VIRUDHUNAGAR S.VELLAICHAMY NADAR POLYTECHNIC COLLEGE
(Affiliated to Directorate of Technical Education, Chennai 600 025)
Virudhunagar - 626 001

MISSION

"Our mission is to produced disciplined and quality technocrats through academic programme of noted Excellence to serve the Society"

Vision

" To be an institute of Excellence in Technical Education and Training of individuals Focusing on the needs of the Nation and Society in tune with Technological Developments"

COURSE MATERIAL	
SCHEME	N1
PROGRAMME	BASIC SCIENCE
TERM	I
COURSE	ENGINEERING CHEMISTRY- I
PREPARED BY	**M.Selvambigai, Lect / Chemistry** **K. Nagarajan, Lect / Chemistry** **S. Nagaraj, Lect / Chemistry** **S. Sountharya, Lect / Chemistry**
VERIFIED BY	

DEPARTMENT OF BASIC SCIENCE

ENGINEERING CHEMISTRY–I (N1BE104)

DETAILED SYLLABUS

Contents: Theory

Unit	*Name of the Topic*	*Hours*
I	***1.1 Atomic Structure and Chemical Bonding*** *Fundamental particles – proton–electron–neutron–atomic number – mass number – extra nuclear part – filling up of electrons – aufbau principle–s–p–d–f orbitals – electronic configuration – octet rule – electrovalent bond –sodium chloride formation – covalent bond – formation of ammonia.*	***5 Hrs.***
	1.2 Periodic Table *Modern periodic law – periodic classification of elements – features of modern periodic table – properties of s–p–d–f block elements.*	***4 Hrs.***
	1.3 Acids and Bases *Properties of acids and bases – Lewis concept of acids and bases – advantages – pH and pOH – Definition – Numerical problems – Indicator – Definition – Buffer solution – Definition – Types of buffer solution with examples – Application of pH in industries*	***4 Hrs***
II	***2.1 Surface Chemistry*** *Colloids – True solution and Colloidal solution – Definition – Differences – Types of colloids – Lyophilic and Lyophobic colloids – Differences – Properties – Optical – mechanical – electrical – Electrophoresis and Coagulation – Industrial applications of colloids – Smoke Precipitation by Cottrell's method, Purification of water, Cleansing action of soap, Sewage disposal – tanning–and artificial rain.*	***5 Hrs.***
	2.2 Catalysis *Catalyst – Positive – Negative catalyst – Definition – Types of catalysis – Homogeneous and Heterogeneous – Promoter – Catalyst poison – active centre – Definition – Characteristics of a catalyst – Industrial applications of catalysts.*	***4 Hrs.***
	2.3 Nanotechnology *Nano particles – definition – properties – application of Nanotechnology – Engineering – medicine – biomaterial.*	***4 Hrs.***

III	***3.1 Technology of Water – I*** *Sources of water – depletion of underground water – Reasons – Rain water harvesting (Basic ideas) – advantages – Hard water and soft water – Hardness of water – Carbonate and Non – carbonate hardness – Methods of expressing hardness – mg/lit and ppm – Simple problems – Disadvantages of hard water – Estimation of total hardness by EDTA method – Problems involving Total, Carbonate and Non – carbonate hardness in ppm – Disadvantages of using hard water in boilers – Scale formation, Corrosion of boiler metal, Caustic Embrittlement – Priming and Foaming.* ***3.2 Technology of Water –II*** *Softening of hard water–Ion – Exchange method and Reverse Osmosis method – Municipal supply – purification of drinking water–Quality of potable water – parameters of potable water – pH–TDS – Dissolved Chlorine permissible limits – determination of ecoli (preliminary idea)* ***3.3Glass*** *Composition of glass – Manufacture of glass – annealing of glass – Varieties – of Glass – Optical glass, Wind shield glass and Photo chromatic glass*	***5 Hrs.***

V	***5.1 Nuclear Chemistry*** *Radio activity – alpha – beta – gamma rays – charge and mass – isotope – isobar – Radioactive decay – alpha emission – beta emission – gamma emission – half life period – simple problems – Nuclear fission – nuclear fusion – chain reaction – nuclear reactor –reactor core – nuclear reactor coolant – Control rods – neutron moderator – steam turbine – Application of radio isotopes.* ***5.2 Cement*** *Definition – Manufacture of Portland Cement – Wet Process – Setting of Cement (No equation) –Ceramics– White pottery – Definition – Manufacture of White pottery – Uses – Definition of glazing – purpose – Method – Salt glazing – liquid glazing.* ***5.3 Refractories*** *Definition – requirements of a good refractory – types with examples and uses–uses of silica, fireclay and alumina.*	***6 Hrs.*** ***5 Hrs.*** ***2 Hrs.***

Text Book:

1. Engineering Chemistry – I Tamil Nadu Text Book Corporation
2. Engineering Chemistry – Jain & Jain – Dhanpat Rai & Sons.
3. A Text Book of Engineering Chemistry – S.S. Dara – S. Chand Publication.

Reference Book:

1. Engineering Chemistry – Uppal – Khanna Publishers.
2. Chemistry – Higher Secondary – Second Year – Volume I & II – Tamil Nadu Text BookCorporation – 2018
3. Rain Water Harvesting – Hand Book – Chennai Metro Water.

UNIT - I

1.1 ATOMIC STRUCTURE AND CHEMICAL BONDING

INTRODUCTION

Chemistry is a branch of science that deals with the study of the nature of matter, its composition, occurrence, isolation, methods of preparation, properties and uses.

An **atom** is the smallest form of a chemical particle that retains the properties of the particle. The word 'atom' comes from the Greek word 'atomos', meaning 'unable to be cut'. The original meaning of atom was the smallest, indivisible form of a chemical particle. Now we know how to divide atoms into sub-atomic particles, the definition of an atom includes the concept that the particle must retain its chemical properties.

ATOM

An Atom is the smallest invisible particle of element, having all the characteristics of the parent element, which can neither be created nor destroyed by any chemical change. It cannot exist freely. It is the ultimate particle of an element, which may or may not have independent existence. The atoms of certain elements such as hydrogen, oxygen, nitrogen, etc., do not have independent existence whereas atoms of helium, neon, argon, etc., do have independent existence. All elements are composed of atoms.

FUNDAMENTAL PARTICLES OF AN ATOM

Almost the atoms of all elements are made up of three main particles known as fundamental particles. They are electrons, protons and neutrons. Hydrogen is the only element that do not have neutron.

PROTON

- The proton is a positively charged particle.
- It has unit positive charge and unit mass. The mass of proton is approximately equal to the mass of one hydrogen atom. It is equal to 1.00732 amu.
- The proton is present in atoms of all the elements.
- The protons are present inside the nucleus of an atom.

ELECTRON

- The electron is a negatively charged particle.
- It has unit negative charge and negligible mass.
- The mass of and electron is about 1/1837 of mass of a hydrogen atom.
- Electrons are present in all the atoms.
- Electrons are revolving around the nucleus in various circular orbits (shell).

NEUTRON

- The neutron is a neutral particle. Hence, it has no charge.
- It has unit mass. The neutron is present in atoms of all elements except hydrogen. The mass of a neutron is slightly greater than the mass of a proton. It is equal to 1.00871 amu.
- Neutron is present inside the nucleus of an atom.

ATOMIC NUMBER (Z)

The atomic number is the number protons present in the nucleus of an atom or number of electrons revolving around the nucleus in an atom. Based on the carbon standard the atomic mass of an element may be defined as the ratio between the mass of one atom of the element and $1/12^{th}$ of mass of an atom of carbon.

Atomic number = Number of protons = Number of electrons

MASS NUMBER (A)

The mass number of an element is given by the total number of protons and neutrons present in the nucleus of an atom. **A= (P+N)**

Therefore the number of neutrons is = A-Z.

STRUCTURE OF ATOM

The atom consists of two parts. They are

1. The central nucleus
2. The outer extra nuclear part.

1. The central Nucleus:

The nucleus is the central part of an atom consists of protons and neutrons. Since the protons are positively charged particle and neutrons are neutral, the nucleus is always positive part of an atom. The entire weight of an atom is present only in the nucleus.

2. The outer extra nuclear part:

1. It is the part around the nucleus. It contains all electrons of an atom.

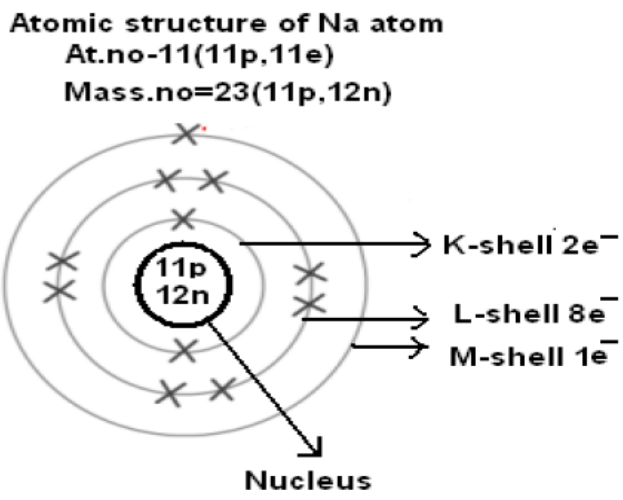
2. The shells or orbits are numbered, as 1,2,3,4 etc from the nucleus. They are also known as **K, L, M, N** Shell.

3. which is given by the formula $\mathbf{2n^2}$ where the 'n' is the number of the shell. Therefore, the numbers of electrons that are accommodated in the 1st, 2nd, 3rd shell respectively are 2,8,18.

4. The electrons present in the outer most orbit is called as **valence electron**.

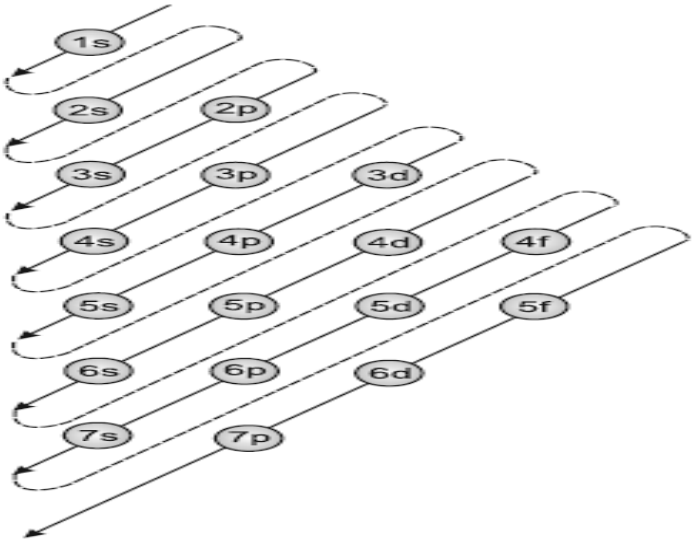
5. The atom as whole is a neutral one. Since the number of protons (positively charges) is equal to the number of electrons (negative charges).

The atomic structure of Sodium atom is given below:



AUFBAU PRINCIPLE

In the ground state of the atoms, the orbitals are filled in order of their increasing energies.



s-Orbitals

It is a spherically-shaped region. Due to it has only one orientation. It has l = m = 0

p-Orbitals

It is a dumb-bell shaped. It has three sub level orbitals. All p-orbitals have l = 1 with 3 possible values for m (-1, 0, +1)

d-Orbitals

It is a dumb-bell with a ring around it shape. It has n = 1, l = 0, m = 0

f-Orbitals

It is a spherically shaped. It has n = 1, l = 0, m = 0

Element	Atomic number	Electronic configuration
Helium	2	2 **(H-1 Unstable for – stable 2)**
Neon	10	2,**8**
Argon	18	2,8,**8**
Krypton	36	2,8,18,**8**
Xenon	54	2,8,18,18,**8**
Radon	86	2,8,18,32,18,**8**

OCTET RULE

The inert gases have the stable configuration of eight electrons (octet structure) in their outer most orbits except helium which 2 have only electrons. Due to their stable octet structure, these gases are inert in nature. They do not chemically react with other elements. ”According to Lewis “**octet theory, all the elements with an unstable or incomplete electronic configuration have a tendency to attain the stable electronic configuration of the nearest inert gas configuration either by complete transfer of valence electron from one atom to another or by mutual sharing of valence electron between the atoms”.** This tendency to attain the stable electronic configuration is responsible for the formation of **chemical bonding**.

TYPES OF BONDING

The process by which unstable atoms acquire a stable configuration has been found to take place in two different ways.

1. The complete transfer of valency electrons from one atom to another. This is called Ionic bond (or) Electrovalent bonding.

2. The mutual sharing of (pair of) valency electrons between the atoms. The shared pair of electrons is given by both atoms. This is called as Covalent bonding.

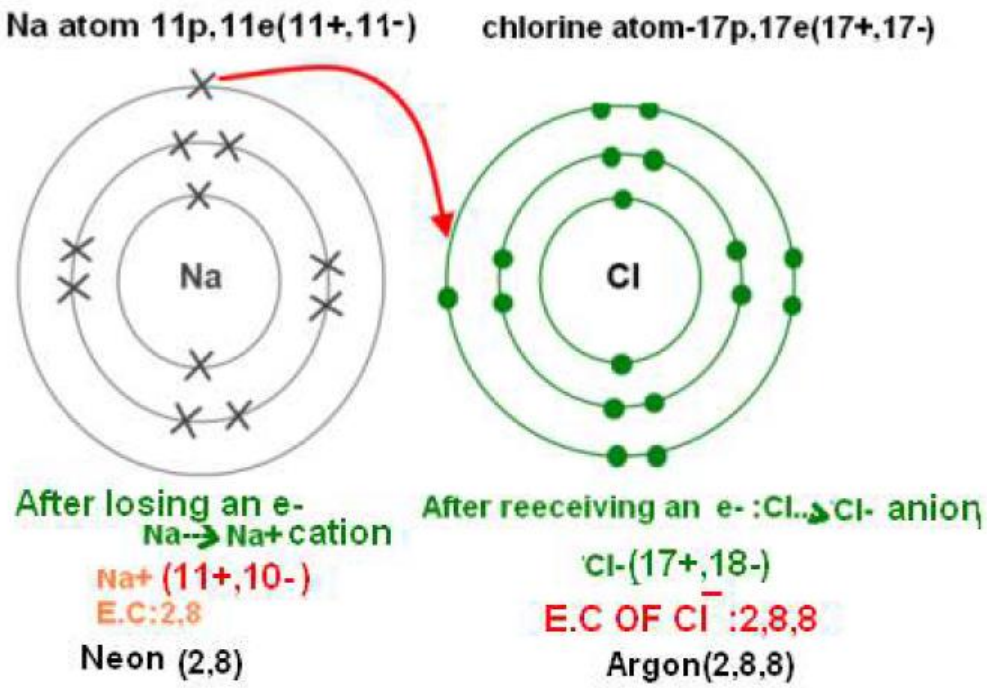
IONIC (OR) ELECTRO VALENT BOND

This type of bond is formed as a result of the complete transfer of one or more electrons from one atom to other. This bond is generally present in inorganic compounds.

Example : Formation of Sodium Chloride

Explanation :

1. The atomic number of sodium is 11(11P/11e=11+/11-)
   The electronic configuration is $1s^2$, $2s^2$, $2p^6$, $3s^1$ (2, 8, 1).
   Sodium has only one electron in its outermost orbital.
2. The atomic number of chlorine is 17(17p/17e=17+/17-)
   The electronic configuration is $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^5$ (2, 8, 7)



Sodium has one electron in excess of the stable neon configuration (2, 8) and chlorine is one electron short of the stable argon configuration (2, 8, 8).

When these atoms are in contact, sodium has a tendency to lose its single valence electron and chlorine has a tendency to accept a single electron to reach the stable electronic configuration of the nearest inert gas. By transferring one electron from sodium to chlorine, sodium acquires a unit positive charge while by gaining the electron; the chlorine atom acquires a unit negative charge.

Now sodium has attained the stable electronic configuration of neon (2,8). Similarly chlorine has attained the stable electronic configuration of neon(2,8,8). These charged ions are held together by electrostatic attraction and form a neutral molecule of sodium chloride.

Compounds formed in this way are called electrovalent or ionic compounds and the bond is called Ionic bond or electrovalent bond.

