# CHEMISTRY NOTES

CLASS 9TH SCIENCE

THE CITIZEN MODEL ACADEMY

## INDEX PAGE



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# CHAPTER 1

# FUNDAMENTALS OF CHEMISTRY

## CHEMISTRY

"The branch of Natural science which deals with the study of composition, properties, structure, changes and the laws governing the changes that occurring inside the matter is called Chemistry."

## BRANCHES OF CHEMISTRY

There are many branches in your book but here we are discussing 5 branches.

1) **PHYSICAL CHEMISTRY:** The branch of chemistry which deals with the laws and the principles governing the combination of atoms and molecules in chemical reaction and study of physical properties of matter is called PHYSICAL CHEMISTRY.
2) **ORGANIC CHEMISTRY:** The branch of chemistry which deals with the study of Hydrocarbon and their derivatives with the exception of CO2, CO, metal carbonates Bicarbonates and carbides is known as ORGANIC CHEMISTRY.
3) **INORGANIC CHEMISTRY:** The branch of chemistry which deals with the study of chemistry of elements and their compounds, generally obtained from non-living organism, i.e. from minerals is known as INORGANIC CHEMISTRY.
4) **ANALYTICAL CHEMISTRY:** The branch of chemistry which deals with separation and analysis of kind, quality and quantity of various components in given substance, it used in chromatography, electrophoresis and spectroscopy. It is known as ANALYTICAL CHEMISTRY.
5) **BIOCHEMISTRY:** The branch of chemistry which deals with the study of compounds chemical reaction involves in living organism i.e. plants and animals and their metabolism in the living body is known as BIOCHEMISTRY.

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## IMPORTANT TERMS

**MATTER:**
Anything having mass and occupy space is known as Matter. There are three commonly known states of matter. According to latest Information
There are four states of matter
1. Solid
2. Liquid
3. Gas
4. Plasma (newly discovered fourth state of matter but not known commonly)

**ATOM:**
The smallest particle of an element, which may or may not have an independent existence but always takes place in a chemical reaction is called an atom. An atom is composed of three particles, namely, neutrons, protons and electrons which are called subatomic particles.

**MOLECULE:**
A molecule is a collection of two or more atoms that make up the smallest recognizable unit into which a pure material may be split while maintaining its makeup and chemical characteristics.

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- If the molecule of an element contains 1 atom it's called a monoatomic molecule.
  E.g. Na, He, etc.
- If the molecule of an element contains 2 atoms it's called a diatomic molecule.
  E.g. $O_2$, $N_2$
- If the molecule of an element contains more than 2 atoms it's called a polyatomic molecule.
  E.g. $P_4$, $S_8$

**VALENCY:**
Valency is the combining capacity of an atom of an element with atoms of other elements to form molecules.

**COMPOUND:**
A substance made from two or more different elements that have been chemically joined. Examples of compounds include

- Water ($H_2O$), which is made from the elements hydrogen and oxygen.
- Table salt (NaCl), which is made from the elements sodium and chloride.

**EMPIRICAL FORMULA (E.F) OR SIMPLEST FORMULA:**
The formula that shows the simplest ratio between the atoms of different elements of a compound is called empirical formula.

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**MOLECULAR FORMULA:**
Molecular Formula is the formula which represents a molecule of an element or a compound with exact number of atoms.

| COMPOUND | MOLECULAR FORMULA | EMPIRICAL FORMULA |
|---|---|---|
| Benzene | $C_6H_6$ | CH |
| Gulocose | $C_6H_{12}O_6$ | $CH_2O$ |
| water | $H_2O$ | $H_2O$ |

**MOLAR MASS:**
Molar mass of the substance is its relative Atomic mass, Molecular mas or Formula mass expressed in grams. Molar mass SI unit is g/mol

- **EXAMPLE**
  **MOLAR MASS OF $Na_2CO_3$**
  Since sodium carbonate contains two atoms of sodium, one atom of carbon and three atoms of oxygen. The molecular weight would be
  Na: 2 x 23.0 = 46
  C: 1 x 12.0 = 12
  O: 3 x 16 = 48
  when we add up the total values i.e., 46 + 12 + 48 = 106
  therefore, the molar mass of $Na_2CO_3$ is **106 g/mol.**

**MOLECULAR MASS:**
Molecular mass of a compound is defined as the mass of one molecule. Molecular mass differs because of the isotopes. The unit in which molecular mass is measured is amu. Amu stands for atomic mass units.

