Penmanship. Per dozen

This "round hand" system of Penmanship in twelve numbers, commends itself by its simplicity and thoroughness. The first four numbers are primary books. Nos. 5 to 7, advanced books for boys. Nos. 8 to 10, advanced books for girls. Nos. 11 and 12, ornamental penmanship. These books are printed from steel plates (engraved by McLees), and are unexcelled in mechanical execution. Large quantities are annually sold.

Beers' Slated Copy Slips, per set

All beginners should practice, for a few weeks, slate exercises, familiarizing them with the form of the letters, the motions of the hand and arm, &c., &c. These copy slips, 32 in number, supply all the copies found in a complete series of writing-books, at a trifling cost.

Payson, Dunton & Scribner's Copy-B'ks. P. doz.,

The National System of Penmanship, in three distinct series—(1) Common School Series, comprising the first six numbers; (2) Business Series, Nos. 8, 11, and 12; (3) Ladies' Series, Nos. 7, 9, and 10.

Fulton & Eastman's Chirographic Charts,

To embellish the school room walls, and furnish class exercise in the elements of Penmanship.

Payson's Copy-Book Cover, per hundred

Protects every page except the one in use, and furnishes "lines" with proper slope for the penman, under. Patented.

National Steel Pens, Card with all kinds

Pronounced by competent judges the perfection of American-made pens, and superior to any foreign article.

SCHOOL SERIES.		Index Pen, per gross . . .	75
School Pen, per gross, . . .$	60	BUSINESS SERIES.	
Academic Pen, do . .	63	Albata Pen, per gross, . .	40
Fine Pointed Pen, per gross	70	Bank Pen, do . .	70
POPULAR SERIES.		Empire Pen, do . .	70
Capitol Pen, per gross, . .	1 00	Commercial Pen, per gross .	60
do do pr. box of 2 doz.	25	Express Pen, do .	75
Bullion Pen (imit. gold) pr. gr.	75	Falcon Pen, do .	70
Ladies' Pen do	63	Elastic Pen, do .	75

Stimpson's Scientific Steel Pen, per gross $1 50

One forward and two backward arches, ensuring great strength, well-balanced elasticity, evenness of point, and smoothness of execution. One gross in twelve contains a Scientific Gold Pen.

Stimpson's Ink-Retaining Holder, per doz. 1 50

A simple apparatus, which does not get out of order, withholds at a single dip as much ink as the pen would otherwise realize from a dozen trips to the inkstand, which it supplies with moderate and easy flow.

Stimpson's Gold Pen, $3 00; with Ink Retainer 4 50

Stimpson's Penman's Card, $0 25

One dozen Steel Pens (assorted points) and Patent Ink-retaining Pen holder.

HISTORY.

Monteith's Youth's History.

A History of the United States for beginners. It is arranged upon the catechetical plan, with illustrative maps and engravings, review questions, dates in parentheses (that their study may be optional with the younger class of learners), and interesting Biographical Sketches of all persons who have been prominently identified with the history of our country.

Willard's United States, School and University Editions.

The plan of this standard work is chronologically exhibited in front of the title-page; the Maps and Sketches are found useful assistants to the memory, and dates, usually so difficult to remember, are so systematically arranged as in a great degree to obviate the difficulty. Candor, impartiality, and accuracy, are the distinguishing features of the narrative portion.

Willard's Universal History.

The most valuable features of the "United States" are reproduced in this. The peculiarities of the work are its great conciseness and the prominence given to the chronological order of events. The margin marks each successive era with great distinctness, so that the pupil retains not only the event but its time, and thus fixes the order of history firmly and usefully in his mind, Mrs. Willard's books are constantly revised, and at all times written up to embrace important historical events of recent date.

Lancaster's English History,

By the Master of the Stoughton Grammar School, Boston. The most practical of the "brief books." Though short, it is not a bare and uninteresting outline, but contains enough of explanation and detail to make intelligible the *cause and effect* of events. Their relations to the history and development of the American people is made specially prominent.

Willis' Historical Reader,

Being Collier's Great Events of History adapted to American schools. This rare epitome of general history, remarkable for its charming style and judicious selection of events on which the destinies of nations have turned, has been skillfully manipulated by Prof. Willis, with as few changes as would bring the United States into its proper position in the historical perspective. As reader or text-book it has few equals and no superiors.

Berard's History of England,

By an authoress well known for the success of her History of the United States, The social life of the English people is felicitously interwoven, as in fact, with the civil and military transactions of the realm.

Ricord's History of Rome

Possesses the charm of an attractive romance. The Fables with which this history abounds are introduced in such a way as not to deceive the inexperienced, while adding materially to the value of the work as a reliable index to the character and institutions, as well as the history of the Roman people.

Hanna's Bible History.

The only compendium of Bible narrative which affords a connected and chronological view of the important events there recorded, divested of all superfluous detail.

Summary of History; American, French and English.

A well-proportioned outline of leading events, condensing the substance of the more extensive text-book in common use into a series of statements so brief, that every word may be committed to memory, and yet so comprehensive that it presents an accurate though general view of the whole continuous life of nations.

Marsh's Ecclesiastical History.

Affording the History of the Church in all ages, with accounts of the pagan world during Biblical periods, and the character, rise, and progress of all Religions, as well as the various sects of the worshipers of Christ. The work is entirely non-sectarian, though strictly catholic. A separate volume contains carefully prepared QUESTIONS for class use.

HISTORY—Continued.

BARNES' ONE-TERM HISTORY.

A Brief History of the United States,

This is probably the MOST ORIGINAL SCHOOL-BOOK published for many years, in any department. A few of its claims are the following:

1. **Brevity.**—The text is complete for Grammar School or intermediate classes, in 290 12mo pages, large type. It may readily be completed, if desired, in one term of study.

2. **Comprehensiveness.**—Though so brief, this book contains the pith of all the wearying contents of the larger manuals, and a great deal more than the memory usually retains from the latter.

3. **Interest** has been a prime consideration. Small books have heretofore been bare, full of dry statistics, unattractive. This one is charmingly written, replete with anecdote, and brilliant with illustration.

4. **Proportion of Events.**—It is remarkable for the discrimination with which the different portions of our history are presented according to their importance. Thus the older works being already large books when the civil war took place, give it less space than that accorded to the Revolution.

5. **Arrangement.**—In six epochs, entitled respectively, Discovery and Settlement. the Colonies, the Revolution, Growth of States, the Civil War, and Current Events.

6. **Catch Words.**—Each paragraph is preceded by its leading thought in prominent type, standing in the student's mind for the whole paragraph.

7. **Key Notes.**—Analogous with this is the idea of grouping battles, etc. about some central event, which relieves the sameness so common in such descriptions, and renders each distinct by some striking peculiarity of its own.

8. **Foot Notes.**—These are crowded with interesting matter that is not strictly a part of history proper. They may be learned or not, at pleasure. They are certain in any event to be read.

9. **Biographies** of all the leading characters are given in full in foot-notes.

10. **Maps.**—Elegant and distinct Maps from engravings on copper-plate, and beautifully colored, precede each epoch, and contain all the places named.

11. **Questions** are at the back of the book, to compel a more independent use of the text. Both text and questions are so worded that the pupil must give intelligent answers IN HIS OWN WORDS. "Yes" and "No" will not do.

12. **Historical Recreations.**—These are additional questions to test the student's knowledge, in review, as: "What trees are celebrated in our history?" "When did a fog save our army?" "What Presidents died in office?" "When was the Mississippi our western boundary?" "Who said, 'I would rather be right than President?'" etc.

13. **The Illustrations**, about seventy in number, are the work of our best artists and engravers, produced at great expense. They are vivid and interesting, and mostly upon subjects never before illustrated in a school-book.

14. **Dates.**—Only the leading dates are given in the text, and these are so associated as to assist the memory, but at the head of each page is the date of the event first mentioned, and at the close of each epoch a summary of events and dates.

15. **The Philosophy of History** is studiously exhibited—the causes and effects of events being distinctly traced and their interconnection shown.

16. **Impartiality.**—All sectional, partisan, or denominational views are avoided. Facts are stated after a careful comparison of all authorities without the least prejudice or favor.

17. **Index.**—A verbal index at the close of the book perfects it as a work of reference.

It will be observed that the above are all particulars in which School Histories have been signally defective, or altogether wanting. Many other claims to favor it shares in common with its predecessors.

BARNES' ONE-TERM HISTORY—Continued.

From PROF. WM. F. ALLEN, *State Univ. of Wisconsin.*

I think the author of the new "Brief History of the United States" has been very successful in combining brevity with sufficient fullness and interest. *Particularly*, he has avoided the excessive number of names and dates that most histories contain. Two features that I like *very much* are the *anecdotes* at the foot of the page and the "*Historical Recreations*" in the Appendix. The latter, I think, is quite a *new* feature, and the other is *very* well executed.

From HON. NEWTON BATEMAN, *Supt. Pub. Inst., Illinois.*

Barnes' One-Term History of the United States is an exceedingly attractive and spirited little book. Its claim to several new and valuable features seems well founded. Under the form of six well-defined Epochs, the History of the United States is traced tersely, yet pithily, from the earliest times to the present day. A good map precedes each epoch, whereby the history and geography of the period may be studied together, *as they always should be.* The syllabus of each paragraph is made to stand in such bold relief, by the use of large, heavy type, as to be of much *mnemonic* value to the student. The book is written in a sprightly and piquant style, the interest never flagging from beginning to end—a rare and difficult achievement in works of this kind.

From the "Chicago Schoolmaster" (Editorial).

A thorough examination of Barnes' Brief History of the United States brings the examiner to the conclusion that it is a superior book in almost every respect. The book is neat in form, and of good material. The type is clear, large, and distinct. The facts and dates are correct. The arrangement of topics is just the thing needed in a history text-book.

A Brief History of France, ... $1.00

By the author of the "Brief United States," **with all the attractive features of that** popular work (which see), and new ones of its own.

It is believed that the history of France has never before been presented in such brief compass, and this is effected without sacrificing one particle of interest. The book reads like a romance, and, while drawing the student by an irresistible fascination to his task, impresses the great outlines indelibly upon the memory.

Gilman's First Steps in General History, ... 90

A "suggestive outline" of rare compactness. Each country is treated by itself, and the United States receive special attention. Frequent Maps, contemporary events in Tables, References to Standard Works for fuller details, and a minute Index constitute the "Illustrative Apparatus." From no other work that we know of can so succinct a view of the world's history be obtained. Considering the necessary limitation of space, the style is surprisingly vivid, and at times even ornate. In all respects a charming, though not the less practical, text-book.

Gilman's "Seven Historic Ages," 70

This book is written in the style used by a father talking with his children on the progress of history. As one Age after another is taken up, the author brings before the young reader the prominent men and characteristic events by which it is to be remembered. The object is to stimulate the pupil in school or the child at home to study history, to think of it as a lively picture of the doings of men, and not as a dead list of uninteresting dates.

Topical History Chart Book, ... 1.40

By Miss Ida P. Whitcomb. To be used in connection with *any History, Ancient or Modern*, instead of the ordinary blank book for summary. It embodies the names of *contemporary rulers* from the earliest to the present time, with blanks under each, in which the pupil may write the summary of the life of the ruler.