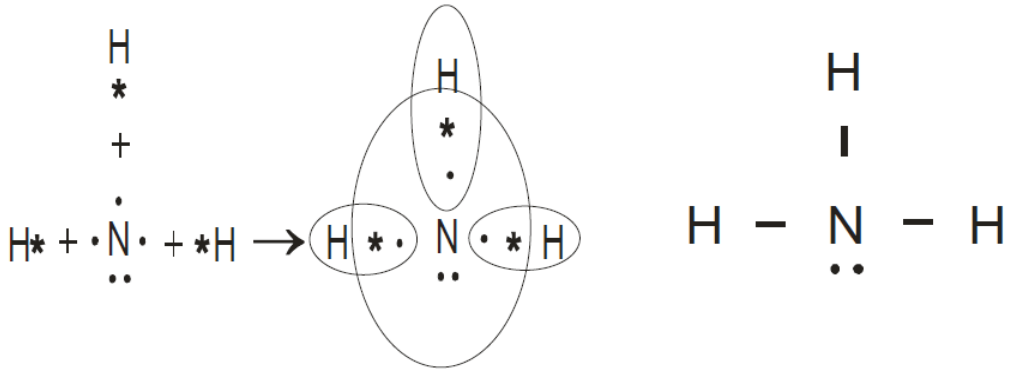
COVALENT BOND

FORMATION OF A COVALENT COMPOUND (NH_3)

This type of bond is formed by the mutual sharing of pair of electrons between two atoms each atom supplying equal number of electrons for sharing. The covalent bond is indicated by (-).

Example : Formation of Ammonia (NH_3).

Explanation :



1. The atomic no of Nitrogen is 7. (E.C:2, 5 unstable)
   The electronic configuration $1s^2,2s^2,2p^3$.
   The electron dot formula of N is

2. The electron dot formula of H is

3. The atomic number of Hydrogen is 1. The electronic configuration $1s^1$(E.C:1 unstable)
4. To get stable electronic configuration Nitrogen shares its three electrons with electrons of three Hydrogen atoms.

Ammonia is formed by the covalent bonding between one atom of hydrogen and three atoms of hydrogen. Nitrogen has five valence electrons. The electronic configurationis2,5 (unstable). Therefore, it needs three electrons to attain stable inert gas configuration. Hydrogen has one electron. So it needs one electron to attain the stable inert gas configuration of Helium. The nitrogen atom shares three of its valence electron with three hydrogen atom forming the covalent bonds. All the four atoms attain the stable configuration. Thus, the covalent bond is formed.

QUESTIONS

PART-A

1. What is the charge of a nucleus of an atom?
2. What is an atomic number?
3. What is mass number?

PART-B

1. We can call H^+ ion as a proton. How?
2. Atomic number and mass number of an element is 9 & 19 respectively. What is the number of neutrons present in the atom of the element?
3. Define - Octet rule.
4. Define – Aufbau principle.

PART-C

1. Why do atoms of elements combine?
2. Which is more stable Na or Na^+ Why?
3. Explain the formation of NaCl.
4. Explain the formation of NH_3.
5. While atoms of most of the elements are unstable but atoms of noble gases are stable. Explain.
6. Which is more stable Cl or Cl^- ?Why?

1.2 PERIODIC TABLE

INTRODUCTION

The eighteenth and nineteenth centuries witnessed a rapid development in chemistry in all spheres of scientific activities. By 1860, scientists had already discovered 60 elements and determined their atomic masses. They noticed that some elements had similar properties and hence arranged them into groups. During this period, several new elements were discovered. These elements were found to have different properties. It was realized that instead of studying the properties of all these elements individually, it would be more convenient to divide them into groups and periods in such a way that each group contained a certain number of elements **(like an array of fruits and vegetables showing orderliness)** with similar properties and periods showing a regular gradation. So, scientists made several attempts to arrange elements in a logical way.

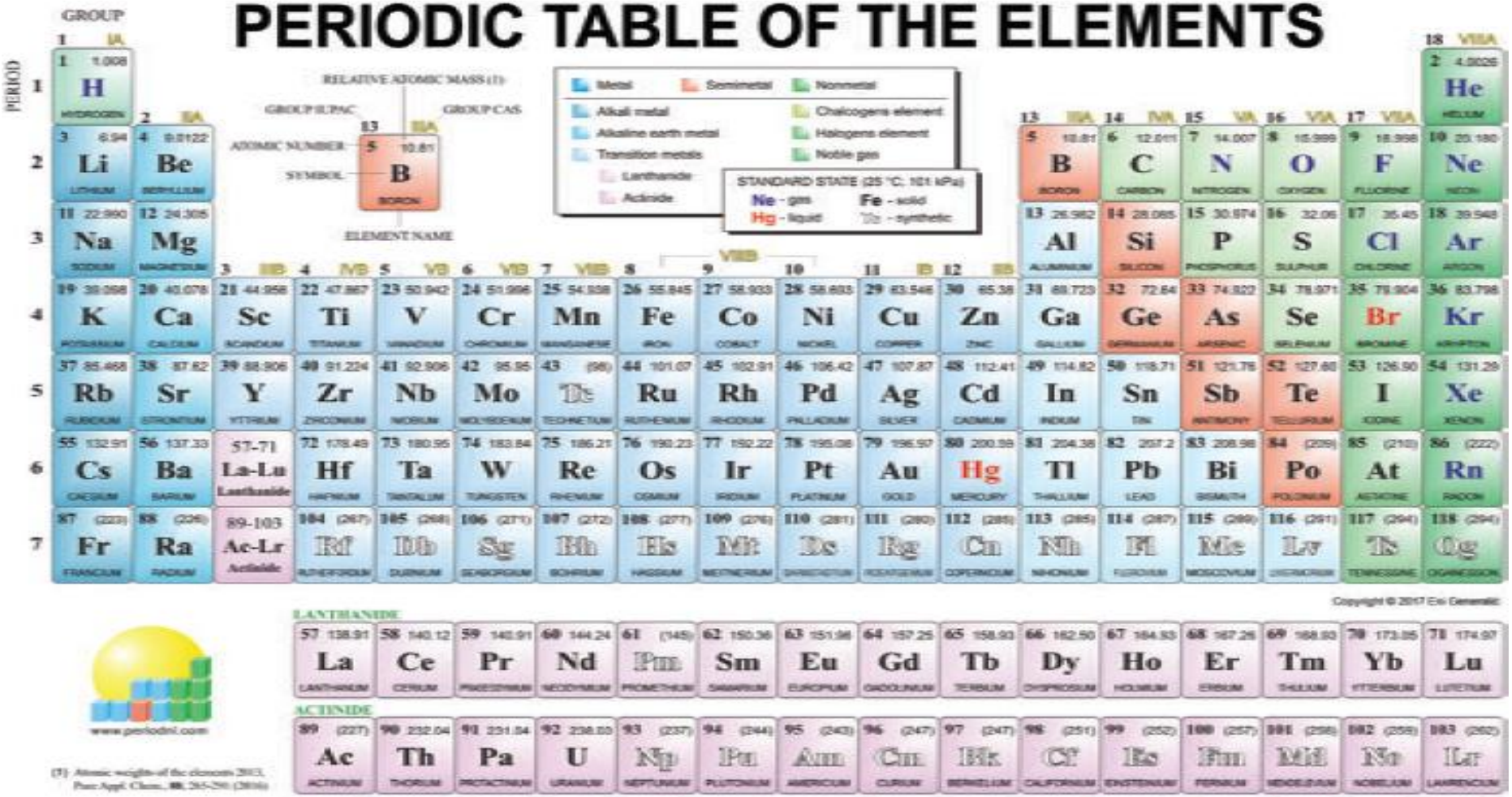
MODERN PERIODIC LAW

Mendeleev's periodic table had some discrepancies, which were difficult to overcome. For example, the atomic mass of argon (39.95 amu) is greater than that of potassium (39.10 amu), but argon comes before potassium in the periodic table. If elements were arranged solely according to increasing atomic mass, argon would appear in the position occupied by potassium in our modern periodic table (see in Figure 8.1). No chemist would place argon, a gas with no tendency to react, in the same group as lithium and sodium,which are two highly reactive metals. This kind of discrepancies suggested that some fundamental property other than atomic mass must be the basis of periodicity. The fundamental property turned out to be the number of protons in an atom's nucleus, something that could not have been known by Mendeleev and his contemporaries.

Henry Moseley, a British scientist in 1912, discovered a new property of elements called atomic number, which provided a better basis for the periodic arrangement of the elements. It is a well-known fact that atomic number of an element is equal to the number of protons or the number of electrons present in the neutral atom of an element. The periodic law was, therefore, modified to frame a **modern periodic law,** which states that

"The physical and chemical properties of the elements are the periodic functions of their atomic numbers".

PERIODIC TABLE OF THE ELEMENTS



PERIODIC CLASSIFICATION OF ELEMENTS

- s-block elements
- p-block elements
- d-block elements
- f-block elements

FEATURES OF MODERN PERIODIC TABLE

FEATURES OF PERIODS

The **horizontal rows are called periods**. There are **seven** periods in the periodic table.

- **First period** (Atomic number 1 and 2): This is the shortest period. It contains only two elements (Hydrogen and Helium).
- **Second period** (Atomic number 3 to 10): This is a short period. It contains eight elements (Lithium to Neon).
- **Third period** (Atomic number 11 to 18): This is also a short period. It contains eight elements (Sodium to Argon).
- **Fourth period** (Atomic number 19 to 36): This is a long period. It contains eighteen elements (Potassium to Krypton). This includes 8 normal elements and 10 transition elements.
- **Fifth period** (Atomic number 37 to 54): This is also a long period. It contains 18 elements (Rubidium to Xenon). This includes 8 normal elements and 10 transition elements.
- **Sixth period** (Atomic number 55 to 86): This is the longest period. It contains 32 elements (Caesium to Radon). This includes 8 normal elements, 10 transition elements and 14 inner transition elements (Lanthanides).
- **Seventh period** (Atomic number 87 to 118): Like the sixth period, this period also accommodates 32 elements. Recently 4 elements have been included by IUPAC.

FEATURES OF GROUPS

The vertical columns in the periodic table starting from top to bottom are called **groups.** There are **18 groups** in the periodic table.

Based on the common characteristics of elements in each group, they can be grouped as various families.

Group Number	Family
1	Alkali metals
2	Alkaline earth metals
(3 to 12)	Transition metals
13	Boron family
14	Carbon family
15	Nitrogen family
16	Oxygen family or chalcogen family
17	Halogens
18	Noble gases

- The Lanthanides and Actinides, which form part of Group 3 are called **inner transition elements**.
- Except 'group 0', all the elements present in each group have the same number of electrons in their valence shell and thus have the same valency. For example, all the elements of group 1 have one electron in their valence shells ($1s^1$). So, the valency of all the alkali metals is '1'.
- As the elements present in a group have identical valence shell electronic configurations, they possess similar chemical properties.
- The physical properties of the elements in a group such as melting point, boiling point and density vary gradually.
- The atoms of the 'group 0' elements have stable electronic configuration in their valence shells and hence they are unreactive.

PROPERTIES OF s-BLOCK ELEMENTS

- They are soft metals
- Low melting point
- Low boiling point
- Very reactive metals
- Good conductors of heat and electricity

PROPERTIES OF p-BLOCK ELEMENTS

- It includes both metals and non-metals
- Good conductors of heat and electricity

- These block contains noble gases
- Number of non-metals is much higher than that of metals
- Ionisation enthalpy is higher than that of s-block elements

PROPERTIES OF d- BLOCK ELEMENTS

- They are hard metals
- High melting point
- High boiling point
- Good conductors of heat and electricity
- These compounds are generally coloured

PROPERTIES OF f-BLOCK ELEMENTS

- They are hard metals
- High melting point
- High boiling point
- These compounds are generally coloured
- It contains radioactive elements

QUESTIONS

PART-A

1. Define modern periodic law.
2. How modern periodic tables are classified?

PART-B

1. What are the properties of s-block elements?
2. What are the properties of p-block elements?
3. What are the properties of d-block elements?
4. What are the properties of f-block elements?

PART-C

1. Explain the features of modern periodic table.

1.3 ACIDS AND BASES

INTRODUCTION

Depending upon the ions produced in the solution, the substances are classified into acids and bases. The acidic and basic nature of matter is more essential to study about the chemical reactions.

ACIDS

An acid is a substance that gives hydrogen ions (H^+) by itself or in aqueous solution.

Example:

$$\mathbf{HCl \rightarrow H^+ + Cl^-}$$

BASES

A base is a substance that gives ions (OH^-) by itself or in aqueous solution.

Example:

$$\mathbf{NaOH \rightarrow Na^+ + OH^-}$$

PROPERTIES OF ACIDS

- Sour taste
- Corrosive nature
- It turns Blue litmus paper into red colour
- pH is less than 7
- React with base to give salt

PROPERTIES OF BASES

- Bitter taste
- Corrosive nature
- It turns Red litmus paper into blue colour
- pH is greater than 7
- Conduct electricity

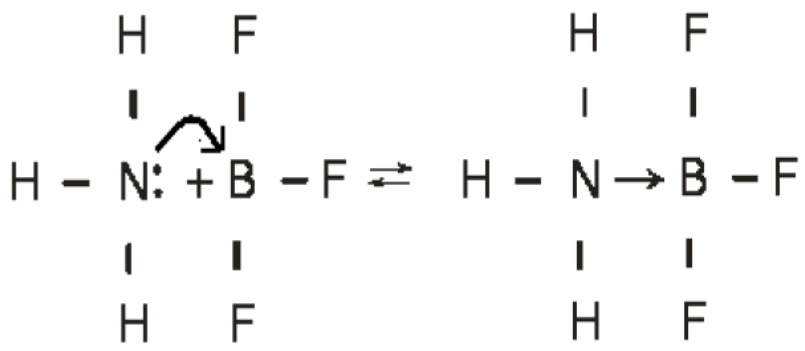
LEWIS THEORY (1923) - (ELECTRONIC CONCEPT)

Lewis concept is known as electronic concept because it involves electron pair transfer during base formation.

Example:

According to this theory, an acid is s substance that accepts a pair of electrons. So, acid is an **electron pair acceptor.**

A base is a substance that donates a pair of electrons. So, base is an **electron Pair donor**.



Ammonia donates a pair of electron to Boron trifluride and is called as Lewis acid. Hence it is called as electron pair donor. Boron trifluride accepts the electron pair from ammonia. Hence it is called as Lewis acid.

ADVANTAGES

1. It explains the acid base reactions by way of electron transfer.

2. It gives an idea about the acidic character of substances that do not contain hydrogen. The acidic nature of the following substances like BF_3, $FeCl_3$, and $AlCl_3$ can be easily explained by this concept.

3. The neutralization of acidic oxides and basic oxides can also be easily explained by this concept.

4. The concept can be easily understood.

CONCEPT OF pH AND pOH (S.P.L Sorenson)

PH is a convenient way of expressing acidity or the concentration of H^+ in solution. It helps to avoid the use of large of negative power of 10.

$$P^H = -\log_{10}[H^+]$$

$$[H^+] = 10^{-PH}$$

Higher the concentration of H^+, lower will be the value of pH.

DEFINITION pH and pOH

pH of a solution is defined as negative of logarithm to the base 10 of the hydrogen ion concentration $[H^+]$.

$$\mathbf{pH = -\log_{10}[H^+]}$$

Similarly,

pOH of a solution is defined as negative of logarithm to the base 10 of the hydroxyl ion concentration $[OH^-]$

$$\mathbf{pOH = -\log_{10}[OH^-]}$$

In a neutral aqueous solution,

$$[H^+] \times [OH^-] = 10^{-14} \text{ g ions/litre.}$$

$$\log_{10}[H^+] + \log_{10}[OH^-] = \log 10^{-14} = -14$$

$$-\log [H^+] + \{-\log [OH^-]\} = 14$$

So,

$$\mathbf{pH + pOH = 14}$$

POINTS TO BE REMEMBERED

1. For pure water, pH and pOH values = 7
2. The sum of pH and pOH should be equal to 14

   pH + pOH = 14.
3. Ionic product of water is 1×10^{-14}.
4. pH = < 7 Acid

   pH = 7 Neutral

   pH = > 7 Base

PROBLEMS

1. Calculate the P^H of a solution whose hydrogen ion concentration 4.6×10^{-4} g ions/litre.

$$\mathbf{P^H = -\log_{10}[H^+]}$$

$$= -\log_{10}[4.6 \times 10^{-4}]$$

$$= -[\log_{10} 4.6] + [\log_{10} 10^{-4}]$$

$$= -[0.6627 - 4]$$

$$= -[-3.3373]$$

$$\mathbf{P^H} = 3.3373$$

2. Calculate the P^H of 0.003M HCl solution. The hydrogen ion concentration is 0.003.

$$\mathbf{P^H = - \log_{10}[H+]}$$

$$= - \log_{10} [1x10^{-3}]$$

$$= - \log_{10} [1] + \log_{10} [10^{-3}]$$

$$= - (0-3)$$

$$\mathbf{P^H} = 3$$

3. If the P^H of a solution is 5.25, calculate the hydrogen ion concentration of solution.

$$P^H = 5.25$$

$$\mathbf{P^H = - \log_{10}[H+]}$$

$$5.25 = - \log_{10}[H+]$$

$$\log_{10}[H+] = -5.25 = (-6+0.75)$$

$$[H^+] = \text{antilog } (0.75) \text{ x } 10^{-6}$$

$$= 5.623\text{x } 10^{-6} \text{ g ions/litre.}$$

4. Calculate the P^H of 0.1m of NaOH solution

0.1m of NaOH solution

= 0.1g ions/litre

$$\mathbf{P^{OH} = - \log_{10}[OH-]}$$

$$= - \log_{10}[0.1]$$

$$= - \log_{10}[1X10-1]$$

$$= - [-1]$$

$$= 1$$

Therefore $\mathbf{P^H + P^{OH} = 14}$

$$P^H + 1 = 14$$

$$P^H = 13.$$

5**.** If pH of a solution is 5, what is its pOH? (Oct 2014).

pH + pOH = 14

5 + pOH = 14

pOH = 9

INDICATORS

An indicator is a substance, which has one colour in acid solution and a different colour in alkaline solution. Indicator is a substance, which indicates the exact completion of a chemical reaction by changing colour at the end point.