**FORMULA MASS:**

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Formula mass of a substance is the sum of the atomic masses of all atoms in a formula unit of the substance. Some compounds are not available in molecular form. For example NaCl is available in ionic form NaCl, so we can consider its formula mass and not molecular mass.

**MOLE:**

The atomic mass, Molecular mass or Formula mass of a substance expressed in grams is known as Mole.

SI unit is mol.

**Formula**

Number of moles = (Mass of substance in grams)/ (Gram Atomic mass OR formula mass OR molar mass)

- **EXAMPLE**

  Calculate the number of moles in 50g of each: (a) Na (b) $H_2O$

  **1) MOLES OF Na**

  Given mass of Na = 50g

  Atomic mass of Na = 23 a.m.u

  **FORMULA**

  Number of moles of Na = (Mass of Na in grams)/ (Gram Atomic mass of Na) = 50/23

  Number of moles of Na = **2.173** moles of Na.

  **2) MOLES OF $H_2O$**

  Given mass of H20 = 50g

  Atomic mass of H20 = 18 a.m.u

  **FORMULA**

  Number of moles of H20 = (Mass of H20 in grams)/ (Molar mass of H20) = 50/18

  Number of moles of H20 = **2.777** moles of H20.

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**AVOGADRO'S NUMBER (NA):**

One mole of any substance contains 6.02x10 particles (atoms, molecules, ions or formula units). This constant number is called Avogadro's number.

The units may be electrons, atoms, ions, or molecules, depending on the nature of the substance.

**FORMULA**

No. of molecules= moles*Na

**IONS:**

Ions is an atom or group of atoms having a charge on it. It may be positive or negative.

There are two types of ions

- Cations
- Anions

- Cations form when an atom losses electron from its outer most shell.

  For **example** $Na^{+1}$, $K^{+1}$

- Anions form when an atom gains electron from its outer most shell.

  For **example** $Cl^{-1}$

**MOLECULAR IONS:**

The ion that results from the loss or gain of an electron is called the molecular ion. It also may be positive or negative like ions.

- If it has negative charge than it is called anionic molecular ion **For example** $CO_3^{-2}$
- If it has positive charge than it is called cationic molecular ion. **For example** $CH^{+4}$

**FREE RADICAL:**

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A free radical can be defined as an atom or molecule containing one or more unpaired electrons in valence shell. Represented by a DOT symbol

**For example** $H^{O}$, $Cl^{O}$

**MIXTURE:**

A mixture is a substance which consist of two or more elements or compounds physically combined together without a fixed ratio

**TYPES OF MITURE**

- **Homogenous mixture.** Those mixtures in which the substances are completely mixed together and can't be separated **FOR EXAMPLE** Blood, salt water
- **Heterogeneous mixture.** Those mixtures in which the substances remain separate. **FOR EXAMPLE** Pizza, Rocks.

## IMPORTANT DIFFERENCES

| ATOM | VS | ION |
|---|---|---|
| An atom is the fundamental unit of all matter | | An ion is an atom or a molecule that has a net electrical charge |
| Neutrally charged | | Positively charged or negatively charged |
| Not attracted to an electrical field | | Attracted to electrical fields and can be manipulated with electromagnetic forces |
| Composed of equal numbers of electrons and protons | | Composed of unequal numbers of electrons and protons |

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## MOLECULE VS MOLECULAR ION

| | MOLECULE | MOLECULAR ION |
|---|---|---|
| i. | It is the smallest particle of an element or compound which can exist independently and shows all the properties of that compound. | It is formed by gain or loss of electrons by a molecule. |
| ii. | It is always neutral. | It can have negative or positive charge |
| iii. | It is formed by the combination of atoms. | It is formed by the ionization of a molecule. |
| iv. | It is a stable unit. | It is a reactive specie. |

## IONS VS FREE RADICAL

- The charged species are known as ions. An ion is electrically charged it can either be positive or negative.
- Electrons in ions are paired.
- They are formed due to heterolytic fission
- Ions are more stable than radicals.