English History in Short Stories, ... 70

A Compendium of facts about England, its History, Government and Antiquities. It contains a series of sketches of each of the English Monarchs; not histories of their reigns or complete biographies, but *estimates of the historical importance of each.* The dates and facts have been collected with the greatest care.

Baker's Brief History of Texas, ... 75

Dimitry's History of Louisiana, ... 60

DRAWING.

Chapman's American Drawing Book,

The standard American text-book and authority in all branches of art. A compilation of art principles. A manual for the amateur, and basis of study for the professional artist. Adapted for schools and private instruction.

CONTENTS.—"Any one who can Learn to Write can Learn to Draw."—Primary Instruction in Drawing.—Rudiments of Drawing the Human Head.—Rudiments in Drawing the Human Figure.—Rudiments of Drawing.—The Elements of Geometry.—Perspective.—Of Studying and Sketching from Nature.—Of Painting.—Etching and Engraving.—Of Modeling.—Of Composition.—Advice to the American Art-Student. The work is of course magnificently illustrated with all the original designs.

Chapman's Elementary Drawing Book,

A Progressive Course of Practical Exercises, or a text-book for the training of the eye and hand. It contains the elements from the larger work, and a copy should be in the hands of every pupil; while a copy of the "American Drawing Book," named above, should be at hand for reference by the class.

The Little Artist's Portfolio,

25 Drawing Cards (progressive patterns), 25 Blanks, and a fine Artist's Pencil, all in one neat envelope.

Clark's Elements of Drawing,

A complete course in this graceful art, from the first rudiments of outline to the finished sketches of landscape and scenery.

Fowle's Linear and Perspective Drawing,

For the cultivation of the eye and hand, with copious illustrations and directions for the guidance of the unskilled teacher.

Monk's Drawing Books—Six Numbers, per set,

Each book contains *eleven* large patterns, with opposing blanks. No. 1. Elementary Studies. No. 2. Studies of Foliage. No. 3. Landscapes. No. 4. Animals, I. No. 5. Animals, II. No. 6. Marine Views, etc.

Allen's Map-Drawing, Scale,

This method introduces a new era in Map-Drawing, for the following reasons:—1. It is a system. This is its greatest merit.—2. It is easily understood and taught.—3. The eye is trained to exact measurement by the use of a scale.—4. By no special effort of the memory, distance and comparative size are fixed in the mind.—5. It discards useless construction of lines.—6. It can be taught by any teacher, even though there may have been no previous practice in Map-Drawing.—7. Any pupil old enough to study Geography can learn by this System, in a short time, to draw accurate maps.—8. The System is not the result of theory, but comes directly from the school-room. It has been thoroughly and successfully tested there, with all grades of pupils.—9. It is economical, as it requires no mapping plates. It gives the pupil the ability of rapidly drawing accurate maps.

Ripley's Map-Drawing,

Based on the Circle. One of the most efficient aids to the acquirement of a knowledge of Geography is the practice of map-drawing. It is useful for the same reason that the best exercise in orthography is the *writing* of difficult words. Sight comes to the aid of hearing, and a double impression is produced upon the memory. Knowledge becomes less mechanical and more intuitive. The student who has sketched the outlines of a country, and dotted the important places, is little likely to forget either. The impression produced may be compared to that of a traveller who has been over the ground, while more comprehensive and accurate in detail.

BOOK-KEEPING.

Powers' Practical Book-keeping, ... $0.90
Powers' Blanks to Practical Book-keeping, ... 40

A Treatise on Book-Keeping, for Public Schools and Academies. By Millard R. Powers, M.A. This work is designed to impart instruction upon the science of accounts, as applied to mercantile business, and it is believed that more knowledge, and that, too, of a more practical nature, can be gained by the plan introduced in this work, than by any other published.

Folsom's Logical Book-keeping, ... $1.40
Folsom's Blanks to Book-keeping, ... 3.50

This treatise embraces the interesting and important discoveries of Prof. Folsom (of the Albany "Bryant & Stratton College"), the partial enunciation of which in lectures and otherwise has attracted so much attention in circles interested in commercial education.

After studying business phenomena for many years, he has arrived at the positive laws and principles that underlie the whole subject of Accounts; finds that the science is based in *Value* as a generic term; that value divides into *two classes* with varied species; that all the exchanges of values are reducible to nine equations; and that all the results of all these exchanges are limited to *thirteen* in number.

As accounts have been universally taught hitherto, without setting out from a radical analysis or definition of values, the science has been kept in great obscurity, and been made as difficult to impart as to acquire. On the new theory, however, these obstacles are chiefly removed. In reading over the first part of it, in which the governing laws and principles are discussed, a person with ordinary intelligence will obtain a fair conception of the *double entry* process of accounts. But when he comes to study thoroughly these laws and principles as there enunciated, and works out the examples and memoranda which elucidate the *thirteen results* of business, the student will neither fail in readily acquiring the science as it is, nor in becoming able intelligently to apply it in the interpretation of business.

Smith & Martin's Book-keeping, ... $0.90

Smith & Martin's Blanks, ... 40

This work is by a practical teacher and a practical book-keeper. It is of a thoroughly popular class, and will be welcomed by every one who loves to see theory and practice combined in an easy, concise, and methodical form.

The Single Entry portion is well adapted to supply a want felt in nearly all other treatises, which seem to be prepared mainly for the use of wholesale merchants, leaving retailers, mechanics, farmers, etc., who transact the greater portion of the business of the country, without a guide. The work is also commended, on this account, for general use in Young Ladies' Seminaries, where a thorough grounding in the simpler form of accounts will be invaluable to the future housekeepers of the nation.

The treatise on Double Entry Book-keeping combines all the advantages of the most recent methods, with the utmost simplicity of application, thus affording the pupil all the advantages of actual experience in the counting-house, and giving a clear comprehension of the entire subject through a judicious course of mercantile transactions.

NATURAL SCIENCE.

FAMILIAR SCIENCE.

Norton & Porter's First Book of Science,

By eminent Professors of Yale College. Contains the principles of Natural Philosophy, Astronomy, Chemistry, Physiology, and Geology. Arranged on the Catechetical plan for primary classes and beginners.

Chambers' Treasury of Knowledge,

Progressive lessons upon—*first*, common things which lie most immediately around us, and first attract the attention of the young mind; *second*, common objects from the Mineral, Animal, and Vegetable kingdoms, manufactured articles, and miscellaneous substances; *third*, a systematic view of Nature under the various sciences. May be used as a Reader or Text-book.

NATURAL PHILOSOPHY.

Norton's First Book in Natural Philosophy,

By Prof. NORTON, of Yale College. Designed for beginners. Profusely illustrated, and arranged on the Catechetical plan.

Peck's Ganot's Course of Nat. Philosophy,

The standard text-book of France, Americanized and popularized by Prof. PECK, of Columbia College. The most magnificent system of illustration ever adopted in an American school-book is here found. For intermediate classes.

Peck's Elements of Mechanics,

A suitable introduction to Bartlett's higher treatises on Mechanical Philosophy, and adequate in itself for a complete academical course.

Bartlett's SYNTHETIC, AND ANALYTIC, Mechanics,

Bartlett's Acoustics and Optics,

A system of Collegiate Philosophy, by Prof. BARTLETT, of West Point Military Academy.

Steele's 14 Weeks Course in Philos. (see p. 34)

Steele's Philosophical Apparatus,

Adequate to performing the experiments in the ordinary text-books. The articles will be sold separately, if desired. See special circular for details.

GEOLOGY.

Page's Elements of Geology,

A volume of Chambers' Educational Course. Practical, simple, and eminently calculated to make the study interesting.

Emmons' Manual of Geology,

The first Geologist of the country has here produced a work worthy of his reputation.

Steele's 14 Weeks Course (see p. 34)

Steele's Geological Cabinet,

Containing 125 carefully selected specimens. In four parts. Sold separately, if desired. See circular for details.

Peck's Ganot's Popular Physics.

TESTIMONIALS.

From PROF. ALONZO COLLIN, *Cornell College, Iowa.*

I am pleased with it. I have decided to introduce it as a text-book.

From H. F. JOHNSON, *President Madison College, Sharon, Miss.*

I am pleased with Peck's Ganot, and think it a magnificent book.

From PROF. EDWARD BROOKS, *Pennsylvania State Normal School.*

So eminent are its merits, that it will be introduced as the text-book upon elementary physics in this institution.

From H. H. LOCKWOOD, *Professor Natural Philosophy U. S. Naval Academy.*

I am so pleased with it that I will probably add it to a course of lectures given to the midshipmen of this school on physics.

From GEO. S. MACKIE, *Professor Natural History University of Nashville, Tenn.*

I have decided on the introduction of Peck's Ganot's Philosophy, as I am satisfied that it is the best book for the purposes of my pupils that I have seen, combining simplicity of explanation with elegance of illustration.

From W. S. MCRAE, *Superintendent Vevay Public Schools, Indiana.*

Having carefully examined a number of text-books on natural philosophy, I do not hesitate to express my decided opinion in favor of Peck's Ganot. The matter, style, and illustration eminently adapt the work to the popular wants.

From REV. SAMUEL MCKINNEY, D.D., *Pres't Austin College, Huntsville, Texas.*

It gives me pleasure to commend it to teachers. I have taught some classes with it as our text, and must say, for simplicity of style and clearness of illustration, I have found nothing as yet published of equal value to the teacher and pupil.

From C. V. SPEAR, *Principal Maplewood Institute, Pittsfield, Mass.*

I am much pleased with its ample illustrations by plates, and its clearness and simplicity of statement. It covers the ground usually gone over by our higher classes, and contains many fresh illustrations from life or daily occurrences, and new applications of scientific principles to such.

From J. A. BANFIELD, *Superintendent Marshall Public Schools, Michigan.*

I have used Peck's Ganot since 1863, and with increasing pleasure and satisfaction each term. I consider it superior to any other work on physics in its adaptation to our high schools and academies. Its illustrations are superb— better than three times their number of pages of fine print.

From A. SCHUYLER, *Prof. of Mathematics in Baldwin University, Berea, Ohio.*

After a careful examination of Peck's Ganot's Natural Philosophy, and an actual test of its merits as a text-book, I can heartily recommend it as admirably adapted to meet the wants of the grade of students for which it is intended. Its diagrams and illustrations are *unrivaled.* We use it in the Baldwin University.

From D. C. VAN NORMAN, *Principal Van Norman Institute, New York.*

The Natural Philosophy of M. Ganot, edited by Prof. Peck, is, in my opinion, the best work of its kind, for the use intended, ever published in this country. Whether regarded in relation to the natural order of the topics, the precision and clearness of its definitions, or the fullness and beauty of its illustrations, it is certainly, I think, an advance.

☞ For many similar testimonials, see current numbers of the Illustrated Educational Bulletin.

NATURAL SCIENCE—Continued.

CHEMISTRY.

Porter's First Book of Chemistry,

Porter's Principles of Chemistry,

The above are widely known as the productions of one of the most eminent scientific men of America. The extreme simplicity in the method of presenting the science, while exhaustively treated, has excited universal commendation.

Darby's Text-Book of Chemistry,

Purely a Chemistry, divesting the subject of matters comparatively foreign to it (such as heat, light, electricity, etc.), but usually allowed to engross too much attention in ordinary school-books.

