OPEN EDUCATION RESOURCE:

ENVIRONMENTAL ENGINEERING

LABORATORY MANUAL

Work done as part of AICTE approved FDP on Use of ICT in Education for Online and Blended Learning

RC1278 (S.D.M.I.T. Ujire , Karnataka) _Team 03

Dr. Shanthala B

Mr. Jagadisha

Mr. Mithesh Kumar

GOVERNMENT ENGINEERING COLLEGE , KARWAR

Affiliated to Visvesvaraya Technological University, Belgum

Approved by AICTE New Delhi & Govt of Karnataka

Department: Civil Engineering			
LABORATORY MANUAL			
A. OVERVIEW			
Semester :	VII semester	*Academic Year:*	**2016-17**
Laboratory Title:	Environmental Engineering	*Laboratory Code:*	10CVL77
Total Contact Hours:	42	*Duration of SEE:*	**03 Hours**
IA Marks:	**25 Marks**	*SEE Marks:*	**50 Marks**
Lab Manual Author:	Dr. Shanthala B Prof. Mithesh Kumar Prof. Jagadisha		

B. LABORATORYOBJECTIVES

This Laboratory experiments cover the examination of waters of a wide range of quality, including water suitable for domestic or industrial supplies, surface water, and ground water, treated or untreated municipal or industrial water.

- Discussion after each experiment should be based on the following points:
    - ✓ Limit prescribed for that constituent in drinking water standards.
    - ✓ The suitability of the sample for drinking purpose with respect to that particular constituent.
    - ✓ Able to explain possible causes of water pollution &its purification method.

C. DESCRIPTION

1. LEARNING OBJECTIVES:
    - Understand the importance of quality of water.
    - Learn to analyze different parameters of water and wastewater.
    - Check the suitability of water for different usages.
    - Compare the results with IS codes and CPCB standards.

2. LEARNING OUTCOMES:
    - Students can analyze the different parameters of water and can compare with different codes.
    - Procedures to analyze the different parameters.
    - Understand the overall analysis of water and wastewater.

3. PREREQUISITES:
    - Water and waste water parameters

4. BASE COURSE:
    - Civil Engineering
    - Water and waste water analysis

5. INTRODUCTION:
   Concurrent with the evaluation of environmental engineering practice, analytical methods have been developed to obtain the factual information required for the resolution and solution of problems. Environmental engineering is perhaps most demanding in this respect, for it requires the use of not only the conventional measuring devices employed by engineers but, in addition many of the techniques and methods of measurement used by chemists, physicists and some of those.

6. RESOURSES REQUIRED
    - "Standard Methods for the Examination of Water and Waste Water", American.
    - "Manual of Water and Wastewater Analysis" – NEERI Publication.
    - Chemicals, glass wears, instruments, indicators, reagents.

7. GENERAL INSTRUCTIONS:

- **SAFE LABORATORY PROCEDURES**

GENERAL RULES

✓ Eye contact: Promptly flush eyes with water for a prolonged period (minimum of 15 min.) and seek immediate medical attention.

✓ Ingestion: Drink large amounts of water.

✓ Skin Contact: Promptly flush the affected area with water for approximately 15 min. and remove any contaminated clothing. If symptoms persist after washing, seek medical attention.

✓ Clean up: Promptly clean up spills, using appropriate apparel and equipment and proper disposal procedures.

✓ Working alone: AVOID WORKING ALONE. Do not work alone in a laboratory if the procedures to be conducted are hazardous.

✓ Avoid unnecessary exposure to chemicals.

✓ Do not smell or taste chemicals.

✓ **DO NOT EAT, DRINK, SMOKE, AND CHEW GUM OR APPLY COSMETICS IN THE LABORATORY.**

✓ **ALWAYS WASH HANDS BEFORE INHALING ANYTHING.**

✓ Wash areas of exposed skin well before leaving the laboratory.

✓ AVOID PRACTICAL JOKES or other behavior that might confuse, startle or distract another worker.

✓ Do not use mouth suction for pipetting or starting a siphon.

✓ Confine long hair and loose clothing. Wear shoes all the time but do not wear sandals or perforated shoes in the laboratory.

✓ Do not discharge any of the following into sewers: Concentrated Acids or bases, highly toxic and malodorous substances, substances that may cause fire hazards, explosions, structural damage or obstruct flow.

- **REFERENCES**

- "Chemistry for Environmental Engineers", Sawyer and McCarty, Tata Mc-Graw Hill.
- "International Standards for Drinking Water" — World Health Organisation.
- "IS 2490 - 1981, IS 3306 - 1974, IS 3307 - 1977, IS 7968 - 1976, IS 2296 – 1974", Bureau of Indian Standards, New Delhi.
- "Manual of Standards of Quality for Drinking Water Supplies", Indian Council of Medical Research, New Delhi.
- Garg, S.K. Environmental Engineering Vol. I, New Delhi; Khanna Publishers.
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- Gopalan. R, Amirtha Anand, Wilgred Sugumar, R (2003). A Laboratory Manual in Environmental Chemistry, New Delhi: IK International Pvt. Ltd.
- **http://nitttrc.ac.in/index.php?option=com_content&view=article&id=141&Itemid=142 dated 05/07/2016.**
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- Modi, P.N. Environmental Engineering Vol. I . New Delhi: Standard Book House.
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- Public Health Association, 1015, 15th Street, N.W., Washington D.C., 2005.
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	Evaluation Scheme			
	1. Laboratory Activities – **30%.** 2. Moodle Activities - **40** %. 3. Internal Exam at the end of semester – **30%.**			

LIST OF ABBREVIATIONS AND CHEMICAL FORMULAE

LIST OF ABBREVIATIONS			CHEMICAL FORMULAE	
BOD	Biochemical Oxygen Demand		$AgNO_3$	Silver Nitrate
BP	Bleaching Powder		K_2CrO_4	Potassium Chromate
BR	Burette Reading		$NaCl$	Sodium Chloride
COD	Chemical Oxygen Demand		Cl	Chloride
DO	Dissolved Oxygen		H_2SO_4	Sulfuric Acid
DW	Distilled Water		$NaOH$	Sodium Hydroxide
DS	Double Strength		$CaSO_4$	Calcium Sulfate
EDTA	Ethylene DiamineTetraacetic Acid		$MgSO_4$	Magnesium Sulfate
FAS	Ferrous Ammonium Sulfate		HCI	Hydrochloric Acid
LPG	Liquefied Petroleum Gas		Na_2SO_4	Sodium Sulfate
MBAS	Methylene Blue Active Substances		CO_2	Carbon Dioxide
μS	micro Siemen		$Na_2S_2O_3$	SodiumThiosulfate
μg	Microgram		$CaCO_3$	Calcium Carbonate
ml	milli liter		$MnSO_4.XH_2O$	Manganese Sulfate
mS	milli Siemen		MnO_2	Manganese Oxide
mg	Milligrams		H_2O	Water
mg/L	milligrams per Liter		$Mn(OH)_2$	Manganese Hydroxide
M	Molarity		$CaCI_2$	Calcium Chloride
MPN	Most Probable Number		$FeCl_3$	Ferric Chloride
nm	Nanometer		$K_2Cr_2O_7$	Potassium Dichromate
NTU	Nephelometric Turbidity Unit		Ag_2SO_4	Silver Sulfate
N	Normality		$Fe (NH_4)_2 SO_4$	Ferrous Ammonium Sulfate
NBP	Normality of Bleaching Powder		CH_3COOH	Acetic Acid
ppm	parts per million		Kl	Potassium Iodide
PAH	Polynuclear Aromatic Hydrocarbons		$NH_2OH.HCl$	Hydroxyl Amine
Qty	Quantity		$NH_4C_2H_3O_2$	Ammonium Acetate
rpm	revolutions per minute		$C_{12}H_8N_2.H_2O$	Phenanthroline Monohydrate
S	Siemen		$NaC_2H_3O_2.H_2O$	Sodium Acetate
SS	Single Strength		$ZrOCl_2.8H_2O$	Zirconyl Chloride Octahydrate
TDS	Total Dissolved Solids		Na	Sodium
UVV	UltraViolet- Visible		K	Potassium
VBP	Volume of Bleaching Powder		HNO_3	Nitric Acid
Wt	Weight		NO_3	Nitrate

CONVERSION FACTORS

Mass

1 Ton (metric)	=	1000 Kilograms (kg)
1 Kg	=	1000 Grams (gm)
I Gram	=	1000 Milli Grams (mg)
1 Milli gram	=	1000 Micro Grams (g)
1 Pound	=	0.45359 Kilograms

Area

1 Square Foot	=	929.0304 Square Centimeters
	=	0.09290304 Square Meters
1 Square Inch	=	6.4516 Square Centimeters
1 Square Yard	=	0.836127 Square Meters
1 Acre	=	100 Cent
1 Cent	=	435.60 Square Feet, 40.46 Square Meters

Volume

1 Cubic Foot	=	28,316.85 Cubic Centimeters
	=	0.02831685 Cubic Meters
	=	28.31685 Liters
1 Gallon	=	3.785 Liters [U.S.A] & 4.546 Liters [British]

Time

1 Hour	=	60 Minutes
	=	3600 Seconds

Temperature

1 Centigrade or Celsius Degree	=	1.8 Fahrenheit Degree
Temperature, Kelvin	=	$T°C + 273.15$
Temperature, Fahrenheit	=	$9/5 \ T°C + 32$
Temperature, Centigrade or Celsius	=	$5/9 \ (T°F - 32)$

Force

1 Pound Force	=	4.448222 Newtons
	=	32.174 Poundals

Pressure

Normal atmospheric pressure 1 Atm	=	760 Millimeter of Mercury (Hg) at 0°C

SAMPLING TECHNIQUES

Water sample for analysis should be collected in such a manner that the sample truly represents the water source or the main body of water or waste water.

Types of sampling:
- Grab or random sampling.
- Composite or pooled sampling.

- **Grab or random sampling:** Mainly collected manually from pipes, reservoirs, rivers, streams or drains at a single spot or multiple spots at different depths and analyzed separately. Each sample provides data on quality at the time of collection of sample but cannot represent average conditions. However, grab samples are useful in determining the effects of extreme conditions of the water or wastewater during the time samples are being collected or when the water or wastewater flow is intermittent. Grab samples should never use as a basis for design parameter of any treatment plant.

- **Composite or pooled sampling:** Composite samples are essentially weighted series of grab samples, the volume of each being proportional to the rate of flow of water or wastewater at the time and site of sample collection. Composite or pooled samples can be manually prepared by mixing single grab samples obtained from an automatic sampler according to times or quantities. Such samples enable conclusions to be drawn about the water/wastewater quality over longer periods.

  However in most cases, peak concentrations cannot be identified in such composite sampling.
  - In designing of water treatment plant or sewage treatment plant composite sampling has to be taken for analysis.
  - Sample containers for bacteriological examinations must be of glass and sterilized before use by heating for some time at 180°C together with their stoppers.
  - The samples should be tested in lab within 24 hours from the time of collection.
  - If the sample analyzing time exceeds 24 hours then they have to be preserved at 4°C and the analysis has to be done within 48 hours (Even cooling).
  - A sample volume between 2 — 3 liters is normally sufficient for a fairly complete analysis.

WATER SAMPLING FROM DIFFERENT SOURCES:

A water analysis is often essential before water is used for stock, domestic, or irrigation purposes. Chemical or biological composition can adversely affect crops, soils, humans, animals, or equipment.

Having an analysis carried out is not as simple as filling a bottle and giving it to an analyst. The accuracy of a water analysis is very much dependent on the sampling method used and the time elapsed between sampling and analysis.

☞ **Collecting the sample:**

The most suitable bottles to use are made from polyethylene or glass and should hold one liter. Soft drink, milk or chemical containers are not acceptable because residues likely to remain in them, even if they have been washed out.

The bottle should be cleaned prior to sampling by rinsing the bottle three times in the water to be sampled (except in the case of sterile bottles used for bacteriological sampling). The bottle should be filled to the top with as little air as possible remaining, and sealed tightly.

All samples should be properly labeled with details of the source, date of sampling, your name and address and the intended use of the water.

☞ **Surface water samples:**

For flowing water the sample should be collected from mid-stream and mid-depth. This should ensure that the sample is representative of the entire flow in a stream or channel. A note should be made of the condition of flow in the stream (volume and/or velocity of flow etc.) as this often influences the quality of water at different times of the year.

For still waters such as lakes, reservoirs and dams, samples should be taken away from the water's edge and at a depth that represents normal pumping depth.

Stratification (i.e. thermal and chemical layering of the body of water due to seasonal changes and chemical content) can significantly affect results.

☞ **Groundwater samples:**

When sampling water from bores and wells, the first step is to remove the 'stale' water that lies inside the casing. It may not be representative of the water from the aquifer. It is usual to remove about three times the volume of the well storage. Take note of the pumping rate, the water level and the time of sampling after pumping has started.

  ✓ Some bores may draw water from several aquifers.
  ✓ Should samples from different depths be required, specific techniques must be used.
  ✓ You should refer to your water analyst for these techniques.

☞ **Bacteriological content:**

A sample for bacteriological analysis should be collected in a sterile container supplied by the analytical laboratory.

A minimum volume of 200 ml is required. The sample should be placed in cold storage immediately. These samples should ideally be analyzed within 6 hours, but certainly no longer than 24 hours after collection.

EQUIVALENT WEIGHTS OF COMPOUNDS

As Equivalent weights are assigned for elements, it is possible to assign equivalent weights for compounds also. But the value of equivalent weights of a compound depends upon whether the compound acts like an acid, as a base, as an oxidizing agent or as a reducing agent in the reaction.

1. Equivalent Weight for an acid:

Basicity of an acid - The number of replaceable hydrogen (W) atoms present in one molecule of an acid is called basicity of an acid.

For example:

Monobasic acids - I molecule of HCI (Hydrochloric acid) contains I replaceable hydrogen atom.

Similarly HNO_3 (Nitric acid)

CH_3COOH (Acetic acid)

H-COOH   (Formic acid) etc.

Dibasic acids - 1 molecule of H_2SO_4 (Sulfuric acid), $H_2C_2O_4$ (Oxalic acid) etc contain two replaceable hydrogen atoms (H2). They are dibasic acids.

Tribasic acids - I molecule of H_3PO_4 (Ortho phosphoric acid) has three replaceable hydrogen atoms (H34). They are tribasic acids.

Therefore, Equivalent Weight for an acid $= \dfrac{\text{Molecular weight}}{\text{Basicity of an acid}}$

Name of the Acid	Molecular Formula	Molecular Weight	Basicity	Equivalent weight
Hydrochloric acid	HCl	1 + 35.5 = 36.5	1	36.5/1 = 36.5
Nitric acid	HNO_3	1 + 14 + 48 = 63	1	63/1 = 63
Sulfuric acid	H_2SO_4	2 + 32 + 64 = 98	2	98/2 = 49
Oxalic acid	$H_2C_2O_4$	2 + 24 + 64 = 90	2	90/2 = 45
Orthophosphoric acid	H_3PO_4	3 + 31 + 64 = 98	3	98/3 = 33.6

2. Equivalent Weight for a Base:

Acidity of a Base — The number of replaceable hydroxyl (OH) groups present in one molecule of the base is called acidity of the base.

For NaOH, KOH, NH_4OH etc,   Acidity = 1 [Mono acidic bases]

For $Ca(OH)_2$, $Ba(OH)_2$, $Mg(OH)_2$ etc   Acidity = 2 [Di acidic bases]

For Al $(OH)_3$ Acidity = 3 [Tri acidic bases]

Equivalent weight of a base is that weight which neutralizes one equivalent weight of an acid.

Therefore, Equivalent Weight of a base $= \dfrac{\text{Molecular weight}}{\text{Acidity of a base}}$

Name of the Base	Molecular Formula	Molecular Weight	Acidity	Equivalent weight
Sodium hydroxide	NaOH	23+ 16+1 =40	1	40/1=40
Potassium hydroxide	KOH	39+16+1 = 56	1	56/1=56

Calcium hydroxide	$Ca(OH)_2$	40+(2X17) = 74	2	74/2=37
Barium Hydroxide	$Ba(OH)_2$	137+(2X17)=171	2	171/2=85.5
Aluminium hydroxide	$Al(OH)_3$	27+(3X17) = 78	3	78/3=26

3. Equivalent Weight for Salts:

A salt is a compound formed by the action of an acid on a base. In the case of a salt, which is neither an oxidizing agent nor a reducing agent, the equivalent weight is calculated from following relation,

Equivalent weight for a salt = Molecular weight I Total Number of charges on the cation.

For example:

i) Sodium carbonate

$$Na_2CO_3 \rightarrow \quad 2Na^+ \quad + \quad CO_3^{--}$$
$$\text{(Cation)} \qquad \text{(Anion)}$$

Total charge = 2(Na) = 2 x 1 = 2

Equivalent Weight of Na_2CO_3 = $\dfrac{\text{Molecular weight}}{2}$ = $\dfrac{46+12+48}{2}$ = 53

ii) Silver Nitrate

$$AgNO_3 \rightarrow \quad Ag^+ \quad + \quad NO_3^-$$
$$\text{(Cation)} \qquad \text{(Anion)}$$

Equivalent Weight of $AgNO_3$ = $\dfrac{\text{Molecular weight}}{1}$ = $\dfrac{107+14+48}{1}$ = 169

iii) Calcium phosphate – $Ca_3(PO_4)_2$

$$Ca_3(PO_4)_2 \rightarrow 3Ca^{++} \quad + \quad 2PO_4^{---}$$

Total charge $3(Ca^{++})$ = 3 x 2 = 6

Therefore Equivalent Weight of $Ca_3(PO_4)_2$ = $\dfrac{\text{Molecular weight}}{6}$ $\dfrac{310}{6}$

$$= 51.7$$

4. Equivalent Weight for an Oxidizing agent:

Equivalent weight for an oxidizing agent is that weight which contains one equivalent weight of available oxygen for oxidation.

For Example:

i) Equivalent weight of Potassium permanganate in acid mediumreaction of KMnO4 as an oxidizing agent in acid medium can be represented by the equation.

$$2KMNO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$
$$\qquad\qquad\qquad\qquad\qquad 5 \text{ x } 16 = 80 \text{ parts}$$
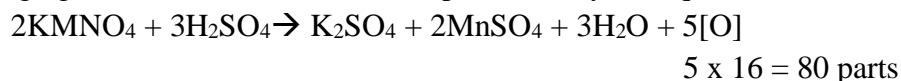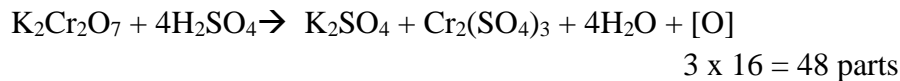
80 parts of available oxygen = 2 (molecular weight of $KMnO_4$)

8 parts (1 equivalent) of oxygen = 2 x 8 / 80 = 1/5 of molecular weight

Therefore, Equivalent Weight of $KMnO_4$ = $\dfrac{\text{Molecular weight}}{}$

$$= \dfrac{39+55+(4x16)}{5}$$

$$= 158/5 = 31.6$$

ii) Equivalent weight of Potassium dichromate in acid medium.

The reaction of $K_2Cr_2O_7$ in acid medium can be represented by the equation.

$$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + [O]$$

$$3 \times 16 = 48 \text{ parts}$$

8 parts (1 equivalent) oxygen = 1 molecular weight of $K_2Cr_2O_7$

8 parts (1 equivalent) oxygen = 1 x 8/48 = 1/6 of molecular weight of $K_2Cr_2O_7$

Therefore, Equivalent Weight of $K_2Cr_2O_7$ = $\dfrac{\text{Molecular weight}}{6}$ = $\dfrac{(2 \times 39) + 2(52) + 7(16)}{6}$

$$= 49$$

5. Equivalent Weight of a Reducing agent:

Equivalent weight of a reducing agent is that weight which reacts with one equivalent weight of any oxidizing agent.

For Example:

i) Equivalent weight of Ferrous sulfate

Consider the reaction: $2FeSO_4 + H_2SO_4 + [O] \rightarrow Fe_2(SO_4)_3 + H_2O$
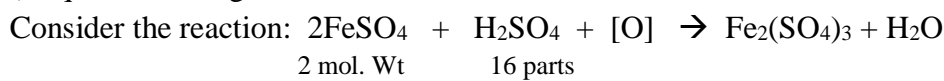
2 mol. Wt   16 parts

16 parts of oxygen = 2 molecular weight of $FeSO_4$

8 parts (1 equivalent) =   = 1

Equivalent weight of $FeSO_4$ = Molecular weight of $FeSO_4$ = 56 +32+64 = 152

Similarly for Ferrous ammonium sulfate (Mohr's salt): $FeSO_4 (NH_4) SO_4.6H_2O$

Equivalent weight = $\dfrac{2 \times 8}{16 \text{ mol. Wt. of } FeSO_4}$

Molecular weight for Mohr's salt = 392

☞ **NORMALITY (N):** The number of gram equivalent weight of substance dissolved in 1 liter of distilled water is called Normality (i.e., I Normal solution).

For Example: The gram equivalent weight of HCI is 36.5 grams. So, if 36.5 grams of HCl is added to 1 liter of water, it gives a solution of 1N.

Similarly for oxalic acid = 90 / 2 = 45 grams in 01 liter of water, it gives a solution of 1N.

➢ **MOLARITY (M):** The number of gram molecular weight of the substance dissolved in 1 liter of distilled water is called Molarity (i.e., 1 Molar solution).

For Example: The gram molecular weight of oxalic acid is 90 grams. If 90 grams of Oxalic acid is dissolved in 1 liter of water it is called I molar solution. (1 M)

☞ **MOLALITY :** The number of gram moles of substance dissolved in 1 Kg (1000 grams) of the solvent.