- An atom of an element/group of atoms of different elements that have at least one unpaired electron is known as a radical.
- A radical has at least one unpaired electron.
- They are formed due to homolytic fission
- Radicals are less stable than ions.

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# Chapter :-01
# Fundamentals Of Chemistry

## Numericals:

### Question no:-01

### Balancing the Equation

(a) $4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$

| Reactant | | Product | |
|---|---|---|---|
| N | $1 \times 4 = 4$ | N | $1 \times 4 = 4$ |
| H | $3 \times 4 = 12$ | H | $2 \times 6 = 12$ |
| O | $2 \times 5 = 10$ | O | $4 \Rightarrow (4 \times 1) + (6 \times 1) = 10$ |

$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$

(b) $4KNO_3 \longrightarrow 4KNO_2 + 2O_2$

| Reactant | | Product | |
|---|---|---|---|
| K | $1 \times 4 = 4$ | K | $1 \times 4 = 4$ |
| N | $1 \times 4 = 4$ | N | $1 \times 4 = 4$ |
| O | $3 \times 4 = 12$ | O | $4 \Rightarrow (4 \times 2) + (2 \times 2) = 12$ |

$4KNO_3 \longrightarrow 4KNO_2 + 2O_2$

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(c) $Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$

| Reactant | Product |
|---|---|
| Ca = 1 | Ca = 1 |
| H = 2 × 2 = 4 | H = 4 |
| O = 1 × 2 = 2 | O = 2 |

$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$

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(d) $2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

| Reactant | Product |
|---|---|
| Na = 1 × 2 = 2 | Na = 2 |
| H = 1 × 2 = 2 | H = 2 |
| C = 1 × 2 = 2 | C = 2 |
| O = 3 × 2 = 6 | O = 6 |

$2NaHCO_3 \longrightarrow Na_2CO_3 + H_2O + CO_2$

$2CO + O_2 \longrightarrow 2CO_2$

| Reactant | Product |
|---|---|
| C = 1 × 2 = 2 | C = 1 × 2 = 2 |
| O = 3 => (2 × 1) + (2) = 4 | O = 2 × 2 = 4 |

$2CO + O_2 \longrightarrow 2CO_2$

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# Question no:- 02

Calculate the formula mass of the following

(1) $Al_2O_3$ (Al = 27, O = 16)

Solution

Al = 27 × 2 = 54

O = 16 × 3 = 48

102 a.m.u

(2) $MgCl_2$ (Mg = 24, Cl = 35.5)

Solution

Mg = 24 × 1 = 24

Cl = 35.5 × 2 = 71

95 a.m.u

(3) NaCl (Na = 23, Cl = 35.5)

Solution

Na = 23 × 1 = 23

Cl = 35.5 × 1 = 35.5

58.5 amu

(4) $KNO_3$

Solution

K = 39 × 1 = 39

N = 14 × 1 = 14

O = 16 × 3 = 48

101 amu

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# Question no:- 03

Calculate the molecular mass of the following

(1) $C_2H_5OH$

(2) $H_2O$

(3) $NH_3$

(4) $CO_2$

Try to solve it same as Question no:- 02.

Answers - (1) 46 a.m.u (3) 17 amu

(2) 18 a.m.u (4) 44 amu

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# Question no:- 04

How many moles are required to prepare 40 gm of $H_2SO_4$??

**Data:-**

given mass = 40 gm

molar mass of $H_2SO_4$:-

H = 1 × 2 = 02

S = 32 × 1 = 32

O = 16 × 4 = 64

98 g/mol

Required:-

Moles of $H_2SO_4$ = ??

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**Solution:-**

moles = $\frac{\text{Given mass}}{\text{molar mass}}$

= $\frac{40}{98}$

moles = 0.408 mol.

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# Question no:- 05

Calculate the no. of moles and no. of molecules present in the following

(a) 16gm of $H_2CO_3$.