Gregory's Chemistry, (Organic and Inorganic, each)

The science exhaustively treated. For colleges and medical students.

Steele's Fourteen Weeks Course,

A successful effort to reduce the study to the limits of a *single term.* (See page 34.)

Steele's Chemical Apparatus,

Adequate to the performance of all the important experiments.

BOTANY.

Thinker's First Lessons in Botany,

For children. The technical terms are largely dispensed with in favor of an easy and familiar style adapted to the smallest learner.

Wood's Object-Lessons in Botany,

Wood's American Botanist and Florist,

Wood's New Class-Book of Botany,

The standard text-books of the United States in this department. In style they are simple, popular, and lively; in arrangement, easy and natural; in description, graphic and strictly exact. The Tables for Analysis are reduced to a perfect system. More are annually sold than of all others combined.

Wood's Descriptive Botany, ... $1.25

A complete Flora of all Plants growing east of the Mississippi River.

Wood's Illustrated Plant Record, ... 55

A simple form of Blanks for recording observations in the field.

Wood's Botanical Apparatus, ... 8.00

A portable Trunk, containing Drying Press, Knife, Trowel, Microscope, and Tweezers, and a copy of Wood's Plant Record—the Collector's complete outfit.

Willis's Flora of New Jersey, ... 1.50

The most useful book of reference ever published for collectors in all parts of the country. It contains also a Botanical Directory, with addresses of living American botanists.

Young's Familiar Lessons in Botany, ... 1.40

Combining simplicity of diction with some degree of technical and scientific knowledge, for intermediate classes. Specially adapted for the Southwest.

Darby's Southern Botany, ... 1.40

Embracing general Structural and Physiological Botany, with vegetable products, and descriptions of Southern plants, and a complete Flora of the Southern States.

Steele's 14 Weeks Course in Botany—(see p. 34). . . 1.00

NATURAL SCIENCE—Continued.

WOOD'S BOTANIES.

TESTIMONIALS.

From PROF. RICHARD OWEN, *University of Indiana.*

I am well pleased with the evidence of philosophical method exhibited in the general arrangement, as well as with the clearness of the explanations, the ready intelligibility of the analytical tables, and the illustrative aid furnished by the numerous and excellent wood-cuts. I design using the work as a text-book with my next class.

From PRIN. B. R. ANDERSON, *Columbus Union School, Wisconsin.*

I have examined several works with a view to recommending some good text-book on Botany, but I lay them all aside for "Wood's Botanist and Florist." The arrangement of the book is in my opinion excellent, its style fascinating and attractive, its treatment of the various departments of the science is thorough, and last, but far from unimportant, I like the topical form of the questions to each chapter. It seems to embrace the entire science. In fact, I consider it a complete, attractive, and exhaustive work.

From M. A. MARSHALL, *New Haven High School, Conn.*

It has all the excellencies of the well-known Class-Book of Botany by the same author in a smaller book. By a judicious system of condensation, the size of the Flora is reduced one-half, while no species are omitted, and many new ones are added. The descriptions of species are very brief, yet sufficient to identify the plant, and, when taken in connection with the generic description, form a complete description of the plant. The book as a whole will suit the wants of classes better than anything I have yet seen. The adoption of the Botanist and Florist would not require the exclusion of the Class-Book of Botany, as they are so arranged that both might be used by the same class.

From PROF. G. H. PERKINS, *University of Vermont and State Agricultural College.*

I can truly say that the more I examine Wood's Class-Book, the better pleased I am with it. In its illustrations, especially of particulars not easily observed by the student, and the clearness and compactness of its statements, as well as in the territory its flora embraces, it appears to me to surpass any other work I know of. The whole science, so far as it can be taught in a college course, is well presented, and rendered unusually easy of comprehension. The mode of analysis is excellent, avoiding as it does to a great extent those microscopic characters which puzzle the beginner, and using those that are obvious as far as possible. I regard the work as a most admirable one, and shall adopt it as a text-book another year.

AGRICULTURE.

Pendleton's Scientific Agriculture,

A text-book for colleges and schools; treats of the following topics: Anatomy and Physiology of Plants; Agricultural Meteorology; Soils as related to Physics; Chemistry of the Atmosphere; of Plants; of Soils; Fertilizers and Natural Manures; Animal Nutrition, etc. By E. M. PENDLETON, M. D., Prof. of Agriculture in the University of Georgia.

From President A. D. WHITE, *Cornell University.*

Dear Sir: I have examined your "Text-book of Agricultural Science," and it seems to me excellent in view of the purpose it is intended to serve. Many of your chapters interested me especially, and all parts of the work seem to combine scientific instruction with practical information in proportions dictated by sound common sense.

From President ROBINSON, *of Brown University.*

It is scientific in method as well as in matter, comprehensive in plan, natural and logical in order, compact and lucid in its statements, and must be useful both as a text-book in Agricultural colleges, and as a hand-book for intelligent planters and farmers.

NATURAL SCIENCE—Continued.

PHYSIOLOGY.

Jarvis' Elements of Physiology,

Jarvis' Physiology and Laws of Health,

The only books extant which approach this subject with a proper view of the true object of teaching Physiology in schools, viz., that scholars may know how to take care of their own health. In bold contrast with the abstract *Anatomies*, which children learn as they would Greek or Latin (and forget as soon), to *discipline the mind*, are these text-books, using the *science* as a secondary consideration, and only so far as is necessary for the comprehension of the *laws of health*.

Hamilton's Vegetable and Animal Physiology,

The two branches of the science combined in one volume lead the student to a proper comprehension of the Analogies of Nature.

Steele's Fourteen Weeks Course,

In the popular style, avoiding technical and purely scientific formulas. It contains beautiful and vivid illustrations, some of them colored, and a blackboard analysis of the skeleton. The sections on diseases and accidents, and their prompt home treatment, give the book great practical value (see p. 34).

ASTRONOMY.

Willard's School Astronomy,

By means of clear and attractive illustrations, addressing the eye in many cases by analogies, careful definitions of all necessary technical terms, a careful avoidance of verbiage and unimportant matter, particular attention to analysis, and a general adoption of the simplest methods. Mrs. Willard has made the best and most attractive *elementary* Astronomy extant.

McIntyre's Astronomy and the Globes,

A complete treatise for intermediate classes. Highly approved.

Bartlett's Spherical Astronomy,

The West Point course, for advanced classes, with applications to the current wants of Navigation, Geography, and Chronology.

Steele's Fourteen Weeks Course,

Reduced to a single term, and better adapted to school use than any work heretofore published. Not written for the information of scientific men, but for the inspiration of youth, the pages are not burdened with a multitude of figures which no memory could possibly retain. The whole subject is presented in a clear and concise form. (See p. 34.)

NATURAL HISTORY.

Carll's Child's Book of Natural History,

Illustrating the Animal, Vegetable, and Mineral Kingdoms, with application to the Arts. For beginners. Beautifully and copiously illustrated.

ZOOLOGY.

Chambers' Elements of Zoology,

A complete and comprehensive system of Zoology, adapted for academic instruction, presenting a systematic view of the Animal Kingdom as a portion of external Nature.

Steele's Fourteen Weeks Course,

Notable for its superb and entertaining illustrations, which include every animal named; blackboard tables of classification and tabular review of the whole animal kingdom; interesting and characteristic facts and anecdotes; directions for collecting and preserving specimens, etc., etc. (See p. 34.)

Jarvis' Physiology and Laws of Health.

TESTIMONIALS.

From Samuel B. McLane, *Superintendent Public Schools, Keokuk, Iowa.*

I am glad to see a really good text-book on this much neglected branch. This is clear, concise, accurate, and eminently adapted to the *class-room.*

From William F. Wyers, *Principal of Academy, West Chester, Pennsylvania.*

A thorough examination has satisfied me of its superior claims as a text-book to the attention of teacher and taught. I shall introduce it at once.

From H. R. Sanford, *Principal of East Genesee Conference Seminary, N. Y.*

"Jarvis' Physiology" is received, and fully met our expectations. We immediately adopted it.

From Isaac T. Goodnow, *State Superintendent of Kansas—published in connection with the "School Law."*

"Jarvis' Physiology," a common-sense, practical work, with just enough of anatomy to understand the physiological portions. The last six pages, on Man's Responsibility for his own health, are worth the price of the book.

From D. W. Stevens, *Superintendent Public Schools, Fall River, Mass.*

I have examined Jarvis' "Physiology and Laws of Health," which you had the kindness to send to me a short time ago. In my judgment it is far the best work of the kind within my knowledge. It has been adopted as a text-book in our public schools.

From Henry G. Denny, *Chairman Book Committee, Boston, Mass.*

The very excellent "Physiology" of D. Jarvis I had introduced into our High School, where the study had been temporarily dropped, believing it to be by far the best work of the kind that had come under my observation; indeed, the reintroduction of the study was delayed for some months, because Dr. Jarvis' book could not be had, and we were unwilling to take any other.

From Prof. A. P. Peabody, D.D., LL.D., *Harvard University.*

* * I have been in the habit of examining school-books with great care, and I hesitate not to say that, of all the text-books on Physiology which have been given to the public, Dr. Jarvis' deserves the first place on the score of accuracy, thoroughness method, simplicity of statement, and constant reference to topics of practical interest and utility.

From James N. Townsend, *Superintendent Public Schools, Hudson, N. Y.*

Every human being is appointed to take charge of his own body; and of all books written upon this subject, I know of none which will so well prepare one to do this as "Jarvis' Physiology"—that is, in so small a compass of matter. It considers the pure, simple *laws of health* paramount to science; and though the work is thoroughly scientific, it is divested of all cumbrous technicalities, and presents the subject of physical life in a manner and style really charming. It is unquestionably the best textbook on physiology I have ever seen. It is giving great satisfaction in the schools of this city, where it has been adopted as the standard.

From L. J. Sanford, M.D., *Prof. Anatomy and Physiology in Yale College*

Books on human physiology, designed for the use of schools, are more generally a failure perhaps than are school-books on most other subjects.

The great want in this department is met, we think, in the well-written treatise of Dr. Jarvis, entitled "Physiology and Laws of Health." * * The work is not too detailed nor too expansive in any department, and is clear and concise in all. It is not burdened with an excess of anatomical description, nor rendered discursive by many zoological references. Anatomical statements are made to the extent of qualifying the student to attend, understandingly, to an exposition of those functional processes which, collectively, make up health; thus the laws of health are enunciated, and many suggestions are given which, if heeded, will tend to its preservation.

☞ For further testimony of similar character, see current numbers of the **Illustrated Educational Bulletin.**

NATURAL SCIENCE.

"FOURTEEN WEEKS" IN EACH BRANCH.

By J. DORMAN STEELE, A. M.

Steele's 14 Weeks Course in Chemistry (New Ed.)
Steele's 14 Weeks Course in Astronomy
Steele's 14 Weeks Course in Philosophy
Steele's 14 Weeks Course in Geology
Steele's 14 Weeks Course in Physiology
Steele's 14 Weeks Course in Zoology
Steele's 14 Weeks Course in Botany

Our Text-Books in these studies are, as a general thing, dull and uninteresting. They contain from 400 to 600 pages of dry facts and unconnected details. They abound in that which the student cannot learn, much less remember. The pupil commences the study, is confused by the fine print and coarse print, and neither knowing exactly what to learn nor what to hasten over, is crowded through the single term generally assigned to each branch, and frequently comes to the close without a definite and exact idea of a single scientific principle.