Example:

Phenolphthalein, Methyl Orange, Methyl Red

Indicators are used in titrations to determine the end point. During the acid-bass titration, if certain pH is reached, indicator changes its colour.

It is very clear from a study of the above table that phenolphthalein which becomes colorless when pH = 8 will indicate that the solutions is acidic. Methyl orange shows a yellow alkali colour when pH = 4.5 will indicate the solution is acidic. Therefore selection of indicators is more important for acid-base titrations. It depends upon the nature of acid and the base involved in that titration.

BUFFER SOLUTION

Maintaining of pH is more important in many industries. For that buffer solution is needed. Buffer solution is one which maintains a constant pH even when small amount of acid or alkali are added to the solution.

Buffer solution is classified into two types.

1. Acidic buffer
2. Basic buffer

Acidic buffer is obtained by mixing a weak acid with a salt of the same weak acid.

Example

$CH_3COOH + CH_3COONa$

(Acetic acid + sodium acetate)

Basic buffer is obtained by mixing a weak base with a salt of the same weak base.

Example

$NH_4OH + NH_4Cl$

(Ammonium Hydroxide + Ammonium chloride)

INDUSTRIAL APPLICATIONS OF pH

pH is more important in many industries to get high yield and the quality. pH plays a vital role in the following industries.

1. Textile Industry:

In textile industry, the pH of dye has to be maintained otherwise dying will not be uniform and permanent.

2. Sugar Industry:

The pH of the sugarcane juice should be maintained between 8 and 9. Otherwise crystallization of sugar will not be better.

3. Leather Industry:

The pH of solution for Tanning purpose should be 2.5 to 3.5. If not, the hides will purify.

4. The pH of liquid chlorine is more effective in the pH range of 5 to 6.5 in water treatment.
5. The pH of the soil should be maintained for plants to grow and to get better yield.
6. The pH of human blood is 7.2. If not, it causes coagulation of blood which leads to death.
7. The pH of a gastric juice is 1.4 to 2. Otherwise it may cause vomiting and stomach disorder.
8. Here are the industries were pH plays a vital role: Paper industry, Alcohol industry, Medicine and Chemical industry, Food production industry etc.

QUESTIONS

PART-A

1. What is pH?
2. What is pOH?
3. What is Buffer solution?

PART-B

1. What is an Indicator? Give examples.
2. What is Lewis concept of acid and base?
3. What are the properties of acids?
4. What are the properties of bases?

PART-C

1. Explain the Lewis concept of acids and bases with examples. Mention its advantages also.
2. Write a note on applications of PH in industries.

PROBLEMS

3. The hydrogen ion concentration of a solution is $2x10^{-4}$ g ions/litre. Calculate the pH of the solution.
4. The hydroxyl ion concentration of a solution is $1x10^{-9}$ g ion/litre. Calculate the PH of the Solution.
5. The pH of a solution is 4.28.Calculate the hydrogen ion concentration of the solution.
6. The pH of a solution is 11.5. Calculate the hydrogen ion concentration of the solution.

UNIT – II

1.1 SURFACE CHEMISTRY

COLLOIDS

INTRODUCTION

An aqueous solution of salt or sugar is homogeneous and it contains the solute particles as single molecules or ions. This is called a **true solution**.

In sugar solution, the sugar particles are not visible to the naked eye or under microscope. The diameter of the solute particle is less than 10^{-7} cm.

On the other hand when we mix sand and water, a heterogeneous mixture called coarse suspension is formed. The sand particles are visible because the diameter of the particle is greater than 10^{-5} cm. A heterogeneous mixture of dispersed particle in the dispersion medium falling in the range 10^{-7} to 10^{-5} cm is called as colloid.

The particles, which are larger than a molecule and smaller than a suspended particle, are said to be colloids and such solutions are called colloidal solutions or sols.

Molecular size	<	colloids	<	suspension
10^{-7} cm		10^{-7} to 10^{-5} cm		(More than 10^{-5} cm)

DEFINITION

A colloidal system is made up of two phases. The substance distributed as a colloidal particle is called the dispersed phase (analogous to solute) and the phase where the colloidal particles are dispersed is called the dispersion medium (analogous to solvent).

A heterogeneous mixture of a dispersed phase and dispersion medium is called as 'Colloid'.

A colloidal solution can form eight different types based upon the physical state (solid, liquid, gas) of dispersed phase and dispersion medium.

The common examples of colloids are milk, curd, cheese, clouds, paint etc.

Table: Differences between true solution and colloidal solutions

S.No	Property	True solution	Colloidal solution
1	Nature	Homogeneous system	Heterogeneous system
2	Size	1-10 A^o (10^{-1} cm)	10 A^o - 2000A^o(10^{-1} to10^{-5} cm)
3	Filtration	Cannot be filtrated	Can be filtrated through animal or starch membrane
4	Scattering of light	It does not scatter light	It scatters light
5	Brownian movement	Does not exhibit	Does exhibit
6	Electrophoresis	Does not show	Does show
7	Coagulation	Cannot be coagulated	Can be coagulated

THE DISPERSED PHASE:

A substance which is dispersed into particles of colloidal size in a dispersion medium is called the dispersed phase.

THE DISPERSION MEDIUM:

The continuous medium in which the colloidal particles are dispersed is called the dispersion medium.

For example, in colloidal starch solution, starch is the dispersed phase and water is the dispersion medium.

TYPES OF COLLOIDS

Based on the affinity between the dispersion medium and dispersed phase the colloid is classified into two types. They are

1. Lyophilic colloids

Colloidal solutions in which the dispersed phase has more affinity for the dispersion medium are called Lyophilic colloids [Lyo-solvent; philic-attract].

E.g. gelatin, protein, starch. The Lyophilic and Lyophobic colloids have different characteristics.

2. Lyophobic colloids

Colloidal solutions in which the dispersed phase has very little affinity for the dispersion medium are termed as lyophobic colloids [Lyo-solvent; phobichate].

E.g. colloidal solutions of metals and sulphur in water.

Table: Differences between Lyophilic and Lyophobic colloids

S.no	Property	Lyophilic solution	Lyophobic solution
1	Preparation	Can be easily prepared	Need some special methods to prepare
2	Affinity towards solvent	Solvent attracting	Solvent hating
3	Coagulation	Coagulation requires large quantity of electrolytes	A Small quantity of electrolyte is sufficient
4	Detection through ultra microscope	Cannot be easily detected	Can be easily detected
5	Viscosity	Very much different from that of dispersion medium	Almost the same as that of dispersion medium
6	Surface tension	Very much different from that of dispersion medium	Almost the same as that of dispersion medium
7	Density	Very much different from that of dispersion medium	Almost the same as that of dispersion medium

PROPERTY OF COLLOIDS

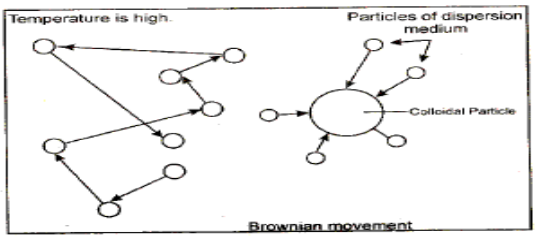
Colloids exhibit certain exclusive properties. They are:

- Mechanical / kinetic property
- Optical property
- Electrical property
- Chemical property

MECHANICAL / KINETIC PROPERTY (BROWNIAN MOVEMENT)

When the colloidal particles are seen through an ultra microscope, it is found that the colloidal particles are found to be in constant zig-zag, chaotic motion.

Fig- Brownian movement

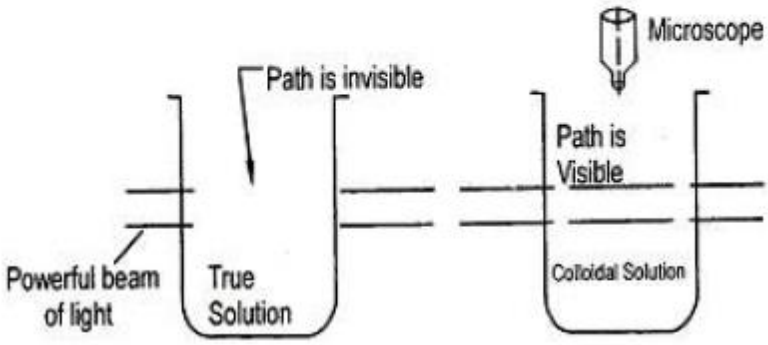


This was first observed by Brown and so **this random movement of colloidal particles is called Brownian movement.** This movement is due to the unequal collisions of colloidal particles with the molecules of the dispersion medium. The motion becomes more rapid when the temperature of the dispersion medium is high and less viscous.

OPTICAL PROPERTY (TYNDALL EFFECT)

When the beam of light is passed through a true solution and if it is observed at right angles to the direction of the beam, the path of the light is not clear. At the same time, if the beam of light is passed through a colloidal solution, the path of the light is quiet distinct due to scattering of light by the colloidal particles. **The phenomenon of scattering of light by the colloidal particles is known as "Tyndall effect"**

Fig.3.2. Tyndall effect



ELECTRICAL PROPERTY (ELECTROPHORESIS)

If an electric potential is applied across two platinum electrodes immersed in a colloidal solution, the colloidal particles move in a particular direction, depending upon the charge of the particles. **Thus the movement of colloidal particles under the influence of electricity is called electrophoresis.**

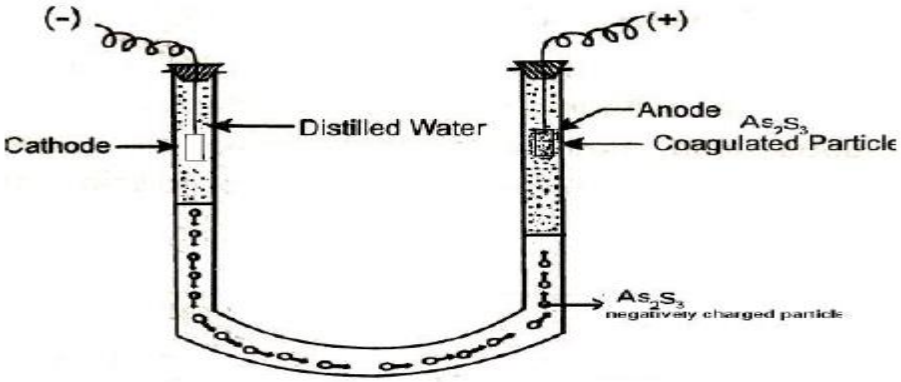


Fig. Electrophoresis

This phenomenon can be demonstrated by placing a layer of arsenic sulphide solution under two limbs of a U-tube. When current is passed through the limbs, it can be observed that the level of the colloidal solution drops out at one end of the limb and rises on the other end.

COAGULATION OF COLLOID :(CHEMICAL PROPERTY)

The entire colloidal particles are electrically charged. The particles are either positively charged or negatively charged. Therefore every colloidal particle repels each other and remains stable. In order to coagulate a colloid, first of all these charges have to be nullified. This can be done in three ways:

- By adding a double salt (electrolyte)
- By introducing an electrode of opposite charge
- By introducing another colloid of opposite charge

After neutralizing the charges, the colloidal particles are brought together and they are large enough to settle down. **Thus the process of precipitating a colloidal solution is called coagulation.**

INDUSTRIAL APPLICATIONS OF COLLOIDS

1. **Smoke precipitation by cottrell's method**

Smoke is a colloidal suspension of carbon particles in air. The smoke is first introduced into a chamber and subjected to a very high voltage. The particles are deposited in one of the electrodes and the hot air alone is let out through the chimney.

2. **Purification of drinking water**

The suspended impurities of the water cannot be filtered. So it is better to coagulate them. This is done by adding potash alum.

3. **Cleaning action of soap**

The dirt particles stick to the cloth or body by the greasy oily substance. It forms an emulsion with soap. The dirt particles get detached from the cloth / body and washed away along with soap with excess of water.

4. **Tanning of leather**

Animal hides are colloidal in nature. When a hide (positively charged particles) soaked in tannin (negatively charged particle) mutual coagulation takes place. This results in hardening of leather and the process is called tanning. Chromium salts are used as tannin.

5. **Disposal of sewage**

Sewage dirt particles are electrically charged. So the sewage is allowed to pass through disposal tanks. It is then subjected to high potential. The sewage particles lose the charges and coagulated. Clean water is recycled or used for gardening. Sludge is used as manure.

6. **Artificial rain**

Cloud contains colloidal water particles. When adding oppositively charged colloidal dust to the clouds by aeroplane, then coagulation takes place causes artificial rain.

QUESTIONS

PART-A

1. What is a colloids?
2. Give any two examples for colloids.
3. What are the two types of colloids?
4. Give any two examples for lyophilic colloids.

PART-B

1. Define Tyndall effect.
2. What is called Brownian movement?
3. What is meant by electrophoresis?
4. Write a note on Tyndall effect.
5. Define coagulation of colloids.

Part-C

1. Distinguish between true solution and colloidal solution.
2. What are the differences between Lyophilic and Lyophobic colloids?
3. Write down any five applications of colloids.

2.2 CATALYSIS

INTRODUCTION

Catalyst plays an important role in chemical reaction. Catalytic reagents are better than ordinary reagents. Catalyst mainly used to prevents the environmental pollution. It helps us to achieve the goal of green chemistry.

DEFINITION

A catalyst is a substance which alters the speed of a chemical reaction without itself taking part in the chemical reaction. The process of using a catalyst to alter the speed of a chemical reaction is called as catalysis.

Example,

$$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$$

Decomposition of potassium chlorate is very slow under normal conditions. When a small amount of manganese dioxide is added the rate of decomposition of potassium chlorate increases. In the above reaction, MnO_2 acts as a catalyst. The reaction is called as catalysis.

TYPES OF CATALYST:

There are two types of catalysts

- Positive catalyst
- Negative catalyst

1. POSITIVE CATALYST

A catalyst which increases the speed of the reaction is called positive catalyst and the phenomenon is known as positive catalysis. Various examples are given below:

Iron is used as a positive catalyst in the synthesis of ammonia by Haber's process.

$$N_{2\,(g)} + 3H_{2\,(g)} \xrightarrow{Fe_{(S)}} 2NH_{3(g)}$$

2. NEGATIVE CATALYST:

A catalyst which decreases the speed of the reaction is called negative catalyst and the phenomenon is known as negative catalysis.

The decomposition of hydrogen peroxide is decreases in the presence of glycerin.

$$2H_2O_2 \xrightarrow{\text{Glycerin}} 2H_2O + O_2$$

PROMOTERS:

Promoter is a substance which increases the activity of the catalyst.

The activity of a catalyst can be increased by addition of a small quantity of a second material. These substances which, though itself not a catalyst, promotes the activity of a catalyst is called a promoter.

Some examples of the promoters are given below.

In the Haber's process for the synthesis of ammonia, traces of molybdenum increase the activity of finely divided iron which acts as a catalyst.

$$N_2 + 3H_2 \xrightarrow[\text{Mo (promoter)}]{\text{Fe (solid)}} 2NH_3$$

CATALYTIC POISONS:

Catalytic poison is a substance which lowers the activity of the catalyst.

A substance which destroys the activity of the catalyst is called a poison and the process is called catalytic poisoning. Some of the examples are:

The iron catalyst used in the synthesis of ammonia in Haber process is poisoned by H_2S.

$$N_2 + 3H_2 \xrightarrow[\text{(Poisoned by } H_2S)]{\text{Fe (solid)}} 2NH_3$$

TYPES OF CATALYTIC REACTIONS

The process of using a catalyst to alter the speed of a chemical reaction is called as catalysis.

Catalytic reactions are classified into two broad types;

- Homogeneous catalysis
- Heterogeneous catalysis

HOMOGENEOUS CATALYSIS:

If the catalyst and the reactants are in the same phase, then it is called as homogenous catalysis.

Example:

In the lead chamber process Oxidation of sulphur dioxide into sulphur trioxide with oxygen in the presence of nitric oxide is used as the catalyst

$$SO_{2\,(g)} + O_{2\,(g)} \xrightarrow{NO_{2(g)}} SO_{3(g)}$$

In above reactions, the catalyst and the reactants are in same phase, hence these reactions are called as homogenous catalysis reactions.