**Data:-**

Given mass = 16 gm

Molar mass of $H_2CO_3$ =

$H = 1 \times 2 = 2$

$C = 12 \times 1 = 12$

$O = 16 \times 3 = 48$

62 amu

**Required:-**

no. of moles = ??

no. of molecules = ??

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**Solution:-**

$$\text{moles} = \frac{\text{Given mass}}{\text{molar mass}}$$

$$\text{moles} = \frac{16}{62}$$

$$\text{moles} = 0.26 \text{ mol}$$

No. of molecules = moles $\times N_A$

$= 0.26 \times 6.02 \times 10^{23}$

$= 1.56 \times 10^{23}$ molecules

**Note:-**

"$N_A$" is the avagadro's constant which has value $6.02 \times 10^{23}$ molecules/atoms

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# CHAPTER 2

# ATOMIC STRUCTURE

## FUNDMENTAL PARTICLES OF ATOM:

Modern research showed that an atom consists of many subatomic particles. These sub atomic particles Proton, Electron and Neutron are very important to the chemists.
These particles are called fundamental particles.

**a. Electron:**

Electron is negatively charged particle. Its mass is equal to 0.000548597 amu or $9.11 \times 10^{-31}$ kg. Charge of an Electron is $1.6022 \times 10^{-19}$ C with negative sign. Electrons are very light small particles with revolve the nucleus in orbits.

**b. Proton:**

Proton is positively charged particle. Its mass is equal 1.0072766 amu or $1.6726 \times 10^{-27}$ kg. Charge of proton is $1.6022 \times 10^{-19}$ C with positive sign. Proton is 1837 times heavier than an electron. Proton are present in the nucleus of an atom.

**c. Neutron:**

Neutron is a neutral particle because it has no charge. Its mass is equal to 1.0086654 amu or $1.6749 \times 10^{-27}$ kg. Neutron is 1842 times heavier than an electron.

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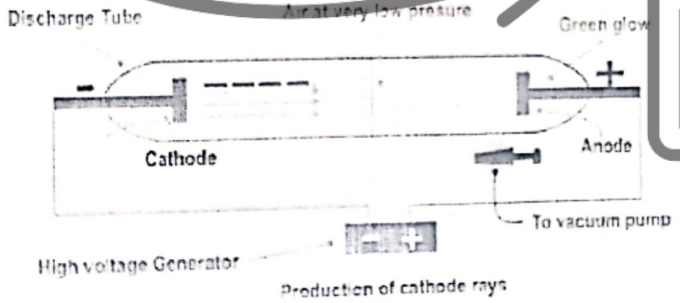
## Discovery of Electron

A discharge tube is a glass tube. It has two electrode, a source of electric current and a vacuum pump. (Diagram)
Sir William Crooks (1895 performed experiments by passing electric current through gas in the discharge tube at very low pressure. He observed that at 10-4 (-4 is power to 10) atmosphere pressure, shining rays are emitted from cathode. These rays were named cathode rays. Cathode rays are material particles as they have mass and momentum.




Production of cathode rays

## PROPERTIES OF CATHODE RAYS

1. They travel in straight line from cathode towards Anode.
2. They produce sharp shadow of an opaque object placed in their path.
3. They have negative charge and bend towards positive plate in electric and magnetic field.
4. These rays when strike with glass and other material cause material glow.
5. The (e/m) charge and mass ratio of cathode particles is 1.7588x10 coulomb per gram. This is same for all electrons, regardless of any gas in discharge tube.
6. They can produce mechanical pressure indicating they possess kinetic energy (K.E)

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## DISCOVERY OF PROTON

Gold Stein (1886) observed that in addition to the cathode rays, another type of rays were present in the discharge tube. These rays travel in a direction opposite to cathode rays. These rays were named positive rays. By using perforated cathode in the discharge tube the properties of these rays can be studied. Positive rays are also composed of metered particles. The positive rays are not emitted from anode. They are produced by the ionization of residual gas molecules in the discharge tube. When cathode rays strike with gas molecule, electrons are removed and positive particles are produced.