Steele's Fourteen Weeks Courses contain only that which every well-informed person should know, while all that which concerns only the professional scientist is omitted. The language is clear, simple, and interesting, and the illustrations bring the subject within the range of home life and daily experience. They give such of the general principles and the prominent facts as a pupil can make familiar as household words within a single term. The type is large and open; there is no fine print to annoy; the cuts are copies of genuine experiments or natural phenomena, and are of fine execution.

In fine, by a system of condensation peculiarly his own, the author reduces each branch to the limits of a single term of study, while sacrificing nothing that is essential, and nothing that is usually retained from the study of the larger manuals in common use. Thus the student has rare opportunity to *economize his time*, or rather to employ that which he has to the best advantage.

A notable feature is the author's charming "style," fortified by an enthusiasm over his subject in which the student will not fail to partake. Believing that Natural Science is full of fascination, he has moulded it into a form that attracts the attention and kindles the enthusiasm of the pupil.

The recent editions contain the author's "Practical Questions" on a plan never before attempted in scientific text-books. These are questions as to the nature and cause of common phenomena, and are not directly answered in the text, the design being to test and promote an intelligent use of the student's knowledge of the foregoing principles.

Steele's General Key to his Works, ... $1.00

This work is mainly composed of Answers to the Practical Questions, and Solutions of the Problems, in the author's celebrated "Fourteen Weeks Courses" in the several sciences, with many hints to teachers, minor Tables, &c. Should be on every teacher's desk.

Steele's 14 Weeks in each Science.

TESTIMONIALS.

From L. A. Bikle, *President N. C. College.*

I have not been disappointed. Shall take pleasure in introducing this series.

From J. F. Cox, *Prest. Southern Female College, Ga.*

I am much pleased with these books, and expect to introduce them.

From J. R. Branham, *Prin. Brownsville Female College, Tenn.*

They are capital little books, and are now in use in our institution.

From W. H. Goodale, *Professor Readville Seminary, La.*

We are using your 14 Weeks Course, and are much pleased with them.

From W. A. Boles, *Supt. Shelbyville Graded School, Ind.*

They are as entertaining as a story book, and much more improving to the mind.

From S. A. Snow, *Principal of High School, Uxbridge, Mass.*

Steele's 14 Weeks Courses in the Sciences are a perfect success.

From John W. Doughty, *Newburg Free Academy, N. Y.*

I was prepared to find Prof. Steele's Course both attractive and instructive. My highest expectations have been fully realized.

From J. S. Blackwell, *Prest. Ghent College, Ky.*

Prof. Steele's unexampled success in providing for the wants of academic classes, has led me to look forward with high anticipations to his forthcoming issue.

From J. F. Cook, *Prest. La Grange College, Mo.*

I am pleased with the neatness of these books and the delightful diction. I have been teaching for years, and have never seen a lovelier little volume than the Astronomy.

From M. W. Smith, *Prin. of High School, Morrison, Ill.*

They seem to me to be admirably adapted to the wants of a public school, containing, as they do, a sufficiently comprehensive arrangement of elementary principles to excite a healthy thirst for a more thorough knowledge of those sciences.

From J. D. Bartley, *Prin. of High School, Concord, N. H.*

They are just such books as I have looked for, viz., those of interesting style, not cumbersome and filled up with things to be omitted by the pupil, and yet sufficiently full of facts for the purpose of most scholars in these sciences in our high schools; there is nothing but what a pupil of average ability can thoroughly master.

From Alonzo Norton Lewis, *Principal of Parker Academy, Conn.*

I consider Steele's Fourteen Weeks Courses in Philosophy, Chemistry, &c., the *best* school-books that have been issued in this country.

As an introduction to the various branches of which they treat, and especially for that numerous class of pupils who have not the time for a more extended course, I consider them *invaluable.*

From Edward Brooks, *Prin. State Normal School, Millersville, Pa.*

At the meeting of Normal School Principals, I presented the following resolution, which was unanimously adopted: "*Resolved,* That Steele's 14 Weeks Courses in Natural Philosophy and Astronomy, or an amount equivalent to what is contained in them, be adopted for use in the State Normal Schools of Pennsylvania." The works themselves will be adopted by at least three of the schools, and, I presume, by them all.

LITERATURE.

Gilman's First Steps in English Literature,

The character and plan of this exquisite little text-book may be best understood from an analysis of its contents:

INTRODUCTION. Chapter I, Historical; II, Definition of Terms; III, Languages of Europe, with Chart.

PERIOD OF IMMATURE ENGLISH, with Chart. Chapter IV, Original English; V, Broken English; VI, Dead English; VII, Reviving English.

PERIOD OF MATURE ENGLISH, with Chart. Chapter VIII, The Italian Influence; IX, Puritan Influence; X, French Influence; XI, Age of Pope; XII, Age of Johnson; XIII, Age of Poetical Romance; XIV, Age of Prose Romance.

The volume concludes with a Chart of Bible Translations, a Bibliography or Guide to General Reading, and other aids to the student.

Cleveland's Compendiums,

ENGLISH LITERATURE. AMERICAN LITERATURE.
ENGLISH LITERATURE OF THE XIXTH CENTURY.

In these volumes are gathered the cream of the literature of the English-speaking people for the school-room and the general reader. Their reputation is national. More than 125,000 copies have been sold.

Boyd's English Classics,

MILTON'S PARADISE LOST. THOMSON'S SEASONS.
YOUNG'S NIGHT THOUGHTS. POLLOK'S COURSE OF TIME.
COWPER'S TASK, TABLE TALK, &C. LORD BACON'S ESSAYS.

This series of annotated editions of great English writers, in prose and poetry, is designed for critical reading and parsing in schools. Prof. J. R. Boyd proves himself an editor of high capacity, and the works themselves need no encomium. As auxiliary to the study of Belles Lettres, etc., these works have no equal.

Pope's Essay on Man,

Pope's Homer's Iliad,

The metrical translation of the great poet of antiquity, and the matchless "Essay on the Nature and State of Man," by ALEXANDER POPE, afford superior exercise in literature and parsing.

ÆSTHETICS.

Huntington's Manual of the Fine Arts,

A view of the rise and progress of Art in different countries, a brief account of the most eminent masters of Art, and an analysis of the principles of Art. It is complete in itself, or may precede to advantage the critical work of Lord Kames.

Boyd's Kames' Elements of Criticism,

The best edition of this standard work; without the study of which none may be considered proficient in the science of the Perceptions. No other study can be pursued with so marked an effect upon the taste and refinement of the pupil.

CLEVELAND'S COMPENDIUMS.

TESTIMONIALS.

From the New Englander.

This is the very best book of the kind we have ever examined.

From GEORGE B. EMERSON, Esq., *Boston.*

The Biographical Sketches are just and discriminating; the selections are admirable, and I have adopted the work as a text-book for my first class.

From PROF. MOSES COIT TYLER, *of the Michigan University.*

I have given your book a thorough examination, and am greatly delighted with it; and shall have great pleasure in directing the attention of my classes to a work which affords so admirable a bird's-eye view of recent "English Literature."

From the Saturday Review.

It acquaints the reader with the characteristic method, tone, and quality of all the chief notabilities of the period, and will give the careful student a better idea of the recent history of English Literature than nine educated Englishmen in ten possess.

From the Methodist Quarterly Review, New York.

This work is a transcript of the best American mind; a vehicle of the noblest American spirit. No parent who would introduce his child to a knowledge of our country's literature, and at the same time indoctrinate his heart in the purest principles, need fear to put this manual in the youthful hand.

From REV. C. PEIRCE, *Principal, West Newton, Mass.*

I do not believe the work is to be found from which, within the same limits, so much interesting and valuable information in regard to English writers and English literature of every age, can be obtained; and it deserves to find a place in all our high schools and academies, as well as in every private library.

From the Independent.

The work of selection and compilation—requiring a perfect familiarity with the whole range of English literature, a judgment clear and impartial, a taste at once delicate and severe, and a most sensitive regard to purity of thought or feeling—has been better accomplished in this than in any kindred volume with which we are acquainted.

POLITICAL ECONOMY.

Champlin's Lessons on Political Economy,

An improvement on previous treatises, being shorter, yet containing everything essential, with a view of recent questions in finance, etc., which is not elsewhere found.

From J. L. BOTHWELL, *Prin. Public School No. 14, Albany, N.Y.*

I have examined Champlin's Political Economy with much pleasure, and shall be pleased to put it into the hands of my pupils. In quantity and quality I think it superior to anything that I have examined.

From PRES. N. E. COBLEIGH, *East Tennessee Wesleyan University.*

An examination of Champlin's Political Economy has satisfied me that it is the book I want. For brevity and compactness, division of the subject, and clear statement, and for appropriateness of treatment, I consider it a better text-book than any other in the market.

From the Evening Mail, New York.

A new interest has been imparted to the science of political economy since we have been necessitated to raise such vast sums of money for the support of the government. The time, therefore, is favorable for the introduction of works like the above. This little volume of two hundred pages is intended for beginners, for the common school and academy. It is intended as a basis upon which to rear a more elaborate superstructure. There is nothing in the principles of political economy above the comprehension of average scholars, when they are learly set forth. This seems to have been done by President Champlin in an easy and graceful manner.

ELOCUTION.

Thwing's Vocal Culture.

A Drill-Book for voice and gesture, by Rev. Prof. Thwing, of Brooklyn Tabernacle Lay College. Price 50 cts.

Taverner Graham's Reasonable Elocution,

Based upon the belief that true Elocution is the right interpretation of THOUGHT, and guiding the student to an intelligent appreciation, instead of a merely mechanical knowledge, of its rules.

Zachos' Analytic Elocution.

All departments of elocution—such as the analysis of the voice and the sentence, phonology, rhythm, expression, gesture, etc.—are here arranged for instruction in classes, illustrated by copious examples.

Sherwood's Self Culture.

Self-culture in reading, speaking, and conversation—a very valuable treatise to those who would perfect themselves in these accomplishments.

SPEAKERS.

Northend's Little Orator, . $0.40 Child's Speaker, . $0.40

Two little works of the same grade but different selections, containing simple and attractive pieces for children under twelve years of age.

Northend's Young Declaimer, $0.50 National Orator, . 70

Two volumes of Prose, Poetry, and Dialogue, adapted to intermediate and grammar classes respectively.

Northend's Entertaining Dialogues, ... 70

Extracts eminently adapted to cultivate the dramatic faculties, as well as entertain.

Oakey's Dialogues and Conversations, ... 60

For School Exercises and Exhibitions, combining useful instruction.

James's Southern Selections for Reading and Oratory, 1.10

Embracing exclusively Southern literature.

Swett's Common School Speaker, ... 90

Raymond's Patriotic Speaker, ... 1.25

A superb compilation of modern eloquence and poetry, with original dramatic exercises. Nearly every eminent modern orator is represented.

COMPOSITION AND RHETORIC.