For Example: If 40 grams of NaOH (Molecular weight = 40) of Sodium hydroxide is dissolved in 1 Kg of water, the molality of the solution is 1.

NOTE: For dilute aqueous solution of water, Molarity of the solution is nearly equal to Molality.

❖ **gm/L = ppt = parts per thousand (10^3)**

❖ **mg/L = ppm = parts per million (10^6)**

❖ **μg/L = ppb = parts per billion (10^9)**

BUREAU OF INDIAN STANDARDS (BIS) SPECIFICATION FOR DRINKING WATER (BIS: 10500 — 1991)

Characteristic or Parameter	DL	Undesirable effect outside the Desirable Limit	PL
Color, Hazen units, max	05	Above 05 consumer acceptance decreases.	25
Odor (TON)	Un-objectionable	-	-
Taste	Agreeable	-	-
Turbidity, NTU, max	05	Above 05, consumer acceptance decreases	10
pH value	6.5 - 8.5	Beyond this range the water will affect the mucous membrane and I or water supply system.	No relaxation
Total hardness (as CaCO$_3$) mg/L, max	300	Encrustation in water supply structure and adverse affect on domestic uses	600
Iron (as Fe) mg/L, max	0.3	Beyond this limit taste I appearances are affected, has adverse affect on domestic uses and water supply structures, and promotes iron Bacteria.	1.0
Chlorides (as Cl) mg/L, max	250	Beyond this limit, taste, corrosion and palatability are affected.	1000
Residual, free chlorine, mg/L, mm	0.2	-	-
Total Dissolved Solids (TDS) mg/L, max	500	Beyond this palatability decreases and may cause gastro intestinal irritation	2000
Calcium (as Ca) mg/L, max	75	Encrustation in water supply structure and adverse effects on domestic use	200
Manganese (as Mn) mg/L, max	0.1	Beyond this limit taste / appearances are affected, has adverse affect on domestic uses and water supply structures	0.3
Sulfate (as SO$_4$) mg/L, max	200	Beyond this causes gastro intestinal irritation When magnesium or sodium are present	400
Nitrate (as NO$_3$) mg/L, max	45	Beyond this Mathemoglobinemia (blue baby disease) takes place in infants	100
Fluoride, (as F) mg/L, max	1.0	Fluoride may be kept as low as possible. High fluoride may cause fluorosis	1.5
Phenotic compounds (as C$_5$H$_5$OH) mg/L, Max	0.001	Beyond this, it may cause objectionable taste and odor	0.002
Mercury (as Hg) mg/L, max	0.001	Beyond this, the water becomes toxic	No relaxation
Cadmium (as Cd) mg/L, max	0.01	Beyond this, the water becomes toxic	No relaxation
Selenium (as Se)	0.01	Beyond this, the water becomes toxic	No

			relaxation
mg/L, max			
Arsenic (as As) mg/L, max	0.05	Beyond this, the water becomes toxic	No relaxation
Cyanide (as CN),mg/L,max	0.05	Beyond this, the water becomes toxic	No relaxation
Lead (as Pb) mg/L,_max	0.05	Beyond this, the water becomes toxic	No relaxation
Zinc (as Zn) mg/L, Max	05	Beyond this limit it can cause astringent taste and an opalescence in water	15
Anionic detergents (as MBAS) mg/L, max	0.2	Beyond this limit it can cause a light froth in water	1.0
Polynuclear Aromatic Hydrocarbons (as PAH) mg/L, max	-	May be carcinogenic	-
Mineral oil, mg/L, Max	0.01	Beyond this limit undesirable taste and odor after chlorination takes place.	0.03
Pesticides, mg/L, max	Absent	Toxic	0.001
Radioactive materials: a) α (Alpha) emitters, Bq/L,max	-	-	0.1
b) β (Beta) emitters, pci/L,max	-	-	1
Alkalinity, mg/L, Max	200	Beyond this limit taste becomes unpleasant	600
Aluminium, (as Al), mg/L, max	0.03	Cumulative effect is reported to cause dementia	0.2
Boron, (as Bo), mg/L, max	01	-	05
Magnesium, (asMg), mg/L, max	30	Encrustation to water supply structure and adverse effects on domestic use.	100
Chromium (as0.05 Cr6) mg/L,Max	0.05	May be carcinogenic above this limit	No Relaxation
Copper (as Cu) mg/L, max	0.05	Astrigent taste, discolouration and corrosion of pipes, fittings and utensils will be caused beyond this.	1.5

  ✓ **DL**= Desirable Limit also known as Requirable limit.
  ✓ **PL** = Permissible Limit in absence of alternate source i.e., if the river dries up during summer season, the water demand has to be met by underground resources

TREATED EFFLUENT STANDARDS
GENERAL STANDARDS FOR DISCHARGE OF ENVIRONMENTAL POLLUTANTS: SEWAGE (AS PER CPCB, NEW DELHI)

Characteristics/ Parameter	STANDARDS			
	Inland surface water	Public Sewers	Land for Irrigation	Marine coastal areas
Color and odor	*	-	*	*
Suspended solids mg/L, max.	100	600	200	a) For process waste water- 100 b) For cooling water effluent 10% above total suspended matter of effluent
Particle sizes of Suspended solids	Shall pass 850 micron IS sieve	-	-	a) Floatable solids, Max. 3mm size b) Settelable solids, max, 850 microns
pH value	5.5 - 9.0	5.5 - 9.0	5.5 - 9.0	5.5 - 9.0
Temperature in °C	Shall not exceed 5° C above the receiving water Temp	-	-	Shall not exceed 5° C above the receiving water Temp
Oil and grease, mg/L, max.	10	20	10	20
Total residual chlorine, mg/L, max	1.0	-	-	1.0

* = All efforts should be made to remove color & odor as far as practicable.

Note: Inland surface water - Streams, Rivers, Ponds, Lakes etc.
Marine coastal areas — into sea or ocean.

Characteristics/ Parameter	STANDARDS			
	Inland surface water	Public Sewers	Land for Irrigation	Marine coastal areas
Free ammonia as (NH3) mg/L, max	5.0	-	-	5.0
Biochemical Oxygen Demand, mg/L max. (BOD_5 or BOD_3)	30	350	100	100
Chemical Oxygen Demand (COD) mg/L	250	-	-	250

Arsenic (as As), mg/L, max	0.2	0.2	0.2	0.2
Mercury (as Hg) mg/L, max	0.01	0.01	-	0.01
Lead (as Pb) mg/L, max	0.1	1.0	-	2.0
Calcium (as Ca) mg/L, max	2.0	1.0	-	2.0
Hexavalent Chromium s Cr) mg/L, max	0.1	2.0	-	1.0
Total Chromium (as Cr) mg/L,max	2.0	2.0	-	2.0
Copper (as Cu) mg/L, max	3.0	3.0	-	3.0
Zinc (as Zn) mg/L, max	5.0	15	-	15
Selenium (as Se) mg/L, max	0.05	0.05	-	0.05
Nickel (as Ni) mg/L, max	3.0	3.0	-	5.0
Dissolved Phosphate (as P) mg/L, max	5.0	-	-	-
Manganese (as Mn) mg/L	02	02	-	02
Iron (as Fe) mg/L	03	03	-	03
Sulfide (as S) mg/L, max	2.0	-	-	5.0
Cyanide (as CN) mg/L, max	0.2	2.0	0.2	0.2
Fluoride (as F) mg/L, max	2.0	15	-	15
Vanadium (as V) mg/L	0.2	0.2	-	0.2
Nitrate Nitrogen mg/L	10	-	-	20
Ammonical nitrogen (as N), mg/L, max.	50	50	-	50
Total kjeldhal nitrogen [N], mg/L, max	100	-	-	100
Radioactive materials: a) Alpha emitters α [micron curie/mL] max b)	10^{-7}	10^{-7}	10^{-8}	10^{-7}
Beta emitters β [micro curie/mL] max	10^{-6}	10^{-6}	10^{-7}	10^{-6}

Source:SathpalPuliani& B. Shivalingaiah, "The Environment Protection and Pollution Control Manuar Karnataka Law Journal publications, 2000 Edition, Law publishers, Bangalore.

CPCB: Central Pollution Control Board. New Delhi.

EXPERIMENT NO:	Date Conducted	Marks
1		

- **TITLE**: **ALKALINITY TEST** (By Titrimetric Method)

- **LEARNING OBJECTIVES:**
  - Understand the concept of alkalinity.
  - Methodology to determine alkalinity.
  - IS values.

- **AIM:** To determine the Phenolphthalein Alkalinity and Methyl Orange Alkalinity or Total Alkalinity of a given sample of water.

- **METHODOLOGY:** The sample is titrated against Standard Acid using Phenolphthalein and Methyl Orange indicator (Using Titration).

- **APPARATUS:**
  - 250ml cap. Conical Flask.
  - 250ml cap. Beaker.
  - 50ml Burette.
  - 25ml Pipette.

- **REAGENTS USED:**
  - Standard Sulphuric Acid of 0.02N(H_2SO_4).
  - Phenolphthalein Indicator.
  - Methyl Orange Indicator.
  - 0.1N Sodium Thiosulphate ($Na_2S_2O_3.5H_2O$).
  - CO_2 Free Distilled Water.

- **THEORY:**

  Alkalinity is a measure of ability of water to neutralize acids [acid neutralizing capacity - ANC]. The major portion of alkalinity in natural waters is caused by bicarbonates (HCO_3), carbonates (CO_3) and hydroxides (OH) of calcium (Cat) and magnesium (Mg). However, when water becomes too alkaline, it may taste like soda and could have a drying effect on the skin. Moreover, it becomes "hard." Carbonate rocks, such as limestone, are the main sources to turning water alkaline. In the pH scale from zero to 4.2 there will be no alkalinity, from 4.2 to 8.2 alkalinity is due to bicarbonates (HCO), from 8.2 to 11 alkalinity is due to carbonates (CO_3) and hydroxides (OH) and the maximum alkalinity in the range of 11 to 14 will be due to hydroxides (OH). Highly alkaline waters affect the boilers by forming scales on the inner surface. The alkalinity of water has little public health significance. Highly alkaline waters are usually unpalatable because of bitter taste and the consumers tend to seek other supplies. As per BIS: 10500-1991 the desirable limit for alkalinity is less than 200 mgIL, beyond this the water becomes bitter in taste affecting its taste or palatability. Excess alkalinity in water is harmful to irrigation, which leads to soil damage, and reduce crop yield due to reduced fertility. For RCC works alkalinity should be less than 250 mgIL. But when water (especially drinking water) becomes too alkaline, treatments, such as reverse osmosis, distillation and deionization, are used to remove excessive amounts of minerals to reduce alkalinity.

✓ **OBSERVATION:**

1. Conical Flask : 25ml of Water sample.
2. Burette : 0.02N Sulphuric Acid (H_2SO_4).
3. Indicators : Phenolphthalein and Methyl Orange.
4. End Point : a) Pink to Colourless.
   b) Yellow to Faint Orange .

TABULAR COLUMN:

Sl. No.	Sample Used	Indicator Used	Burette Reading			Volume of 0.02N H_2SO_4 used
			FR	IR	(FR – IR)	
A.	Water Sample Supplied in Lab	Phenolphthalein				V_1=.....................ml
B.	Water Sample Supplied in Lab	Methyl Orange				V_2=.....................ml

✓ **CALCULATIONS:**

A. **Phenolphthalein Alkalinity as CaCO3(mg/l)**

$$= \frac{V_1 \text{ x N x 50 x 1000}}{\text{ml of sample used}} \text{ mg/l}$$

=

=

B. **Methyl Orange Alkalinity as CaCO3(mg/l)**

$$= \frac{V_2 \text{ x N x 50 x 1000}}{\text{ml of sample used}} \text{ mg/l}$$

=

=

✓ **PROCEDURE:**

A. Phenolphthalein Alkalinity
1. Pipette out 25ml of given sample of water into a 250ml conical flask.
2. Add 1 drop of 0.1N Sodium thiosulphate solution to remove free Residual Chlorine, if present.
3. Add 2 to 3 drops of Phenolphthalein indicator.
4. If the sample turns to Pink colour, then titrate with 0.02N Standard H_2SO_4, till the Pink colour just disappear.
5. The end point is Pink colour to Colourless.
6. Note down the volume of Acid is used (V_1).
7. If the pink colourdoes not exists, indicates that, Phenolphthalein alkalinity is absent. Then continue the titration with Methyl Orange indicator.

B. Total Alkalinity or Methyl Orange Alkalinity
1. Add 2 to 3 drops of Methyl Orange indicator to the sample.
2. If the solution turns yellow, continue the titration with 0.02N standard H_2SO_4 till the solution turns yellow to Faint orange colour.
3. Note down the total volume of acid used (V_2).

Alkalinity Relationship (P & T)

The values obtained from Phenolphthalein and Total alkalinity determination for a given sample of water are used to estimate three forms of alkalinity shown below.

Results of Titration	Hydroxide alkalinity / Caustic alkalinity as $CaCO_3$ (OH)	Carbonate alkalinity as CO_3	Bicarbonate alkalinity as HCO_3
P = 0	0	0	T
P <½ T	0	2P	T – 2P
P = ½ T	0	2P	0
P >½ T	2P – T	2 (T – P)	0
P = 1	T	0	0

Where,　　P = Phenolphthalein alkalinity
　　　　　　T = Total alkalinity

C. <u>Total Alkalinity as CaCO₃(mg/l)</u>

$$= (A+B) = \text{.........................} \text{ mg/l}$$

or

$$= \frac{(V_1 + V_2) \text{ x N x 50 x 1000}}{\text{ml of sample used}} \text{mg/l}$$

$$=$$

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	Phenolphthalein alkalinity as$CaCO_3$	…………….. mg/l
2.	Methyl Orange alkalinity as $CaCO_3$	…………….. mg/l
3.	Total alkalinity as $CaCO_3$	…………….. mg/l
4.	Hydroxide alkalinity as $CaCO_3$	…………….. mg/l
5.	Carbonate alkalinityas$CaCO_3$	…………….. mg/l
6.	Bicarbonate alkalinity as $CaCO_3$	…………….. mg/l

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

✓ **OBSERVATION:**

1. Conical Flask : 25ml of water sample.
2. Burette : 0.02N NaOH.
3. Indicator : Phenolphthalein and Methyl Orange.
4. End Point : a) Yellow to Faint Orange.
   b) Colourless to Faint Pink Colour.

✓ **TABULAR COLUMN:**

Sl. No.	Sample Used	Indicator Used	Burette Reading			Volume of 0.02N NaOH used
			FR	IR	(FR – IR)	
A.	Water Sample Supplied in Lab	Methyl Orange				V_1=.....................ml
B.	Water Sample Supplied in Lab	Phenolphthalein				V_2=.....................ml

✓ **CALCULATION:**

A. **Methyl Orange Acidity as CaCO₃ in mg/l**

$$= \frac{V_1 \text{ x N x 50 x 1000}}{\text{ml of sample used}} \text{ mg/l}$$

$$=$$

$$=$$

EXPERIMENT NO:	Date Conducted	Marks
2		

- ✓ **TITLE**: **ACIDITY TEST** (By Titrimetric Method)

- ✓ **LEARNING OBJECTIVES:**
  - Understand the concept of Acidity.
  - Methodology to determine acidity.
  - IS values

- ✓ **AIM:** To determine the Methyl Acidity and Phenolphthalein or Total Acidity of a given sample of water.

- ✓ **METHODOLOGY:**
  The sample is titrated against Standard Alkalinity using Phenolphthalein and Methyl Orange Indicator.

- ✓ **APPARATUS:**

  1. 250ml cap. Conical Flask.
  2. 250ml cap. Beaker.
  3. 50ml Burette.
  4. 25ml Pipette.

- ✓ **REAGENTS USED:**

  1. 0.02N Standard NaOH Solution.
  2. Phenolphthalein Indicator.
  3. Methyl Orange Indicator.
  4. 0.1N Sodium thiosulphate ($Na_2S_2O_3.5H_2O$).
  5. CO_2Free Distilled Water.

- ✓ **THEORY:**
  Acidity of water is its quantitative capacity to neutralize a strong base to a designated pH. Acidity of water is significant in many water supply systems, because acidity influences certain chemical and biological process in water.

  Acidity of water is due to Hydrogen ions (H^+) present in a sample of water. As a result, dissociation of hydrolysis of solution is neutralized by titration with standard solution of strong base in the presence of an indicator. Dissolved Carbon Dioxide is usually the major acidic component of surface water sample. Acidity is usually determined by titration with 0.02N solution of Sodium hydroxide. The amount of Sodium hydroxide required for the sample to reach the pH 4.5 in a measure of mineral acidity and amount to reach pH 8.3 (Phenolphthalein end point) is a measure of total acidity.

  It is the measure of the ability of water to neutralize the bases HCO, CO_3 and OH. Carbon dioxide (CO_2) acidity is due to presence of free CO_2 in ground and surface waters. Mineral acidity is due to the presence of HCI, H_2SO_4, HNO_3 acids and strong organic acids like acetic acid and fumic acid mainly discharged from industries. It is expressed in terms of

B. Phenolphthalein Acidity or Total Acidity as CaCO₃ in mg/l

$$= \frac{V_2 \text{ x N x 50 x 1000}}{\text{ml of sample used}} \text{ mg/l}$$

$$=$$

$$=$$

$CaCO_3$ equivalent of the hydroxyl ions neutralized. Acid waters are of concern because of their corrosive nature and the expense involved in removing or controlling the corrosion producing substances. On the pH scale of 0 to 14, there will be maximum acidity from 0 (zero) to 4.2 due to mineral acids such as HCl, H_2SO_4, HNO_3, 4.2 to 8.2 the acidity is due to carbon dioxide and from 8.2 to 14 there will be no acidity. Major industries discharging acidic effluents are electroplating industries, fertilizer industry, distilleries, mining industries etc. There is no limit for acidity in drinking water as per BIS: 10500-1991, since it has no adverse effect on consumers. Only the taste becomes sour if the pH is less than 04. Acidity in water can be removed by neutralization with lime (CaO) or sodium hydroxide (NaOH). The permissible of total acidity, as $CaCO_3$ in water used for RCC works should be less than 50 mg/L because of its corrosive nature.

✓ **PROCEDURE:**

A. **Methyl Orange Acidity**

1. Pipette out 25ml of given sample of water into a 250ml conical flask.
2. Add 1 drop of 0.1N Sodium thiosulphate solution to remove the free residual chlorine if present.
3. Add 2 drops of Methyl Orange indicator. If solution turns to yellow, note down the pH value and stop the experiment. If the solution changes to faint red colour, titrate against 0.02N NaOH solution upto Faint orange colour.

> **NOTE:** If yellow color is directly observed instead of pink after the addition of methyl orange indicator then V1 has to be recorded as **ZERO** ml & it is an indication of **NIL mineral acidity**.

4. Note down the ml of titrant used (V_1).

B. **Phenolphthalein Acidity or Total Acidity**

1. Pipette out 25ml of given sample of water into a conical flask.
2. Add 1 drop of 0.1N standard $Na_2S_2O_3$ solution.
3. Add 2 or 3 drops of Phenolphthalein indicator.
4. If the sample turns to pink colour it means that, Phenolphthalein acidity is absent and stop the experiment.
5. If there is no colour, then titrate with 0.02N standard NaOH solution till faint pink colour appears. The end point is colourless to Faint pink colour.
6. Note down the ml of titrant used (V_2).

✓ **RESULTS:**

Sl. No.	Parameters Analyzed	Results
1.	Methyl Orange Acidity as $CaCO_3$	…………….. mg/l
2.	Phenolphthalein Acidity as $CaCO_3$ **or** Total Acidity as $CaCO_3$	…………….. mg/l

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
3		

✓ **TITLE:CHLORIDE TEST**(By Argentometric or Mohr's Titrimetric Method)

✓ **LEARNING OBJECTIVE:**
- Understand the effects of Chloride.
- Methodology to determine chloride.
- Compare the values with relevant Standards.

✓ **AIM:** To determine the amount of Chloride in a given sample of water.

✓ **METHODOLOGY**:

Mohr's method (Argentometric) the sample after neutralization is titrated with Silver Nitrate solution.

✓ **APPARATUS:**

1. 250ml cap. Conical flask.
2. 250ml cap. Beaker.
3. 50ml Burette.
4. 25ml Pipette.

✓ **REAGENTS USED:**

1. Chloride free Distilled water.
2. Standard Silver Nitrate solution ($AgNO_3$) of 0.0141N.
3. Potassium Chromate indicator (K_2CrO_4).

✓ **THEORY:**

Chloride in the form of Chlorine ion is one of the major inorganic anions. The salty taste produced by Chloride concentration is variable and dependent on the chemical composition of water.

The Chloride is higher in waste water than in raw water, because unchanged through digestive system. Along the sea coastal, Chloride may be present in high concentration, because of intrusion of salt water into the water and sewage system. The salty taste canalsobe acceptable in drinking water. Hence Chlorides are estimated from water supplies.