HETEROGENEOUS CATALYSIS:

If the catalyst and the reactants are in the different phase, then it is called as heterogeneous catalysis. Some of the examples of heterogeneous catalysis are given below.

Iron is used as a positive catalyst in the synthesis of ammonia by Haber's process.

$$N_{2(g)} + 3H_{2(g)} \xrightarrow{Fe(s)} 2NH_3$$

The reactants are in gaseous phase while the catalyst is in solid phase. Hence this reaction is called as heterogeneous catalysis reaction.

ACTIVE CENTRE:

The active centre is the site where the substrate binds to the catalyst in order for catalysis to takes place.

GENERAL CHARACTERISTICS OF A CATALYST:

The following characteristics are generally common to most of the catalytic reactions.

- The catalyst remains unchanged in mass and in chemical composition at the end of the reaction. But it may undergo physical change.
- Only a small quantity of catalyst is generally needed.
- A catalyst cannot initiate a reaction.
- The function of a catalyst is only to alter the speed of the reaction which is ready occurring at a particular rate.
- A catalyst does not alter the position of equilibrium in a reversible reaction.
- The catalyst is generally specific in its action.
- A catalyst cannot change the nature of the products obtained in a reaction.
- A catalyst is efficient only at a particular temperature.

APPLICATIONS OF CATALYST:

In order to increase the yield of products and also to increase the rate of reaction, catalysts are employed for various applications in industries. They are,

- In the Haber's process for the synthesis of ammonia, traces of molybdenum increase the activity of finely divided iron which acts as a catalyst.
- In the contact process of preparation of sulphuric acid, platinum is used as a catalyst.
- In the manufacture of ethyl alcohol from sucrose, the enzyme Invertase and zymase are used as catalyst.
- In the manufacture of hydrogen chloride from hydrogen and chloride, activated carbon is used as catalyst.
- In the manufacture of methyl alcohol from CO and H_2, zinc oxide is used as Catalyst.
- In the refining of petroleum, phosphoric acid is used as a catalyst.
- In the cracking of petroleum fractions, silica is used as a catalyst.
- In the hydrogenation of vegetable oil, nickel is used as a catalyst.

QUESTIONS

Part - A

1. Define catalyst.
2. Define promoters.
3. What is catalytic poison?
4. Define the term catalysis.
5. Name the types of catalysis.

Part - B

1. What is a catalyst poison? Explain with example
2. What is a promoter? Explain with example?
3. Explain the heterogeneous catalysis with example

PART- C

1. Explain any five industrial applications of catalyst.
2. Write any five characteristics of a catalyst?

2.3 NANO TECHNOLOGY

INTRODUCTION

Nano technology is the study of matter on an atomic and molecular scale. One nanometer is one billionth or 10^{-9}m. The carbon-carbon bond length is in the range of 0.12-0.15 nm, the DNA double helix has a diameter of 2nm, and that of bacteria will be around 200nm. **So particles of nanometer size are called Nano particles.**

DEFINITION

Nano particles are particles that have size ranging from 10 to 100 nanometer. 1nm=10^{-9}m. These are usually particles at the atomic or molecular size.

PROPERTIES

- Hardness is 5 to 10 times higher
- Improved thermal conductivity
- Improved electrical conductivity
- Good corrosion resistance property
- Increases the efficiency of electronic device

APPLICATION OF NANO TECHNOLOGY IN MEDICINE

The biological and medical research communities have exploited the properties of Nano particles for various applications:

1. Integration of Nano materials with biology led to the development of diagnostic devices and drug delivery vehicles.
2. **Diagnostics:**

   Gold Nano particles tagged with DNA can be used for the detection of genetic sequence.

   Manganese oxide nanoparticles have been used as contrast agent for magnetic resonance imaging (MRI).The results of an MRI scan can be used to help diagnose conditions, plan treatments and assess how effective previous treatment has been.

   Nanoparticles are used for early and specific cancer detection and therapy.
3. **Drug Delivery*:*** Drug can be delivered for specific cell using Nano particles.

4. **Tissue Engineering**

- This may replace today's conventional treatment like organ transplants/artificial implants.
- Advanced forms in tissue engineering may lead to life extension.
- It can repair the targeted damaged tissue.
- Lipid based nanoparticles are used in cosmetics and Creams.
- The zinc oxide nanoparticles block the UV rays, hence it is used in Sunscreen lotion.

APPLICATIONS OF NANO TECHNOLOGY IN BIOMATERIALS

- Problems in Food and bioprocessing industry for manufacturing high quality of safe food can be solved using nanotechnology.
- Bacteria identification and food quality monitoring using biosensors are examples of application of Nano technology.
- A Nano composite coating act as anti microbial agents.
- Natural bone surface is 100nm across. If the artificial bone implant is smooth, the body rejects it. So Nano sized finishing of hip and knee would help the body to accept the implant.

APPLICATIONS OF NANO TECHNOLOGY IN ENGINEERING

- Nano materials are used to increase the energy storage of a battery
- IC in Nano scale are used in CPU
- GMR increases the data storage of the hard disc
- Carbon Nano tubes are highly used in Nano tubes
- Quantum dot laser offer a high beam quality than conventional diodes.

QUESTIONS

PART-A

1. What are nanoparticles?
2. Mention few unique characteristics of nanoparticles.

PART-B

1. Explain the applications of Nano Technology in biomaterials.

PART-C

1. Mention few applications of nanotechnology in engineering.
2. How the Nano technology becomes useful in the field of medicine?

UNIT-III

3.1 TECHNOLOGY OF WATER - I

INTRODUCTION

Water is the most essential compound for all living matter on the earth. It plays an important role in human living, industrial and agricultural purposes. So there is no life in the earth without water.

SOURCES OF WATER

`The two important sources of water are

(1) surface water and

(2) underground water.

Surface water

The water available on the earth's surface is called as surface water. Surface water includes rainwater, river water, lake water and seawater.

Underground water

Underground water includes water present between the rocks in the earth crust, spring water, well water etc.

REASON FOR DEPLETION OF UNDERGROUND WATER

The decrease in the quantum of underground water is depletion of water. Depletion of water is mainly caused by,

1. Modernization, industrialization and population growth
2. Global warming causing excess evaporation of surface water
3. Deforestation
4. Decrease in rainfall caused by seasonal changes and
5. Effluents from the industries spoiling the ground water source.

To meet out this depletion of ground water sources, it is essential to find alternate plans rain water harvesting using water management techniques to recharge the ground water sources. One of the techniques adopted is rainwater harvesting.

RAIN WATER HARVESTING

Rainwater harvesting (RWH) is a technique of capturing and storing of rainwater (tanks, slums, lake) for useful purposes and recharging the excess water into the ground.

The methods employed are

1. Roof top harvesting
2. Open space harvesting

Roof top harvesting

Rainwater is directly used for recharging open wells and bore wells by directing them into it. It can also be stored in sumps or overhead tanks and used directly.

Open space Harvesting

Open spaces around the buildings are used for rainwater harvesting as follows

1. with percolation/recharge pits
2. Recharge trenches
3. Recharge wells

The recharge method used depends on the soil condition.

Advantages of rain water harvesting

1. RHW increases the ground water level.
2. It avoids the depletion of underground water.
3. Soil erosion is prevented.
4. It also prevents flooding in urban areas during rainy season.
5. It ensures the availability of water for our future generation.

Types of impurities present in water

There are three types of impurities present in water. They are

(i) Suspended and colloidal impurities.

(ii) Dissolved salts.

(iii) Microorganisms.

Types of water

There are two types of water.

They are (i) soft water and (ii) hard water.

I. **Soft water** readily gives lather with soap.

II. **Hard water** does not give lather with soap.

Hardness of water

There are two types of hardness in water.

They are:

(i) Temporary Hardness: (Carbonate hardness)

It is due to the presence of calcium bicarbonate [$Ca(HCO_3)_2$] and magnesium bicarbonate [$Mg(HCO_3)_2$].

Temporary Hardness can be removed by boiling.

(ii) Permanent Hardness: (Non-Carbonate hardness)

It is due to the presence of chloride and sulphate salts of calcium and Magnesium. ($CaCl_2$, $CaSO_4$, $MgCl_2$, $MgSO_4$). Hence it is called as permanent hard water.

Methods of expressing the Hardness

The hardness of water can be expressed by any one of the following two methods.

Units for measuring hardness

1. mg/litre of $CaCO_3$

It is the number of mg $CaCO_3$ of present in one litre of water or mg/lit

2. Parts per million of $CaCO_3$

It is the number of parts by weight of $CaCO_3$ present in million parts of water or ppm.

1mg / litre = 1 ppm

Usually, the hardness of water is expressed in terms of calcium carbonate equivalents. The formula used to convert the mass of hardness producing salt to the mass of $CaCO_3$ equivalent is given below.

$$\text{Calcium Carbonate Equivalents} = \frac{\text{Mass of salt x Molecular mass of } CaCO_3}{\text{Molecular mass of salt}}$$

To prove the relation between mg/litre and ppm

Let us consider a water sample whose hardness is 'x' mg/litre of $CaCO_3$.

Therefore, Mass of $CaCO_3$ present in 1000ml of water =Y mg

i.e. Mass of $CaCO_3$ present in 1000g of water = $Y \times 10^{-3}$ g

Therefore,

Mass of $CaCO_3$ present in 10^6 g of water = $Y \times 10^{-3} g \times 10^6$

= Yx1000g.

Hence hardness of water is = Y ppm.

Therefore, 1 mg / litre = 1 ppm. Hence it is proved.

Even though $CaCO_3$ is not a hardness producing salt and is insoluble in water, it is used as the standard to express the hardness of water. Since the hardness producing salts are present in traces, mass of $CaCO_3$ equivalent to hardness producing salt is calculated to express the hardness of a water sample.

The formula used to convert the mass of hardness producing salt to mass of $CaCO_3$ is given as follows.

One molecular mass of Hardness producing salt = one molecular mass of $CaCO_3$

Note: Molecular masses of hardness producing salts are given below,

Hardness producing salt	**Molecular Mass**
$CaSO_4$	136
$MgSO_4$	120
$CaCl_2$	111
$MgCl_2$	95
$Ca(HCO_3)_2$	162
$Mg(HCO_3)_2$	146

1. A water sample contains 48 mg of $MgSO_4$ per 200ml of water. Calculate the hardness in terms of $CaCO_3$ equivalent in mg/litre of $CaCO_3$.

Solution:

One molecular mass of $MgSO_4$ = one molecular mass of $CaCO_3$

i.e. 120 mass of Mg SO_4 = 100 mass of $CaCO_3$

Therefore mass of 48mg of $MgSO_4$ = $\frac{48 \times 100}{120}$ = 40mg of $CaCO_3$

Mass of $CaCO_3$ present in 200 ml of water = 40mg

Therefore,

Mass of $CaCO_3$ present in 1000ml of water = 200mg

Hardness of water = 200mg/litre of $CaCO_3$

Disadvantages of a hard water sample

- Hard water cannot be used for drinking, as it does not quench thirst.
- It cannot be used for cooking purposes.
- It cannot be used for bathing and washing purposes as it does not give lather with soap.
- Hard water cannot be used in laboratories as it gives unwanted chemical reactions.
- Hard water cannot be used in boilers in steam raising.
- It cannot be used in sugar and paper industries.
- Hard water cannot be used in textile and leather industries.

ESTIMATION OF HARDNESS OF WATER -EDTA METHOD

EDTA method is used to determine the hardness of a sample of water. EDTA refers to Ethylene-diamine tetra acetic acid. This method is also called Modern method.

PRINCIPLE:

This is a volumetric method based on the principle of formation of complexes. Ethylene diamine tetra acetic acid (EDTA) forms colorless complexes with Ca^{2+} and Mg^{2+} ions present in water. Similarly Eriochrome Black-T, another dye, also forms wine red coloured complexes with Ca^{2+} and Mg^{2+} ions. Pure Eriochrome Black-T is blue in colour. At the pH range of 9 to 10, the Eriochrome complexes are less stable when compared to EDTA complexes. Thus when EDTA solution is added to Eriochrome-Ca^{2+} or Mg^{2+} complexes it displaces pure Eriochrome to form EDTA-Ca^{2+} or Mg^{2+} complexes. Thus at the end point EDTA frees the total Eriochrome Black-T to change the colour of the solution from wine red to steel blue.

Eriochrome-Ca^{2+} + EDTA---> EDTA-Ca^{2+} + Eriochrome Black-T

Wine Red **Steel Blue**

PROCEDURE:

The burette is filled with the standard EDTA solution. A 50-ml pipette is washed with distilled water and rinsed with the sample of hardwater. Exactly 50 ml of hard-water is pipetted out into a conical flask and 5 ml of NH_4Cl - NH_4OH buffer solution is added. A pinch of Eriochrome Black-T indicator is added. The colour of the conical flask solution changes into wine red. The water sample is titrated against the EDTA Solution taken in the burette. The colour changes from wine red to steel blue. This is the end point of the titration. The burette reading is noted. Titrations are repeated until two consecutive values agree. From the volume of EDTA the hardness of the sample of water is calculated

. **Note:** In the estimation of hardness of water, a standard already established formula is used. This gives a standard data relating the mass of $CaCO_3$ and volume of 0.01M EDTA solution. The formula is

1ml of 0.01M EDTA solution ≡ 1mg of $CaCO_3$

HARD WATER Vs EDTA

Sl. No.	Volume of Hard water	Burette Reading		Volume of EDTA (ml)	Indicator
		Initial	Final		
1	20	0			
2	20	0			Eriochrome Black-T
3	20	0			

CALCULATION:

Let V ml be the volume of EDTA Hard water.

1 ml of 0.01 M EDTA = 1 mg of $CaCO_3$

Therefore V ml of 0.01 M EDTA = V mg of $CaCO_3$

50 ml of hard water contains V mg of $CaCO_3$

Therefore Weight of $CaCO_3$ present in 1000 ml of Hard water

$$= \frac{V \times 1000}{50} \text{ mg}$$

$$= 20 \text{ V mg}$$

HARDNESS OF WATER = 20V mg / litre of $CaCO_3$

(Note: In the estimation of hardness, 0.01M EDTA solution is prepared by dissolving 3.72 g of Disodium salt of EDTA in 1000 ml of distilled water.

NH_3 - NH_4Cl buffer solution is prepared by dissolving 67.5 g of ammonium chloride (AR) in 200ml of water and by adding 570ml of Liquor ammonia (AR) with specific gravity 0.92 and the total volume is made up to one litre.)

WORKED OUT EXAMPLE

1. A sample of 100 ml of hard water consumes 25 ml of 0.01M EDTA solution. Calculate the hardness of the sample of water.

Formula

1 ml of 0.01M EDTA solution ≡ 1mg of $CaCO_3$

Therefore, 25 ml of 0.01M EDTA solution ≡ 25 mg of $CaCO_3$

By titration, 25 ml of 0.01M EDTA solution ≡100 ml of hard water

Therefore

Mass of $CaCO_3$ present in 100 ml of hard water = 25 mg

Therefore

Mass of $CaCO_3$ present in 1000 ml of hard water = 250mg

Hence hardness of water = 250mg/litre of $CaCO_3$

<u>To give in ppm</u>

Mass of $CaCO_3$ present in 100 ml of hard water = 25 mg

Mass of $CaCO_3$ present in 100g of hard water = 25×10^{-3}g

Therefore

Mass of CaCO3 present in 106g of hard water = $\frac{25\times10^{-3}g\times10^{6}}{100}$

= 250g

Hence hardness of water = 250 ppm of $CaCO_3$.

2. A sample of 100 ml of water consumed 12.5 ml of 0.01 M EDTA solution. In another titration 100 ml of the same sample, after boiling for half an hour consumed 8.2 ml of the same EDTA solution. Calculate the carbonate and non-carbonate hardness of the sample of water.

(NOTE: In the given problem, volume of EDTA consumed in the first titration is equivalent to total hardness of water which includes both carbonate and non-carbonate hardness. But the volume of EDTA consumed by the water after boiling is equivalent to non-carbonate hardness as carbonate hardness in water can be removed by boiling water.)

<u>Total hardness</u>

1ml of 0.01M EDTA solution ≡ 1mg of $CaCO_3$

Therefore,

12.5ml of 0.01M EDTA solution ≡ 12.5 mg of $CaCO_3$

By titration,

12.5ml of 0.01M EDTA solution ≡100 ml of hard water

Therefore

Mass of $CaCO_3$ present in 100 ml of hard water = 12.5 mg

Therefore mass of $CaCO_3$ present in 1000ml of Hard water =125mg

Hence Total hardness of water = 125 mg/litre of $CaCO_3$

<u>Non-carbonate Hardness</u>

1ml of 0.01M EDTA solution ≡ 1mg of $CaCO_3$

Therefore,

8.2ml of 0.01M EDTA solution ≡ 8.2 mg of $CaCO_3$

By titration,

8.2ml of 0.01M EDTA solution ≡100 ml of hard water

Therefore

Mass of $CaCO_3$ present in 100 ml of hard water = 8.2 mg

Therefore

Mass of $CaCO_3$ present in 1000ml of hard water = 82 mg

Hence

Non-carbonate hardness of water =82 mg/litre of $CaCO_3$

Therefore

Carbonate Hardness = Total hardness – Non-carbonate hardness

= (125 – 82) = 43 mg/litre of $CaCO_3$

BOILER FEED WATER

Water is used in boilers, steam engines etc., to raise steam. When a sample of hard water is used in boiler to prepare steam, the following problems will occur.