Brookfield's First Book in Composition, ... $0.35

Making the cultivation of this important art feasible for the smallest child. By a new method, to induce and stimulate thought.

Boyd's Composition and Rhetoric, ... 1.00

This work furnishes all the aid that is needful or can be desired in the various departments and styles of composition, both in prose and verse.

Day's Art of Rhetoric, ... 90

Noted for exactness of definition, clear limitation, and philosophical development of subject; the large share of attention given to Invention, as a branch of Rhetoric, and the unequalled analysis of style.

PUNCTUATION.

Cocker's Hand-Book of Punctuation, ... $0.50

With Instructions for Capitalization, Letter-Writing and Proof-Reading. Most works on this subject are so abstruse and technical that the unprofessional reader finds them difficult of comprehension; but this little treatise is so simple and comprehensive that persons of very ordinary intelligence can readily understand and apply its principles.

MIND AND MORALS.

Mahan's Intellectual Philosophy 1.25

The subject exhaustively considered. The author has evinced learning, candor, and independent thinking.

Mahan's Science of Logic 1.40

A profound analysis of the laws of thought. The system possesses the merit of being intelligible and self-consistent. In addition to the author's carefully elaborated views, it embraces results attained by the ablest minds of Great Britain, Germany and France, in this department.

Boyd's Elements of Logic 0.90

A systematic and philosophic condensation of the subject, fortified with additions from Watts, Abercrombie, Whately, &c.

Watts on the Mind 0.35

The Improvement of the Mind, by Isaac Watts, is designed as a guide for the attainment of useful knowledge. As a text-book it is unparalleled; and the discipline it affords cannot be too highly esteemed by the educator.

Peabody's Moral Philosophy 0.90

A short course; by the Professor of Christian Morals, Harvard University—for the Freshman Class and for High Schools.

Alden's Text-Book of Ethics 0.40

For young pupils. To aid in systematizing the ethical teachings of the Bible, and point out the coincidences between the instructions of the sacred volume and the sound conclusions of reason.

Willard's Morals for the Young 0.50

Lessons in conversational style to indicate the elements of moral philosophy. The study is made attractive by narratives and engravings.

GOVERNMENT.

Howe's Young Citizen's Catechism 0.50

Explaining the duties of District, Town, City, County, State, and United States Officers, with rules for parliamentary and commercial business.

Young's Lessons in Civil Government 0.90

A comprehensive view of Government, and abstract of the laws showing the rights, duties, and responsibilities of citizens.

Mansfield's Political Manual 0.90

This is a complete view of the theory and practice of the General and State Governments, designed as a text-book. The author is an esteemed and able professor of constitutional law, widely known for his sagacious utterances in the public press.

Martin's Civil Government 0.90

Emanating from Massachusetts State Normal School. Historical and statistical. Each chapter summarized by a succinct statement of underlying principles on which good government is based.

Gallaudet's International Law 0.90

Published 1879, and the only work bringing the subject within the compass of a convenient text-book.

MODERN LANGUAGE.

Illustrated Language Primers,

FRENCH AND ENGLISH. GERMAN AND ENGLISH.
SPANISH AND ENGLISH.

The names of common objects properly illustrated and arranged in easy lessons.

Ledru's French Fables,

Ledru's French Grammar,

Ledru's French Reader,

The author's long experience has enabled him to present the most thoroughly practical text-books extant, in this branch. The system of pronunciation (by phonetic illustration) is original with this author, and will commend itself to all American teachers, as it enables their pupils to secure an absolutely correct pronunciation without the assistance of a native master. This feature is peculiarly valuable also to "self-taught" students. The directions for ascertaining the gender of French nouns—also a great stumbling-block—are peculiar to this work, and will be found remarkably competent to the end proposed. The criticism of teachers and the test of the school-room is invited to this excellent series, with confidence.

Worman's French Echo,

To teach conversational French by actual practice, on an entirely new plan, which recognizes the importance of the student learning *to think* in the language which he speaks. It furnishes an extensive vocabulary of words and expressions in common use, and suffices to free the learner from the embarrassments which the peculiarities of his own tongue are likely to be to him, and to make him thoroughly familiar with the use of proper idioms.

Worman's German Echo,

On the same plan. See Worman's German Series, page 42.

Pujol's Complete French Class-Book,

Offers, in one volume, methodically arranged, a complete French course—usually embraced in series of from five to twelve books, including the bulky and expensive Lexicon. Here are Grammar, Conversation, and choice Literature—selected from the best French authors. Each branch is thoroughly handled; and the student, having diligently completed the course as prescribed, may consider himself, without further application, *au fait* in the most polite and elegant language of modern times.

Pujol's French Grammar, Exercises, Reader,

These volumes contain Part I, Parts II and III, and Part IV of the Complete Class-Book respectively, for the convenience of scholars and teachers. The Lexicon is bound with each part.

Maurice-Poitevin's Grammaire Francaise,

American schools are at last supplied with an American edition of this famous text-book. Many of our best institutions have for years been procuring it from abroad rather than forego the advantages it offers. The policy of putting students who have acquired some proficiency from the ordinary text-books, into a Grammar written in the vernacular, cannot be too highly commended. It affords an opportunity for finish and review at once; while embodying abundant practice of its own rules.

Joynes' French Pronunciation,

Willard's Historia de los Estados Unidos,

The History of the United States, translated by Professors TOLON and DE TORNOS, will be found a valuable, instructive, and entertaining reading-book for Spanish classes.

Pujol's Complete French Class-Book.

TESTIMONIALS.

From Prof. Elias Peissner, *Union College.*

I take great pleasure in recommending Pujol and Van Norman's French Class-Book, as there is no French grammar or class-book which can be compared with it in completeness, system, clearness, and general utility.

From Edward North, *President of Hamilton College.*

I have carefully examined Pujol and Van Norman's French Class-Book, and am satisfied of its superiority, for college purposes, over any other heretofore used. We shall not fail to use it with our next class in French.

From A. Curtis, *Pres't of Cincinnati Literary and Scientific Institute.*

I am confident that it may be made an instrument in conveying to the student, in from six months to a year, the art of speaking and writing the French with almost native fluency and propriety.

From Hiram Orcutt, A. M., *Prin. Glenwood and Tilden Ladies' Seminaries.*

I have used Pujol's French Grammar in my two seminaries, exclusively, for more than a year, and have no hesitation in saying that I regard it the best text-book in this department extant. And my opinion is confirmed by the testimony of Prof. F. De Launay and Mademoiselle Marindin. They assure me that the book is eminently accurate and practical, as tested in the school-room.

From Prof. Theo. F. De Fumat, *Hebrew Educational Institute, Memphis, Tenn.*

M. Pujol's French Grammar is one of the best and most practical works. The French language is chosen and elegant in style—modern and easy. It is far superior to the other French class-books in this country. The selection of the conversational part is very good, and will interest pupils; and being all completed in only one volume, it is especially desirable to have it introduced in our schools.

From Prof. James H. Worman, *Bordentown Female College, N. J.*

The work is upon the same plan as the text-books for the study of French and English published in Berlin, for the study of those who have not the aid of a teacher, and these books are considered, by the first authorities, the best books. In most of our institutions, Americans teach the modern languages, and heretofore the trouble has been to give them a text-book that would dispose of the difficulties of the French pronunciation. This difficulty is successfully removed by P. and Van N., and I have every reason to believe it will soon make its way into most of our best schools.

From Prof. Charles S. Dod, *Ann Smith Academy, Lexington, Va.*

I cannot do better than to recommend "Pujol and Van Norman." For comprehensive and systematic arrangement, progressive and thorough development of all grammatical principles and idioms, with a due admixture of theoretical knowledge and practical exercise, I regard it as superior to any (other) book of the kind.

From A. A. Forster, *Prin. Pinehurst School, Toronto, C. W.*

I have great satisfaction in bearing testimony to M. Pujol's System of French Instruction, as given in his complete class-book. For clearness and comprehensiveness, adapted for all classes of pupils, I have found it superior to any other work of the kind, and have now used it for some years in my establishment with great success.

From Prof. Otto Fedder, *Maplewood Institute, Pittsfield, Mass.*

The conversational exercises will prove an immense saving of the hardest kind of labor to teachers. There is scarcely any thing more trying in the way of teaching language, than to rack your brain for short and easily intelligible bits of conversation, and to repeat them time and again with no better result than extorting at long intervals a doubting "oui," or a hesitating "non, monsieur."

☞ For further testimony of a similar character, see special circular, and current numbers of the Educational Bulletin.

Worman's German Grammars.

TESTIMONIALS.

From Prof. R. W. Jones, *Petersburg Female College, Va.*

From what I have seen of the work it is almost certain *I shall introduce it* into this institution.

From Prof. G. Campbell, *University of Minnesota.*

A valuable addition to our school-books, and will find many friends, and do great good.

From Prof. O. H P. Corprew, *Mary Military Inst., Md.*

I am better pleased with them than any I have ever taught. I have already ordered through our booksellers.

From Prof. R. S. Kendall, *Vernon Academy, Conn.*

I at once put the Elementary Grammar into the hands of a class of beginners, and have used it *with great satisfaction.*

From Prof. D. E. Holmes, *Berlin Academy, Wis.*

Worman's German works are *superior.* I shall use them hereafter in my German classes.

From Prof. Magnus Buchholtz, *Hiram College, Ohio.*

I have examined the Complete Grammar, and find it *excellent.* You may rely that it will be used here.

From Prin. Thos. W. Tobey, *Paducah Female Seminary, Ky.*

The Complete German Grammar is worthy of an extensive circulation. It is *admirably adapted* to the class-room. I shall use it.

From Prof. Alex. Rosenspitz, *Houston Academy, Texas.*

Bearer will take and pay for 3 dozen copies. Mr. Worman deserves the approbation and esteem of the teacher and the thanks of the student.

From Prof. G. Malmene, *Augusta Seminary, Maine.*

The Complete Grammar cannot fail to *give great satisfaction* by the simplicity of its arrangement, and by its completeness.

From Prin. Oval Pirkey, *Christian University, Mo.*

Just such a series as is positively necessary. I do hope the author will succeed as well in the French, &c., as he has in the German.

From Prof. S. D. Hillman, *Dickinson College, Pa.*

The class have lately commenced, and my examination thus far warrants me in saying that I regard it as *the best* grammar for instruction in the German.

From Prin. Silas Livermore, *Bloomfield Seminary, Mo.*

I have found a classically and scientifically educated Prussian gentleman whom I propose to make German instructor. I have shown him both your German grammars. He has expressed *his approbation* of them generally.

From Prof. Z. Test, *Howland School for Young Ladies, N. Y.*

I shall introduce the books. From a cursory examination I have no hesitation in pronouncing the Complete Grammar *a decided improvement* on the text-books at present in use in this country.

From Prof. Lewis Kistler, *Northwestern University, Ill.*

Having looked through the Complete Grammar with some care I must say that you have produced *a good book;* you may be awarded with this gratification—that your grammar promotes the facility of learning the German language, and of becoming acquainted with its rich literature.

From Pres. J. P. Rous, *Stockwell Collegiate Inst., Ind.*

I supplied a class with the Elementary Grammar, and it gives *complete satisfaction.* The conversational and reading exercises are well calculated to illustrate the principles, and lead the student on an easy yet thorough course. I think the Complete Grammar equally attractive.