Some of the common chlorides include sodium chloride (Na^+Cl^-) and magnesium chloride ($MgCl_2$). Small amounts of chlorides are required for normal cell functions in plant and animal life. Chloride ion is essential to the electrolytic balance in our bodies. Chlorides are found in all natural waters at greatly varying concentration depending on the geochemical conditions. Chlorides concentration in water can be attributed to leaching of chloride containing rocks and soils, discharge of effluents from chemical industries, ice-cream plant effluents, edible oil mill operations, sewage disposal, irrigation drainage, contamination from refuse leachates and sea water intrusion in coastal regions. Man discharges 8 to 10 grams/day of NaCI through urine and excreta. Chlorides can only be removed by Reverse Osmosis process, evaporation & distillation method or electro dialysis method. Seawater has a chloride

✓ **OBSERVATION:**

1. Conical Flask : a) 25ml given sample of water
      b) 50ml of distilled water
2. Burette : Standard $AgNO_3$, Solution of 0.0141N
3. Indicator : Potassium Chromate Solution K_2CrO_4
4. End Point : Yellowish green to reddish brown

> 1000 ml of 1M $AgNO_3$ = 35.46 g C1

✓ **TABULAR COLUMN:**

Sl. No.	Sample Used	Indicator Used	Burette Reading			Volume of 0.0141N $AgNO_3$ used
			FR	**IR**	**(FR – IR)**	
A.	Given Water Sample	Potassium Chromate				V_1=....................ml
B.	Blank Test Distilled water	Potassium Chromate				V_2=....................ml

✓ **CALCULATION:**

Chloride as Cl in mg/l

$$= \frac{(V_1 - V_2) \text{ x N x } 35.45 \text{ x } 1000}{\text{ml of sample used}} \text{ mg/l}$$

$=$

content of 19,000 to 20,000 mg/L (3.5% salt). Chlorides in reasonable concentrations are not harmful to humans. At concentrations above 250 mg/L (as per BIS: 10500 - 1991) they give a salty taste to the water, which is objectionable to many people. Chlorides are not usually harmful to people; however, the sodium part of table salt has been linked to heart and kidney disease.

If water is used for irrigation then its chloride concentration should be less than 355 otherwise it causes soil salination and water logging reducing the fertility of soil, water, which is used in concrete making, must have chloride concentration less than 500 mg/L. High levels of chloride in a water system increase the rate of corrosion of metallic pipes.

In this method, slightly alkaline solution is used. Potassium chromate can indicate the end point is of silver nitrate titration of chloride is quantitatively precipitated before red silver chromate is formed.

$$NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$$
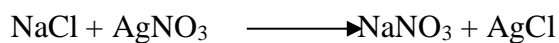
In this titration, Chloride ions precipitated as white.

$$Ag + Cl \longrightarrow AgCl$$
$$2Ag + 2CrO_4 \longrightarrow 2AgCrO_4$$
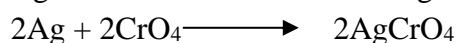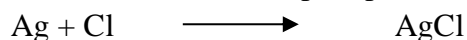
The pH must be in the range of 7 to 8 because Ag^+ is precipitated as Silver Hydroxide ($AgOH^-$) at high pH levels and CrO_4^{2-} is converted to $Cr_2O_4^{2-}$ at low pH levels.

✓ **PROCEDURE:**
   Part A (Sample Test)

1. Pipette out 25ml of given sample of water into a 250ml conical flask.
2. Adjust the pH using dilute acid or dilute alkali solution.
3. Add 2 to 3 drops of Potassium Chromate indicator. The colour of the solution turns to yellowish green.
4. Titrate against standard $AgNO_3$ solution of 0.0141N.
5. End point is yellowish green to Reddish Brown colour or Brick red colour.
6. Note down the volume of $AgNO_3$ used as V_1.

Part B (Blank Test)

1. Take 25ml of distilled water in a conical flask and repeat the procedure from steps in Part A from 2 to 5.
2. The blank showing the end points colour should be placed near the sample being titrate to acid in detection of colour change and note down the volume of titration used.

✓ **RESULTS**:

Sl. No.	Parameters Analysed	Results
1.	Chloride in water, as Cl	…………….. mg/l

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
4		

✓ TITLE:**HARDNESS TEST**(By EDTA Titrimetric Method)

✓ **LEARNING OBJECTIVE:**
- Understand the Causes of hardness.
- Methodology to determine hardness.
- Understand difference between temporary, permanent hardness.
- Compare the values with relevant Standards.

✓ **AIM:** To determine the Total Hardness, Carbonate Hardness and Non-Carbonate Hardness of a given sample of water.

✓ **METHODOLOGY:**

EDTA, Titrimetric Method.

✓ **APPARATUS:**

1. 250ml cap. Conical flask.
2. 250ml cap. Beaker.
3. 50ml Burette.
4. 25ml Pipette.

✓ **REAGENTS USED:**

1. Standard EDTA solution of 0.01M.(Ethylene Diamine Tetra Acetic acid is a Complex Reagent)
2. Ammonia Buffer solution.
3. Eriochrome Black -T indicator (EBT).

✓ **THEORY:**
Originally hardness of water is a measure of soap consuming capacity to produce a foam or lather. Also produce scale in hot water pipes, heaters, boilers and other units, precipitate chiefly by Calcium and Magnesium ions commonly present in water. Also may be precipitated by ions of other poly-valent metals such as, Aluminium, Iron, Manganese, Strontium, Zinc and by Hydrogen ions. Calcium and Magnesium ions are usually present in significant concentrations in natural water. Hardness of water varied considerably from place to place. Surface waters are softer than the ground water, due to the dissolved salts of Carbonates, Bicarbonates, Chlorides, Sulphate, Nitrates of Calcium and Magnesium. Temporary Hardness is mainly due to Carbonate and Bicarbonate of Calcium and Magnesium. Permanent Hardness is mainly due to Sulphate and Chlorides. The hardness of water is expressed as $CaCO_3$ in mg/l. If topsoil is thick and lime stone formations are present then it causes hard water. If topsoil is thin and granite rock formations are present then it causes soft water. Usually surface water is softer then ground water. Cat ions are responsible for more consumption of soap and an ion are responsible for formation of scales in boilers.

✓ **OBSERVATION:**
1. Conical Flask : 25ml of sample
2. Burette : Standard EDTA Solution of 0.01M
3. Indicator : Eriochrome Black T
4. End Point : Wine Red to Blue

✓ **TABULAR COLUMN:**

Sl. No.	Sample Used	Indicator Used	Burette Reading (ml)			Volume of EDTA used
			FR	IR	(FR – IR)	
A.	Raw water Supplied in Lab	Eriochrome Black-T				V_1=....................ml
B.	Boiled and Cool Water	Eriochrome Black-T				V_2=....................ml

✓ **CALCULATION:**

A. Total Hardness as CaCO$_3$ in mg/l

$$= \frac{V_1 \times B \times 1000}{ml\ of\ sample\ used}\ mg/l$$

Where, B=1, i.e. 1ml of EDTA Solution = 1mg of CaCO$_3$ = 0.01M EDTA.

B. Permanent Hardness as CaCO$_3$ in mg/l

$$= \frac{V_2 \times B \times 1000}{ml\ of\ sample\ used}\ mg/l$$

$$=$$

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MAJOR CAT IONS	MAJOR AN IONS
Calcium Ca^{++}	Bicarbonates HCO_3^-
Magnesium Mg^{++}	Carbonates CO_3^{--}
Strontium Sr^{++}	Sulfate SO_4^-
Iron Fe^{++}	Chlorides Cl^-
Manganese Mn^{++}	Hydroxides OH^-
Aluminium Al^{++}	Nitrates NO_3^-

EDTA compound or Sodium salt are soluble complex,when added to a solution of certain metallic cation. A small amount of dye Eriochrome Black-T is added to hard water containing Calcium and Magnesium ion. The solution will become Wine Red. EDTA is then added as a titrant. Calcium and Magnesium are complexed after sufficient EDTA has been added. The solution turns from Wine Red to Blue. This is the end point of titration; a pH value of 10.2 is usually maintained.

For regular public supplies hardness of water should be between 75 to 115 mg/L or ppm. Hard waters are undesirable because they consume more soap, forms scales on boilers and incrustation of pipes, it also makes food tasteless. Water samples are commonly classified in terms of the degree of hardness as follows:

Degree of hardness	Mg/L as $CaCO_3$
Soft	0-50
Moderately soft	50-100
Slightly hard	100-150
Moderately hard	150-200
Hard	200-300
Very hard	Above 300

✓ **PROCEDURE:**

A. Total Hardness
1. Pipette out 25ml given sample of water into a 250ml conical flask.
2. Add 0.5ml of Ammonia Buffer solution to maintain a pH 10 ± 0.2 and mix well.
3. Add a pinch of Eriochrome Black-T indicator powder. The colour of the solution turns to Wine Red.
4. Titrate immediately with standard EDTA solution by slowly mixing until the colour changes from Wine Red to blue.
5. Note down the ml of titrant used(V_1).

B. Permanent Hardness
    Take 100ml of water sample, boil and cool. Then take 25ml of water from this, in a conical flask. Follow the same procedure as in total hardness. Note down the volume of EDTA used (V_2).

C. Temporary Hardness

Temporary hardness is mainly due to Carbonate and Bicarbonate of Calcium and Magnesium. This can be determined using Total and Permanent Hardness values and is expressed as $CaCO_3$ in mg/l.

Temporary hardness as $CaCO_3$ in mg/l = (Total Hardness – Permanent Hardness)

D. Temporary Hardness as $CaCO_3$ in mg/l

Temporary Hardness as $CaCO_3$ in mg/l = (Total Hardness – Permanent Hardness)

$$= $$

$$= \underline{\hspace{3cm}} \text{ mg/l}$$

✓ **RESULTS:**

Sl. No.	Parameters Analyzed	Results
1.	Total Hardness, as $CaCO_3$	.... mg/l
2.	Permanent Hardness, as $CaCO_3$	.... mg/l
3.	Temporary Hardness, as$CaCO_3$	.... mg/l

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
5		

- ✓ **TITLE: CALCIUM AND MAGNESIUM TEST**

- ✓ **LEARNING OBJECTIVE:**
  - Understand the effects of Calcium, magnesium hardness.
  - Methodology to determine hardness.
  - Compare the values with relevant Standards.

- ✓ **AIM:** To determine the Calcium Hardness and Magnesium Hardness of a given sample of water.

- ✓ **METHODOLOGY:** Titration Method.

- ✓ **APPARATUS:**
  1. 250ml cap. Conical flask.
  2. 50ml Burette.
  3. 25ml Pipette.

- ✓ **REAGENTS USED:**

  1. Standard Sodium Hydroxide Solution of 2N.
  2. Murexide Indicator.
  3. Standard EDTA Solution of 0.01M.

- ✓ **THEORY:**

  Calcium and Magnesium are common constituents of natural water and important contributors to the hardness in water. Calcium and Magnesium content may range from zero to several hundred milligrams per litre, depending on source of water. These salts break down on heating to form harmful scale in boilers, pipes and cooking utensils. Small concentration of Calcium Carbonate forms corrosion in metallic pipes by laying down as a scale. Softening treatment methods like, Reverse Osmosis, Electro Dialysis or Iron Exchange, are used to reduce the levels of Calcium and Magnesium in water, and required for potable and industrial purpose.

  ☞ Permanent hardness or non-carbonate hardness is due to sulfates, chlorides and nitrates of calcium and magnesium. This hardness can be effectively removed by (1) Soda-lime process (2) Base exchange or Zeolite process and (3) Demineralization process. Using these 3 softening methods temporary as well as permanent hardness can be removed.

  As per BIS: 10500-1 991 for drinking water the limits are as given in table below:

Types of hardness as $CaCO_3$	Desirable limit	Permissible limit
Total hardness	≤ 300 mg/L	≤ 600 mg/L
Calcium Hardness	≤ 75 mg/L	≤ 200 mg/L
Magnesium Hardness	≤ 30 mg/L	≤ 100 mg/L

- ✓ **OBSERVATIONS:**

| Sl. No. | Sample Used | Indicator Used | Burette Reading | | | Volume of 0.01M EDTA used |
			FR	IR	(FR – IR)	
A	Water supplied in Lab	Eriochrome Black-T				V_1=.....................ml
B	Water supplied in Lab	Murexide Powder				V_2=.....................ml

✓ **CALCULATION:**

A. <u>**Total Hardness as CaCO$_3$ in mg/l**</u>

$$= \frac{V_1 \text{ x B x } 1000}{\text{ml of sample used}} \text{ mg/l}$$

$$=$$

$$=$$

B. <u>**Calcium Hardness as CaCO$_3$ in mg/l**</u>

$$= \frac{V_2 \text{ x B x } 1000}{\text{ml of sample used}} \text{ mg/l} \qquad\qquad \text{Where, B = 1.}$$

$$=$$

$$=$$

C. <u>**Calcium Hardness as Ca, in mg/l**</u>

$$= (0.40 \text{ x Calcium Hardness as CaCO}_3)$$

$$=$$

$$=$$

✓ **PROCEDURE:**

Part-A - (Total Hardness)

Determine the Total Hardness, for the given sample of water.

1. Pipette out 25ml given sample of water into a 250ml conical flask.
2. Add 0.5ml of Ammonia Buffer solution to maintain a pH 10 ± 0.2 and mix well.
3. Add a pinch of Eriochrome Black-T indicator powder. The colour of the solution turns to Wine Red.
4. Titrate immediately with standard EDTA solution by slowly mixing until the colour changes from Wine Red to blue.
5. Note down the ml of titrant used (V_1)

Part-B - (Calcium Analysis)

1. Pipette out 25ml of given sample of water in a 250ml conical flask.
2. Add 1ml of NaOH solution of 2N to raise pH value to about 12.0.
3. Add a pinch of Murexide indicator powder and colour changes to Pink.
4. Titrate immediately with EDTA solution till pink colour changes to purple and note down the volume of EDTA used (V_2 ml)
5. Run a reagent blank and keep it aside to compare the end point of sample titrations.

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	Total Hardness as $CaCO_3$	…………….. mg/l
2.	Calcium Hardness as $CaCO_3$	…………….. mg/l
3.	Calcium Hardness as Ca	…………….. mg/l
4.	MagnesiumHardness as $CaCO_3$	…………….. mg/l
5.	MagnesiumHardness as Mg	…………….. mg/l

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

D. Magnesium Hardness as $CaCO_3$ in mg/l

      = (Total Hardness as $CaCO_3$ – Calcium Hardness as $CaCO_3$)

      = (A – B) mg/l

      =

E. Magnesium Hardness as Mg in mg/l

      = (0.24 x Magnesium Hardness as $CaCO_3$)

      =

      =

EXPERIMENT NO:	Date Conducted	Marks
6		

- ✓ **TITLE:DISSOLVED OXYGEN TEST (By Azide Modification or Winkler's Method)**

- ✓ **LEARNING OBJECTIVE:**
  - Understand the Concept of Dissolved oxygen.
  - Methodology to determine Dissolved oxygen.
  - Analyze the suitability of water for various purposes.

- ✓ **AIM:** To determine the Quantity of Dissolved Oxygen present in a given sample of water.

- ✓ **METHODOLOGY:** Winkler's Method (Azide modification)

- ✓ **APPARATUS:**
  1. 300ml Capacity of BOD bottle with stopper.
  2. 500ml Capacity Conical Flask.
  3. 100ml Measuring Jar.
  4. 50ml Burette.
  5. 10ml Pipette.

- ✓ **REAGENTS USED:**
  1. Manganous Sulphate Solution.($MnSO_4.H_2O$)
  2. Alkali Iodine solution (Azide)(KI).
  3. Conc. Sulphuric Acid(H_2SO_4).
  4. Standard Sodium thiosulphate solution of 0.025N (N/40) ($Na_2S_2O_3.5H_2O$).
  5. Starch solution.

- ✓ **THEORY:**
     All living organisms are dependent upon Oxygen in one or the other form to maintain their metabolic process that produces energy for growth and reproduction. The solubility of atmospheric Oxygen in fresh water ranges from 14.6 mg/l @ 0ºC to about 7 mg/l @ 35ºC under atmospheric pressure. Solubility varies directly with respect to the atmospheric temperature. It is one of the most important test that the environmental engineer uses.

     The saturation DO value decreases with increase in temperature. Due to natural aeration and photosynthesis process by aquatic plants oxygen will be present in surface water bodies like lakes, rivers etc. A rapid fall of DO level in river waters is one of the first indication of organic pollution. Aquatic life in natural surface water bodies needs a minimum DO of 04 mg/L for the survival. Oxygen levels that remain below 02 mg/L for a few hours can result in large fish kills. Much higher values of DO are also not desired, since high DO value may cause corrosion of pipes supplying such waters. For domestic water supplies, DO value of about 4 to 8 mg/L may be sufficient. The DO test was first developed by Mr. Lajos Winkler while working on his doctoral dissertation in 1888 A.D.

     The analysis of DO is a key test in water pollution control activities and waste treatment process control. The Winkler's test remains the most precise and reliable titrimetric procedure for DO analysis. The test is based on the addition of divalent Manganese solution followed by strong alkali to the water sample in a glass stoppered bottle. In the presence of Iodine ions and upon acidification, the oxidized Manganese prevents to the divalent state with

✓ **OBSERVATION:**
1. Conical Flask : 203ml of sample from BOD Bottle (X ml).
2. Burette : Sodium Thiosulphate 0.025N.
3. Indicator : Starch Solution.
4. End Point : Yellow to Pale Yellow and Blue to Colourless.

ml of sample taken for titration from BOD bottle $= \dfrac{\text{Capacity of the Bottle x 200}}{\left(\text{Capacity of the Bottle - 4}\right)}$

$= \text{X ml}$

$=$

Sl. No.	Bottle No.	Volume of Bottle in ml	Volume of sample for titration in ml	Burette Reading			Volume of 0.025N $Na_2S_2O_3$ used
				FR	IR	(FR – IR)	
1.							V_1=....................ml
2.							

✓ **CALCULATIONS:**

DO present in a given sample of water $= V \times 1.0$

$=$

$= \text{..............}$ PPM

the liberation of Iodine, equivalent to the original DO content in the sample. The Iodine is then titrated with a standard solution of thiosulphate.

✓ **PROCEDURE:**
1. Collect the water sample in 300ml BOD bottle and taking care to avoid contact of sample with air.
2. Add 2ml of Manganous Sulphate by a pipette dipping the end below the water surface. Insert the stopper; the excess liquid is spilled out by inverting the bottle and mix thoroughly.
3. Add 2ml of Alkali Iodine (Azide) solution, dipping the end below the water surface and insert the stopper carefully to exclude air bubbles and mix by inverting the bottle and keep for 15 minutes.
4. If DO is ABSENT in the water sample, the manganese ions reacts with hydroxide ions to form a white precipitate of manganese hydroxide - $Mn(OH)_2$

$$Mn^{++} + 2(OH^-) \longrightarrow Mn(OH)_2 \text{ [White precipitate]}$$
$$\text{Manganese hydroxide}$$
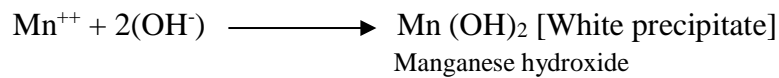
If DO is PRESENT, some Mn^{++} is oxidized to Mn^{++++} and precipitates as a brown colored manganic oxide.

$$Mn^{++} + 2(OH) + \tfrac{1}{2} O_2 \longrightarrow MnO_2 \text{ [Brown precipitate] } + H_2O$$
$$\text{Manganic oxide}$$
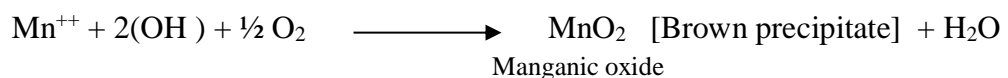
5. When the precipitate settle, leaving clear supernate above the Manganese Hydroxide floc, shake again, keep it for 5 minutes.
6. After setting, carefully remove the stopper and immediately add 2ml of Con. H_2SO_4 by allowing the acid to run down the neck of the bottle.
$$MnO_2 + 2I^- + 4H^+ \longrightarrow Mn + I_2 + 2H_2O$$
7. Re-stopper and mix by gentle inversion until the dissolution is completed and allow for 5 minutes.
8. Measure out 203ml of solution from the bottle to a conical flask.
9. Titrate with 0.025N $Na_2S_2O_3$ solution to a pale straw colour.
10. Add 1 to 2ml starch solution. Now yellow colour change to dark blue colour. Continue the titration till the blue colour just disappears (colourless).
11. Note down the volume of Sodium thiosulphate used (V).

✓ **REACTIONS:**
$$MnSO_4 + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4$$
$$Mn(OH)_2 + 2H_2SO_4 \longrightarrow Mn(SO_4)_2 + 3H_2O$$
$$Mn(SO_4)_2 + 2KI \longrightarrow MnSO_4 + K_2SO_4 + I_2$$
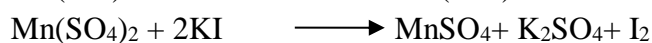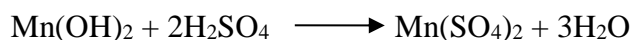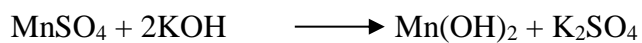
The quantity of Iodine liberated by these reaction is equivalent to the quantity of Oxygen present in the sample.

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	DO in a given sample	……………… mg/l @ ......ºC

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
7		

- ✓ **TITLE:RESIDUAL CHLORINE TEST (By Iodometric Method)**

- ✓ **LEARNING OBJECTIVE:**
  - Understand the Concept of disinfection.
  - Requirement of chlorine in drinking water.
  - Methodology to determine Chlorine.

- ✓ **AIM:** Estimation of Residual Chlorine in a given sample of water.

- ✓ **METHODOLOGY:** Iodometric Method.

- ✓ **APPARATUS:**
  1. 500ml Cap. Conical flask.
  2. 100ml Measuring jar.
  3. 50ml Burette.
  4. 10ml Pipette.

- ✓ **REAGENTS USED:**
  1. Standard Sodium thiosulphate solution of 0.01N.
  2. Glacial Acetic acid.
  3. Potassium Iodide (KI) crystals.
  4. Starch Indicator Solution.