1. Scale formation
2. Corrosion of boiler metal
3. Caustic Embrittlement and
4. Priming and foaming.

Boiler Scale Formation:

When hard water is used in boilers to get steam, the impurities that are present in the hard water will settle down on the sides of the boiler. This residue in due course will adhere to the boiler vessel surface in the form of a sludge or scale. This is called as boiler scale. The following calcium salts are responsible for the formation of boiler scale $CaSO_4$, $CaCO_3$, $Ca(OH)_2$, $Mg(OH)_2$ etc.

Disadvantages of using hard water Boilers

1. The salt deposit formed is a poor conductor of heat. Therefore fuel is wasted in raising the temperature of the boiler.

2. Due to the increase in the temperature, the plates may melt. This may lead to explosion of boiler.

3. At higher temperature, more oxygen may be absorbed by the boiler metal, which causes corrosion of boiler metal.

4. The sudden spalling of the boiler scale exposes the hot metal suddenly to Super-heated steam, which causes corrosion of boiler.

Methods employed to prevent scale formation are,

1. Internal conditioning method
2. External conditioning method.

1. **Internal conditioning methods** involve addition of complexing agents like Chalgon to boiler feed water. Another method of internal conditioning is Phosphate conditioning. In this method, sodium phosphate is added to boiler feed water which forms non-sticky Calcium and Magnesium Phosphate Which can be removed by blow down operation**.**

2. In External conditioning methods water is purified either by Zeolite process or by ion-exchange method before being fed into boilers.

CORROSION OF BOILER METAL:

Water containing the following impurities is responsible for the corrosion of boiler metal. The impurities such as dissolved oxygen, dissolved Carbon dioxide, mineral acids, dissolved salts of calcium and magnesium, organic matter etc. are responsible for the corrosion of the boilers.

The dissolved matter undergoes hydrolysis and forms acids. The acid slowly attacks the inner part of the boiler.

The dissolved oxygen attacks iron at high temperature. The CO_2 and H_2O form carbonic acid (H_2CO_3), which slowly attacks the metal.

Prevention of Boiler Corrosion:

1. By using proper water treatment procedures.
2. By degasification to remove the dissolved gases like oxygen, CO_2 etc.,
3. The dissolved CO_2 can be removed by the addition of limewater.
4. Adding calculated amount of base could neutralize the mineral acids.

CAUSTIC EMBRITTLEMENT:

Sometimes cracks appear inside the boiler parts, particularly at the places, which are under stress. Metal becomes brittle at these places. It is due to the high concentration of caustic soda (NaOH) and a little amount of silica in water. This is called as caustic embrittlement.

Caustic soda is formed by the hydrolysis of Na_2CO_3.

$$Na_2CO_3 + H_2O \rightarrow 2NaOH + CO_2$$

Removal of Na_2CO_3 present in water can prevent caustic embrittlement.

This can be done by the following methods.

1. By adding sulphuric acid.
2. By adding $CaSO_4$ and $CaCl_2$ to boiler water
3. By adding Na_2SO_4.
4. By adding trisodium phosphate. etc.

FOAMING

Foaming is nothing but the formation of foam. Bubbles of water will enter the surface of water inside the boilers and results in the formation of foam. Foam comes out of the boiler along with the steam. Hence the steam becomes wet and the heat content of the steam is reduced considerably. This type of wet steam spoils the machine parts where it is used. The main cause for foaming is the presence of dissolved salts in water. Hence soft water should be used in boilers to avoid foaming.

PRIMING

Priming is violent and rapid boiling of water inside the boiler. Due to priming, the water particles mix up with the steam when it comes out of the boiler. Like foaming, priming also reduces the heat content of the steam and reduces the efficiency of the steam.

Main reasons for Priming:

a) Defective design of the boiler.

b) Presence of large quantities of dissolved salts, oily matter, alkaline and suspended matter.

Control

1. Priming can be controlled by proper design of the boiler
2. By uniformly heating the water in the boiler.
3. By using a better sample of water.

QUESTIONS

PART – A

1. Define hard and soft water.
2. List the salts that cause Carbonate and non-carbonate hardness in a water sample.
3. What is rain water harvesting?
4. Mention any two problems caused by using hard water sample.
5. What are boiler scales?
6. What is caustic embrittlement?
7. What is priming?
8. What is foaming?
9. Give any one problem caused by boiler scale.

PART – B

1. List the problems caused by hard water.
2. What is rainwater harvesting? What are its goals?

PART-C

1. Explain EDTA method of estimating hardness of a sample of water.
2. Describe the method used in water supply schemes to get potable water.
3. What are boiler scales? List the problems caused by boiler scale? How to overcome this problem?
4. Explain caustic embrittlement, priming and foaming in boilers during the production of steam.

3.2 TECHNOLOGY OF WATER - II

SOFTENING OF HARD WATER

The method of converting the hard water into soft water is called softening of hard water. Two important methods of softening the hard water are

1. Ion- Exchange method
2. Reverse Osmosis method.

Ion Exchange method

(Demineralization Method or de-ionization method)

In this method the hard water is first passed through an acidic resin having replaceable hydrogen ion (RH_2) to remove the cations [Ca^{2+}, Mg^{2+}] and then it is passed through a basic resin [$R'(OH)_2$] having replaceable hydroxyl ion to remove the anion. Thus both types of ions are totally removed.

Acid resin is represented by RH_2.

Base resin is represented by $R'(OH)_2$.

Softening Process:

When the hard water sample is passed through the acid resin, calcium and magnesium ions are removed.

$2RH + Ca^{2+}$ ----------> $R_2Ca + 2H^+$

Acidic resin

$2RH + Mg^{2+}$ ----------> $R_2Mg + 2H^+$

Acidic resin

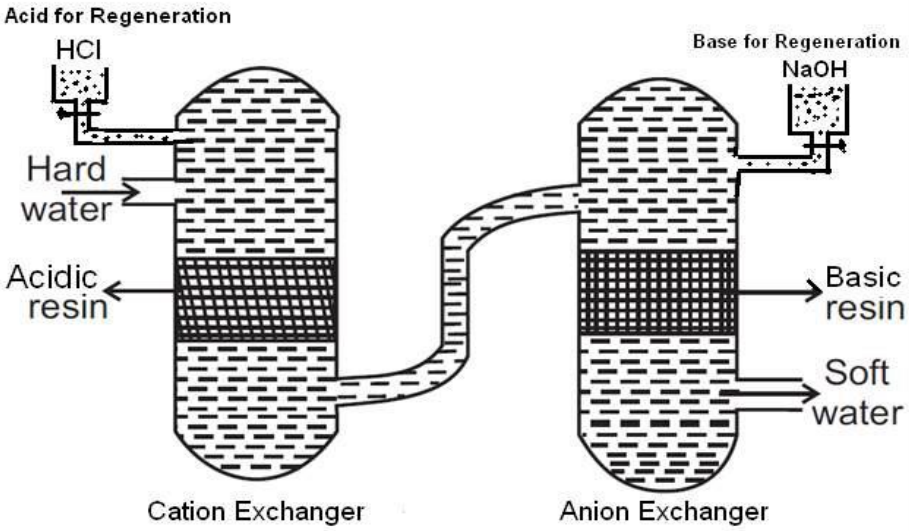
When this water is passed through the base resin, chloride, bicarbonate and sulphate ions are removed.

$R'OH + Cl^-$ ----------> $R'Cl + OH^-$

Basic resin

$2R'OH + SO_4^{2-}$ ----------> $R'_2SO_4 + 2OH^-$

Basic resin



ION-EXCHANGE METHOD

Thus both types of ions are removed from water. The H^+ and OH^- ions combine together to form water.

$$\mathbf{H^+ + OH^- \text{ ----------> } H_2O}$$

The quality of water obtained by this method is equivalent to distilled water.

Regeneration of Acidic Resin and Basic Resin:

After a long use, the acidic resin can be regenerated by washing it with strong solution of Hydrochloric acid.

$R_2Ca + 2HCl$ ----------> $2RH + CaCl_2$

The basic resin after a long use can be regenerated by washing it with a strong solution of NaOH.

$R'Cl + NaOH$ ----------> $R'OH + NaCl$

$R'_2SO_4 + 2NaOH$ ---------> $2R'OH + Na_2SO_4$

Advantages

1) In this method, both types of hardness are removed.

2) The quality of water obtained is equivalent to distilled water.

3) There is no wastage of water.

REVERSE OSMOSIS METHOD

OSMOSIS

When two solutions of different concentrations are separated by a semi-permeable membrane, solvent molecules move from the region of low concentrated side to the region of high concentrated side until the two concentrations become equal. This process is called osmosis. The pressure gradient produced due to osmosis is called osmotic pressure.

Reverse Osmosis

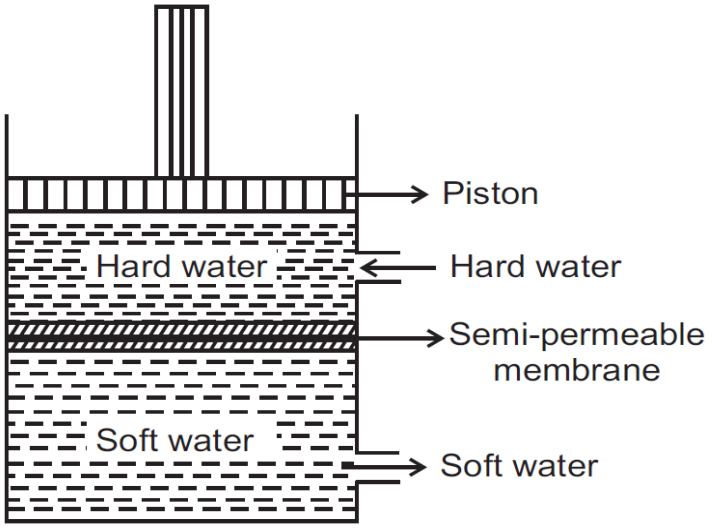
When a hydrostatic pressure greater than the osmotic pressure is applied on the high concentration region, solvent molecules move from high concentration region to the low concentration region across the semi permeable membrane. This is called reverse osmosis. This principle is used in Reverse Osmosis plants to soften hard water.

Method

- In this method hard water and soft water are taken in two different chambers separated by semi permeable membrane.
- When a hydrostatic pressure greater than the osmotic pressure is applied on the hard waterside, the water molecules move from hard waterside to soft waterside leaving the impurities on the membrane due to reverse osmosis.

  Thus hard water is converted to soft water by Super filtration or hyper filtration

Diagram



- The semi permeable membrane is made of polysulphone or cellulose acetate or polyamide.

Advantages

- In this method ionic, non-ionic, colloidal, and organic particles are removed from water.
- The semipermeable membrane can be replaced and reused.
- There is no wastage of water.

MUNICIPAL WATER SUPPLY

WATER FOR DRINKING PURPOSE (Potable water)

Water used for drinking should be

1. Colourless and odourless
2. Free from colloidal and suspended impurities and
3. Free from microorganisms and bacteria.

The three stages involved in purifying a water sample for drinking purpose are

1. SEDIMENTATION
2. FILTRATION
3. STERILISATION

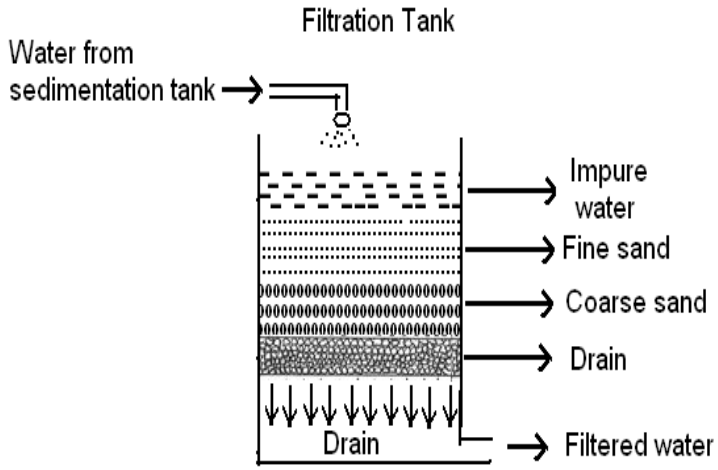
SEDIMENTATION

Water from river or lake is taken in the big tank called sedimentation tank. Here the insoluble matter settles down at the bottom of the tank as sediments. In this tank, the colloidal impurities are converted into precipitate by adding Alum. The clear water from the top layer is sent to the next tank called Filtration tank.

FILTRATION TANK

In filtration tank, the suspended impurities and the microorganisms are removed. In all types of filtration, the filter bed used is constructed as follows.

The filter bed consists of a layer of fine sand followed by the layer of coarse sand, which is then followed, by a layer of gravel. There is a drain at the bottom to remove the filtered water. The layer of fine sand acts as the filtering unit and the other two beds support the fine sand layer. Generally filtration is done due to the gravitational force. The filtered water is then taken to the sterilization tank.



(Note: In drinking water supply schemes, generally gravity filters are used. However, in industrial areas where large amount of drinking water is required in short period, pressure filters are used in which water is sent through filter beds using external pressure. In gravity filtration, there are two types namely slow sand filtration and rapid sand filtration. The difference between these two methods is mainly in the recovery of filter beds used.)

STERILIZATION

Sterilization is the process of killing the bacteria. It is done by Chlorination.

Chlorination

Chlorination is addition of chlorine. Chlorine is added to water in the acidic pH range of 6.5 to 7. When chlorine is added to water, it forms HCl and HOCl. The hypochlorous acid molecule enters into the living cells of bacteria and kills them.

$$H_2O + Cl_2 \rightarrow HCl + HOCl \quad \textbf{(Hypochlorous acid)}$$

Other sterilizing agents used apart from chlorine are chloramines, bleaching powder etc. The advantage of using chloramines is that it does not evaporate out easily and can be carried over to a longer distance along with the water.

Ultra-violet rays can also be used for sterilizing purpose.

QUALITY OF POTABLE WATER

Drinking water, also known as **potable water**, is **water** that is safe to drink or to use for food preparation. The amount of **drinking water** required to maintain good health varies, and depends on physical activity level, age, health-related issues, and environmental conditions.

PARAMETERS OF POTABLE WATER

TDS

TDS (Total Dissolved Solids) is must be less than 300 mg/ litre

Level of TDS (milligrams per litre)	Rating
Less than 300	Excellent
300 – 600	Good
600 – 900	Fair
900 – 1200	Poor
Above 1200	Unacceptable

pH

pH = 6.5 to 8.5

DISSOLVED CHLORINE PERMISSIBLE LIMITS

0.2 m.g / litre

DETERMINATION OF EColi

E. coli is a type of fecal coliform bacteria commonly found in the intestines of warm blooded animals and humans.

The presence of E. coli in water is a strong indication of recent sewage or animal waste contamination.

Membrane filtration method

The membrane filtration method involves filtering several different-sized portions of the sample using filters with a standard diameter and pore size, placing each filter on a selective nutrient medium in a petri plate, incubating the plates at a specified temperature for a specified time period, and then counting the colonies that have grown on the filter.

This method varies for different types of bacteria.

QUESTIONS

PART – A

1. List any two methods of softening of hard water.
2. What is an osmosis?
3. What is an osmotic pressure?
4. Explain reverse osmosis.
5. Name the membranes used in RO method of softening of hard water
6. What is sedimentation?
7. What is sterilization of water?

PART – B

1. What is the parameter of portable water?

PART-C

1. Explain Ion Exchange method of softening a hard water sample.
2. What is regeneration of Ion-exchange plant? How is it carried out?
3. Explain Reverse Osmosis method of softening a hard water sample.
4. Describe the method used in water supply schemes to get potable water.
5. Explain the determination of E.coli.

3.3-GLASS

INTRODUCTION:

Glass is an engineering material. It may be defined as an amorphous, rigid, brittle, hard, transparent super cooled liquid. It is resistant to heat. It is a transparent mixture of silicates of potassium or sodium.

It is produced by the fusion of certain basic oxides and acidic oxides, with sand and other materials.

Composition of Glass:

The composition of some common verities of glass is as follows.

1. Soda lime glass $Na_2O.\ CaO.6SiO_2$
2. Potash lime Glass: $K_2O.CaO.6SiO_2$
3. Potash lead glass: $K_2O.PbO.6SiO_2$

RAW MATERIAL REQUIRED FOR THE MANUFACTURE OF GLASS:

The raw materials for the manufacture of ordinary glass are of two kinds.