THE CLASSICS.

LATIN.

Silber's Latin Course,

The book contains an Epitome of Latin Grammar, followed by Reading Exercises, with explanatory Notes and copious References to the leading Latin Grammars, and also to the Epitome which precedes the work. Then follow a Latin-English Vocabulary and Exercises in Latin Prose Composition, being thus complete in itself, and a very suitable work to put in the hands of one about to study the language.

Searing's Virgil's Æneid,

It contains only the first six books of the Æneid. 2. A very carefully constructed Dictionary. 3. Sufficiently copious Notes. 4. Grammatical references to four leading Grammars. 5. Numerous Illustrations of the highest order. 6. A superb Map of the Mediterranean and adjacent countries. 7. Dr. S. H. Taylor's "Questions on the Æneid." 8. A Metrical Index, and an Essay on the Poetical Style. 9. A photographic *fac simile* of an early Latin M.S. 10. The text according to Jahn, but paragraphed according to Ladewig. 11. Superior mechanical execution.

"Have examined it with great pleasure and can safely say it is the best edition of Virgil with which I am acquainted."—PROF. LESLIE WAGGENER, *Bethel College, Ky.*

"Am *very* much pleased. In following points think it surpasses: instructive illustrations, pointed and sensible notes where they are convenient to use, and a vocabulary that gives the *derivation of Latin words.*"—PRIN. E. L. RICHARDSON, *Addison Union School, N. Y.*

"A fine specimen of art, and edited in a *masterly manner.*"—SUPT. W. C. ROTE, *Lawrence Public Schools, Kansas.*

"Of Searing's Virgil I cannot speak in too high terms. While as a text-book it contains as many excellences as any I have ever seen, the fineness of the paper and the beauty of typography and exceeding neatness make it an ornament for the centre-table."—PRIN. E. C. SPALDING, *Nunda Academy, N. Y.*

☞ *For further testimonials, see page 45.*

Blair's Latin Pronunciation,

An inquiry into the proper sounds of the Language during the Classical Period. By Prof. Blair, of Hampden Sidney College, Va.

GREEK.

Crosby's Greek Grammar,
Crosby's Xenophon's Anabasis,

MYTHOLOGY.

Dwight's Grecian and Roman Mythology.

School edition, University edition,

A knowledge of the fables of antiquity, thus presented in a systematic form, is as indispensable to the student of general literature as to him who would peruse intelligently the classical authors. The mythological allusions so frequent in literature are readily understood with such a Key as this.

SEARING'S VIRGIL.

SPECIMEN FRAGMENTS OF LETTERS.

"I adopt it gladly."—PRIN. V. DABNEY, *Loudoun School*, *Va.*

"I like Searing's Virgil."—PROF. BRISTOL, *Ripon College*, *Wis.*

"Meets my desires very thoroughly."—PROF. CLARK, *Berea College*, *Ohio.*

"Superior to any other edition of Virgil."—PRES. HALL, *Macon College*, *Mo.*

"Shall adopt it at once."—PRIN. B. P. BAKER, *Searcy Female Institute*, *Ark.*

"Your Virgil is a *beauty*."—PROF. W. H. DE MOTTE, *Illinois Female College.*

"After use, I regard it the best."—PRIN. G. H. BARTON, *Rome Academy*, *N. Y.*

"We like it better every day."—PRIN. R. K. BUEHRLE, *Allentown Academy*, *Pa.*

"I am delighted with your Virgil."—PRIN. W. T. LEONARD, *Pierce Academy*, *Mass.*

"Stands well the test of class-room."—PRIN. F. A. CHASE, *Lyons Col. Inst.*, *Iowa.*

"I do not see how it can be improved."—PRIN. N. F. D. BROWNE, *Charl. Hall*, *Md.*

"The most complete that I have seen."—PRIN. A. BROWN, *Columbus High School*, *Ohio.*

"Our Professor of Language very highly approves."—SUPT. J. G. JAMES, *Texas Military Institute.*

"It responds to a want long felt by teachers. It is beautiful and complete."—PROF. BROOKS, *University of Minnesota.*

"The ideal edition. We want a few more classics of the same sort."—PRIN. C. F. P. BANCROFT, *Lookout Mountain Institute*, *Tenn.*

"I certainly have never seen an edition so complete with important requisites for a student, nor with such fine text and general mechanical execution."—PRES. J. R. PARK, *University of Deseret*, *Utah.*

"It is charming both in its design and execution. And, on the whole, I think it is the best thing of the kind that I have seen."—PROF. J. DE F. RICHARDS, *Pres. pro tem. of University of Alabama.*

"In beauty of execution, in judicious notes, and in an adequate vocabulary, it merits all praise. I shall recommend its introduction."—PRES. J. K. PATTERSON, *Kentucky Agricultural and Mechanical College.*

"Containing a good vocabulary and judicious notes, it will enable the industrious student to acquire an accurate knowledge of the most interesting part of Virgil's works."—PROF. J. T. DUNKLIN, *East Alabama College.*

"It wants no element of completeness. It is by far the best classical text-book with which I am acquainted. The notes are just right. They help the student when he most needs help."—PRIN. C. A. BUNKER, *Caledonia Grammar School*, *Vt.*

"I have examined Searing's Virgil with interest, and find that it more nearly meets the wants of students than that of any other edition with which I am acquainted. I am able to introduce it to some extent at once."—PRIN. J. EASTER, *East Genesee Conference Seminary.*

"I have been wishing to get a sight of it, and it exceeds my expectations. It is a beautiful book in every respect, and bears evidence of careful and critical study. The engravings add instruction as well as interest to the work. I shall recommend it to my classes."—PRIN. CHAS. H. CHANDLER, *Glenwood Ladies' Seminary.*

"A. S. Barnes & Co. have published an edition of the first six books of Virgil's Æneid, which is superior to its predecessors in several respects. The publishers have done a good service to the cause of classical education, and the book deserves a large circulation."—PROF. GEORGE W. COLLORD, *Brooklyn Polytechnic*, *N. Y.*

"My attention was called to Searing's Virgil by the fact of its containing a vocabulary which would obviate the necessity of procuring a lexicon. But use in the class-room has impressed me most favorably with the accuracy and just proportion of its notes, and the general excellence of its grammatical suggestions. The general character of the book in its paper, its typography, and its engravings is highly commendable, and the fac-simile manuscript is a valuable feature. I take great pleasure in commending the book to all who do not wish a complete edition of Virgil. It suits our short school courses admirably."—HENRY L. BOLTWOOD, *Master of Princeton High School*, *Ill.*

RECORDS.

Cole's Self-Reporting Class-Book,

For saving the Teacher's labor in averaging. At each opening are a full set of Tables showing any scholar's standing at a glance and entirely obviating the necessity of computation.

Tracy's School-Record, Pocket edition,

For keeping a simple but exact record of Attendance, Deportment, and Scholarship. The larger edition contains also a Calendar, an extensive list of Topics for Compositions and Colloquies, Themes for Short Lectures, Suggestions to Young Teachers, etc.

Brooks' Teacher's Register,

Presents at one view a record of Attendance, Recitations, and Deportment for the whole term.

Carter's Record and Roll-Book,

This is the most complete and convenient Record offered to the public. Besides the usual spaces for General Scholarship, Deportment, Attendance, etc., for each name and day, there is a space in red lines enclosing six minor spaces in blue for recording Recitations.

National School Diary,

A little book of blank forms for weekly report of the standing of each scholar, from teacher to parent. A great convenience.

REWARDS.

National School Currency,

A little box containing certificates in the form of Money. The most entertaining and stimulating system of school rewards. The scholar is paid for his merits and fined for his shortcomings. Of course the most faithful are the most successful in business. In this way the use and value of money and the method of keeping accounts are also taught. One box of Currency will supply a school of fifty pupils.

TACTICS.

The Boy Soldier,

Complete Infantry Tactics for Schools, with illustrations, for the use of those who would introduce this pleasing relaxation from the confining duties of the desk.

CHARTS.

McKenzie's Elocutionary Chart,

Baade's Reading Case,

This remarkable piece of school-room furniture is a receptacle containing a number of primary cards. By an arrangement of slides on the front, one sentence at a time is shown to the class. Twenty-eight thousand transpositions may be made, affording a variety of progressive exercises which no other piece of apparatus offers. One of its best features is, that it is so exceedingly simple as not to get out of order, while it may be operated with one finger.

Marcy's Eureka Tablet,

A new system for the Alphabet, by which it may be taught without fail in nine lessons.

Scofield's School Tablets,

On Five Cards, exhibiting Ten Surfaces. These Tablets teach Orthography, Reading, Object-Lessons, Color, Form, etc.

Watson's Phonetic Tablets,

Four Cards, and Eight Surfaces; teaching Pronunciation and Elocution phonetically—for class exercises.

Page's Normal Chart,

The whole science of Elementary Sounds tabulated. By the author of Page's Theory and Practice of Teaching.

Clark's Grammatical Chart,

Exhibits the whole Science of Language in one comprehensive diagram.

Davies' Mathematical Chart,

Mathematics made simple to the eye.

Monteith's Reference Maps, School series, Grand series,

Eight Numbers. Mounted on Rollers. Names all laid down in small type, so that to the pupil at a short distance they are Outline Maps, while they serve as *their own key* to the teacher.

Willard's Chronographers,

Historical. Four Numbers. Ancient Chronographer; English Chronographer; American Chronographer; Temple of Time (general). Dates and Events represented to the eye.

APPARATUS.

Harrington's Geometrical Blocks,

These patented blocks are *hinged*, so that each form can be dissected.

Harrington's Fractional Blocks,

Steele's Chemical Apparatus,

Steele's Philosophical Apparatus, (see p.28)

Steele's Geological Cabinet, (see p.28)

Wood's Botanical Apparatus, (see p.30)

Bock's Physiological Apparatus.

MUSIC.

The National School Singer,

Bright, new music for the day school, embracing Song Lessons, Exercise Songs, Songs of Study, Order, Promptness and Obedience, of Industry and Nature, Patriotic and Temperance Songs, Opening and Closing Songs; in fact, everything needed in the school-room. By an eminent Musician and Composer.

Jepson's Music Readers. 3 vols.

These are not books from which children simply learn songs, parrot-like, but teach the subject progressively—the scholar learning to read music by methods similar to those employed in teaching him to read printed language. Any teacher, however ignorant of music, provided he can, upon trial, simply sound the scale, may teach it without assistance, and will end by being a good singer himself. The "Elementary Music Reader," or first volume, fully develops the system. The two companion volumes carry the same method into the higher grades, but their use is not essential.

The First Reader is also published in three parts, at 30 cents each, for those who prefer them in that form.

Bartley's Songs for the School.

A selection of appropriate Hymns of an unsectarian character, carefully classified and set to popular and "singable" Tunes, for opening and closing exercises. The Secular Department is full of bright and well selected music.

Nash & Bristow's Cantara,

The first volume is a complete musical text-book for schools of every grade. No. 2 is a choice selection of Solos and Part Songs. The authors are Directors of Music in the public schools of New York City, in which these books are the standard of instruction.