- ✓ **THEORY:**

  Since Chlorine is the widely employed method of disinfection the presence of Chlorine is common with potable water where chlorinated industrial effluents and sewage water are discharged. The primary function of chlorination in water and waste water is to destroy the diseases causing organisms and the overall improvement in water quality.

  Chlorine in water may be present as free available Chlorine or hypochlorite ion or both and as combined chloride. Free chlorine reacts readily with Ammonia and certain nitro-genius compounds to form combined available chlorine.

  Usually a free chlorine residue of 0.2 to 0.3 mg/l after contact period of 10 to 30 minutes is considered to be sufficient and satisfactory to take care of the future recontamination of the water to be supplied to consumers by the distribution network having different diameter pipes. As per BIS: 10500-1991 the residual free chlorine content in drinking water should not be more than 0.2 mg/l, otherwise it gives bitter taste and bad odor for potable water which may not be liked by certain sensitive tongued people.

  Both free available Chlorine and combined available Chlorine liberates free Iodine, with Potassium Iodide. The liberated Iodine is titrated with standard Sodium thiosulphate solution using starch as an indicator.

The reaction is preferably carried out in a pH of about 3 to 4.

$$2KI + Cl_2 \longrightarrow 2KCl + I_2$$
$$I_2 + 2Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + 2NaCl + (2NaI)$$
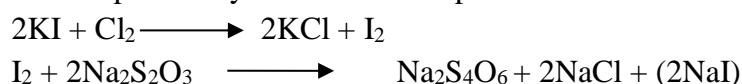
✓ **OBSERVATION:**
   1. Conical Flask : 200ml chlorinated with sample
   2. Burette   : Standard Sodium Thiosulphate of 0.01N
   3. Indicator   : Starch Solution
   4. End Point   : Blue to Colourless

✓ **TABULAR COLUMN:**

Sl. No.	Sample Used	Burette Reading			Volume of 0.01N $Na_2S_2O_3$ used in ml
		FR	**IR**	**(FR – IR)**	
1. **2.** **3.**	Chlorinated water supplied in Lab.				V=....................ml

✓ **CALCULATIONS:**

$$\text{Residual Chlorine as Chlorine in mg/l} = \left(\frac{V \times N \times 35.45 \times 1000}{\text{ml of sample used}} \right)$$

$$=$$
$$= \text{…………………} \ mg/l$$

✓ **PROCEDURE:**

1. Take 200ml of Chlorinated water sample in a conical flask.
2. Add 5ml of Acetic acid and mix well. Note down the pH value should be 3 to 4.
3. Add 1gm of Potassium Iodide crystals and mix well.
4. Titrate immediately with Sodium thiosulphate solution (0.01N) till the light yellow colour appears.
5. Now add 1ml of starch indicator, the yellow colour changes to dark Blue colour.
6. Continue the titration till the Blue colour just disappears note down the volume of titrant used (V).

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	Residual Chlorine as Chlorine	…………….. mg/l

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
8		

✓ **TITLE: DETERMINATION OF PERCENTAGE AVAILABLECHLORINE IN BLEACHING POWDER (By Titrimetric Method)**

✓ **LEARNING OBJECTIVE:**
- Understand the Concept of disinfection.
- Amount of chlorine in bleaching powder.
- Methodology to determine Chlorine.

✓ **AIM:** Estimation of Percentage of Chlorine available in a given sample of Bleaching Powder.

✓ **APPARATUS:**
1. 250ml Cap. Conical flask.
2. 250ml Cap. Volumetric flask
3. 50ml Burette.
4. 10ml and 25ml Pipette.
5. Porcelain Crucible with a glass rod.

✓ **REAGENTS USED:**
1. Standard Sodium thiosulphate solution of 0.025N.
2. Bleaching powder.
3. Potassium Iodide (KI) crystal.
4. Glacial Acetic acid.
5. Starch Indicator solution.
6. Distilled water.

✓ **THEORY:**

The chemicals (or) substances which are used for killing the bacteria from water are known as Disinfectants and the process is known as Disinfection of water. Chlorine is heavier than air, greenish yellow coloured and toxic gas. It is used in water and waste water treatment for disinfections to destroy pathogens and control nuisance causing micro-organisms and for oxidation. It is a strong oxidizing agent reacting with most of the elements and compounds. As an oxidant it is used in Iron and Manganese removal, destruction of taste and odour compounds and elimination of ammonia, Nitrogen from water.

Bleaching powder is commonly used as disinfectant in small water treatment plants. Normally bleaching powder contains chlorine up to 35%. It is an unstable compound and hence it requires very careful storing. To find out the amount of available chlorine in bleaching powder, gets reduced with time, this test should always be conducted before adding bleaching powder to water. This bleaching powder loses its chlorine content if it is exposed to the atmosphere and also due to prolonged storage. Hence, the amount of chlorine contained in it needs to be ascertained before using it as a disinfectant. Through bleaching powder is known as 'hypo chlorination'. Calcium is used for the disinfection of drinking water & swimming pool water.

Iodometric method is considered as the standard one against other methods. It provides the means for standardizing the chlorine water using in preparing temporary standard

✓ **OBSERVATION:**

1. Conical Flask : 25ml of bleaching powder solution.
2. Burette   : Standard Sodium Thiosulphate solution of 0.025N.
3. Indicator   : Starch Solution.
4. End Point   : Blue to Colourless.

✓ **TABULAR COLUMN:**

Sl. No.	Sample Used	Indicator Used	Burette Reading			Volume of 0.025N $Na_2S_2O_3$ used in ml
			FR	IR	(FR – IR)	
1. 2. 3. 4.	Bleaching Powder Solution	Starch solution				V=.....................ml

✓ **CALCULATIONS:**

mg of Chlorine present in 1 mg of Bleaching Powder $= \left(\dfrac{V \times N \times 35.45}{V_{sample}} \right)$

$= \qquad$ X mg/ml

Therefore 1 mg of Bleaching Powder contains X mg of Chlorine.

Percentage of Bleaching Powder contains $= \left(\dfrac{X \times 100}{1} \right)$

$=$

$= \ldots\ldots\ldots\ldots\ldots$ %

chlorine, will liberate free iodine from potassium iodide solution when its pH is 8 or less. The liberated iodine is titrated with the standard solution of Sodium thiosulphate using starch as an indicator. The reaction is preferably carried out at pH 3 to 4.

✓ **PROCEDURE:**

1. Dissolve 250mg of given bleaching powder in a 250ml volumetric flask.
2. Take 25ml of Bleaching powder solution in a conical flask.
3. Add 5ml of Acetic acid (Glacial) and mix well. Note down the pH value (3 to 4).
4. Add 1gm of potassium iodide crystal and mix well.
5. Titrate immediately with standard sodium thiosulphate solution till light yellow colour appears.
6. Now add 1ml of starch indicator, the Yellow colour changes to dark Blue.
7. Continue the titration till the Blue colour disappears. Note down the ml of $Na_2S_2O_3$ solution used (V).

RESULTS:

Sl. No.	Parameters Analysed	Results
1.	Percentage Chlorine available in a given sample of Bleaching Powder	……………………%

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
9		

✓ **TITLE: CHLORINE DEMAND**

✓ **LEARNING OBJECTIVE:**
- Understand the Concept of chlorination.
- To know breakpoint chlorination.
- Methodology to determine Chlorine demand.

✓ **AIM:** Estimation of Chlorine Demand for a given Sample of water.

✓ **METHODOLOGY:** Iodometric Method.

✓ **APPARATUS:**
1. 500ml cap. Conical flask of 10 Nos.
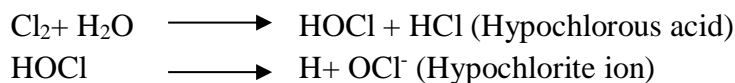2. 250ml cap. Volumetric flask
3. 50ml Burette.
4. 10ml and 25ml Pipette.

✓ **REAGENTS USED:**
1. Standard Sodium thiosulphate solution of 0.025N and 0.01N.
2. Bleaching powder solution / Chlorine solution.
3. Potassium Iodide (KI) crystal.
4. Glacial Acetic acid.
5. Starch Indicator.
6. Distilled water.

✓ **THEORY:**

Chlorine is widely used for disinfection of water and waste water to eliminate disease causing organisms, taste, odour, colour and oxidizes with element of Iron and Manganese. Since it is a powerful oxidizing agent and is cheaply available. The Chlorine demand of water is the difference between the amount of Chlorine added and the amount of free, combined or total available Chlorine remaining at the end of the contact period. The demand varies with the amount of Chlorine applied tissue of contact, pH and temperature. The smallest amount of residual Chlorine considered significant is 0.1 mg/l, the passing Chlorine gas or by adding Chlorine solution into the water.

In small treatment plants bleaching powder is added as a disinfectant which obtain in the form of Hydro chlorite of Calcium which sterilize the water when Chlorine is added to water it reacts with water as follows.

$$Cl_2 + H_2O \longrightarrow HOCl + HCl \text{ (Hypochlorous acid)}$$
$$HOCl \longrightarrow H + OCl^- \text{ (Hypochlorite ion)}$$

The quantity of HOCl and OCl which is present in water is called available Chlorine.

The killing efficiency of HOCl is about 40 to 80 times than that of OCl. It rupture the cell membrane of michrone. The disease producing organisms and the bacterial life is disturbed reaction of bleaching powder with water.
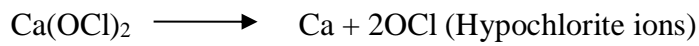
- ✓ **OBSERVATION:**
  1. Conical Flask : 200ml of water sample with addition of B.P solution in 10 flasks
  2. Burette   : Standard Sodium Thiosulphate solution of 0.01N
  3. Indicator   : Starch Solution
  4. End Point   : Blue to colourless

Residual Chlorine Test

Flask No.	1	2	3	4	5	6	7	8	9	10
FR										
IR										
(FR – IR)										
(b) R-Cl (mg/l)										

Calculation

Residual Chlorine as Cl (in mg/l) = $\dfrac{V \times N \times 35.45 \times 1000}{\text{ml of sample used}}$

$Ca(OCl)_2 \longrightarrow Ca + 2OCl$ (Hypochlorite ions)

$OCl^- + H \longrightarrow HOCl$ (Hypochlorous acid)

Hypochlorous acid so formed kills the bacteria the iodometric method is considerd as the standard against other method. It provides the means for standardized the chlorine water using in preparing temporary standard chlorine will liberate free iodine from potassium iodide solution when its pH is 8 or less. The liberated iodine is titrated with the standard solution of Sodium thiosulphate using starch as indicator. The reaction is preferably carried out at pH 3 to 4.

✓ **PROCEDURE:**
1. Prepare a bleaching powder solution of known concentration of Chlorine.
2. Measure out 200ml of water sample for which Chlorine demand has to be found out in a series of 500ml cap. conical flask of say 10 Nos. (Numbering 1, 2, 3, 4, …. 10).
3. Add 0.2ml of bleaching powder solution to first flask and then 0.4ml BP solution to the second flask and so on, in ascending order to the successive portion in series.
4. Mix the solution in each beaker gently and allow for contact time of about 30 minutes for potable water and suitably higher for polluted water and secondary effluents.
5. After the contact period add 5ml of acetic acid (glacial) and 1gm of Potassium Iodide crystal and mix.
6. Now add 1ml of starch indicator to each flasks indicates the presence of excess Chlorine in which the blue colour is not developed indicates that Chlorine demand of water is not sufficient.
7. Titratethe sample with 0.01N $Na_2S_2O_3$ solution till blue colour disappears.
8. Record the ml of $Na_2S_2O_3$consumed and also note down the bleaching powder solution to that flasks separately.

Flask No.	Sample Taken in ml	Concentration of BP Solution (%)	BP Solution Added	Chlorine Added		(b) R-Cl in mg/l	Chlorine Demand (a–b) in mg/l
				200ml	(a) 1000ml		
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

✓ **GRAPH:**

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	Chlorine demand of given sample of water	…………….. mg/l

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
10		

✓ **TITLE: DETERMINATION OF TURBIDITY(By Nephlometry)**

✓ **LEARNING OBJECTIVE:**
- Understand the Concept of physical characteristics of water.
- Understand the concept of turbidity in water.
- Methodology to determine turbidity.
- Comparing the results with relevant standards.

✓ **AIM:** To determine the turbidity of given sample of water.

✓ **METHODOLOGY:** Turbidimetric method (photoelectric measurement)

✓ **APPARATUS:** Digital Nephelo Turbidity Meter

✓ **THEORY:**

Turbidity is the measure of resistance of water to allow the light pass through it. It is caused by the pressure of suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms, turbidity should be clearly understood to be expression of the optical property of sample which causes the light to be scattered and absorbed rather than transmitted in straight line through the sample. The amount and character of the turbidity will depend on the type of soil over which the water has seen and the velocity of water very finely divided clay settle very slowly may require month for complete settlement. The standard method of determination of turbidity has been based on the JACKSON CANDLE TURBIDITY METER. However the lower turbidity which can be measured directly on this instrument is 25 units with treated water generally falling in the range of 0 to 5 units. To estimate the turbidity of such sample can be made using Digital Nephelo Turbidity Meter.

✓ **PRINCIPLE:**

Turbidity measurement by the candle turbidity meter is based on the light path through suspension which just causes the image of the plane of standard candle to disappear that is to become indistinguishable against the general background illumination when the flame is viewed through the suspension. The longer light pass is the lower the turbidity. Measurements of turbidity using the photoelectric turbidity meter is based upon a comparison of the intensity of light scattered by the sample under defined conditions with intensity of light scattered by standard reference suspension under some conditions. The standard unit of turbidity produced by 1mg of silica (SiO_2) in a litre of water i.e. 4mg of SiO_2 per litre = 1 unit of turbidity or one part of fullers earth in 1 litre of water.

Turbidity is measured in Jackson turbidity unit (JTU) and Nephelometric Turbidity unit.
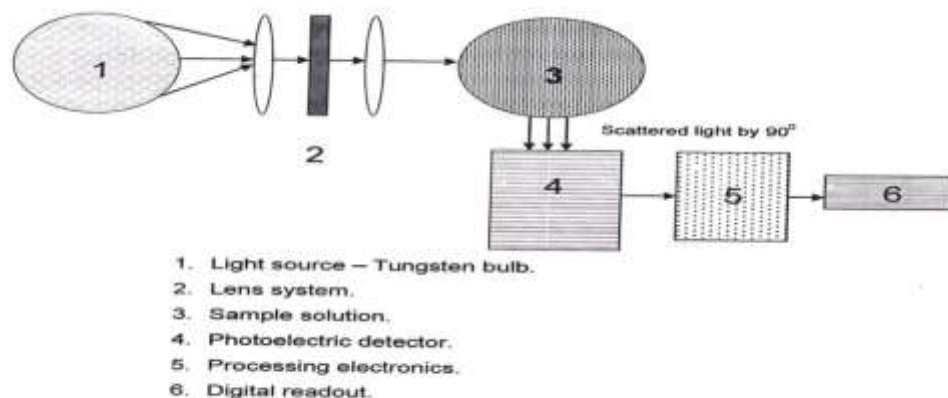

1. Light source — Tungsten bulb.
2. Lens system.
3. Sample solution.
4. Photoelectric detector.
5. Processing electronics.
6. Digital readout.

Fig: Working principle of Nephelometer.

✓ **OBSERVATION TABLE**

Sl. No.	Sample Description	Meter reading NTU				Remarks
		T_1	T_2	T_3	T_{Avg}	
1.	Unknown Sample					
2.	Standard Sample					

✓ **PROCEDURE:**

1. Using standard digital Nephelo turbidity operation of instrument prepares the known standard turbidity solution say 500, 100 and 50 NTU. Shake this solution well before used for calibration of the instrument.
2. Insert three pin plug into the main socket.
3. Switch on the instrument using power switch and allow 10 to 15 minute warming up.
4. Select the appropriate range 0 - 100 NTU or 0 – 50 NTU etc. as per the standard turbidity solution taken, using RANGE switch.
5. Set the standardized control CALIB KNOB to maximum.
6. Insert the test tube with distilled water into cell holder with alignment mark and cover with light shield.
7. Now using set zero control knobs (Coarse and Fine control) adjust the meter indication to zero.
8. Remove the test tube and replace with the test tube containing standard solution of say 100NTU.
9. Adjust the reading to 100 using CALIB knob repeat the steps from 5 to 7.
10. The instrument is calibrated to test the unknown sample.
11. Insert the test tube containing unknown samples in cell holder and note down the reading on meter in NTU.

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	Turbidity of given sample of water	…………….. NTU …………….. NTU …………….. NTU

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
11		

✓ **TITLE: JAR TEST**

✓ **LEARNING OBJECTIVE:**
- Understand the Concept of coagulation.
- Requirement of coagulant for treatment of water.
- Methodology to determine optimum dosage of coagulant.

✓ **AIM:** To determine the optimum coagulant dosage for the given sample of water.

✓ **METHODOLOGY:** Conducting Jar Test with variable dosage of Alum solution.

✓ **APPARATUS:**
1. Jar Test Apparatus.
2. Turbidity Meter.
3. 5ml, 10ml Pipette.
4. 1 litre Beaker

✓ **THEORY:**

Jar test is a method of simulating a full scale water treatment providing system operators a reasonable idea of the way a treatment will behave and operate with a particular type of raw water. Because it mimics full-scale operation, system operators can use jar testing to help determine which treatment chemical will work best for the raw water. Jar testing should be done seasonally, monthly, weekly, daily, or whenever a chemical is being changed, or new pumps, rapid mix motors, new floc motors, or new feeders are installed. Alum [Aluminium sulfate - $Al_2(SO_4)_3.18H_2O$] also called as filter alum is most commonly used as a coagulant in treatment plants for treating raw water from the surface source.

$$Al_2(SO_4) .18H_2O + 3Ca(HCO_3)_2 \longrightarrow 3CaSO_4 + 2Al(OH)_3 \downarrow + 6CO_2 \uparrow$$
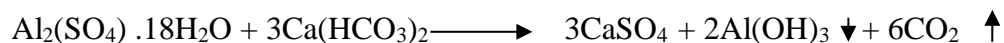
Here Aluminium hydroxide $[2Al(OH)_3]_4$ is the floc which gets settled out along with turbidity causing particles to the bottom of sedimentation tank. Optimum dosage of coagulant has to be fixed in the laboratory by using jar test. Usually the dosage of alum varies from 05 mg/L for clear water to 85 mg/L for turbid water. Average normal dosage will be 17 mg/L. Excess dosage of alum may excess aluminium in drinking water which may become neurotoxic. As per BIS: 10500-1991 aluminium should not be more then 0.O3mg/L in drinking water. Less dosage of alum do not remove turbidity in water, which ultimately increases load on filters and affects disinfection process. So the optimum dosage to be determined by using jar test. Coagulation not only removes turbidity but also color, micro-organisms, algae, phosphate, taste & odor producing substances.

✓ **PRINCIPLE:**

Coagulants are used in water treatment plant to
- Remove natural, suspended and colloidal matter.
- Remove material, which don't settle by plain sedimentation.
- To assist infiltration.

With careful control of coagulant dosage, very clean water can be obtained after coagulants are setting. Jar test is a simple device which with helps in determining the required

✓ **OBSERVATION TABLE:**

Sl. No.	Sample	Alum Dosage		Initial Turbidity	Residual Turbidity	Turbidity Removed
		800ml	**1000ml**			
1.	Sample provided in lab					
2.						
3.						
4.						
5.						
6.						

optimum coagulant dosage. The jar test device consist of jars (5 to 6) provided with stirrers and peddles. Sample will take in jar or beakers varying dose of coagulant will be added simultaneously to all the jars slowly for a minute.

✓ **PROCEDURE:**
1. Measure out the initial turbidity of the given turbidity water sample.
2. Take 6 beakers of 1 litre capacity and measure 1st sample of water in all the 6 beakers and place them the jar test apparatus (Now carefully checkup the position of the stirrers etc. switch on the instrument and adjust the speed of the peddle to 100-200 rpm).
3. Add 1ml of standard alum solution to the 1st beaker, 2ml to the 2nd beaker, 3ml to the 3rd beaker and add to all beakers in increasing order.
4. Allow the rapid mix at 100 – 200 rpm for 1 minute.
5. Bring down the speed to 30-40 rpm (minimum speed) and allow the slow mix for 9 minute.
6. Switch off the instrument and allow the liquid for 20 minutes for setting.
7. After this, take out the supernatant (50ml) without disturbing the settled flask in a conical flask from the each beaker.
8. Measure the turbidity of all the samples with the help of turbidity meter.
9. Repeat the steps from 1 to 8 with higher dosage of alum in necessary.

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	Optimum Coagulant Dosage	…………….. NTU

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
12		

✓ **TITLE: DETERMINATION OF pH**

✓ **LEARNING OBJECTIVE:**
- Understand the Concept of pH and pOH.
- Different method to find pH.
- Methodology to determine pH.

✓ **AIM:** To determine the pH of given sample of water.

✓ **METHODOLOGY:** Using pH paper, pH indicator and pH meter.

✓ **APPARATUS:** Digital pH meter.

✓ **REAGENTS USED:** Turbidity free distilled water.

✓ **THEORY:**
　　　　The pH value of water is defined as the log of reciprocal of hydrogen ion concentration in water. Mr. Sorensen gave the expression for pH in the year 1909A.D. In pH symbol "p" indicates potential difference between two electrodes and "H" denotes hydrogen ion concentration. pH is a chemical parameter, without units.