1. Acidic oxides: sand (SiO_2). Boron oxides (B_2O_3).
2. Basic oxides: Sodium-oxides (Na_2O), potassium oxides (K_2O),calcium oxides (Ca_2O) ,Lead Oxide (PbO), Zinc Oxide (ZnO), Magnesium Oxide (MgO) and Aluminum Oxide (Al_2O_3).

MANUFACTURE OF GLASS:

Raw materials are:

1. Sand
2. Sodium carbonate
3. Calcium carbonate.

Mixing:

The raw materials are powdered well and they are mixed homogeneously. With this some of the broken glass powders are also added to get an intimate mixture known as" Batch".

Fusion:

The batch is then transferred to the tank or pot furnace. This batch is heated to 1400-1500^oC. At this temperature the substances present in the batch react together forming a mixture of silicates. This mixture of silicates is known as glass.

Fining:

The molten glass is kept at the highest temperature for some time to remove gas bubbles. This is called fining. Na_2CO_3 is often added to lower the viscosity of the molten glass. The impurities rise to the top as scum and it is removed. Cullet, oxidizing agents, reducing agents and other materials are also added to the molten glass according to the requirements.

Fabrication:

Coloring material may be added to the molten glass to get desired colored glass. Molten glass is then moulded or fabricated into articles of desired shape by blowing, moulding, or pressing.

Colouring Materials

1. Cobalt oxides - Blue
2. Cuprous salt - Red
3. Chromium oxide - Green
4. Ferric iron - yellow
5. Potassium dichromate - Green

Annealing of Glass:

The method of slow cooling of glass is called annealing. If the manufactured hot glass articles are cooled suddenly, it will easily break. To avoid this glass is cooled very slowly by passing them through several hot chambers. The temperature of the hot chamber is in the decreasing order gradually. This process of slow cooling of glass is called as annealing.

The annealing temperature varies for different types of glasses.

PHOTO CHROMATIC GLASS:

Photo chromic lenses are lenses that darken on exposure to specific types of light, most commonly ultraviolet radiation. Once the light source is removed, the lenses will gradually return to their clear state. Photo chromic lenses may be made of glass, polycarbonate, or another plastic. Traditional photo chromic eyeglasses are generally alkali Boro-alumino -silicates with 0.01 to 0.1 percent silver halide and a small amount of copper. Upon absorption of light, the silver ion reduces to metallic silver, which nucleates to form colloids about 120 angstroms in size. This is small enough to keep the glass transparent, but the colloids are dense enough to make the glass look gray or black.

WINDSHIELD GLASS

A framed pane of usually curved glass or other transparent shielding located in front of the occupants of a vehicle to protect them from the wind. A shield placed to protect an object from the wind. Modern windshields are generally made of laminated safety glass, a type of treated glass, which consists of two (typically) curved sheets of glass with a plastic layer laminated between them for safety, and are bonded into the window frame. Motorbike windshields are often made of high-impact acrylic plastic. Laminated glass is produced by permanently bonding two pieces of glass together with a tough Glass plastic interlayer (polyvinyl

butyral, PVB) under heat and pressure. Once bonded together, the glass and which acts as a single unit and generally appears very similar to standard clear glass. The inter layer is virtually invisible when viewed in transmission with glass on either side.

The benefit of laminated glass is that if broken, glass fragments will adhere to the PVB interlayer rather than falling free, thereby reducing the risk of physical injury and property damage. PVB also has properties that effectively filter over 99% of UV. It also reduces transmission of sound. Hence the windshield glass in cars is a safety device just like seatbelts & airbags.Laminated glass is commonly used in automobiles (for windshields), airports, museums, sound studios, schools, greenhouses. Windshields protect the vehicle's occupants from wind and flying debris such as dust, insects, and rocks, and provide an aerodynamically formed window towards the front.

OPTICAL GLASS: (CROWN GLASS)

Optical glass is a type of optical glass used in lenses and other optical components. It has relatively low refractive index (≈1.52) and low dispersion Crown glass is produced from alkali-lime (RCH) silicates containing approximately 10% potassium oxide and is one of the earliest low dispersion glasses.

QUESTIONS

PART A

1. Define glass.
2. What is glass transition temperature?
3. What is an optical glass?

PART B

1. Write a note on windshield glass.
2. Write a note on photo chromatic glass.
3. When windshield glass of a bus/car broken due to accident, it shatters into harmless fragments. How?
4. Today windshield in cars is a safety device just like seatbelts & airbags. How?

PART C

1. How is ordinary glass manufactured?
2. What is an annealing of glass? Why is it necessary?
3. Write any three varieties of glass.

UNIT – IV

4.1 METALLURGY

The method of separating metals from their ores and the study about their properties is termed as metallurgy. Some general terms involved in metallurgy are

MINERALS

Naturally occurring substances which contain the metals in combined state are called minerals.

ORES

The minerals from which the metal is separated economically is called ore.

Example: ores of iron – Haematite (Fe_2O_3)

GANGUE

The earth impurities such as sand, soil etc.. present in the ore are called gangue.

FLUX

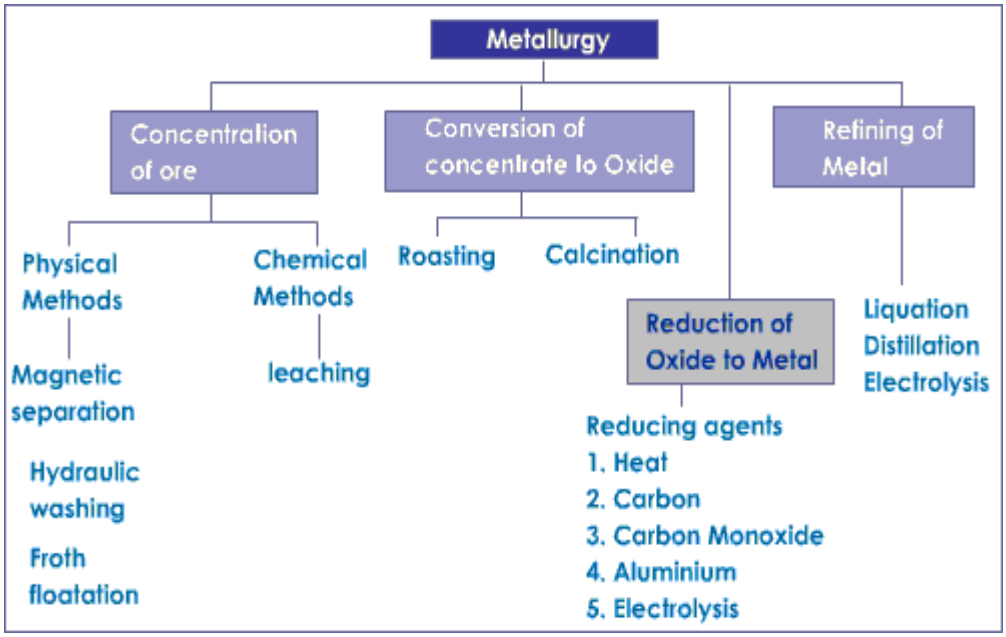
Substance which combines with gangue to form a slag is called flux.

Example Lime stone is used as flux in smelting of iron ore.

$$CaCO_3 \rightarrow CaO + CO_2$$

SLAG

Fusible mass formed by the union of flux with gangue is called slag.

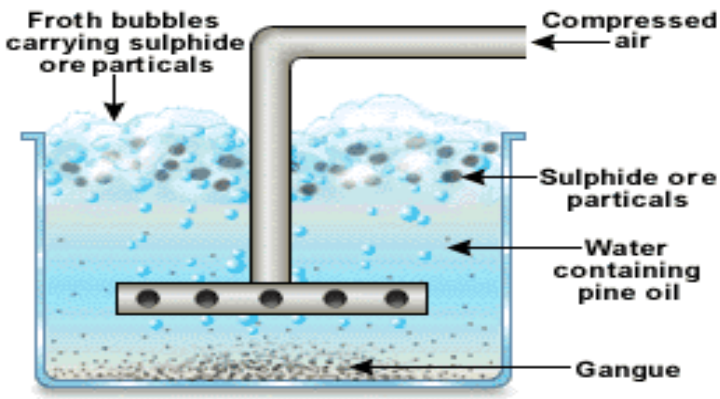


CONCENTRATION OF ORE

Removal of earth impurities from ore is called concentration. This can be done by three ways.

FROTH – FLOATATION PROCESS

In this method, powdered ore is mixed with pine oil and water. This mixture is stirred well by using compressed air. Now froth will be formed and the lightest metal ore will be with the froth while the impurities settle down at the bottom. Sulphide ores such as nickel sulphide and zinc sulphide are concentrated by this method.



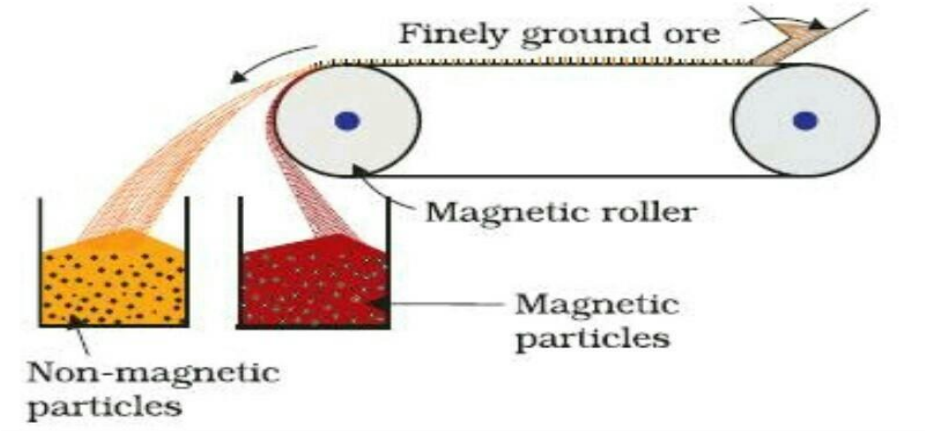
Froth floatation process for the concentration of sulphide ores.

GRAVITY METHOD

Powdered ore is placed at the top of sloping floor and it is washed by stream of water. Now the impurities will be washed away by the water. The heavier ore particles will be left behind. Haematite and chromite ore are concentrated by this method.

MAGNETIC SEPARATION

In this method, powdered ore is allowed to fall on two electromagnetic rollers. Magnetic impurities such as tungstate will be attracted by the magnet and fall away from the magnet.



EXTRACTION OF THE METAL

a) ROASTING

The concentrated ore is heated in excess of air, to a temperature at which the ore does not melt. In this process volatile impurities and moisture are removed and sulphide ore is converted to sulphur dioxide.

b) CALCINATION

It is the process of strong heating of the carbonate ore in limited supply of air. During calcinations carbonate ore is converted to metal oxide and carbon dioxide.

$$CaCO_3 \rightarrow CaO + CO_2$$

$$MgCO_3 \rightarrow MgO + CO_2$$

c) SMELTING

It is the process of reducing the metal oxide into metal by using a reducing agent.

$$Fe_2O_3 + 3CO \rightarrow 2\,Fe + 3\,CO_2$$

REFINING

Generally metals, after separating from its ores, will have some impurities. Removal of these impurities from the metal is called refining.

For refining nickel and chromium, electrolysis method is followed. Metals like mercury and zinc are refined by distillation method.

QUESTIONS

PART – A

1. What is flux?
2. What is slag?
3. What is gangue?

PART – B

1. What is roasting?
2. What is calcinations?
3. What is smelting reduction?

PART – C

1. Explain froth-flotation method for concentration of ores.
2. Explain gravity separation method for concentration of ores.

4.2 EXTRACTION OF IRON

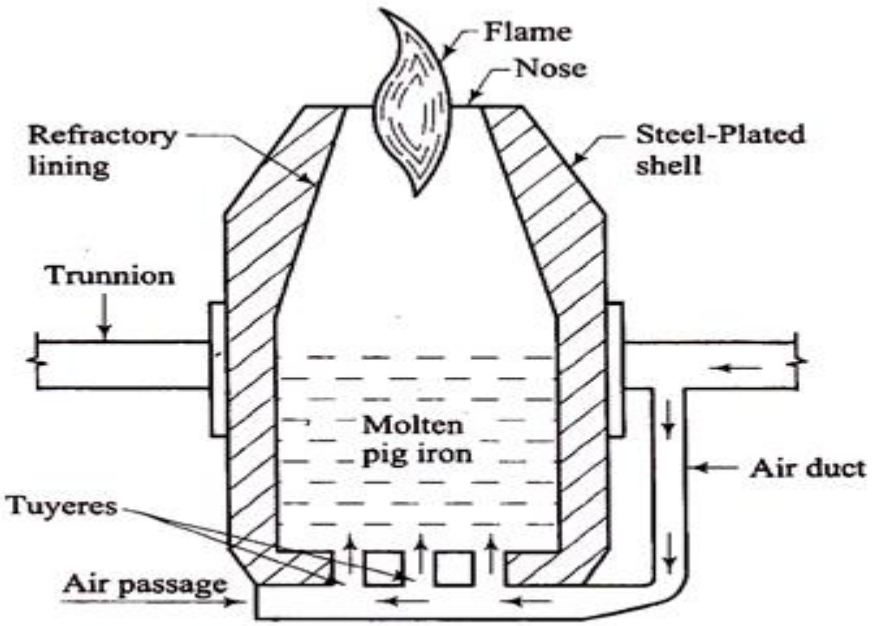
BLAST FURNACE

A blast furnace is a type of metallurgical furnace used for smelting to produce industrial metals, generally pig iron, but also others such as lead or copper. *Blast* refers to the combustion air being "forced" or supplied above atmospheric pressure.

In a blast furnace, fuel (coke), ores, and flux (limestone) are continuously supplied through the top of the furnace, while a hot blast of air (sometimes with oxygen enrichment) is blown into the lower section of the furnace through a series of pipes called tuyeres, so that the chemical reactions take place throughout the furnace as the material falls downward. The end products are usually molten metal and slag phases tapped from the bottom, and waste gases (flue gas) exiting from the top of the furnace. The downward flow of the ore and flux in contact with an up flow of hot, carbon monoxide-rich combustion gases is a counter current exchange and chemical reaction process.

MANUFACTURE OF STEEL

Steel is an alloy of iron. **Steel contains 0.15 -1.5% carbon**. Steel is manufactured from cast iron by using Bessemer converter.



Bessemer converter
FIG. 11-1

Bessemer converter is a large pear shaped furnace. It is made of steel. It is lined inside with firebricks. There is a side tube at the bottom from which hot air is blown inside. The bottom of the furnace has some holes. The converter can be tilted to any position.

Procedure

Bessemer converter is placed in horizontal position and molten cast iron is poured in. The converter is brought to vertical position. Now hot air is send inside through the holes.

Reactions

Carbon present in the cast iron (2-5%) is converted to carbon monoxide. This burns with a blue flame.

$$2C + O_2 \rightarrow 2\ CO \uparrow$$

When the blue flame sinks down passing of hot air is also stopped.

SEPARATION

Required quantity of carbon is added in the form of Spiegel (alloy of Fe, C & Mn). Then the converter is tilted and steel is collected from the Bessemer converter.

TYPES OF IRON

1. **Cast iron**

   Carbon content is 2 -5 %. It is back in colour. It is generally used for making lamp posts, pipes, stoves, carpentry tools, piston and cylinders for automobiles.

2. **Wrought iron**

   Wrought iron is the purest from the iron. Carbon content is 0.1 – 1.5%. Is is very soft. It is used in making rails, bolts, agricultural tools, horse – shoes and electromagnets.

3. **Steel**

   Carbon content is 0.15 – 1.5 %. It is used in making surgical instruments, cooking utensils, railway tracks etc.

HEAT TREATMENT PROCESS

1. Annealing

It is the process of heating steel to a higher temperature and then cooling it slowly. So it becomes soft.

2. Hardening (Quenching)

It is the process of heating the steel to a high temperature and then cooling is suddenly by dipping it in oil or water. By hardening the abrasion resistance increases. It is used for making cutting tools.

3. Tempering

It is the process of heating the already hardened steel and then cooling it slowly. It is used for making cutting tools like blades and chisels.

QUESTIONS

PART – A

1. What is cast iron?
2. What is blast furnace?

PART – B

1. What is hardening of steel?
2. What is an annealing of steel?
3. What is tempering of steel?

PART – C

1. How is steel manufactured by Bessemer converter?

4.3 POWDER METALLURGY

INTRODUCTION

Generally, metal components are prepared by pouring molten metal in the mould castings. Powder metallurgy is a new technique in which moulds are made using compressed metal powders, even though this method is more expensive (As it involves preparation of metal powder). This method has many advantages over the traditional method. Metals and alloy can be made into metal powders. The metal powder is then used for making the articles.