The Polytechnic

Collection of Part Songs for High and Normal Schools and Clubs. This work contains a quantity of exceedingly valuable material, heretofore accessible only in sheet form or scattered in numerous and costly works. The collection of "College Songs" is a very attractive feature.

Curtis' Little Singer,—School Vocalist,

Kingsley's School-Room Choir,—Young Ladies' Harp,

Hager's Echo (A Cantata).

DEVOTION.

Brooks' School Manual of Devotion,

This volume contains daily devotional exercises, consisting of a hymn, selections of Scripture for alternate reading by teacher and pupils, and a prayer. Its value for opening and closing school is apparent.

Brooks' School Harmonist,

Contains appropriate *tunes* for each hymn in the "Manual of Devotion" described above.

A. S. BARNES & CO.'S CATALOGUE.

DEPARTMENT OF GENERAL LITERATURE.

PRICES INCLUDING POSTAGE.

THE TEACHERS' LIBRARY.

Object Lessons—Welch, - - - - - $1 00

This is a complete exposition of the popular modern system of "object-teaching," for teachers of primary classes.

Theory and Practice of Teaching—Page, - - 1 50

This volume has, without doubt, been read by two hundred thousand teachers, and its popularity remains undiminished—large editions being exhausted yearly. It was the pioneer, as it is now the patriarch, of professional works for teachers.

The Graded School—Wells, - - - - - - 1 25

The proper way to organize graded schools is here illustrated. The author has availed himself of the best elements of the several systems prevalent in Boston, New York, Philadelphia, Cincinnati, St. Louis, and other cities.

The Normal—Holbrook, - - - - - 1 50

Carries a working school on its visit to teachers, showing the most approved methods of teaching all the common branches, including the technicalities, explanations, demonstrations, and definitions introductory and peculiar to each branch.

School Management—Holbrook, - - - - 1 50

Treating of the Teacher's Qualifications; How to overcome Difficulties in Self and Others; Organization; Discipline; Methods of inciting Diligence and Order; Strategy in Management; Object Teaching.

The Teachers' Institute—Fowle, - - - - 1 25

This is a volume of suggestions inspired by the author's experience at institutes, in the instruction of young teachers. A thousand points of interest to this class are most satisfactorily dealt with.

Schools and Schoolmasters—Dickens, - - - 1 25

Appropriate selections from the writings of the great novelist.

The Metric System—Davies, - - - - - 1 50

Considered with reference to its general introduction, and embracing the views of John Quincy Adams and Sir John Herschel.

The Student; The Educator—Phelps, - - each, 1 50

The Discipline of Life—Phelps, - - - - 1 75

The authoress of these works is one of the most distinguished writers on education, and they cannot fail to prove a valuable addition to the School and Teachers' Libraries, being in a high degree both interesting and instructive.

A Scientific Basis of Education—Hecker, - - 2 50

Adaptation of study and classification by temperaments.

Teachers' Hand-Book — Phelps - - - - $1 50

By Wm. F. Phelps, Principal of Minnesota State Normal School. Embracing the objects, history, organization and management of Teachers' Institutes, followed by Methods of Teaching, in detail, for all the fundamental branches. Every young teacher, every practical teacher, every experienced teacher even, needs this book.

From the New York Tribune.

"The discipline of the school should prepare the child for the discipline of life. The country schoolmaster, accordingly, holds a position of vital interest to the destiny of the republic, and should neglect no means for the wise and efficient discharge of his significant functions. This is the key-note of the present excellent volume. In view of the supreme importance of the teacher's calling, Mr. Phelps has presented an elaborate system of instruction in the elements of learning, with a complete detail of methods and processes, illustrated with an abundance of practical examples and enforced by judicious counsels.

Stone's Topical Course of Study - - - - 40

This volume is a compilation from the courses of study of our most successful public schools, and the best thought of leading educators. The pupil is enabled to make full use of any and all text-books bearing on the given topics, and is incited to use all other information within his reach.

American Education — Mansfield - - - - 1 50

A treatise on the principles and elements of education, as practised in this country, with ideas towards distinctive republican and Christian education.

American Institutions — De Tocqueville - - - 1 50

A valuable index to the genius of our Government.

Universal Education — Mayhew - - - - 1 75

The subject is approached with the clear, keen perception of one who has observed its necessity, and realized its feasibility and expediency alike. The redeeming and elevating power of improved common schools constitutes the inspiration of the volume.

Higher Christian Education — Dwight - - - 1 50

A treatise on the principles and spirit, the modes, directions and results of all true teaching; showing that right education should appeal to every element of enthusiasm in the teacher's nature.

Oral Training Lessons — Barnard - - - - 1 00

The object of this very useful work is to furnish material for instructors to impart orally to their classes, in branches not usually taught in common schools, embracing all departments of Natural Science and much general knowledge.

Lectures on Natural History — Chadbourne - - 75

Affording many themes for oral instruction in this interesting science—especially in schools where it is not pursued as a class exercise.

Outlines of Mathematical Science — Davies - - 1 00

A manual suggesting the best methods of presenting mathematical instruction on the part of the teacher, with that comprehensive view of the whole which is necessary to the intelligent treatment of a part, in science.

Nature and Utility of Mathematics — Davies - - 1 50

An elaborate and lucid exposition of the principles which lie at the foundation of pure mathematics, with a highly ingenious application of their results to the development of the essential idea of the different branches of the science.

Mathematical Dictionary — Davies and Peck - - 4 00

This cyclopædia of mathematical science defines, with completeness, precision, and accuracy, every technical term; thus constituting a popular treatise on each branch, and a general view of the whole subject.

Liberal Education of Women—Orton . . *$1 50

Treats of "the demand and the method;" being a compilation of the best and most advanced thought on this subject, by the leading writers and educators in England and America. Edited by a Professor in Vassar College.

Education Abroad—Northrop *1 50

A thorough discussion of the advantages and disadvantages of sending American children to Europe to be educated; also, Papers on Legal Prevention of Illiteracy, Study and Health, Labor as an Educator, and other kindred subjects. By the Hon. Secretary of Education for Connecticut.

The Teacher and the Parent—Northend . . *1 50

A treatise upon common-school education, designed to lead teachers to view their calling in its true light, and to stimulate them to fidelity.

The Teachers' Assistant—Northend *1 50

A natural continuation of the author's previous work, more directly calculated for daily use in the administration of school discipline and instruction.

School Government—Jewell *1 50

Full of advanced ideas on the subject which its title indicates. The criticisms upon current theories of punishment and schemes of administration have excited general attention and comment.

Grammatical Diagrams—Jewell *1 00

The diagram system of teaching grammar explained, defended, and improved The curious in literature, the searcher for truth, those interested in new inventions, as well as the disciples of Prof. Clark, who would see their favorite theory fairly treated, all want this book. There are many who would like to be made familiar with this system before risking its use in a class. The opportunity is here afforded.

The Complete Examiner—Stone *1 25

Consists of a series of questions on every English branch of school and academic instruction, with reference to a given page or article of leading text-books where the answer may be found in full. Prepared to aid teachers in securing certificates, pupils in preparing for promotion, and teachers in selecting review questions.

School Amusements—Root *1 50

To assist teachers in making the school interesting, with hints upon the management of the school-room. Rules for military and gymnastic exercises are included. Illustrated by diagrams.

Institute Lectures—Bates *1 50

These lectures, originally delivered before institutes, are based upon various topics in the departments of mental and moral culture. The volume is calculated to prepare the will, awaken the inquiry, and stimulate the thought of the zealous teacher.

Method of Teachers' Institutes—Bates . . . *75

Sets forth the best method of conducting institutes, with a detailed account of the object, organization, plan of instruction, and true theory of education on which such instruction should be based.

History and Progress of Education *1 50

The systems of education prevailing in all nations and ages, the gradual advance to the present time, and the bearing of the past upon the present in this regard, are worthy of the careful investigation of all concerned in education.

THE SCHOOL LIBRARY.

The two elements of instruction and entertainment were never more happily combined than in this collection of standard books. Children and adults alike will here find ample food for the mind, of the sort that is easily *digested*, while not degenerating to the level of modern romance.

LIBRARY OF LITERATURE.

Milton's Paradise Lost. Boyd's Illustrated Ed., $1 60

Young's Night Thoughts . . . . do. . . 1 60

Cowper's Task, Table Talk, &c. . do. . . 1 60

Thomson's Seasons . . . . do. . . 1 60

Pollok's Course of Time . . . . do. . . 1 60

These works, models of the best and purest literature, are beautifully illustrated, and notes explain all doubtful meanings.

Lord Bacon's Essays (Boyd's Edition) . . . 1 60

Another grand English classic, affording the highest example of purity in language and style.

The Iliad of Homer. Translated by Pope. . . 80

Those who are unable to read this greatest of ancient writers in the original, should not fail to avail themselves of this metrical version.

Compendium of Eng. Literature—Cleveland, 2 25

English Literature of XIXth Century do. 2 25

Compendium of American Literature do. 2 25

Nearly one hundred and fifty thousand volumes of Prof. Cleveland's inimitable compendiums have been sold. Taken together they present a complete view of literature. To the man who can afford but a few books these will supply the place of an extensive library. From commendations of the very highest authorities the following extracts will give some idea of the enthusiasm with which the works are regarded by scholars:

With the Bible and your volumes one might leave libraries without very painful regret.—The work cannot be found from which in the same limits so much interesting and valuable information may be obtained.—Good taste, fine scholarship, familiar acquaintance with literature, unwearied industry, tact acquired by practice, an interest in the culture of the young, and regard for truth, purity, philanthropy and religion are united in Mr. Cleveland.—A judgment clear and impartial. a taste at once delicate and severe.—The biographies are just and discriminating.—An admirable bird's-eye view.—Acquaints the reader with the characteristic method, tone, and quality of each writer.—Succinct, carefully written, and wonderfully comprehensive in detail, etc., etc.

Milton's Poetical Works—Cleveland . . . 2 25

This is the very best edition of the great Poet. It includes a life of the author, notes, dissertations on each poem, a faultless text, and is *the only* edition of Milton with a complete verbal Index.

LIBRARY OF HISTORY.

Seven Historic Ages—Gilman, - - - - $1 00

Or, Talks about Kings, Queens, and Barbarians. These delightful sketches of notable events stir the imagination of the young reader, and give him a taste for further historical reading. Illustrated.

Outlines of General History—Gilman, - - - 1 25

The number of facts which the author has compressed into these outline sketches is really surprising; the chapters on the Middle Ages and Feudalism afford striking examples of his power of succinct but comprehensive statement. In his choice of representative periods and events in the histories of Nations he shows very sound judgment, and his characterization of conspicuous historical figures is accurate and impartial.

Great Events of History—Collier, - - - - 1 50

This celebrated work, edited for American readers by Prof. O. R. Willis, gives, in a series of pictures, a pleasantly readable and easily remembered view of the Christian era. Each chapter is headed by its central point of interest to afford association for the mind. Delineations of life and manners at different periods are interwoven. A geographical appendix of great value is added.

History of England—Lancaster, - - - - 1 50

An arrangement of the essential facts of English History in the briefest manner consistent with clearness. With a fine Map.

History of Liberty—Aiken, - - - - - 1 00

Explaining the growth of the "fair consummate flower" of freedom in America as the result of centuries of trial and experience in the Old World.