By virtue of its logarithmic nature, pH is a dimensionless quantity.

$$pH = \log_{10} (1/ H^+)$$

　　　　It follows that if the pH value is found to be less than 7 (when hydrogen ions predominate) it will become acidic in nature, and if its value is found to be more than 7 (when hydroxyl ions predominate) then it will become alkaline in nature. pH of 7 is for neutral water or distilled water [when H^+=OH]. The permissible pH values for public supplies may range in between 6.5 to 8.5 (as per BIS: 10500-1 991). pH below 4 gives the water a sour taste and becomes corrosive in nature corroding water distribution pipes and above 8.5 gives a bitter taste and causes incrustation (deposition of alkali salts) in water distribution pipes. Normal rainwater has a pH of 5.6.

✓ **PROCEDURE:**
 A. Using pH Meter
1. Follow the manufacture operating instructions.
2. Calibrate the instrument with a buffer solution (known pH solution of pH 4 and 7).
3. Dip the electrodes in the given unknown water sample and note down the instrument reading which will give the direct pH value of the unknown sample.

 B. Using pH Indicator (Universal pH Indicator of pH 4 to 11)
1. Follow the instruction given in the indicator bottle.
2. Pipette out 10ml of given water sample into a small test tube.
3. To this add 0.2ml of Universal pH indicator solution and mix well.
4. Compare the colour developed with the colour chart and note down the pH values.

　　　　This method is also an approximate method of estimation of pH ranging to 4 to 11.

✓ **OBSERVATION TABLE:**

Sl. No.	Sample used	pH Paper	pH Indicator	pH Meter	Remarks
1.	Sample provided in the lab				
2.					

C. pH Paper (pH 0 to 10)

1. Dip the pH paper in the given water sample.
2. Compare the colour developed with that of water given in the wrapper of the pH paper booklet.
3. Note down the pH of sample along with it.

✓ **OUTCOME & CONCLUSIONS:**

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	pH value of given samples by using pH meter	
2.	pH value of given samples by using pH paper	

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
13		

- ✓ **TITLE: ELECTRIC CONDUCTIVITY TEST**

- ✓ **LEARNING OBJECTIVE:**
  - Understand the Concept of conductivity in water.
  - Effect of conductivity.
  - Methodology to determine conductivity.

- ✓ **AIM:** To determine the conductivity of given sample.

- ✓ **METHODOLOGY:** Instrumental method.

- ✓ **APPARATUS:** Conductivity meter.

- ✓ **REAGENTS USED:** KCl, Distilled water.

- ✓ **THEORY:**

    Electrical or Specific Conductivity (EC or SC) is the measure of capacity of a solution to carry an electric current, therefore a measure of the water's ionic activity and content. The higher the concentration of ionic (dissolved) constituents, the higher the conductivity. Conductivity of the water changes substantially as its temperature changes. A conductor such as a metal has high conductivity and a low resistivity. An insulator like glass or a vacuum has low conductivity and a high resistivity. Specific Conductivity is an indirect measure of the presence of total dissolved solids (TDS). By definition, Specific Conductivity is the reciprocal of the specific resistance of a solution measured between two electrodes with opposite electrical charge of 1 cm^2 (1cm x 1 cm) in area and 1 cm apart. Since the resistance of aqueous solution changes with temperature (resistance drops with increasing temperature), the resistance is corrected to the resistance of the solution at 25°C.

    Specific Conductivity (mho/cm or S/cm) is represented by reciprocal value of electrical resistance (ohms) relative to cm3 of water at 25°C.

    Conductance (mho) = if Resistance (ohm)

- ☞ The unit for Conductance is mho or Siemen (S)

    +1 Siemen = 1000 milli Siemen (1 S = 1000 mS)

    or

    1 mho = 1000 miii mho (1 mho = 1000 mmho)

    +1 mS = 1000 micro Siemen (1 mS = 1000µS)

    or

    1 mmho = 1000 micro mho (lmmho = 1000 µmho)

    In water distribution mains a sudden rise of the EC or SC indicates that recontamination has occurred through leaks in joints or cracks in pipes.

- ✓ **PROCEDURE:**
  1. Connect the conductivity meter to the main supply through the main chord.
  2. Keep the power switch in OFF position.
  3. Connect conductivity cell suitable 'K' value to the cell socket.
  4. Connect the temperature probe to the temperature socket.
  5. Turn the power switch ON, display should show SYS-306. After about 3 seconds display will show 'put std'. Now, unit is ready to accept STD solution and CAL command.

OBSERVATION TABLE:

Sl. No.	Sample used	Results	Remarks
1.	KCl 0.1N		
2.	Distilled Water		
3.	Tap Water		
4.	Sample		

6. Take a standard KCl solution as per 7.0 and dip the conductivity cell and temperature probe in it.
7. Stroke the STD solution key until the selected KCl solution indicated by the on LED is same as selected in Step 4.
8. Press CAL key, the unit starts calibrating itself against the standard solution.
9. Remove the conductivity cell and the temperature probe from the solution. Rinse with distilled water and dry with tissue paper. Therefore immerse both in the solution.
10. Press COND key after a while unit will display temperature and conductivity of the solution at the solution temperature.
11. Follow steps 9 and 10 for measurement of conductivity of every other sample.

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	The electric conductivity of given sample	

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
14		

✓ **TITLE: CHEMICAL OXYGEN DEMAND (By Open Reflux Method)**

✓ **LEARNING OBJECTIVE:**
- Understand the Concept of biological parameters of waste water.
- Consequences of COD.
- Methodology to determine COD.

✓ **AIM:**

To determine the Oxygen required for chemical oxidation of organic matter with the help of strong chemical oxidant.

✓ **APPARATUS:**
1. Reflux apparatus consisting of a flat bottom 250 to 500 ml capacity flask with ground glass point and a condenser with 24/40 joint.
2. Burner @ hot plate with ton regulate.

✓ **REAGENTS USED:**
1. Standard Potassium dichromate (K_2Cr_2O7) of 0.25 N — Titrant.
2. Ferrous Ammonium Sulfate (FAS) of 0.25 N — Titrant.
3. Concentrated H_2SO_4 + Ag_2SO_4.
4. Ferroin — Indicator.
5. Mercuric Sulfate (HgSO4).

✓ **THOERY:**

Chemical oxygen demand (COD) is the oxygen required for chemical oxidation of biodegradable organics (BO), non-biodegradable organics (NBO) & inorganic impurities by strong oxidizing agents like potassium dichromate ($K_2Cr_2O_7$) or potassium permanganate ($KMnO_4$) or potassium chromate (K_2CrO_4) under acidic conditions. The basis for the COD test is that nearly all organic compounds can be fully oxidized to carbon dioxide with a strong oxidizing agent under acidic conditions.

The major advantage of COD test is the short time required for determination of total 02 required for oxidation. COD test requires 03 hours instead of 3 or 5 days as needed for measurement of BOD. COD test indicates the total oxidizable organic matter present in the given sample but does not differentiate between BC & NBC. The COD test is much more useful than BOD test for estimating strength of certain industrial effluents of both organic type (pesticide industries) and inorganic type (metallurgical industries) which contain toxic chemicals.

If BOO I COD ≥ 0.68 then it indicates that the wastewater is highly amenable to the biological treatment.

If COD/BOD ratio is less than 1.7 the wastewater can be easily and completely biodegraded.

As per CPCB standards COD of wastewater treated or untreated should be < 250 mg/L for discharging into surface water bodies like streams, rivers, lakes or into the seas & oceans.

OBSERVATION & CALCULATION:

COD (mg/l) = $[(a - b) \times 8000 \times N] /$ ml of sample.

Where a & b = ml of FAS for blank and sample respectively.

N = Normality of FAS (0.1 N)

The organic matter gets oxidized completely by $K_2Cr_2O_7$ in the presence of H_2SO_4 to produce $CO_2 + H_2O$ the excess $K_2Cr_2O_7$ remaining after the reaction is titrated with $Fe(NH_2)_2$ $(SO_4)_2$. The dichromate consumed gives the O_2 required for oxidation of the organic matter.

✓ **PROCEDURE:**
1. Place 0.4g H_2SO_4 in a reflex flask.
2. Add 20ml sample or an aliquot of sample diluted to 20ml with distilled water mix well.
3. Add pumice stone or glass beads followed by 10ml standard $K_2Cr_2O_7$.
4. Add slowly 30ml H_2SO_4 containing Ag_2SO_4 mixing thoroughly. This slow addition along with swirling prevents fatty acids to escape out due to high temperature.
5. Mix well if the colour turns green either take fresh sample with lesser aliquot or add more dichromate and acid.
6. Connect the flask to condenser, mix the contents before heating improper mixing will result in bumping and sample may blown out.
7. Reflux for a minimum of 2 hours cool and then wash down the condenser with distilled water.
8. Dilute for a minimum 150ml cool and titrate excess $K_2Cr_2O_7$ with 0.1N FerrousAmmoniumSulphate using Ferroin Indicator sharp colour change from blue green to wine red indicator end point or completion of the titration.
9. Reflux blank is the manner using distilled water instead of sample.

$$COD \ (mg/l) = [\ (\ a - b) \times 8000 \times N \ ] \ / \ ml \ of \ sample.$$

Where a & b = ml of FAS for blank and sample respectively.
N = Normality of FAS (0.1 N)

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	Chemical Oxygen Demand	…………….. mg/l

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
15		

✓ **TITLE: BIOCHEMICAL OXYGEN DEMAND(By Dilution method)**

✓ **LEARNING OBJECTIVE:**
- Understand the Concept of BOD.
- Effect of pollutional load on water.
- Methodology to determine BOD.

✓ **AIM:** To determine pollutional load of waste water the degree of pollution in lakes and streams at any time and their self purification capacity and efficiency of waste water treatment methods.

✓ **APPARATUS:**
1. BOD Bottles 300ml Capacity
2. Incubator to be controlled at $20^{\circ}C \pm 1^{\circ}C$

✓ **REAGENTS USED:**
1. Phosphate Buffer.
2. Magnesium.
3. Calcium Chloride.
4. Ferric Chloride.
5. Sodium thiosulphate.

✓ **THEORY:**

Microorganisms such as bacteria are responsible for decomposing organic matter. When organic matter such as dead plants, leaves, grass clippings, manure, sewage, food waste is present in a wastewater, the aerobic bacteria will start the oxidation of these wastes. When this happens, much of the available Dissolved Oxygen (DO) is consumed by aerobic bacteria, robbing other aquatic organisms of the oxygen they need to live. The biochemical oxygen demand is measure of oxygen utilized by aerobic micro-organisms during biological oxidation of organic matter. Generally, when BOD levels are high, there will be low DO levels.

$$\text{Organic matter} + O_2 \longrightarrow CO_2 + \text{new bacterias} + H_2O + \text{Heat}$$
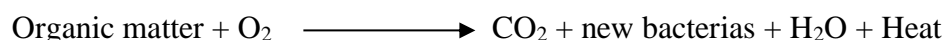
Drinking water must have a BOD of less than 01 mg/L and the water is considered fairly up to 03 mg/L of BOD, but when the BOD value 05 mg/L the water is doubtful in purity.

Ordinary domestic sewage may have a BOD of 200 mg/L. As per CPCB standards the treated or untreated sewage to be discharged into surface water bodies must have BOD of less than 30 mg/L.

✓ **PROCEDURE:**
A. Preparation of Dilution Water:
1. Aerate the required volume of distilled water in a container by bubbling compressed air for 1-2 days to attain DO saturation. Try to maintain the temperature near $20^{\circ}C$.
2. Add 1ml each of Phosphate buffer, magnesium sulphate, Calcium Chloride and Ferric Chloride solutions for each litre of dilution water mix well.
3. In the case of the waste which are not expected to have sufficient bacterial population, added seed to the dilution water. Generally 2ml settled sewage is considered sufficient for 1000ml of dilution water.

B. Dilution of sample:

1. Neutralize sample to pH around 7.0, if it is highly alkaline or acidic.
2. The sample should be free from Residual Chlorine. If it contains residual Chlorine remove it by using $Na_2S_2O_3$ solution as follows. Take 50ml of sample and acidity with addition of 10ml + 1 acidic acid. Add about 1g KI. Titrate with $Na_2S_2O_3$ of 0.025N using starch as indicator. Calculate the volume of $Na_2S_2O_3$ required per ml of the sample and accordingly to the sample to be tested for BOD.
3. Samples having high DO content, i.e. DO 9mg/l due to either algae growth or some other reason. Reduce the content by aerating and agitating the samples.
4. Make several dilutions of the pretreated sample as to obtain about 50% depletion of DO dilution water but not less than 2 mg and the residual Oxygen after 5 days f incubation should not be less than 1 mg/l prepare dilution as follows.

   Siphon out seeded dilution water in a measuring cylinder or volumetric flash half the required volume. Add the required quantity of carefully mixed sample. Dilute to the desired volume by siphoning dilution water and mix well.
   The following dilutions are suggested.

0.1% to 1%	– Strong trade waste
1% to 5%	– Raw or settled sewage
5% to 25%	– Treated effluent
25% to 100%	– River water

5. Siphon the dilution prepared as in 4 in three labeled bottles and stopper immediately.
6. Keep 1 bottle for determination of the initial DO and incubate 2 bottles @ 20°C for 5 days. See that the bottles have water seal.
7. Pressure a blank in duplicate by siphoning plain dilution water (without seed) to measure the O_2 consumption in dilution water.
8. Fix DO of the bottles kept for immediate DO determination and blank by adding 2ml $MnSO_4$ followed by 2ml Alkali-Iodide- Azide as described in the estimation of DO.
9. Determine DO in the sample and in the blank on initial day and after 5 days.

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	Biochemical Oxygen Demand	

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
16		

✓ **TITLE: FLUORIDE TEST (By Aizarian visual comparison method)**

✓ **LEARNING OBJECTIVE:**
- Understand the ill effects of fluoride.
- Understand the concept spectrophotometer.
- Methodology to determine fluoride.

AIM: Determination of Fluoride content in a given water sample.

✓ **METHODOLOGY:** Spand's Method.

✓ **APPARATUS:**
1. Spectrophotometer (Wave length 570mm)
2. Standard flask of 50ml capacity - 10 Nos.

✓ **REAGENTS USED:**
1. Spand's solution.
2. Standard Fluoride solution (1ml = 10mg of NaF).
3. Distilled water free from CO_2.

✓ **THEORY:**

Fluoride exists naturally in water sources and is derived from fluorine, the 131h most common element in the earth's crust. It is well known that fluoride helps prevent and even reverse the early stages of tooth decay. Fluoride (as F) is a geochemical contaminant and natural sources account for much of the fluoride found in surface and ground waters. Generally associated in nature with few sedimentary rocks or igneous rocks, fluoride is seldom found in appreciable quantities in surface waters. Fluoride is essential for the normal mineralization of bones and formation of dental enamel (the hard substance that covers the crown of a tooth). The desirable limit for fluoride in drinking water is exactly 01 mg/L (as per BIS: 10500-1991). If fluoride is less than Olmg/L (especially if it is less than 0.6 mg/L) in drinking water it may cause dental carries (formation of weaker tooth enamel leading to early tooth decay) in children aged between 01 to 13 years. In such cases fluoride has to be added in the form of sodium fluoride (NaF), and the process is called fluoridation of water. NaF is usually added in most of the tooth pastes.

If fluoride concentration is more than 01 mg/L (especially if it is more than 1.5 mg/L) it causes spotting or discoloration of teeth (teeth fluorosis) also known as teeth mottling in children. In mild dental fluorosis, affected teeth lose lustre and show chalkiness. In course of time, spots and transverse bands of light yellow to dark brown color appear. But for the disfigurement of teeth, the victims are otherwise healthy.

When fluoride content is more than 05 mg/L in drinking water symptoms of bone fluorosis starts appearing in the consumers of all ages. The symptoms include:
➢ Body pains, lethargy and tingling sensation in the extremities.
➢ Progressive stiffness of neck, spine and all other joints.
➢ Inability to squat on the floor.
➢ To see someone on side, the patient has to turn the whole body towards that side.
➢ To see an airplane, the patient has to lie on the ground.

➢ Breathing becomes abdominal, gait and posture become ugly, and bones show osteophytic over growths.

➢ Once physiologic saturation of fluorine in hard tissues takes place, there will be flooding of fluoride in the soft tissues resulting in several diseases followed by death.

Removal of excess quantity of fluoride is called defluoridation by using Nalgonda adsorption by activated alumina (AA), ion exchange adsorption method and reverse osmosis process.

✓ **PROCEDURE:**

A. Preparation of Standard Solution

Preparation of standard solution of known concentration of Fluoride to draw a standard graph OD v/s concentration, take 5 numbers of 100ml capacity volumetric flask and give numbering 1 to 6 flask.

Flask 1: Take 1ml of NaF standard solution + 5ml of Spand's solution and make to 50ml using distilled water and mix well.

Flask 2: Take2ml of NaF standard solution + 5ml of Spand's solution and make to 50ml using distilled water and mix well.

Flask 3: Take3ml of NaF standard solution + 5ml of Spand's solution and make to 50ml using distilled water and mix well.

Flask 4: Take4ml of NaF standard solution + 5ml of Spand's solution and make to 50ml using distilled water and mix well.

Flask 5: Take5ml of NaF standard solution + 5ml of Spand's solution and make to 50ml using distilled water and mix well.

Flask 6: Now prepare blank solution without NaF solution. Take 5ml of Spand'ssolution + distilled water, make to 50ml and mix well.

Use after 10 minute to develop uniform colour in all flasks.

* Concentration of F in 1st tube :   01 x 0.01 x 1000 /50= 0.20 mg/L. Similarly for other 05Nessler tubes.

B. Operate the Instrument

1. Switch on the instrument wait for 10 to 15 minutes to warm up the instrument.
2. Set accurately the required wave length range by setting knob.
3. Keep the selection knob to T.
4. Standardize the instrument using blank solution.
5. Then take out the reading of OD using prepare known concentration Fluoride solution flask No. 1, 2, 3, 4, 5, 6.
6. After making OD reading of known concentration of T.

✓ **GRAPH:**
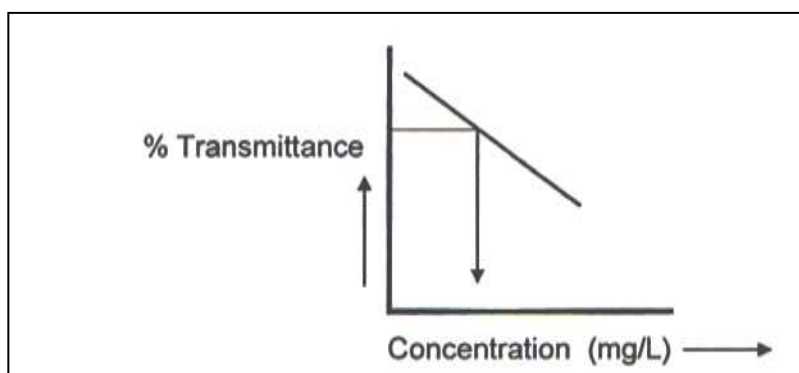
✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	The amount of Fluoride present as F for the given sample	…………….. mg/l

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
17		

✓ **TITLE: IRON TEST (By Phenanthroline method)**

✓ **LEARNING OBJECTIVE:**
- Understand the ill effects of Iron.
- Understand the concept spectrophotometer.
- Methodology to determine Iron.

✓ **AIM:** To determine concentration of total or soluble Fe % in the sample from calibration curve.

✓ **APPARATUS:**
1. Calorimeter with an operating range of 400-700mm.
2. Nessler's Tube.

✓ **REAGENTS USED:**
a) Hydrochloric acid (HCI).
b) Hydroxyl amine hydrochloride solution ($NH_2OH.HCI$).
c) Ammonium acetate ($NH_4C_2H_3O_2$) buffer solution.
d) Phenanthroline solution.
e) Standard Iron solution [1 ml = 0.001 mg of Fe].
f) Sodium acetate solution ($NaC_2H_3O_2.3H_2O$).

✓ **THEORY:**

Iron is one of the earth's most plentiful resources, making up at least 05% of the earth's crust. Rainfall seeping through the soil dissolves iron in the earth's surface and carries it into almost every kind of natural water supply, including well water. Iron is generally divided into 02 main types:

➢ **Soluble type:**

"Clear water" iron, is the most common form and the one that creates the most complaints by water users. This type of iron is identified after pouring a glass of cold clear water, if allowed to stand for a few minutes, reddish brown particles will appear in the glass and eventually settle to the bottom.

➢ **Insoluble type:**

When insoluble iron or "red water" iron is poured into a glass, it appears rusty or has a red or yellow color. Although not very common in most of the water wells, insoluble iron can create serious taste and appearance problems for the water user. Because iron combines with different naturally occurring acids, it may also exist as an organic complex. A combination of acid and iron, or organic iron, can be found in shallow wells and surface water. Although this kind of iron can be colorless, it is usually yellow or brown. Finally, when iron exists along with certain kinds of bacteria, problems can become even worse. Iron bacteria consume iron to survive and leave a reddish brown or yellow slime that can clog plumbing and cause an offensive odor.

Iron is not considered hazardous to health. In fact, iron is essential for good health because it transports oxygen in our blood. Although iron is present in water, it is seldom found at concentrations greater than 10 mg/L or parts per million (ppm). Iron is present

mostly in divalent form (ferrous) in both surface and ground waters under reducing (absence of oxygen) environment. The presence of iron in natural waters can be attributed to the dissolution of rock and minerals, acid mine drainage, landfill leachates, sewage and industrial effluents. The permissible limit of iron in drinking water is 0.3 mg/L. Iron in excess of 0.3 mg/L causes stains to washbasins and steel containers. They also form red spots on cloths and white paper. Long time consumption of drinking water with a high concentration (>0.3 mg/L) of iron can lead to liver diseases or hemosiderosis.