POWDER METALLURGY

Powder metallurgy is an art of making metal articles of desired shape using metal powder by heat treatment and compression. By this method, even complicated structures can be moulded easily. Eg. Aluminium and bronze powders are used in paints. Iron powder is used in welding rods.

Articles can be made by using

1. Single metal powder
2. Mixture of metal powders
3. Mixture of metal and non-metal powders

The powder metallurgical process consist of the following two steps**.**

1. Powder production
2. Powder fabrication

Powder production

Metal powders with particle size ranging from 1 to 100 microns are produced. Usually metal powders with particle size 10 to 20 microns are predominant. The metal powders produced should be pure. They should also have the correct particle size and shape.

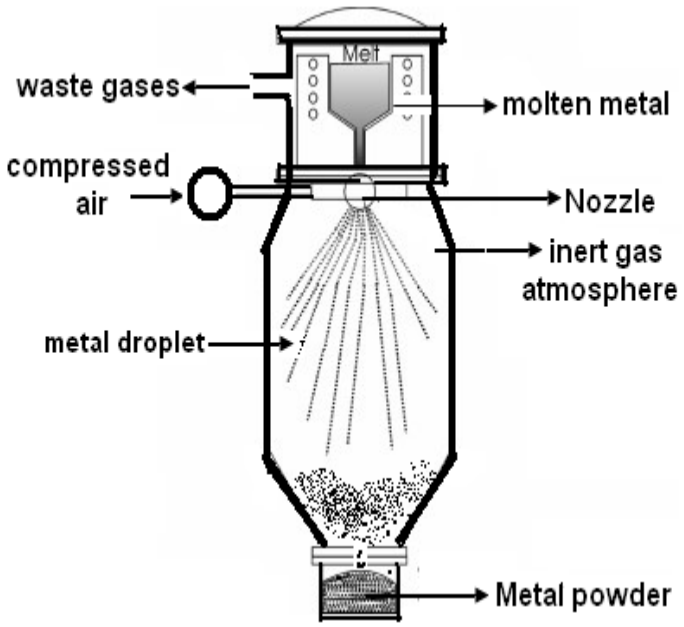
Metal powders are produced by any one of the following methods.

PREPARATION OF METAL POWDER

1. ATOMIZATION

Atomisation method is suitable for metals with low melting point like zinc, lead, tin, aluminium etc.

In this method, a metal is heated to convert it into a molten metal. The molten metal is then forced through an orifice. A compressed stream of air is passed over the molten metal. The liquid metal is broken and sprayed into minute droplets. The droplets are cooled and condensed to get metal powder.



To avoid oxidation of metal powder, inert gas is used instead of air. Powders of low melting metals like zinc, lead and tin are produced by this method.

Advantages:

1. Pure metal powder is obtained.
2. The production cost is high.
3. The grain size of the powder can be controlled.

2. REDUCTION OF METAL OXIDE

Reduction method is suitable for the metals with high melting point like tungsten, iron, copper, nickel etc.

Metal powder can be obtained by passing reducing agent like carbon monoxide or hydrogen on heated metal oxides. The metal thus obtained is then crushed and ground to particle of desired size.

Example:

1. Powder copper can be obtained by reducing copper oxide using hydrogen.

$$Cu_2O + H_2 \rightarrow 2\ Cu + H_2O$$

2. Tungsten powder is obtained by passing hydrogen over WO_2.

$$WO_3 + 3H_2 \rightarrow W + 3H_2O$$

BLENDING

A single powder may not fulfil all the requisite properties and hence, powders of different materials with wide range of mechanical properties are blended to form a final part. Blending is carried out for several purposes as follows.

- Blending imparts uniformity in the shapes of the powder particles.
- Blending facilitates mixing of different powder particles to impart wide ranging physical and mechanical properties,
- Lubricants can be added during the blending process to improve the flow characteristics of the powder particles reducing friction between particles and dies.
- Binders can be added to the mixture of the powder particles to enhance the green strength during the powder compaction process.

COMPACTING

The principle goal of the compaction process is to apply pressurize and bond the particles to form a cohesion among the powder particles. This is usually termed as the green strength. The compaction exercise imparts the following effects.

- Reduces voids between the power particles and enhance the density of the consolidated powder.
- Produces adhesion and bonding of the powder particles to improve green strength in the consolidated powder particles.
- Facilitates plastic deformation of the powder particles to conform to the final desired shape of the part.
- Enhances the contact area among the powder particles and facilitates the subsequent sintering process.

SINTERING

Sintering refers to the heating of the compacted powder perform to a specific temperature (below the melting temperature of the principle powder particles while well above the temperature that would allow diffusion between the neighbouring particles). Sintering facilitates the bonding action between the individual powder particles and increase in the strength of the final part. The heating process must be carried out in a controlled, inert or reducing atmosphere or in vacuum for very critical parts to prevent oxidation. Prior to the sintering process, the compacted powder perform is brittle and confirm to very low green strength. The nature and strength of the bond between the particles depends on the mechanism of diffusion and plastic flow of the powder particles, and evaporation of volatile material from the in the compacted preform.

Bonding among the powder particles takes places in three ways: (1) melting of minor constituents in the powder particles, (2) diffusion between the powder particles, and (3) mechanical bonding. The time, temperature and the furnace atmosphere are the three critical factors that control the sintering process. Sintering process enhances the density of the final part

by filling up the incipient holes and increasing the area of contact among the powder particles in the compact perform.

FINISHING

After sintering, some finishing operations such as re-pressing (to impart dimensional accuracy) and machining are carried out to further improve the quality of the final part. Parts made through the powder metallurgy based processes are also subjected to other finishing operations such as heat treatment, machining and finishing depending on the requirements.

Advantages:

1. The yield is higher in this method.
2. This method is highly convenient and economical.

APPLICATIONS OF POWDER METALLURGY

1. Used for making compact, complicated geometrical shaped objects.
2. Used for making metal bearings embedded with graphite powder.
3. Generator brush and electrical contact brush composite containing highly conductive copper and graphite with lubricating property is manufactured by powder metallurgy.
4. Used for making dense ductile sheets of metals like tungsten and molybdenum.
5. Used for making filaments for bulbs (Tungsten filament).
6. Used to prepare magnetic materials.
7. Very hard cutting tools from carbides of tungsten, titanium, tantalum etc, are manufactured.
8. Used for making diamond impregnated cutting tools.
9. Used for making wear resistance cutting tools (Eg: with cobalt and nickel metal powder).
10. Powder metallurgy techniques are used in surgical implants and in medicinal field.

QUESTIONS

PART – A

1. Define powder metallurgy.
2. Mention the methods of preparation of metal powder.
3. What is blending in powder metallurgy?
4. What is sintering in powder metallurgy?
5. What is compacting in powder metallurgy?

PART – B

1. Explain the preparation of metal powder by atomization.
2. Explain the preparation of metal powder by reduction of metal oxide.

PART – C

1. Explain the two methods of preparation of metal powder.
2. Mention the applications of powder metallurgy.

UNIT – V

2.1 NUCLEAR CHEMISTRY

RADIOACTIVITY

Radioactivity was discovered by Hendry Becquerel in the year 1986. He found that Uranium and some of its salt emit spontaneously some invisible radiations which affected the photographic plate.

Some of the heavy nuclei are unstable and they spontaneously disintegrate to emit radiations. The phenomenon of spontaneous and continuous emission of radiations due to the distintegration of heavy nuclei is called natural radioactivity. The radiations emitted are named alpha, beta and gamma rays.

Later investigation by Madame Curie and Pierre Curie, Rutherford and others proved that the phenonmenon was exhibited by heavy elements like Uranium, Polonium, Radium etc.

ALPHA, BETA AND GAMMA RAYS

Now let compare the properties of alpha, beta and gamma rays.

Property	Alpha rays	Beta rays	Gamma rays
Mass	4 Unit mass	1/ 1840 of a proton	No mass
Charge	2+ve charge	1-ve charge	No charge

ISOTOPES

Isotopes are atoms of the same element with same atomic number but different mass number.

Example: $_1H^1$, $_1H^2$, $_1H^3$

ISOBARS

Isobars are atoms of different elements with same mass numbers but different atomic number.

example: $_{18}K^{40}$, $_{20}Ca^{40}$

RADIOACTIVE DECAY

Disintegration of a radioactive nucleus to emit alpha or beta radiation leads to the formation of a new nucleus. This is called radioactive decay.

For example, ${}_{92}U^{238}$ emits alpha particle (helium nucleus) to form ${}_{90}Th^{234}$

$${}_{92}U^{238} \rightarrow\rightarrow\rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$$

ALPHA EMISSION

A nuclear reaction in which an unstable parent nucleus emits an alpha particle.

E.g.: Decay of uranium (U^{238}) to thorium (Th^{234}) with the emission of an alpha particle.

$${}_{92}U^{238} \longrightarrow {}_{90}Th^{234} + {}_{2}He^{4} \quad (\alpha\text{ - decay})$$

BETA EMISSION

A nuclear reaction, in which an unstable parent nucleus emits a beta particle

E.g.: Beta decay of phosphorous.

$${}_{15}P^{32} \longrightarrow {}_{16}S^{32} + {}_{-1}e^{0} \quad (\beta\text{ - decay})$$

GAMMA EMISSION

In a γ - decay, only the energy level of the nucleus changes. The atomic number and mass number of the radioactive nucleus remain the same.

HALF- LIFE PERIOD

Half-life period is the time taken for half of the initially taken amount of a radioactive substance to disintegrate. It is a constant and characteristics of a radioactive substance. It is represented by the symbol $t_{1/2}$

Half-life period is given by $t_{1/2} = 0.693/ k$

Where k is the decay constant

Worked out problem

1. The half-life period of Sr-90 is 20 years. Calculate its decay constant

$$k = 0.693/ t_{1/2}$$
$$= 0.693/ 20$$
$$= 3.465 \times 10^{-2} \text{ yr}^{-1}$$

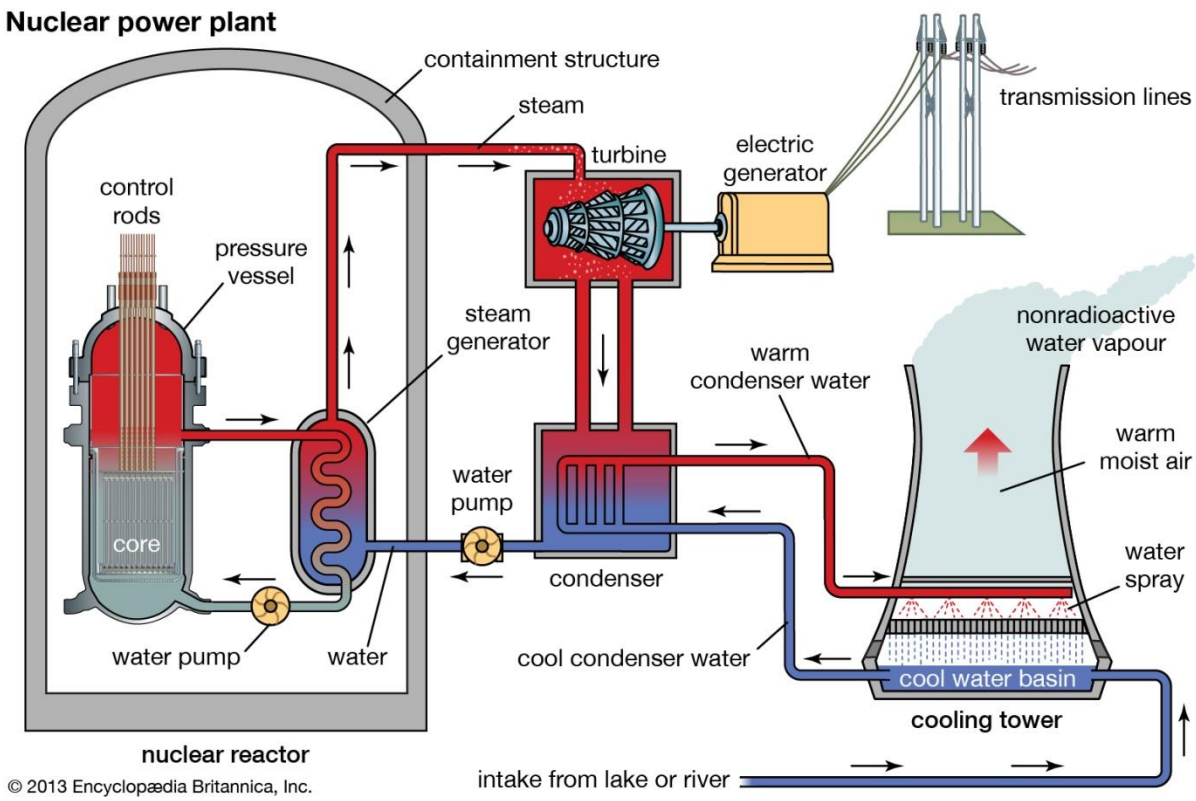
2. The decay constant of Co-60 isotope is 0.132/year. Calculate its half- life period.

$$k = 0.693/ t_{1/2}$$
$$= 0.693/ 0.132$$
$$= 5.25 \text{ years}$$

NUCLEAR FISSION AND NUCLEAR FUSION

S.No	Nuclear fission	Nuclear fusion
1	The process of breaking up (splitting) of a heavy nucleus into smaller nuclei is called "Nuclear fission"	Nuclear fusion is the combination of two lighter nuclei to form a heavier nucleus.
2	Can be performed at room temperature	Extremely high temperature and pressure is needed
3	Alpha, beta and gamma radiations are emitted	Alpha rays, positrons and neutrinos are emitted
4	Fission leads to emission of gamma radiation. This triggers the mutation in the human gene and causes genetic transform diseases.	Only light and heat energy is emitted.

NUCLEAR REACTOR



A Nuclear reactor is used for generation of electricity.

REACTOR CORE:

In the reactor core controlled fission reaction is made to occur. It consists of an assemblage of fuel elements, control rods, coolants and moderator. The following are essential components of a nuclear reactor core.

MODERATOR:

The function of the moderator is to reduce the kinetic energy of fast fission neutrons to slow neutrons to maintain the chain reaction. Moderator generally used for graphite, heavy water, beryllium, etc.

COOLANTS:

Coolants are used to remove the high heat produced in the reactor and to bring it out for utilization. Important coolants are ordinary water, heavy water, liquid sodium, organic liquid and gases (like Co_2).The heat carried by coolant is used to convert water into steam to run turbines to produce electricity.

CONTROL RODS:

Control rods are used to bring the reactor up to the normal operating level for maintaining it at normal level for shutting the reactor under normal and emergency condition and to control the chain reaction from becoming violet. Boron, and cadmium rods are used as control rods.

REFLECTOR:

The reflector, is usually, placed around the core to reflect back some of the neutrons that leak out from reactor core. Reflectors are generally made of the same materials as the moderator. Example: H_2O, D_2O, Graphite.

STEAM TURBINES:

The steam at high pressure generated by the heat exchange is used to operate steam turbines, which drives generator to produce electricity. The exhaust steam is condensed to water and sent back to the heat exchanger.

APPLICATION OF RADIOISOTOPES

In Medicine

- Blood circulation in the body can be checked by using NaCl containing radioactive Na-24.
- Radioactive Iodine-131 is used to diagnose the functioning of the thyroid gland. It is also used to check the functioning of various organs like kidney, liver, spleen etc.
- Radioactive Iron-59 is used to detect the deficiency of red blood cell in the body.
- Radioactive Phosphorus-32 is used to locate tumors especially brain tumor which is otherwise very difficult to locate.
- The pumping action of heart can be studied by radioactive sodium. This helps to find blocks in heart tubes and valves.
- Radio – Cobalt is used in the treatment of cancer.

In Industry

Petroleum companies use the pipelines for the dispatch of their various oil produces though the same pipe. Using the radioactivity isotopes can check the floe of all oils and stopping of any liquid by the other. It also checks any leakage in the system.

In Agriculture

In agriculture the rate of absorption of fertilizers by plants can be studied using radio isotopes.

Radio dating

Radio dating is the technique used to determine the age of earth and old trees, rocks etc. using radioactive carbon.

QUESTIONS

PART – A

1. What is an isotope?
2. What is an isobar?
3. What is reactor core?
4. What is neutron moderator?
5. What is alpha emission?

PART – B

1. Write a short note on half-life period?
2. What is nuclear fusion reaction?
3. What is nuclear fission reaction?

PART – C

1. What are the applications of radio isotopes?
2. Write a note on nuclear reactor.

5.2 CEMENT

INTRODUCTION

Cement is a building material. It is applied in the form of a soft paste with sand and water and later its sets into a hard mass. It is a mixture of calcareous material and argillaceous material. It is a mixture of silicates of calcium and aluminium.

Portland cement

A paste of cement with water on setting and hardening gave a hard mass whose colour and hardness were similar to those of stones from Portland in England. Thus, it derived the name Portland cement. Portland cement is a mixture of silicates of calcium and aluminium.