Critical History of the Civil War—Mahan, - - 3 00

A logical analysis of campaigns and battles, and the causes of victory and defeat. By Dr. Asa Mahan, first President of Oberlin College. Dr. Mahan never forgets that history is "philosophy teaching by examples," and his work should be a text-book for American youth.

History of Europe—Alison, - - - - - 2 50

A reliable and standard work, which covers with clear, connected, and complete narrative the eventful occurrences of the years A. D. 1789 to 1815, being mainly a history of the career of Napoleon Bonaparte.

History of Rome—Ricord, - - - - - 1 75

An entertaining narrative for the young. Illustrated. Embracing successively, The Kings; The Republic; The Empire.

Ecclesiastical History—Marsh, - - - - - 2 00

A history of the Church in all ages, with a comprehensive review of all forms of religion from the creation of the world. No other source affords, in the same compass, the information here conveyed.

History of the Ancient Hebrews—Mills, - - - 1 75

The record of "God's people" from the call of Abraham to the destruction of Jerusalem; gathered from sources sacred and profane.

The Mexican War—Mansfield, - - - - 1 50

A history of its origin, and a detailed account of its victories; with official despatches, the treaty of peace, and valuable tables. Illustrated.

Early History of Michigan—Sheldon, - - - 2 50

A work of value and deep interest to the people of the West. Compiled under the supervision of Hon. Lewis Cass. Portraits.

History of Texas—Baker, - - - - - 1 25

A pithy and interesting resumé. Copiously illustrated. The State constitution and extracts from the speeches and writings of eminent Texans are appended.

NEW LIBRARY OF HISTORY.

Barnes' Centenary History, - - - - - - *$6 00

"*One Hundred Years of American Independence.*" This superbly illustrated work, by the author of "Barnes' Brief Histories" (for schools), is appropriately issued in the "centennial year" (1876). An extended Introduction brings down the history from the earliest times. The leading idea is to make American History *popular* for the masses, and especially with the young. The style is therefore life-like and vivid, carrying the reader along by the sweep of the story as in a novel, so that when he begins an account of an important event he cannot very well lay down the book until he finishes.

Lamb's History of New York City.

One of the most important works ever issued. It opens with a brief outline of the condition of the old world prior to the settlement of the new, and proceeds to give a careful analysis of the two great Dutch Commercial Corporations to which New York owes its origin. It sketches the rise and growth of the little colony on Manhattan Island; describes the Indian Wars with which it was afflicted; gives color and life to its Dutch rulers; paints its subjugation by the English, its after vicissitudes, the Revolution of 1689; in short, it leads the reader through one continuous chain of events down to the American Revolution. Then, gathering up the threads, the author gives an artistic and comprehensive account of the progress of the City, in extent, education, culture, literature, art, and political and commercial importance, during the last century. Prominent persons are introduced in all the different periods, with choice bits of family history, and glimpses of social life. The work contains maps of the City in the different decades, and several rare portraits from original paintings, which have never before been engraved. The illustrations, about 250 in number, are all of an interesting and highly artistic character.

The work is now being published, by subscription only, in about 30 parts, at 50 cents each.

Carrington's Battles of the Revolution, - - - $6 00

A careful description and analysis of every engagement of the War for Independence, with topographical charts prepared from personal surveys by the author, a veteran officer of the U. S. Army, and Professor of Military Science in Wabash College.

Baker's Texas Scrap-Book, - - - - - $5 00

Comprising the History, Biography, Literature, and Miscellany of Texas and its people. A valuable collection of material, anecdotical and statistical, which is not to be found in any other form. The work is handsomely illustrated. (Sheep, $6.00.)

LIBRARY OF REFERENCE.

Home Cyclopædia of Literature and Fine Arts, - $3 00

A complete index to all terms employed in belles lettres, philosophy, theology, law, mythology, painting, music, sculpture, architecture, and all kindred arts.

The Rhyming Dictionary—Walker, - - - 1 25

A serviceable manual to composers, being a complete index of allowable rhymes.

The Topical Lexicon—Williams, - - - - 1 75

The useful terms of the English language *classified by subjects* and arranged according to their affinities of meaning, with etymologies, definitions, and illustrations. A very entertaining and instructive work.

Mathematical Dictionary—Davies and Peck, - - 4 00

A thorough compendium of the science, with illustrations and definitions.

LIBRARY OF BIOGRAPHY.

Autobiography of President Finney, - - - $2 00

The "Memoirs of Rev. Charles G. Finney, written by himself," with Portrait on steel. The work presents the experience, labors, and thoughts of the eminent Evangelist, Preacher, and Teacher. It gives the history of the great revivals in which he labored, and also his work in connection with Oberlin College.

The book is full of personal incidents illustrating the power of the Gospel upon the hearts and lives of men, and of practical suggestions for the promotion of revivals. It is also rich in its exhibition of personal religious experience, and of the nature and the efficacy of prayer.

Life of P. P. Bliss—Whittle, Moody & Sankey, - - 2 00

The memorials of the lamented singer and evangelist which have here been gathered by the hands of loving friends will commend themselves to a great multitude of interested readers. Ten thousand copies of the book were sold within thirty days after publication. It contains steel-plate engravings of the Bliss family, and a number of new songs with music not before published.

Life of Dr. Sam Johnson—Boswell, - - - 2 25

This work has been before the public for seventy years, with increasing approbation. Boswell is known as "the prince of biographers."

Henry Clay's Life and Speeches—Mallory. 2 vols., 4 50

This great American statesman commands the admiration, and his character and deeds solicit the study of every patriot.

Life and Services of General Scott—Mansfield, - 1 75

The hero of the Mexican war, who was for many years the most prominent figure in American military circles, should not be forgotten in the whirl of more recent events than those by which he signalized himself. Illustrated.

Garibaldi's Autobiography, - - - - - 1 50

The Italian patriot's record of his own life, translated and edited by his friend and admirer. A thrilling narrative of a romantic career. With portrait.

Lives of the Signers—Dwight, - - - 1 50

The memory of the noble men who declared our country free at the peril of their own "lives, fortunes, and sacred honor," should be embalmed in every American's heart.

Life of Sir Joshua Reynolds—Cunningham, - - 1 50

A candid, truthful, and appreciative memoir of the great painter, with a compilation of his discourses. The volume is a text-book for artists, as well as those who would acquire the rudiments of art. With a portrait.

Prison Life, - - - - - - - - 75

Interesting biographies of celebrated prisoners and martyrs, designed especially for the instruction and cultivation of youth.

LIBRARY OF TRAVEL.

Texas; the Coming Empire—McDaniel and Taylor, $1 50

Narrative of a two thousand mile trip on horseback through the Lone Star State; with lively descriptions of people, scenery, and resources.

Life in the Sandwich Islands—Cheever, - - 1 50

The "Heart of the Pacific, as it was and is," shows most vividly the contrast between the depth of degradation and barbarism and the light and liberty of civilization, so rapidly realized in these islands under the humanizing influence of the Christian religion. Illustrated.

The Republic of Liberia—Stockwell, - - - 1 25

This volume treats of the geography, climate, soil and productions of this interesting country on the coast of Africa, with a History of its early settlement. Our colored citizens especially, from whom the founders of the new State went forth, should read Mr. Stockwell's account of it. It is so arranged as to be available for a School Reader, and in colored schools is peculiarly appropriate as an instrument of education for the young. Liberia is likely to bear an important part in the future of their race.

Ancient Monasteries of the East—Curzon, - - 1 50

The exploration of these ancient seats of learning has thrown much light upon the researches of the historian, the philologist, and the theologian, as well as the general student of antiquity. Illustrated.

Discoveries in Babylon and Nineveh—Layard, - - 1 75

Valuable alike for the information imparted with regard to these most interesting ruins and the pleasant adventures and observations of the author in regions that to most men seem like Fairyland. Illustrated.

A Run Through Europe—Benedict, - - - 2 00

A work replete with instruction and interest—an admirable guide-book.

St. Petersburgh—Jermann, - - - - - - 1 00

Americans are less familiar with the history and social customs of the Russian people than those of any other modern civilized nation. Opportunities such as this book affords are not, therefore, to be neglected.

The Polar Regions—Osborn, - - - - - - 1 25

A thrilling and intensely interesting narrative of one of the famous expeditions in search of Sir John Franklin—unsuccessful in its main object, but adding many facts to the repertoire of science.

Thirteen Months in the Confederate Army, - - 75

The author, a northern man conscripted into the Confederate service, and rising from the ranks by soldierly conduct to positions of responsibility, had remarkable opportunities for the acquisition of facts respecting the conduct of the Southern armies, and the policy and deeds of their leaders. He participated in many engagements, and his book is one of the most exciting narratives of adventure ever published. Mr. Stevenson takes no ground as a partisan, but views the whole subject as with the eye of a neutral—only interested in subserving the ends of history by the contribution of impartial facts. Illustrated.

LATEST PUBLICATIONS.

The Commonwealth Reconstructed—Clark, - - $1 50

Setting forth why our democracy is a partial failure, with a remedial method.

Nine Lectures on Preaching—Dale, - - - 1 50

By Rev. R. W. Dale, of England. Delivered at Yale College, October 1877. Contents: Perils of Young Preachers; The Intellect in Relation to Preaching; Reading; Preparation of Sermons; Extemporaneous Preaching; Evangelistic Preaching; Pastoral Preaching; Conduct of Public Worship.

The Working Classes in Europe—Hughes, - - 1 00

Choice Articles from the "International Review" on Labor, Republican Government, and kindred topics. By Thomas Hughes, M.P., and other competent writers.

Our National Currency—Amasa Walker, - - - 0 50

The money problem in all its bearings.

The World's Fair in 1876—F. A. Walker, - - 0 75

An historical and critical account by the distinguished chief of the Bureau of Awards, Gen. Francis A. Walker.

Student's Common-Place Book—Fox, - - - $4 50

The result of over thirty years effective reading by a clergyman and teacher, forming a Cyclopedia of Illustration and Fact. Interleaved for Additions by the owner; thus combining a printed Manual of Literature with the Blanks of an Index Rerum. Its double value will make it the favorite book of the library.

Biographical and Critical Essays—Atlas Series, - - 1 50

Choice articles from the International Review on Macaulay, Ticknor, Ernst Curtius, Hamerton, Longfellow, Bryant, Poe, Chas. Tennyson, Freeman, Sumner, John Stuart Mill. By Edward A. Freeman, and other eminent writers.

Formation of Religious Opinions—Palmer, - - 1 25

Hints for the benefit of young people who have found themselves disturbed by inward questionings or doubts concerning the Christian faith.

Outlines of English Literature—Gilman, - - - 1 00

Gives, within the compass of two hundred pages, a suggestive outline sketch of the history of English Literature, grouping authors in accordance with the development of the language and literature.

PERIODICALS.

The International Review, - - - - - - $5 00

As its title indicates, presents "the ripest and best thought of the age" in all countries. Its contributors are the leading thinkers and writers of both Continents Published monthly, $5.00 per year. Bound volumes for 1874 and succeeding years, each, $6.00.

Magazine of American History, - - - 5 00

For the collection and preservation of all material relating to our country. Edited by John Austin Stevens, Librarian of the New York Historical Society. Monthly $5.00 per year.