Treatment considerations for various forms of Iron removal are:
- Aeration: Introducing oxygen to the water source to convert soluble iron to its insoluble form.
- Filtration: Media used to entrap and screen out oxidized particles of iron.
- Usually requires backwashing to remove accumulated iron.
- Water Softener: Removal of soluble iron by ion exchange.
- Ozonation: A specialized form of aeration using ozone to convert soluble iron.
- Ion Exchange: Substituting an acceptable ion (such as sodium) for soluble iron.
- Sequestering: Adding chemical agents to water to keep metals like iron in solution to prevent characteristic red stains.
- Chlorination: Chemical oxidizer used to convert soluble iron to an insoluble, filterable form.

The ferric form of Iron is reduced to Ferrous form by boiling with Hydrochloric Acid and Hydroxylamine Hydrochloride. Later Phenonthroline is added at pH between 3.2 and 3.3 to form soluble chelated complex of orange red colour with Iron. Three molecules of 1, 10 phenonthroline are required to form a complex Iron with each Fe^{++}. The colour obeys Becr's law an dthe intensity odcolour is independent of pH from 3 to 9 total dissolved and suspended iron can be measured with unfiltered and filtered sample (prior to acidification) for study of ferrous-ferric equilibrea. It is sometimes desirable to determine the ferrous content of water sample. For such determination add 10ml of 1-10 phenotholine or bathophenonthroline and 1ml glacial acetic acid to the sample bottle before sample collection for Iron. It will complex soluble Ferrous Iron before it is oxidized to Ferric state. The additional of nitrilotriaceticacid to the system further helps to stabilize the ferrous ferric system.

✓ **PROCEDURE:**

1) Prepare a standard series with the help of standard Iron solution.
   {1 ml = 0.001 mg of Iron).

2) Arrange 10 Nessler tubes in a series and pipette 1, 2, 3, 4, 5, 6, 8, 10, 12 & 16 ml of standard solution into all the 10 Nessler tubes.

> * Concentration of iron in 1st tube (mg/L) = $\dfrac{1 \times 0.001 \times 1000}{50} = 0.02$
>
> Similarly do for other 09 Nessler tubes.

3) Add 01 ml Hydroxyl amine hydrochloride and 02 ml concentrated HCl and distilled water up to 50 ml marking.

4) Transfer the solutions into beakers and place the beakers on burner. Heat the solution till the volume is reduced to half of the total volume due to evaporation.

5) Remove the beakers from burner and allow them to cool and transfer the solutions into Nessler tubes. Add 04 ml Phenanthroline solution and 10 ml of ammonium acetate buffer solution to each Nessler tubes.

6) Mix them and leave them for 30 minutes for color development.

7) Calibrate the digital spectrophotometer (510 nm wavelength) with distilled water and start noting down the % transmittance of each solution for the preparation of standard calibration curve.

8) Similarly carry out above steps for unknown water samples whose iron content is to be determined and calculate the total iron content in mg/L using standard calibration curve.

✓ **GRAPH / STANDARD CALIBRATION CURVE :**
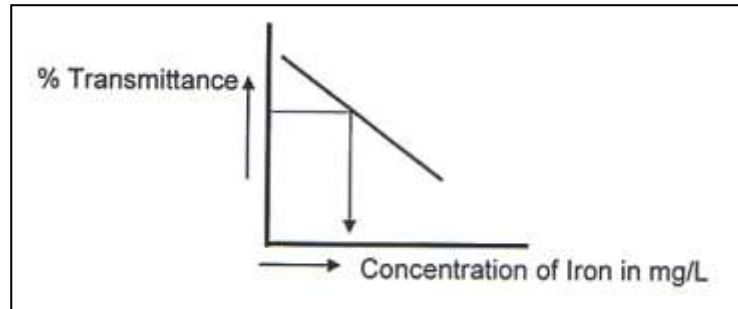
✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
18		

✓ **TITLE: DETERMINATION OF SOLIDS**

✓ **LEARNING OBJECTIVE:**
- Understand the concept of solids.
- Methodology to determine different type of solids.

✓ **AIM:** To determine amount of total solids, dissolved solids, suspended solids and volatile solids.

✓ **METHODOLOGY:**
Sample Method involves, titration, evaporation, Ignition of dried material present in the given water sample.

✓ **APPARATUS:**
1. Evaporating dishes made of porcelain, silicon or platinum
2. Steam Bath.
3. Hot Air Oven.
4. Desiccator.
5. Analytical balance.
6. Filter Paper.
7. Measuring Jar.
8. Funnel etc.

✓ **THEORY:**
One of the most important characteristics of sewage is the solid content. Sewage normally contains 99 % water and 1% solids. Solids test is an important parameter as it is used in:

1. Design of biological units and water pollution control methods, which depend on the concentration of organic solids.
2. In Grit chambers and sedimentation tank design which depends on the quantity of inorganic and organic settleable solids respectively.
3. Dissolved inorganic solids are to be considered in the design of land treatment of Sewage.

Classification of Sewage Solids:
Total solids: Analytically the total solids content of a wastewater is defined as all the matter that remains as residue on evaporation at 103°C and subsequent drying. These solids are very important as they indicate the strength of sewage and amount of treatment required. Total solids in wastewater exist in 3 forms:

Dissolved solids, Colloidal solids and Suspended solids.

Dissolved solids are those which remain dissolved in sewage just as salt in water and are generally organic in nature causing putrefaction and thus increasing the strength of sewage and creating nuisance if disposed off untreated. Colloidal solids are finely divided solids remaining either in solution or in suspension.
Suspended solids are those, which are in suspension and are floating in sewage.

These are further classified into:

Settleable solids, which settle down at the bottom of an Imhoff cone and are an approximate measure of the quality of sludge that will be removed by sedimentation.

Non settleable solids are those, colloidal in nature and can be removed by Chemical treatment.

Fixed solids: Fixed solids are also called inorganic solids consisting of minerals and salts, which include sand, gravel, debris, dissolved salts etc. They constitute about 55°/o of the total solids and are not harmful in sewage treatment operations and require only mechanical appliances such as screens for their removal.

Volatile solids: They are also called organic solids or ignited solids, consisting of organic matter such as carbohydrates, fats, oils etc and constitute about 45% of the total solids and commonly used in the analysis of wastewater sludge's to measure their biological stability.

✓ **PROCEDURE:**
Part-A: Total Solids
1. Ignite the clean evaporating dishes in the muffle furnace for 30 minutes at 550°C and cool in a desiccators.
2. Note down the empty weight of the dish (W_1).
3. Pour a measured portion (50 to 100 ml) of the well-mixed sample into the dish and evaporate the contents by placing the dish on a steam bath.
4. Transfer the dish to an oven maintained at either 103–105°C or 179–181°C and dry it for 1 hour.
5. Allow the dish to cool briefly in air before placing it, while still warm in a desiccator to complete cooling in a dry atmosphere.
6. Weigh the dish as soon as it has completely cooled (W_2).
7. Weight of residue = $W_T = (W_2 – W_1)$ mg. [W_2 and W_1] should be expressed in mg.

Part-B: Total Fixed Solids
1. Keep the same dish (W_T) used for determining total residue in a muffle furnace for 1 hour at 550°C.
2. Allow the dish to partially cool in air until most of the heat has dissipated, then transfer to a desiccator for final cooling in a dry atmosphere.
3. Weigh the dish as soon as it has cooled (W_3).
4. Weight of total fixed residue = $W_F = (W_3 – W_1)$ mg. [W_3 and W_1 should be expressed in mg.]

Part-C: Total Dissolved Solids
1. Filter a measured portion of the mixed sample (50 or 100 ml) through a Whatmann filter paper (No 44).
2. Heat and collect the filtrate in a previously prepared and weighed evaporating dish at 103 °C for 1 to 1.5 hours in a hot air oven and weigh the residue.
3. Allow the dish to cool briefly in air before placing it, while still warm in a desiccators to complete cooling in a dry atmosphere.
4. Weigh the dish as soon as it has completely cooled (W_5).
5. Weight of total dissolved solids = $W_D = (W_5 – W_4)$ mg.

Where,

W_4 = Weight of empty evaporating dish in mg.

W_5 = Weight of empty evaporating dish in mg + Residue left after evaporating the filtrate in mg.

Part D: Total Suspended Solids = W_s= Total Solids – Total Dissolved Solids.

Part E: Total Volatile Solids = W_v = Total Solids – Total Fixed Solids.

Part F: Settleable Solids (by volume) [W_{ss}]

1. Fill an imhoff cone (lit capacity, graduated up to 40ml) to the litre mark with a thoroughly mixed sample.
2. Allow to settle for 45 minutes.
3. Gently stir the sides of the cone with a rod a few times to ensure that all solids adhering to the sides is loosened.
4. Allow to settle for further 15 minutes.
5. Record the volume of settleable matter in the cone as ml/l.

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.	Total Solids	
2.	Dissolved Solids	
3.	Suspended Solids	
4.	Total Volatile Solids	
5.	Dissolved Volatile Solids	
6.	Suspended Volatile Solids	

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

✓ **FACULTY SIGNATURE**

EXPERIMENT NO:	Date Conducted	Marks
19		

✓ **TITLE: SULPHATE TEST (By Titrimetric method)**

✓ **LEARNING OBJECTIVE:**
- Understand the ill effects of Sulphate.
- Methodology to determine Sulphate.

✓ **AIM:** To find the concentration of Sulfate (SO_4) in the given water sample.

✓ **APPARATUS:**
1. Titration apparatus,
2. Hot pan,
3. Filter paper.

✓ **REAGENTS:**
    a) Hydroxylamine chloride.
    b) Benzidine hydrochloride.
    c) Sodium hydroxide (NaOH) of 0.05 N.
    d) Phenolphthalein - Indicator.

✓ **THEORY:**

      Sulfate ion is one of the major an-ion occurring in natural waters up to 50 mg/L. Sulfates in the natural waters ranges from a few milligrams to thousand milligrams per liter. Rainwater has quite high concentration of sulfates particularly in areas with high atmospheric pollution. Sulfate is a naturally occurring substance that contains sulfur and oxygen. It is present in various mineral salts that are found in soil. Sulfate forms salts with a variety of elements including barium, calcium, magnesium, potassium and sodium. Sulfate should not be confused with sulfite. Sulfite also contains sulfur and oxygen, but is chemically different than sulfate. Sulfite is sometimes used as a food preservative. Some people are severely allergic to sulfite. Sulfate may be leached from the soil and is commonly found in most water supplies. Magnesium, potassium and sodium sulfate salts are all soluble in water. Calcium and barium sulfate are not very easily dissolved in water. There are several other sources of sulfate in water. Decaying plant and animal mailer may release sulfate into water. Numerous chemical products including ammonium sulfate fertilizers contain sulfate in a variety of forms. The treatment of water with aluminum sulfate (alum) or copper sulfate also introduces sulfate into a water supply. Human activities such as the combustion of fossil fuels and sour gas processing release sulfur oxides to the atmosphere, some of which is converted to sulfate. Sulfate is generally considered to be nontoxic. The consumption of drinking water containing high amounts of magnesium or sodium sulfate may result in intestinal discomfort, diarrhea and consequently dehydration. This laxative effect is often observed when someone drinks water that contains greater than 500 mg/L of sulfate. Over the time, individuals appear to develop a tolerance to higher concentrations of sulfate. Diarrhea and dehydration are often observed when individuals accustomed to drinking water with low concentrations of sulfate consume water with high amounts of sulfate. It is not advisable to use water that contains high concentrations of sulfate for infant feeding. High amounts of various sulfate salts may give drinking water an offensive taste. Depending upon the type of sulfate salt(s) present in the water, most people begin to notice an offensive taste at concentrations ranging from 250 to 1000 mg/L. High concentrations of sulfate may interfere in the efficiency of chlorination in

some water supplies. Also, sulfate salts may increase the corrosive properties of water. Sulfate reducing bacteria are often sometimes encountered in water supplies. These bacteria produce hydrogen sulfide that results in an unpleasant taste and odor (rotten egg smell). Hydrogen sulfide also increases the corrosive properties of water. Sulfate can only be removed from water by demineralization through the use of reverse osmosis or distillation. Higher concentration of sodium Sulfate in water can cause misfunctioning of the alimentary canal. So the recommended upper limit is 200 mg/L (as per BIS: 10500-1991) in water intended for human consumption.

✓ **PROCEDURE:**
1) Take 125 ml of sample in a clean beaker.
2) Add 05 ml of hydroxylamine chloride and then add 10 ml Benzidine hydrochloride.
3) Stir the mixture vigorously and allow the precipitate to settle.
4) Filter the solution and wash the beaker and the filter paper with distilled water.
5) Pierce the filter paper in the funnel and wash the precipitate formed on the filter paper to the original beaker with 150 ml distilled water.
6) Heat the beaker to dissolve the contents for 30 minutes. Add 2 drops of Phenolphthalein indicator.
7) Titrate with sodium hydroxide- titrant (NaOH) of 0.05 N until pink color appears.

✓ **CALCULATION:**

$$\text{Concentration of Sulfate in mg/L} = \frac{\text{ml of NaOH with 0.05 N x 38.40}}{125 \text{ ml of the sample taken}}$$

✓ **RESULTS:**

Sl. No.	Parameters Analysed	Results
1.		

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
20		

✓ **TITLE: DETERMINATION OF NITRATE (NO₃) (UV-VISIBLE Spectrophotometry)**

✓ **LEARNING OBJECTIVE:**
- Understand the ill effects of Nitrate.
- Understand the concept UV spectrophotometer.
- Methodology to determine Nitrate.

✓ **AIM:** To determine the Nitrate (NO₃) concentration in given water sample.

✓ **APPARATUS:** UV-VISI BLE Spectrophotometer, Quartz cuvettes, etc.

✓ **REAGENTS USED:**

Stock Nitrate solution. (1 ml = 0.1 mg of NO;)

Preparation of Standard series using Stock solution

Sl. No.	ml of Stock Nitrate solution	Concentration in ppm
1	05 ml	05 ppm*
2	10 ml	10 ppm
3	15 ml	15 ppm
4	20 ml	20 ppm
5	25 ml	25 ppm

* $\dfrac{05 \text{ ml} \times 0.1 \times 1000}{100} = 05 \text{ ppm (or mg/L)}$

✓ **THEORY:**

The nitrate ion is a polyatomic ion with the empirical formula N03 and a molecular mass of 62.0049. Almost all inorganic nitrate salts are soluble in water at standard temperature and pressure (STP). Nitrogenous mailer is present in domestic sewage, fertilizer factory effluents, agricultural runoff water and many other industrial and solid waste leachates. Large inputs of nitrogen to surface and subsurface water may result in excess growth of algae and other aquatic weeds. Moreover a build up of nitrate in drinking water supplies is thought to pose a health hazard to humans particularly infants, as well as livestock. Major forms of nitrogen in water and wastewater are ammoniacal nitrogen, organic nitrogen or albuminoid nitrogen, nitrite, nitrate, nitrous oxides and molecular nitrogen.

As per BIS: 10500-1991 nitrate (NO_3^-) content in drinking water should be less than 45 mg/L.

Beyond this limit it may cause mathemoglobinemia or blue baby disease in infants. Infants in particular are especially vulnerable to methemoglobinemia due to nitrate metabolizing triglycerides present in higher concentrations than at other stages of development. Methemoglobinemia is a disorder characterized by the presence of a higher than normal level of methemoglobin (metHb) in the blood. Signs and symptoms of methemoglobinemia (methemoglobin>1%) include shortness of breath, cyanosis, mental status changes (-5O%), headache, fatigue, exercise intolerance, dizziness and loss of consciousness. Arterial blood with elevated methemoglobin levels has a characteristic chocolate-brown color as compared to normal bright red oxygen containing arterial blood.
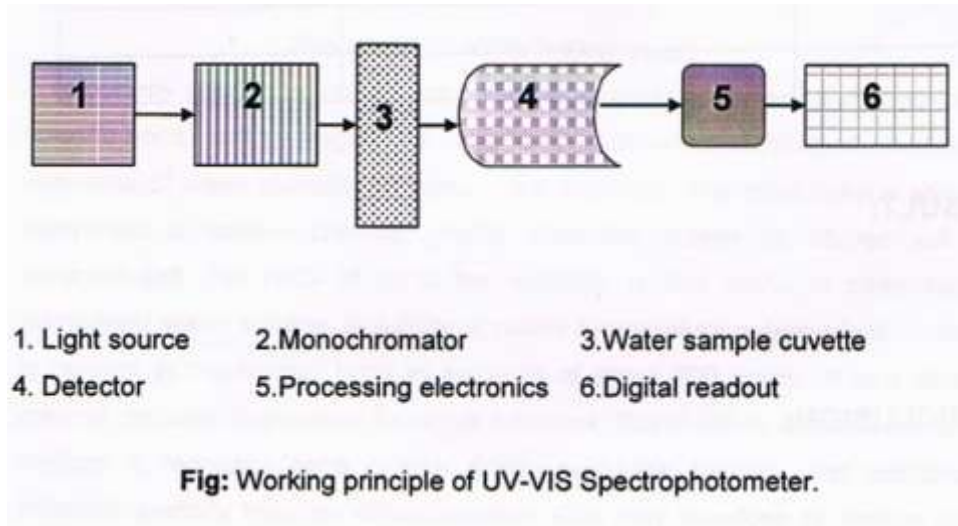
Severe methemoglobinemia (methemoglobin>50%) patients have dysrhythmias, seizures, and the baby may go into coma and may die. Nitrate concentration can be detected by UV-Visible spectrophotometer, which works on the principle of spectrophotometry based on Beer - Lambert's law.

1. Light source   2.Monochromator   3.Water sample cuvette
4. Detector   5.Processing electronics   6.Digital readout

Fig: Working principle of UV-VIS Spectrophotometer.

✓ **PROCEDURE:**
1) Switch on the UV-VISIBLE Spectrophotometer and perform the initial steps of operation.
2) Wait for the initialization, lamps testing & auto calibration.
3) Select the mode of operation by operating the appropriate numerical key from menu keyboard. Start entering the required data as per the self-explanatory instructions from the instrument such as selection of wavelength (220 nm), number of standards (05) and their concentrations (05, 10, 15, 20, 25 ppm), display of unit (ppm), number of samples and number of cuvettes etc.
4) After performing of the above steps, determine the Nitrate concentration in ppm for the given water samples.

✓ **RESULT:**

Sl. No.	Parameters Analysed	Results

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
21		

- ✓ **TITLE: DETERMINATION OF SODIUM AND POTASSIUM (By Flame Photometry)**

- ✓ **LEARNING OBJECTIVE:**
  - Understand the ill effects of sodium and potassium.
  - Understand the concept flame photometer.
  - Methodology to determine Na, K.

- ✓ **AIM:** To determine the Sodium (Na)& Potassium (K) in given water samples.

- ✓ **APPARATUS:** Flame Photometer, Borosil glass wares etc.

- ✓ **REAGENTS:**
100 mg/L combined Na & K solution.

- ✓ **THEORY:**
Sodium (Na): Sodium makes up about 2.6% by weight of the earth's crust, making it the 6th most abundant element overall and the most abundant alkali metal. For billions of years sodium is washed out from rocks and soils, ending up in oceans, where it may remain for about 50×10^6 years. Seawater contains approximately 11,000 ppm of sodium. Rivers contain only about 09 ppm or mg/L of sodium. Drinking water usually contains about 50 ppm or mg/L of sodium. This value is clearly higher for mineral water. In soluble form sodium always occurs as Na ions. Elementary sodium reacts strongly with water, according to the following reaction mechanism:

$$2Na(s)+2H_2O \longrightarrow 2NaOH(aq)+H_2(g)$$
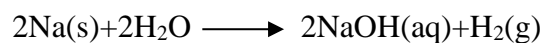
A colourless solution is formed, consisting of strongly alkaline sodium hydroxide (caustic soda) and hydrogen gas. This is an exothermic reaction. A number of of water solubility of sodium are available. The most familiar sodium compound is sodium chloride (NaCI), otherwise known as kitchen salt or common salt. For NaCI at 20°C the solubility is 359 gmIL, in other words adequately water soluble. Solubility is nearly temperature independent. Sodium is present in the human body in amounts of about 100 grams. It is a dietary partially responsible for nerve functions. Blood serum contains 3.3 gm/L sodium. It regulates extra cellular fluids, acid-base balance and membrane partially together with potassium. One may overdose on sodium from salt. This causes increased blood pressure, arteriosclerosis, oedema, confusion and increased risk of infection from excessive Na intake. Sodium shortages may lead to dehydration, convulsion, muscle paralysis,decreased growth and general numbness. Generally, humans require about 300 mg/day sodium chloride to warrant a balanced sodium level. People that have diarrhoea or other health effects that increase salt requirements need a higher dietary amount of sodium than usual. People with heart and kidney disease are recommended a sodium poor diet.The high sodium content is the deterioration of the physical condition of the soil (formation of crusts, water logging, reduced soil permeability. The water infiltration problem occurs within the top few centimeters of the soil and is mainly related to the structural stability of the surface soil. To predict the infiltration problem, the Sodium Absorption Ratio (SAR) is often used. To remove sodium chloride from water, one may apply reverse osmosis, electro dialysis, distillation techniques or ion exchange. Reverse osmosis is most economical considering energy and money requirements.