Major constituents of cement

1. Dicalcium silicates($2CaO.SiO_2$)-28%[C_2S]
2. Tricalcium silicates($3CaO.SiO_2$)-46%[C_3S]
3. Tricalcium aluminates($3CaO.Al_2O_3$)-10%[C_3A]
4. Tetra calcium aluminoferrite($4CaO.Al_2O_3.Fe_2O_3$)-9%[C_4AF]
5. Small quantities of CaO and MgO-7%

MANUFACTURE OF CEMENT BY WET PROCESS

Raw materials required

1. Calcareous materials – These materials supply lime
   Examples: Limestone, chalk, marble
2. Argillaeous materials – These materials supply silica
   Example: Clay
3. Powdered coal (fuel)
4. Gypsum

Process

The cement is manufactured by wet process as follows.

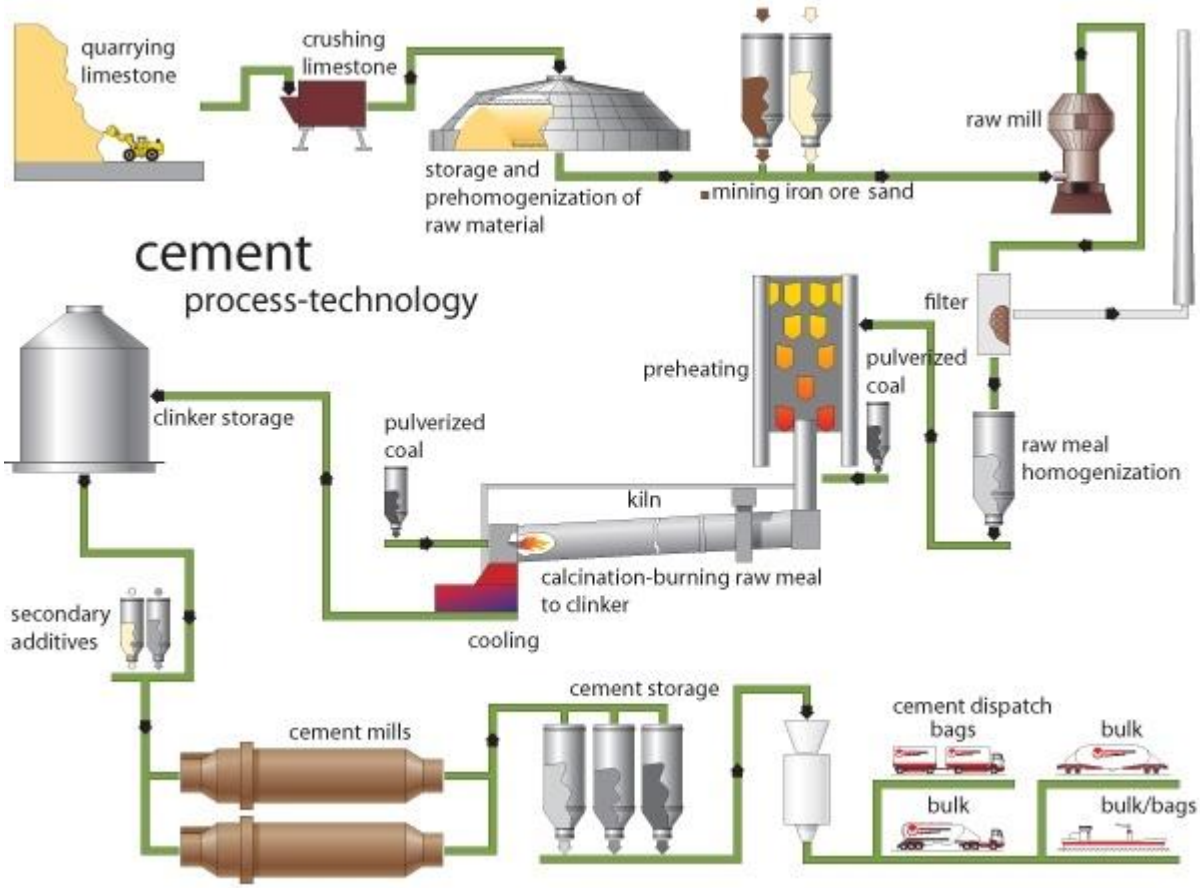
1. The limestone is crushed and powdered well.
2. The clay is intimately mixed with water in wash mill.
3. The powdered limestone and wet clay are mixed and made into a paste in a grinding mill. This paste is known as slurry. The slurry contains 30 to 40% water.
4. The slurry is fed into the top of the rotary kiln. The rotary kiln is made of steel plates lined with fire bricks.
5. The kiln is heated by burning powdered coal which is injected at the lower end by an air blast.
6. In the upper part of the kiln (drying zone) where the temperature is 400°C, the slurry loses all its water.

7. When the charge enters the middle portion of the kiln (calcinations zone) where the temperature is about 900 – 1000°C, limestone decomposes to form CaO and CO_2.

8. Then the charge enters lower portion of the kiln (burning zone) where the temperature is about 1400°C. Lime and clay combines to form calcium silicates and aluminates called clinker.

9. The hot clinker is cooled and then grinded with 3 – 4% gypsum in a grinding mill. Gypsum retards the setting of cement. In the absence of gypsum, cement sets rapidly.

10.The cement coming out of the grinding mills is stored in concrete storage tanks and then packed in bags.



SETTING OF CEMENT

When water is added to cement, sudden setting of cement occurs (flash set). The hardening of cement by the addition of water is known as setting of cement.

The setting and hardening of cement are mainly due to hydration and hydrolysis reactions of the different constituents present in cement. The dicalcium silicate (C_2S), tricalcium silicate (C_3S), tricalcium aluminate(C_3A) and tetracalcium aluminoferrite (C_4AF) present in cement undergoes hydration.

During this process, anhydrous soluble compounds are converted into hydrated insoluble compounds. The hydrated insoluble gel hardens due to dehydration. Finally, after dehydration, the insoluble gel sets into hard mass. It surrounds the sand and binds it strongly with interlocking crystals of $Ca(OH)_2$. This process is known as setting of cement.

CERAMICS

INTRODUCTION

Ceramics find wide application in engineering, medical and domestic usage. Ceramics are increasingly used in motor parts (e.g. ceramic disc brakes, ceramic balls, etc.). Ceramic engine does not require cooling system. They withstand heat upto 3300°C. One of the main applications of ceramics is white pottery.

CERAMICS

Ceramics are inorganic non-metallic materials that are processed at high temperature and subsequent cooling.

Examples: Ceramic wash basin, ceramic tiles, etc.

WHITE POTTERY

They are ceramic materials of china clay which is in white colour after firing is called white wares. They consist of a refractory body and glossy coating.

The raw materials used for manufacture of white pottery are given below.

- China clay(kaolin)[$Al(OH)_4\ SiO_5$]
- Feldspar [$KAlSiO_2$]
- Flint (SiO_2)/quartz.

MANUFACTURE OF WHITE POTTERY

STEP-I

PREPARATION OF BODY WARE

The raw materials are made into fine powder and mixed with water to form a paste.

The excess of water is removed by filtration. The article is prepared from the paste either by hand moulding or by using potter's wheel.

It is dried and then fired in a 'biscuit' oven to get porous ware called 'Bisque'.

STEP-II

GLAZE

In order to make the porous ware (Bisque) into water-tight article, it is covered with glaze by melting it over the surface of the body.

Slurry of glaze is prepared by mixing Feldspar, silica and boric oxide with water. Now the fired articles are dipped in the slurry of glaze and again fired. Now a smooth, glossy and non-porous surface is formed on the articles.

STEP-III

DECORATION

To decorate the article, design are made on the article using pigments and fired again.

Eg. Iron oxide pigments red colour.
Cobalt oxides give blue colour.

USES OF WHITE WARE

They are used for the preparation of

- Spark plugs
- Electrical insulators
- Laboratory equipments
- Crucibles, dishes, insulators sanitary wares etc.

GLAZING

Glazing is the process of giving a smooth, glossy, non-porous surface on the articles using glazes.

A glaze is a fine powder consisting of glass forming materials like lead silicates, borosilicates etc. They are colourless glazing and colour glazing mixtures. Colourless glazing is done with glass forming materials like lead silicate and borosilicate. Colour glazing is done by mixing coloured metal pigments with glass forming materials.

Examples:

- Iron oxide for red and brown
- Copper oxide for green
- Cobalt oxide for blue

PURPOSE OF GLAZING

- To get decorative effect.
- To make the surface impervious (non-porous) to liquids and water..
- To improve appearance of the article.
- To increase the durability of ceramic material.
- To get a smooth glossy appearance.
- To protect the surface from atmospheric action.

METHODS OF GLAZING

There are two methods of glazing

- Salt glazing
- Liquid glazing

1. Salt glazing

In salt glazing, common salt (sodium chloride) is used for getting glossy films over articles. The process consists of throwing sodium chloride into furnace, when the article is in red-hot condition. At high temperature, sodium chloride vapours reacts with silica in the article to form a smooth glossy and impervious film of ‘sodium silicate’. This is known as salt glazing.

2. **Liquid Glazing.**

Slurry of glaze is prepared by mixing Feldspar, silica and boric oxide with water. Now the articles are dipped into the slurry of glaze and then fired. Now a smooth, glossy and non-porous surface is formed on the articles. This is known as Liquid Glazing.

QUESTIONS

PART – A

1. What is cement?
2. What is Portland cement?
3. Why is gypsum added during the manufacture of cement?
4. What are ceramics?
5. Define white pottery.
6. What is called bisque?
7. What is glazing?

PART – B

1. What are the raw materials required for the manufacture of Portland cement?
2. Write a note on setting of cement.
3. What are the raw materials required for the manufacture white pottery?
4. List the uses of white pottery.
5. Explain salt glazing.

PART – C

1. Explain the manufacture of Portland cement by wet process.
2. Describe the manufacture of white pottery.
3. What are the purposes of glazing?
4. Write a note on glazing.

5.3.REFRACTORIES

INTRODUCTION

Refractories find wide application in linings of the furnaces, tanks, converters, kilns, crucibles, ladles, etc. employed for the manufacture of metals, cement, glass, steel, ceramics, paper, etc.

REFRACTORIES

Refractories are materials which can withstand very high temperature. They are resistant to heat and corrosive action of gases, metallic liquids and slags. Examples: Fire clay, Silica.

REQUIREMENTS OF A GOOD REFRACTORY

1. Refractoriness

It is the ability to withstand very high temperature without deformation during operation.

2. Strength or refractoriness under load (RUL)

They must possess high mechanical strength even at very high temperature and bear maximum possible load without breakage.

3. Thermal expansion

A good refractory should have low thermal expansion under normal conditions.

4. Thermal conductivity

In general, a good refractory must have low thermal conductivity to reduce heat losses by radiation. But, when heat is to be supplied from outside, the refractory must possess good conductivity.

5. Porosity

A good refractory should not be porous. In porous refractory, the molten metal and slag enters and weaken the structure. But, porosity helps in the thermal shock-resistance of refractories.

6. Thermal spalling

A good refractory must have low thermal spalling. It is breaking, cracking, peeling off or fracturing of the refractory under high temperature.

7. Chemical composition

A good refractory must be chemically inert.

CLASSIFICATION

The refractories are classified into three types based on the chemical properties.

1. Acid refractories
2. Basic refractories
3. Neutral refractories

S. No.	Type of refractory	Examples	Uses
1	Acid refractories	1. Zirconia 2. Silica	Used in furnaces where the charge and slag are acidic in nature
2	Basic refractories	1. Magnesia 2. Dolomite	Used in furnaces where the charge and slag are basic in nature
3	Neutral refractories	1. Chromite 2. Alumina	Used in furnaces where the charge and slag are either acidic or basic in nature

USES OF A FEW REFRACTORY BRICKS

a. Silica bricks

It contains 90-95% silica and about 2% lime.

1. They are used in open hearth furnaces, electric furnaces and glass furnaces.
2. They are used in coke-ovens and gas retort settings.
3. They are also used in lining of acid converters.

b. Fire clay bricks

It contains major portion of alumina and silica and small percentage of K_2O, FeO, CuO and MgO.

1. They are used in blast furnaces and open hearth furnaces.
2. They are used in stoves, crucibles, furnaces, kilns, regenerators and charging doors.

c. Alumina bricks

It contains more percentage of Al_2O_3.

1. They are used in vertical shaft kilns for burning lime.
2. They are used in linings of rotary kiln in cement manufacture.
3. They are used in brass melting reverberatories, lead-dressing reverberatory furnaces, and aluminium melting furnaces and in oil fired furnaces.

QUESTIONS

PART – A

1. What are refractories?
2. What are the types of refractories?
3. Give two examples for acidic refractories.
4. Give two examples for basic refractories.
5. Give two examples for neutral refractories.

PART – B

1. Mention any three requirements of a good refractory.
2. List the specific uses of fire clay bricks.
3. List the specific uses of silica bricks.
4. List the specific uses of alumina bricks.

PART – C

1. What are the requirements of a good refractory?
2. How are refractories classified? Explain with examples and uses.
3. Mention the uses of fire clay bricks, silica bricks and alumina bricks.

MODEL QUESTION PAPER

ENGINEERING CHEMISTRY-I (N1BE104)

(Time : Three Hours)

(Maximum Marks : 75)

N.B. 1. Answer any five questions in each of PART-A and PART-B.

2. Answer any two divisions of each question in PART-C.

3. Each question carries 2(two) Marks in PART-A, 3(three)Marks in PART-B and 5(five) Marks for each division in PART-C.

PART-A (5 × 2=10 Marks)

1. What are the fundamental particles of an atom?
2. Define - pH.
3. Define - True solution.
4. What are Nano particles?
5. Define - Soft water.
6. Which chemical is added in photo chromatic glass?
7. Define - Slag.
8. What is an isotope?

PART-B (5 × 3=15 Marks)

9. What is Buffer solution? Give its types.
10. Write short note on Tyndall effect.
11. What is positive catalyst? Give an example.
12. Write a short note on Reverse osmosis.
13. Write a short note on atomization.
14. What is an annealing of steel?
15. Write a short note on salt glazing.
16. What are the types of refractory?

[Turn over …

PART - C **(5 × 2 × 5=50 Marks)**

17. (a) Explain the formation of ionic bond in sodium chloride.

    (b) Explain the features of modern periodic table.

    (c) What are the industrial applications of pH in industries?

18. (a) What are the differences between lyophilic and lyophobic colloids?

    (b) Write the industrial applications of catalyst.

    (c) Give the applications of Nano technology in bio materials.

19. (a) How is total hardness of water estimated by EDTA method?

    (b) Explain ion-exchange process of softening of hard water.

    (c) Explain the manufacture of glass.

20. (a) Explain froth flotation method of concentration of ores.

    (b) Explain the manufacture of steel by Bessemer process.

    (c) What are the applications of powder metallurgy?

21. (a) what are the applications of radio isotopes?

    (b) How is cement manufactured by wet process?

    (c) What are the requirements of a good refractory?

* * *

MODEL QUESTION PAPER

ENGINEERING CHEMISTRY-I (N1BE104)

(Time : Three Hours)

(Maximum Marks : 75)

N.B. 1. Answer any five questions in each of PART-A and PART-B.

2. Answer any two divisions of each question in PART-C.

3. Each question carries 2(two) Marks in PART-A, 3(three)Marks in PART-B and 5(five) Marks for each division in PART-C.

PART-A (5 × 2=10 Marks)

1. What is an atomic number?
2. What is modern periodic law?
3. What is positive catalyst?
4. What are Nano particles?
5. What is priming?
6. Define – gangue.
7. What is cast iron?
8. Why gypsum is added to the cement?

PART-B (5 × 3=15 Marks)

9. What is Buffer solution? Give its types.
10. Write short note on Brownian movement.
11. What is catalytic poison? Give an example.
12. What are the reasons for depletion of underground water?
13. Write a note on Reverse osmosis.
14. How is metal powder prepared by reduction of metal oxide?
15. Write short notes on salt glazing?
16. What are the uses of silica bricks?

[Turn over …

PART - C **(5 × 2 × 5=50 Marks)**

17. (a) Explain the formation of ionic bond in sodium chloride.

    (b) Explain the features of modern periodic table.

    (c) Calculate the pH of a solution whose hydrogen ion concentration is 4.6×10^{-4} gm ions / litre.

18. (a) What are the industrial applications of colloids?

    (b) What are characteristics of catalyst?

    (c) Give the applications of Nano technology in the field of medicine.

19. (a) How is total hardness of water estimated by EDTA method?

    (b) Explain ion-exchange process of softening of hard water.

    (c) Explain the manufacture of glass.

20. (a) Explain froth flotation method of concentration of ores.

    (b) Explain the manufacture of steel by Bessemer process.

    (c) What are the applications of powder metallurgy?

21. (a) What are the applications of radio isotopes?

    (b) Describe the manufacture of white pottery.

    (c) What are the requirements of a good refractory?

* * *