Potassium (K): Elemental potassium is does not occur in nature because it reacts violently with water. As various compounds, potassium makes up about 1.5% of the weight of the earth's crust and is the 7th most abundant element. Potassium may be detected by taste because it triggers 3 of the 5 types of taste sensations, according to concentration. Dilute solutions of potassium ion taste sweet (allowing moderate concentrations in milk and juices), while higher concentrations become increasingly bitter/alkaline, and finally also salty to the taste. Potassium ions are an essential component of plant nutrition and are found in most soil types. Its primary use in agriculture, horticulture and hydroponic culture is as a fertilizer as the chloride (KCl), sulfate (K_2SO_4) or nitrate (KNO_3). Seawater contains about 400 ppm of potassium. It tends to settle, and consequently ends up in sediment mostly. Rivers generally contains about 2 to 3 ppm potassium. This difference is mainly caused by a large potassium concentration in oceanic basalts. It reacts with water more rapidly than does sodium, which is placed higher in the periodic chart. Potassium is a dietary requirement for humans, and they take up about 1-6 gm/day at a requirement of -3.5 gm/day. The total potassium amount in the human body lies somewhere between 110 and 140 grams and mainly depends upon muscle mass. Potassium may be removed from water by means of reverse osmosis.

✓ **PROCEDURE:**
1) Switch on the display unit, air compressor and LPG.
2) Ignite the burner and adjust the flame to standard cooking flame.
3) Calibrate the instrument by keeping distilled water for the adjustment of zero value on the display screen.
4) Similarly, 100 mg/L Na & K solution for the display of 100.
5) Aspirate the unknown water sample and observe the constant display and note down the concentrations of Na & K in mg/L.
6) If '1' is observed on the display screen, dilute the sample with distilled water for suitable proportion.

✓ **RESULT:**

Sl. No.	Parameters Analysed	Results

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks

✓ **TITLE: TOTAL COUNT TEST & MPN DETERMINATION(Bacteriological Analysis - Multiple Tube Fermentation Technique)**

✓ **LEARNING OBJECTIVE:**
- Understand the concept of biological parameter.
- Methodology to determine MPN.

✓ **AIM:** To determine the Total Coliform (MPN) in given water sample.

✓ **APPARATUS:** Autoclave, BOD incubator, Durham's tubes, Borosil glasswares etc.

✓ **REAGENTS:**
1. Lauryl tryptose broth
2. Brilliant green lactose bile broth
3. Endo methylene blue agar.
4. Eosin methylene blue agar.
5. Lactose broth

✓ **THEORY :**

Coliform group comprises of all the aerobic, facultative and anaerobic gram-negative non-spore forming rod shaped bacteria that ferment lactose with gas formation within 48 hours at 35°C. The standard test for this group may be carried out either by multiple tube fermentation technique or by membrane filter technique. Escherichia coli (E.coli) are used as an indicator organism for the purpose of sanitary examination of water. The E.coli test by multiple tube fermentation technique consists of 3 phases – presumptive, confirmed and completed. The results are expressed in terms of MPN (Most Probable Number), which is based on certain probability formulae. The estimate may give a value greater than the actual number of coliform present. The accuracy of any single test depends on the number of tubes fermented. This method helps in describing the sanitary quality of water. The safety of the water is generally judged from the knowledge of sanitary condition and mentioned by the number of samples yielding positive or negative results. If more than 95% should yield negative results, the safety is usually assured.

✓ **PROCEDURE:**
1) Wash thoroughly and sterilize all the glass wares before use.
2) Prepare the Broth solution of both double strength (DS) & single strength (SS) as per the specifications
3) Arrange the series of 10, 1.0 & 0.1 ml combination. (05 test tubes for each combination).
4) Place 10 ml broth (DS) solution in each of first 05 test tubes, 10 ml (SS) solution in remaining 10 test tubes.
5) Drop Durham's tube (inverted) in each test tube and plug the test tube with cotton.
6) Again sterilize the solution and other glass wares.
7) Add 10 ml representative sample in each of the first 05 (DS) tubes, 1.0 ml sample in second 05 (SS) tubes and 0.1 ml sample in remaining 05 (SS) tubes and plug the test tube with cotton.
8) Incubate the tubes for initial 24 hours for preliminary observation of +ve tubes another 24 hours for confirmative observation at about 35°C ± 2°C.

9) Note down the +ve test tubes from each combination and refer the MPN table for the final value.

10) If the combination is not matching with the table, use the following formula,

Total Coliform MPN/100 ml = $\dfrac{\text{(No. of +ve tubes x 100)}}{\text{(ml of sample in –ve tubes) x (ml of sample in all tubes)}}$

✓ **TABULAR COLUMN:**

Sample no. or description	Date and time of observation	Date and time of incubation	Results after incubation for various volumes of samples inoculated (mL) + ve or – ve									Test case
			10	10	10	1	1	1	0.1	0.1	0.1	
												Presumptive test 24 hrs
												Presumptive test 48 hrs
												Confirmed test 48 hrs
												Completed test 24 hrs
												Completed test 48 hrs
Number of + ve tubes												
mL of sample in – ve tubes												

✓ **RESULT:**

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

EXPERIMENT NO:	Date Conducted	Marks
23		

✓ **TITLE: DETERMINATION OF OIL & GREASE FOR WASTE WATER (By Gravimetric method) [Additional experiment]**

✓ **LEARNING OBJECTIVE:**
- Understand the ill effects of oil and grease.
- Methodology to determine oil and grease.

✓ **AIM:** To determine the amount of Oil & Grease present in the given waste water sample.

✓ **APPARATUS:**
1. Separator funnel,
2. Evaporating dish,
3. Balance,
4. Hot plate etc.

✓ **REAGENTS:**
a) Petroleum ether — (60°C to 80°C).
b) H_2SO_4 reagent (diluted 1+3).

✓ **THEORY:**

Wastewater discharges containing high concentrations of oil and grease from food service facilities are the main cause of blockages and overflows in the city's wastewater collection system. Overflows of wastewater into the storm water collection system and natural bodies of water could be greatly reduced by controlling the discharge of oil and grease into the wastewater collection system. This source of pollution is also readily preventable by good management practices and proper maintenance at food service facilities. To address this issue, the city has developed an oil and grease management program. The objectives of the oil and grease management program are to:

➢ Eliminate sewer system overflows.
➢ Reduce the amount of oil and grease discharged to the wastewater collection system.
➢ Reduce maintenance costs for the wastewater collection system.
➢ Improve operation of the wastewater collection system.
➢ Recover equitable costs for excessive loading of high strength wastewater   (e.g. wastewater high in COD)

In accordance with standardized testing methods, all samples for testing must be collected as grab samples. A grease trap or interceptor consists of an enclosed chamber, which is designed to separate and retain oil and grease from the kitchen wastewater.

✓ **PROCEDURE:**
1) Measure 200 ml of well mixed waste water sample in clean separatory funnel
2) Add 10 ml H2S04 (1+3) reagent to acidify the sample
3) Add 25 to 50 ml Petroleum ether
4) Shake the funnel to make the separation of oil and grease.
5) Allow the sample to form two distinct layers.
6) Discard the lower layer
7) Collect the upper layer in an evaporating dish (oven dried) of known weight grams using filter paper.
8) Evaporate the petroleum ether and cool the dish.
9) Note down the residue weight (W2) grams along with dish.

✓ **CALCULATION:**

$$\text{Oil \& Grease in mg/L} = \frac{(W_2 - W_1)}{\text{ml of sample}} \times 10^6$$

✓ **RESULT:**

✓ **OUTCOME & CONCLUSIONS:**

✓ **REMARKS:**

FACULTY SIGNATURE

REMEMBER THE IMPORTANT TERMS

- ❖ **Atom** is a basic unit of matter that consists of a dense, central nucleus surrounded by a cloud of negatively charged electrons. The atomic nucleus contains a mix of positively charged protons and electrically neutral neutrons. The electrons of an atom are bound to the nucleus by the electromagnetic force. Likewise, a group of atoms can remain bound to each other, forming a molecule. An atom containing an equal number of protons and electrons is electrically neutral; otherwise it has a positive or negative charge and is an ion. An atom is classified according to the number of protons and neutrons in its nucleus: the number of protons determines the chemical element, and the number of neutrons determines the isotope of the element.

- ❖ **Atomic weight** (relative atomic mass) of an element is the sum of the atomic weights of all the atoms in a molecule.

- ❖ **Ion** is an atom or molecule in which the total number of electrons is not equal to the total number of protons, giving it a net positive or negative electrical charge. An anion is an ion with more electrons than protons, giving it a net negative charge (since electrons are negatively charged and protons are positively charged). Conversely, a cation is an ion with more protons than electrons, giving it a positive charge.

- ❖ **Molecule** is defined as an electrically neutral group of at least two atoms in a definite arrangement held together by very strong (covalent) chemical bonds. Molecules are distinguished from polyatomic ions in this strict sense. in organic chemistry and biochemistry, the term molecule is used less strictly and also is applied to charged organic molecules and biomolecules.

- ❖ **Molecular weight** is the sum of the relative atomic masses of the constituent atoms of a molecule.
- ❖ **Equivalence point,** or stoichiometric point, of a chemical reaction occurs during a chemical titration when the amount of titrant added is stoichiometrically equal to the amount of analyte present in the sample: the smallest amount of titrant that is sufficient to fully neutralize or react with the analyte.

  The end point (similar, but not the same as the equivalence point) refers to the point at which the indicator changes color in a colorimetric titration.

- ❖ **Standard solution** is a chemical term which describes a solution of known concentration. The concentration of the solution is normally expressed in units of moles per Liter (mol/L, often abbreviated to M for molarity). Standard solutions are normally used in titrations to determine the concentration of a substance in solution.

- ❖ **Oxidizing agent** (also called an oxidant, oxidizer or oxidizer) can be defined as either:
  1. A chemical compound that readily transfers oxygen atoms, or
  2. A substance that gains electrons in a redox chemical reaction.

- ❖ **Reducing agent** (also called a reductant or reducer) is the element or compound in a redox (reduction-oxidation) reaction that reduces another species. In doing so, it becomes oxidized, and is therefore the electron donor in the redox.

- ❖ **Quantitative chemistry** is a branch of science' that studies and differentiates matter in a chemical and molecular level using laboratory tests and equipments to show visible results. Volumetric analysis is one of the laboratory tests used in quantitative chemistry to show the relationship of a molecule's composition and the way they react to substances. It is also called volumetric titration because all experiments under this method of analysis are completed by titration reactions.

- ❖ **Volumetric analysis** is a phase of quantitative analysis that depends upon the measurement of liquid reagent volumes of standard solutions needed to complete particular reactions in samples submitted to test.
  For example determination of DO, BOD, COD, chlorides etc.
  Volumetric Analysis - Volumetric analysis is a method of determining chemical differences and principles of redox (reduction-oxidation) reactions between molecules. Chemicals under this topic are classified based on the results obtained from titration.

  Titration- The process of creating a balance chemical equation 'in vitro' is called titration. It typically uses a volumetric flask, hence, called volumetric titration.

There are three types of volumetric titration, which are classified based on the rate of their reaction.
- ➢ Direct titration method (DTM) is a one-step titration process.
- ➢ Indirect method (ITM) involves a two-step titration process.
- ➢ Back titration method (BTM) uses a three-step titration process.

- ❖ **Principle** - The principle involved in all titration methods is to balance a chemical reaction, such as achieving acid and base equilibrium. The most important key is to attain the desired end point regardless of the steps involved in the process. Therefore, it doesn't matter if it is processed using direct, indirect or back titration method because they will still arrive at the same equivalent point.

  The Process - Titration starts by preparing two solutions, the analyte and titrant. Add an indicator to analyte and then slowly add titrant solution in a drop-wise manner until the analyte changes its color.

  Analyte - An analyte is a weak base or acid, Its structure is made from any compound that can be converted to a strong acid or base.

  Titrant - The titrant is a strong acid or base that is slowly added to the analyte until it reaches any visible change in the color of the solution under observation.

  End Point - This is the hint to know if the analyte has reached the minimum amount that is allowed to react with the titrant. Indicator - It is a pH marker added to the analyte that triggers a change in color when equilibrium is reached. It should have a weaker acid/base concentration than the analyte.

- ❖ **Gravimetric analysis** means analysis by weight açd pertains to all determinations wherein the final results are obtained by means of the analytical balance.
  For example determination of total solids, suspended solids, fixed solids etc.

- ❖ **Indicators** are the chemicals that when added to solutions show whether the solution is acidic or basic, by a sudden change of their color. Indicators are substances, which indicate the completion (equivalence point or end point) of a chemical reaction by change in color.

- ❖ **Methylene Blue Active Substances (MBAS)** - Detergents contain synthetic or organic surface-active agents called surfactants which are derived from petroleum product precursors. They have the common property of lowering the surface tensions of water thus allowing dirt or grease adhered to various articles to be washed off. Industrial facilities use detergents to clean machinery. Soap manufacturers and households will also discharge anionic detergents into the surface water. The problem with these types of discharges is that surfactants can present significant environmental pollution problems. In aquatic environments, surfactants may form a surface film and reduce oxygen transfer at the water surface. Some surfactants may be acutely toxic to aquatic organisms. Detergents can damage fish gills by stripping them of their natural oils, thus interrupting oxygen transfer. Surfactants and detergents may also cause suds or foam to form on surface waters, which is aesthetically displeasing. Furthermore, this foam often contains nutrients such as nitrogen and phosphorus which can; in turn, provoke algae blooms. Surfactants can also alter the hydraulic characteristics of soils, affecting the movement of contaminants through soils and into groundwater. Surfactants are very slow to biodegrade and have carcinogenic and reproductively toxic byproducts such as nonylphenol, which is currently regared as a potent endocrine disrupter.

- ❖ **Foaming** - Boiler water carry-over is the contamination of the steam with boiler-water solids. Bubbles or froth actually build up on the surface of the boiler water and pass out with the steam. This is called foaming and it is caused by high concentration of any solids in the boiler water. It is generally believed, however, that specific substances such as alkalis, oils, fats, greases, certain types of organic matter and suspended solids are particularly conducive to foaming. In theory suspended solids collect in the surface film surrounding a steam bubble and make it tougher. The steam bubble therefore resists breaking and builds up foam, It is believed that the finer the suspended particles the greater their collection in the bubble.

- ❖ **Priming** is the carryover of varying amounts of droplets of water in the steam (foam and mist), which lowers the energy efficiency of the steam and leads to the deposit of salt crystals on the super heaters and in the turbines. Priming may be caused by improper construction of boiler, excessive ratings, or sudden fluctuations in steam demand. Priming is sometimes aggravated by impurities in the boiler-water. Priming is common cause of high levels of boiler water carryover. These conditions often lead to super heater tube failures as well. Priming is related to the viscosity Df the water and its tendency to foam. These properties are governed by alkalinity, the presence of certain organic substances and by total salinity or TDS. The degree of priming also depends on the design of the boiler and its steaming rate.

❖ **Atmospheric pressure** is the force per unit area exerted against a surface by the weight of air above that surface in the earth's atmosphere. In most circumstances atmospheric pressure is closely approximated by the hydrostatic pressure caused by the weight of air above the measurement point. Low pressure areas have less atmospheric mass above their location, whereas high pressure areas have more atmospheric mass above their location. Similarly, as elevation increases there is less overlying atmospheric mass, so that pressure decreases with increasing elevation.

The standard atmosphere (symbol: atm) is a unit of pressure and is defined as being equal to 101,325 Pa or 101.325 kPa. The following units are equivalent, but only to the number of decimal places displayed: 760 mmHg (Torr), 29.92 in Hg, 14.696 PSI, 1013.25 millibars.

❖ **Instrument Calibration** Instrument calibration is one of the primary processes used to maintain instrument accuracy. Calibration is the process of configuring an instrument to provide a result for a sample within an acceptable range. Eliminating or minimizing factors that cause inaccurate measurements is a fundamental aspect of instrumentation design.

❖ **Leaching** is the process of extracting minerals from a solid by dissolving them in a liquid, either in nature or through an industrial process. In the chemical processing industry, leaching is known as extraction. Leaching has a variety of commercial applications, including separation of metal from ore using acid, and sugar from beets using hot water. Chloride can also be leached from food.

❖ **Valency** or oxidation number of an atom is determined by number of electrons that it can take on, give up, or share with other atoms. Neutrons and protons (+) are within the nucleus, and electrons (-) are arranged in orderly shells outside.
If the electrons are lost, the atom becomes positively charged, and if electrons are gained, the atom becomes a negatively charged ion.

❖ **Oxidation-Reduction** — An atom, molecule, or ion is said to undergo oxidation when it loses an electron, and to undergo reduction when it gains an electron.
For example determination of DO, BOD, COD, chlorides etc.

❖ **Calibrated glass ware** is of 2 types: (1) That which is calibrated to a definite volume, e.g., volumetric flasks and graduated cylinders; and (2) that which is calibrated to deliver prescribed volumes, e.g., pipettes and For accuracy always use the 2nd type.

❖ **Wavelength** is a parameter of radiant energy, which is the distance between two adjacent crests of a wave in a beam of radiation is normally measured in angstroms (A) or in nanometers (nm).
$1A = 10^{-8}$ cm
1 nm $= 10^{-7}$ cm $= 10$ A

❖ **Water logging** refers to the saturation of soil with water. Soil may be regarded as waterlogged when the water table of the groundwater is too high to conveniently permit an anticipated activity, like agriculture. In agriculture, various crops need air (specifically, oxygen) to a greater or lesser depth in the soil. Water logging of the soil stops air getting in.

❖ **Soil salinity** - Salt affected soils are caused by excess accumulation of salts, typically most pronounced at the soil surface. Salts can be to the soil surface by capillary transport from a salt laden table and then accumulate due to evaporation; they can also be concentrated in soils due to human activity. As soil salinity increases, salt effects can result in degradation of soils and vegetation.

❖ **Monochromator** is an optical device that transmits a mechanically selectable narrow band of wavelengths of light or other radiation chosen from a wider range of wavelengths available at the input. A monochromator can use either the phenomenon of optical dispersion in a prism, or that of diffraction using a diffraction grating, to spatially separate the colors of light.

❖ **Sodium Absorption Ratio (SAR)** is a measure of the suitability of water for use in agricultural irrigation, as determined by the concentrations of solids dissolved in the water. It is also a measure of the sodicity of soil, as determined from analysis of water extracted from the soil.
The formula for calculating sodium adsorption ratio is:
$SAR = [Na^+] / \{([Ca^{2+}] + [Mg^{2+}]) / 2\}^{1/2}$
Where sodium, calcium, and magnesium are in milliequivalents/liter.

- ❖ **Cuvette** is a small tube of circular or square cross section, sealed at one end, made of plastic, glass, or fused quartz (for UV light) and designed to hold samples for spectroscopic experiments. The best cuvettes are as clear as possible, without impurities that might affect a spectroscopic reading.

  There are 3 different types of cuvettes commonly used, with different usable wavelengths:

  - ➤ Glass, with a wavelength from 380 to 780 nm (visible spectrum)
  - ➤ Plastic, with a wavelength from 380 to 780 nm (visible spectrum)
  - ➤ Fused quartz, with a wavelength below 380nm (ultraviolet spectrum)

- ❖ **BOD incubator** is an incubator designed to maintain 20°C necessary to perform a test called Biochemical Oxygen Demand (BOD). It involves incubating samples saturated with oxygen at 20°C for (usually) five days. Such an incubator has a compressor to depress the temperature below ambient and a heater to bring it back up to 20°C. These work against each other and produce very precise temperature control, often as close as +/- 0.1°C. The term "incubators' is a general term which includes BOO incubators and other incubators designed to maintain other temperatures.

- ❖ **Buffer solution** is an aqueous solution consisting of a mixture of a weak acid and its conjugate base or a weak base and its conjugate acid. It has the property that the pH of the solution changes very little when a small amount of strong acid or base is added to it. Buffer solutions are used as a means of keeping pH at a nearly constant value in a wide variety of chemical applications.

- ❖ **Eutrophication** is an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases the primary productivity of the ecosystem. Eutrophication is often the result of anthropogenic pollution with nutrients, particularly the release of sewage effluent and agricultural run-off carrying fertilizers into natural waters. Eutrophication generally promotes excessive plant growth and decay, favors simple algae and plankton over other more complicated plants, and causes a severe reduction in water quality.

- ❖ Gait is the pattern of movement of the limbs of animals, including humans, during locomotion over a solid substrate. Most animals use a variety of gaits, selecting gait based on speed, terrain, the need to maneuver, and energetic efficiency.

- ❖ Posture is the position in which you hold your body upright against gravity while standing, sitting or lying down. Good posture involves training your body to stand, walk, sit and lie in positions where the least strain is placed on supporting muscles and ligaments during movement or weight- bearing activities. Proper posture:

- ❖ Keeps bones and joints in the correct alignment so that muscles are being used properly.

  - Helps decrease the abnormal wearing of joint surfaces that could result in arthritis.
  - Decreases the stress on the ligaments holding the joints of the spine together.
  - Prevents the spine from becoming fixed in abnormal positions.
  - Prevents fatigue because muscles are being used more efficiently, allowing the body to use less energy.
  - Prevents strain or overuse problems.
  - Prevents backache and muscular pain.
  - Contributes to a good appearance.

- ❖ **Fatigue** (also called exhaustion, lethargy, languidness, languor, lassitude, and listlessness) is a state of awareness describing a range of afflictions, usually associated with physical and/or mental weakness, though varying from a general state of lethargy to a specific work-induced burning sensation within one's muscles. Physical fatigue is the inability to continue functioning at the level of one's normal abilities. It is ubiquitous in everyday life, but usually becomes particularly noticeable during heavy exercise. Mental fatigue, on the other hand, rather manifests in somnolence (sleepiness).Fatigue is considered a symptom, as opposed to a medical sign, because it is reported by the patient instead of being observed by others. Fatigue and 'feelings of fatigue' are often confused.

- ❖ **Serum** in blood is the component that is neither a blood cell nor a clotting factor it is the blood plasma with the fibrinogens removed. Serum includes all proteins not used in blood clotting and all the electrolytes, antibodies, antigens, hormones, and any exogenous substances (e.g., drugs and microorganisms).

  The study of serum is serology. Serum is used in numerous diagnostic tests, as well as in blood typing.)

❖ **Bone mineralization** pattern refers to the types of minerals (calcium is of paramount importance) that are incorporated into bone, the amount of the minerals that are present (referred to as the bone density), and the possible differences in bone mineral composition and density in different regions of the skeleton.

Calcium, in the form of calcium phosphate, is incorporated into bone as a highly structured crystal called hydroxyapatite. This crystallized mineral is essential for the hardness of bones, and for their rigidity—the latter is important, otherwise the bones may inadvertently bend when a force is applied.

❖ **Oedema** is the medical term for fluid retention in the body. It occurs when there is a build-up of fluid (mainly water) in the body's tissues, swelling to occur in the affected area. As well as swelling or puffiness of the skin, oedema can cause:
  ❖ skin discoloration
  ❖ fluid-filled areas of skin that temporarily hold the imprint of your finger when pressed (known as pitting oedema)
  ❖ aching, tender limbs
  ❖ stiff joints
  ❖ weight gain or weight loss
  ❖ raised blood pressure and pulse rate
    Qedema is often a symptom of an underlying condition. It can also be caused by a variety of factors such as high salt intake in the diet or being immobile for long periods of time.

❖ **Hydroponics** is a method of growing plants using mineral nutrient solutions, in water, without soil. Terrestrial plants may be grown with their roots in the mineral nutrient solution only or in an inert medium, such as perlite, gravel, mineral wool, or coconut husk. When the required mineral nutrients are introduced into a plant's water supply artificially, soil is no longer required for the plant to thrive. Almost any terrestrial plant will grow with hydroponics.

❖ **Electrolytes** are essential components of body fluids, such as blood and urine. Typical electrolytes found in the body are sodium, calcium, potassium, chloride and magnesium. They each have an important function in the human body. The human body strives to maintain the correct amount of electrolytes in all areas, replacing any electrolytes lost with new ones to preserve the electrolyte balance. An electrolyte imbalance occurs when the levels are not in normal range and is a serious health situation. Electrolytes help regulate water distribution throughout the body and they play a major role in the acid-base balance, or pH, of body.

❖ **Mucous membrane** - lined tube of the digestive system through which food passes, in which digestion takes place, and from which wastes are eliminated. It extends from the mouth to the anus and includes the pharynx, esophagus, stomach, and intestines. Also called digestive tract. Other names for the alimentary canal include the gastrointestinal (GI) tract, digestive tract, alimentary tract, and nourishment canal. In real life, the alimentary canal consists of the mouth, pharynx, esophagus, stomach, small intestine, and large intestine. In adults, the alimentary canal is about 30 feet long.

❖ **Photosynthesis** is a process that converts carbon dioxide into organic especially sugars, using the energy from sunlight. Photosynthesis occurs in plants, algae, and many species of bacteria, but not in archaea. Photosynthetic organisms are called photoautotrophs, since they can create their own food.

❖ **Neurotoxicity** occurs when the exposure to natural or artificial toxic substances, which are called neurotoxins, alters the normal activity of the nervous system in such a way as to cause damage to nervous tissue. This can eventually disrupt or even kill neurons, key cells that transmit and process signals in the brain and other parts of the nervous system. Neurotoxicity can result from exposure to substances used in chemotherapy, radiation treatment, drug therapies, certain drug abuse, and organ transplants, as well as exposure to heavy metals, certain foods and food additives, pesticides, industrial and/or cleaning solvents, cosmetics, and some naturally occurring substances.

❖ **Iron bacteria** are a type of bacteria that feed on small amounts of iron in water. Iron bacteria are not a health threat, but are a nuisance because they form strands, masses, or thin films that plug pipes, toilets, and plumbing fixtures and reduce flow from wells. In the management of water-supply wells, iron bacteria are bacteria that derive the energy they need to live and multiply by oxidizing dissolved ferrous iron (or the less frequently available manganese). The resulting ferric oxide is insoluble, and appears as brown gelatinous slime that will stain plumbing fixtures, and clothing or utensils washed with the water carrying it. They are known to grow and proliferate in waters containing as low as 0.1 mg/I of iron. However, at least 0.3 mg/L or ppm of dissolved oxygen is needed to carry out oxidation.

❖ **Leachate** is any liquid that, in passing through mailer, extracts solutes, suspended solids or any other component of the material through which it has passed. Leachate is a widely used term in the Environmental sciences where it has the specific meaning of a liquor that has dissolved or entrained environmentally harmful substances which may then enter the environment. It is most commonly used in the context of land-filling of putrescible or industrial waste.

❖ **Acid mine drainage** (AMD), or acid rock drainage (ARD), refers to the ouf flow of acidic water from (usually abandoned) metal mines or coal mines. However, other areas where the earth has been disturbed (e.g. construction sites, subdivisions, transportation corridors, etc.) may also contribute acid rock drainage to the environment.

❖ **Tooth enamel** along with dentin, cementum, and dental pulp is one of the four major tissues which make up the tooth in vertebrates. It is the hardest and most highly mineralized substance in the human body. Tooth enamel is also found in the dermal denticles of sharks. It is the normally visible dental tissue of a tooth because it covers the anatomical crown and must be supported by underlying dentin. Ninety-six percent of enamel consists of mineral, with water and organic material composing the rest. In humans, enamel varies in thickness over the surface of the tooth, often thickest at the cusp, up to 2.5 mm, and thinnest at its border with the cementum at the cement o enamel junction (CEJ). The normal color of enamel varies from light yellow to grayish white.

❖ **Crown** is a type of dental restoration which completely caps or encircles a tooth or dental implant and is typically bonded to the tooth using dental cement. Crowns can be made from many materials, which are usually fabricated using indirect methods. Crowns are often used to improve the strength or appearance of teeth.

❖ **Photoelectric sensors** represent perhaps the largest variety of problem solving choices in the industrial sensor market. Today 'S photoelectric technology has advanced to the point where it is common to find a sensor that will detect a target less than 1 mm in diameter while other units have a sensing range up to 60 m. These factors make them extremely adaptable in an endless array of applications. Although many configurations are available including laser-based and fiber optic sensors, all photoelectric sensors consist of a few of basic components. Each contains an emitter, which is a light source such as an LED (light emitting diode) or laser diode, a photodiode or phototransistor receiver to detect the light source, as well as the supporting electronics designed to amplify the signal relayed from the receiver.

❖ **Heavy metal** is a member of an ill-defined subset of elements that exhibit metallic properties, which would mainly include the transition metals, some metalloids, lanthanides, and actinides. Many different definitions have been proposed—some based on density, some on atomic number or atomic weight, and some on chemical properties or toxicity. The tem heavy metal has been called a "misinterpretation" in an IUPAC technical report due to the contradictory definitions and its lack of a "coherent scientific basis". Living organisms require varying amounts of "heavy metals." Iron, cobalt, copper, manganese, molybdenum, and zinc are required by humans. Excessive levels can be damaging to the organism. Other heavy metals such as mercury, plutonium, and lead are toxic metals that have no known vital or beneficial effect on organisms, and their accumulation over time in the bodies of animals can cause serious illness. Certain elements that are normally toxic are, for certain organisms or under certain conditions, beneficial. Examples include vanadium, tungsten, and even cadmium.

❖ **Cardiac dysrhythmia** (also known as arrhythmia) is a term for any of a large and heterogeneous group of conditions in which there is abnormal electrical activity in the heart. The heart beat may be too fast or too slow, and may be regular or irregular.

❖ **Astringent in taste** - A substance which produces heaviness in tongue, dryness in mouth and results in irregular and difficult respiration due to unusual feeling of blockage in throat or chest is said to be astringent in taste.

Common substances that are astringent in taste are: Lentil, black plum, myrobalan, nut of belerica, honey, catechu, betel nut, dates, lotus flower, banyan tree, pipal tree, pearl, coral etc.

❖ **Dementia** is a decline of reasoning, memory, and other mental abilities (the cognitive functions). This decline eventually impairs the ability to carry out everyday activities such as driving; household chores; and even personal care such as bathing, dressing, and feeding (often called activities of daily living, or ADLs).

Dementia is most common in elderly people; it used to be called senility and was considered a normal part of aging.

- ❖ Diarrhea also spelled diarrhoea, is the condition of having three or more loose or liquid bowel movements per day. It is a common cause of death in developing countries and the second most common cause of infant deaths worldwide. The loss of fluids through diarrhea can cause dehydration and electrolyte imbalances.

- ❖ **Dehydration** is loss of water and important blood salts like potassium (K+) and sodium (Na+). Vital organs like the kidneys, brain, and heart can't function without a certain minimum of water and salt. In underdeveloped countries, dehydration from diseases like cholera and dysentery kills millions every year (usually infants and children). Still, with vomiting or diarrhea and occasionally with excessive sweating, one can become dangerously dehydrated.

- ❖ **Hemosiderosis** is the medical term for iron overload, a condition that occurs when the body stores too much iron in organ tissues due to a lack of properly functioning red blood cells. Iron overload can damage organ tissue and cause serious health complications.

- ❖ **Methemoglobinemia** is a disorder characterized by the presence of a than normal level of methemoglobin (metHb) in the blood. Methemoglobin is a form of hemoglobin that has extremely high affinity to oxygen, resulting in almost no oxygen delivery to the tissues. When it's is elevated in red blood cells, tissue hypoxia can occur.

- ❖ **Methemoglobin** is a form of the oxygen-carrying protein hemoglobin, in which the iron in the heme group is in the Fe^{3+} (ferric) state, not the Fe^{2+} (ferrous) of normal hemoglobin. Methemoglobin cannot carry oxygen. It is a bluish chocolate-brown in color.

- ❖ **Arterioloscierosis** is any hardening (and loss of elasticity) of small and arterioles (small arteries). It is often associated with hypertension. The most common sites for arteriosclerosis are arteries in the brain, kidneys, heart, abdominal aorta, or legs. Risk factors for arteriosclerosis include smoking, obesity, high blood pressure and/or stress, and diabetes.

- ❖ **Convulsion** is a medical condition where body muscles contract and relax rapidly and repeatedly, resulting in an uncontrolled shaking of the body. Convulsions are when a person's body shakes rapidly and uncontrollably. During convulsions, the person's muscles contract and relax repeatedly.

  The term "convulsion" is often used interchangeably with "seizure," although there are many types of seizures, some of which have subtle or mild symptoms instead of convulsions. Seizures of all types are caused by disorganized and sudden electrical activity in the brain.

- ❖ **Numbness** and tingling are abnormal sensations that can occur anywhere in your body, but are often felt in your fingers, hands, feet, arms, or legs.

- ❖ Mucous membrane is a layer of epithelial tissue which lines an area of the body which comes into contact with air. Mucous membranes are moist because of the presence of glands which secrete a thick fluid known as mucus, and they are important for a number of bodily functions. Mucous membranes line the urogenital tract, digestive tract, and respiratory tract, with one of the more well known mucous membranes being the lining of the interior of the nose.

- ❖ Carcinogen is any substance, radionuclide or radiation, that is an agent directly involved in the exacerbation of cancer or in the increase of its propagation. This may be due to the ability to damage the genome or to the disruption of cellular metabolic processes. Several radioactive substances are considered carcinogens, but their carcinogenic activity is attributed to the radiation, for example gamma rays and alpha particles, which they emit. Common examples of carcinogens are inhaled asbestos, certain dioxins, and tobacco smoke.

- ❖ Hemoglobin (also spelled haemoglobin and abbreviated Hb or Hgb) is the iron-containing oxygen-transport metalloprotein in the red blood cells of vertebrates and the tissues of some invertebrates. Hemoglobin in the blood is what transports oxygen from the lungs or gills to the rest of the body (i.e. the tissues) where it releases the oxygen for cell use.

- ❖ **Muffle furnace** used in many research facilities, for example by chemists in order to determine what proportion of a sample is non-combustible and non-volatile (i.e., ash) Laboratory muffle furnace outer body is made of thick mild steel sheet. Temperature controlled by energy regulator with indicator. Temperature range: 0°C to 1200°C.

- ❖ **Hot air oven** is an electrical device used in sterilization. The oven uses heat to stenlize articles. Generally, they can be operated from 50 to 300 °C (122 to 572 °F). There is a thermostat controlling the temperature. These are digitally controlled to maintain the temperature. Their double walled insulation keeps the heat in and conserves energy, the inner layer being a poor conductor and outer layer being metallic. There is also an air filled space in between to aid insulation.

- ❖ **Autoclave** is a device to sterilize equipment and supplies by subjecting them to high pressure saturated steam at 121 °C or more, typically for 15 to 20 minutes depending on the size of the load and the contents. Autoclaves are widely used in microbiology, medicine, tattooing, body veterinary science, mycology, dentistry, chiropody and prosthetic fabrication.

- ❖ **Calibration curve** in an analytical chemistry is a general method for determining the concentration of a substance in an unknown sample by comparing the unknown to a set of standard samples of known concentration.111 A calibration curve is one approach to the problem of instrument calibration; other approaches may mix the standard into the unknown, giving an internal standard.

- ❖ **Gooch crucible** named after Frank Austen Gooch, is a filtration device for laboratory use. It is convenient for collecting a precipitate directly within the crucible in which it is finally to be weighed. The crucible is typically a few centimeters high and is made of porcelain. The bottom of a Gooch crucible is perforated with a number of small holes.

- ❖ **Porcelain Evaporating Dishes** are utilized whenever high chemical resistance and extremely elevated temperatures are needed. Always economical to use with temperatures that reach 1050°C. Porcelain is the best material when operating under these adverse conditions.

- ❖ **Desiccators** are sealable enclosures containing desiccants used for preserving moisture-sensitive items. A common use for desiccators is to protect chemicals which are hygroscopic or which react with water from humidity.

- ❖ **Cell constant** of a conductivity cell defined as: $k_{cell} = kR$
  Where R is the measured resistance of the cell and k is the conductivity (formerly called the specific conductance).

- ❖ **Radioactive pollution** is defined as the physical pollution of air, water and the other radioactive materials. The ability of certain materials to emit the proton, gamma rays and electrons by their nuclei is known as the radioactivity. The protons are known as the alpha particle and the electrons are also known as the beta particle. Those materials are known as the radioactive elements. The environmental radiations can be from different sources and can be natural or manmade. The natural radiations are also known as the background radiations. In this the cosmic rays are involved and reach the surface of earth from space. It includes the radioactive elements like radium, uranium, thorium, radon, potassium and carbon. These occur in the rock, soil and water. The man made radiations include the mining and refining of plutonium and thorium. This production and explosion of nuclear weapons include the nuclear fuels, power plants and radioactive isotopes.

- ❖ **Microorganism** also spelled micro organism or micro-organism or microbe is an organism that is microscopic (too small to be seen by the naked human eye). The study of microorganisms is called microbiology, a subject that began with Anton van Leeuwenhoek's discovery of microorganisms in 1675 A.D., using a microscope of his own design. Microorganisms are very diverse; they include bacteria, fungi, archaea, and protists; microscopic plants (green algae); and animals such as plankton and the planarian. Some microbiologists also include viruses, but others consider these as non-living. Most microorganisms are unicellular but this is not universal, since some multicellular organisms are microscopic, while some unicellular protists and bacteria, like Thiomargaritanamibiensis, are macroscopic and visible to the naked eye. Microorganisms live in all parts of the biosphere where there is liquid water, including soil, hot springs, on the ocean floor, high in the and deep inside rocks within the Earth's crust. Microorganisms are critical to nutrient recycling in ecosystems as they act as decomposers. As some microorganisms can fix nitrogen, they are a vital part of the nitrogen cycle, and recent studies indicate that airborne microbes may play a role in precipitation and weather.

- ❖ **Digital Spectrophotometer** is an analytical instrument used to measure the intensity of light as a function of its wavelength. Spectrophotometer is a common tool in physics laboratories, commonly used to measure light absorption. It measures transmission or apparent of light as a function of wavelength. Thus it allows precise analysis of color or accurate comparison of luminous intensities of two sources or specific

❖ Wavelengths. The two major measurement classes of spectrophotometers are: Single beam and Double beam spectrophotometers. There are certain differences between the single beam and the double beam spectrophotometers. In the early days of spectroscopy, double beam spectrophotometers were popular but now it is thought that the single beam spectrophotometer is more advantageous. Single Beam Spectrophotometer: A single beam spectrophotometer is used to measure the absolute light intensity. Double Beam Spectrophotometer: It is used to measure the ratio of light intensities on two separate light paths. Spectrophotometers use a monochromator to analyze the spectrum. Some spectrophotometers also use arrays of photo-sensors. Spectrophotometer quantitatively evaluates the fraction of light that passes through a given solution. A light from the lamp is guided through a monochromator, which selects light of one particular wavelength out of the continuous spectrum. This light is then passed through the sample that is being measured. As the light passes through the sample, the intensity of the remaining light is measured with a photo diode or other light sensor. Then the transmittance for this wavelength is calculated. The sequence of events in a spectrophotometer can be listed as follows:

➢ The light source enters the sample.
➢ The sample absorbs light.
➢ Then the detector detects that how much light is absorbed by the sample.
➢ The detector then converts the amount of light absorbed by the sample into a number.
➢ The numbers are plotted straight away, or are transmitted to a computer to be further manipulated.

Spectrophotometer consists of the following components:

a) A required Light Source.
b) A Mortochromator.
c) An Appropriate Photomultiplier.
d) A Photo-detector.

The most common application of spectrophotometers is the measurement of light absorption. They are used to measure diffuse or specular reflectance. Spectrophotometer is an essential piece of equipment in any lab. It has found applications in physiological, biochemical and molecular research.

❖ **Durham tubes** are used in microbiology to detect production of gas by microorganisms. They are simply smaller test tubes inserted upside down in another test tube. This small tube is initially filled with the solution in which the microorganism is to be grown. If gas is produced after inoculation and incubation, a visible gas bubble will be trapped inside the small tube. The initial air gap produced when the tube is inserted upside down is lost during sterilization, usually performed at 121°C for 15 or so

❖ **A blank titration** has a number of purposes: A blank titration is done without the analyte present to check for possible sources of error in the "blank" solution. For example, deionized water is slightly acidic and may affect the results of an acid base titration (if you want a highly accurate concentration). So you would do a blank titration to find the concentration of H3O in the water and use it to correct the concentration of your analyte. A back titration is used when it is diffucult to find an endpoint in a normal titration (for example, if the analyte is not very soluble in water). You react the analyte with an excess of titrant and then titrtate the excess Subtracting the moles of excess titrant from the original amount you used gives the moles of titrant reacted with the analyte. From that you can figure out moles of analyte.

➢ Blank samples help to determine if there are extraneous sources of pollutants.
➢ To compensate for the difference between the equivalence point & what an eye can detect.
➢ Compensate for interferences, in this case other trace organics which may be oxidized in addition to oxalate.
➢ The blank titration improves the accuracy of the titration.

❖ Pathogen, an infectious agent, or more commonly germ, is a biological agent that causes disease to its host. There are several substrates and pathways whereby pathogens can invade a host; the principal pathways have different episodic time frames, but soil contamination has the longest or most persistent potential for harboring a pathogen. Pathogenic viruses are mainly those of the families of: Adenoviridae, Picornaviridae, Herpesviridae, Hepadnaviridae, Flaviviridae, Retroviridae, Orthomyxoviridae, Paramyxoviridae, Papovaviridae, Polyomavirus, Rhabdoviridae, Togaviridae. Some notable pathogenic viruses cause: smallpox, influenza, mumps, measles, chickenpox, ebola, and rubella. Viruses typically range between 20-300 nanometers in length.

❖ Although the vast majority of bacteria are harmless or beneficial, a few pathogenic bacteria can cause infectious diseases. The most common bacterial disease is tuberculosis, caused by the bacterium Mycobacterium tuberculosis, which affects about 2 million people mostly in sub-Saharan Africa. Pathogenic bacteria contribute to other globally important diseases, such as pneumonia, which can be caused by bacteria

- ❖ Such as Streptococcus and Pseudomonas, and foodborne illnesses, which can be caused by bacteria such as Shigella, Campylobacter and Salmonella. Pathogenic bacteria also cause infections such as tetanus, typhoid fever, diphtheria, syphilis and Hansen's disease. Bacteria can often be killed by antibiotics. They typically range between 1-5 micrometers in length.

- ❖ **Escherichia coil** (E-coli) is a Gram negative rod-shaped bacterium that is commonly found in the lower intestine of warm-blooded organisms (endotherms). Most E. coli strains are harmless, but some, such as serotype 0157:H7, can cause serious food poisoning in humans, and are occasionally responsible for product recalls. The harmless strains are part of the normal flora of the gut, and can benefit their hosts by producing vitamin K2, and by preventing the establishment of pathogenic bacteria within the intestine.

  E. coli are not always confined to the intestine, and their ability to survive for brief periods outside the body makes them an ideal indicator organism to test environmental samples for fecal contamination. The bacteria can also be grown easily and its genetics are comparatively simple and easily manipulated or duplicated through a process of metagenics, making it one of the best-studied prokaryotic model organisms, and an important species in biotechnology and microbiology.

  E. coli was discovered by German pediatrician and bacteriologist Theodor Escherich in 1885 A.D., and is now classified as part of the Enterobacteriaceae family of gamma-proteobacteria.

  Solubility: The maximum amount of solute in grams that dissolves in 01 liter of water to make a saturated solution at a given temperature is known as the solubility of the solute. The solute can be a solid, a liquid or gas.

  Saturated solution is one in which no more solute can dissolve. The solubility measures the concentration of a saturated solution.