## PROPERTIES OF CANAL RAYS (PROTONS)

1. They travel in straight line from Anode towards Cathode.
2. They produce sharp shadow of object placed in their path.
3. They have positive charge and bend towards negative plate in electric and magnetic field.
4. The (e/m) charge and mass ratio of positive particles is much smaller than electron. It varies according to nature of gas present in tube. 5. The mass of proton is 1836 times more than electron

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## DISCOVERY OF NEUTRON

Rutherford predict that atom must possess another neutral particle with equivalent mass of proton. Different scientists started working on this neutral particle. Later on 1932 Chadwick become successful to discover Neutron. Chadwick found that when alpha (μ) particles bombarded on Beryllium some penetrating radiations were given out. Chadwick suggested that these radiations were due to material particle with mass comparable to hydrogen atom but have no charge. These radiations (particle) are called Neutron. It can expressed in equation as follows. The neutron is fundamental part of an Atom, present in nucleus with proton and include in atomic mass.

## PROPERTIES OF NEUTRON

1. The Neutrons are neutral particles.
2. They have no charge.
3. The mass of neutron is almost equal to that of proton.
4. These particles are most penetrating in matter.

## ATOMIC NUMBER (Z)

- The number of protons in the nucleus of an atom is called Atomic Number.
- Atomic number represented by **Z**. The elements are identify by their atomic number.
- Different elements have different atomic numbers because of different number of protons.
- In neutral atoms number of protons are equal to number of electrons, so the atomic number also indicate total number of electrons outside the nucleus.

**EXAMPLE**

Atomic number of Carbon(C) is 6. It mean that each carbon atom has 6 protons and 6 electrons in it.



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**FORMULA**

Atomic number= Z =

Number of proton in nucleus = Total number of electron around nucleus

Atomic number (Z) is written as subscript on the left hand side of the chemical symbol

E.g. some other examples are as follows. $C_6$ $Li_3$, $O_8$.

## ATOMIC MASS (A)/MASS NUMBER

- The total sum of proton and neutrons in the nucleus of an atom is called Mass Number.
- Mass number represented by A.

**EXAMPLE**

For example, the sodium (Na) atom has atomic number 11 and mass number 23. It indicates that sodium atom has 11 protons and 12 neutrons. The mass number (A) is written as superscript on left hand side of chemical symbol. e.g.

$^{23}_{11}Na$

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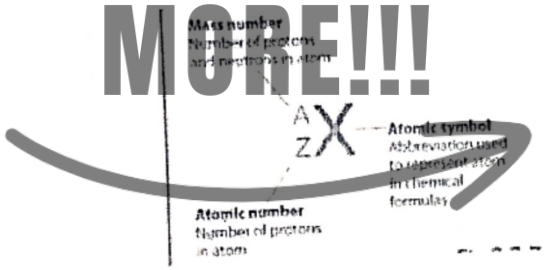
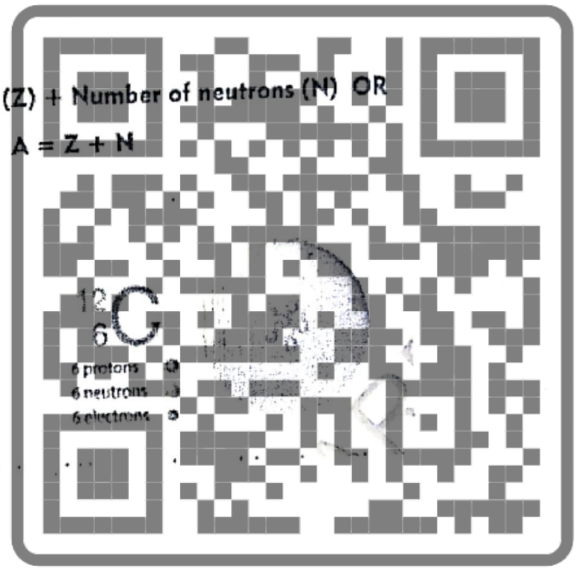
**FORMULA**

Mass number = A = Number of protons (Z) + Number of neutrons (N) OR

Mass number $A = Z + N$




## THEORIES AND EXPERIMENTS RELATED TO ATOMIC STRUCTURE

## RUTHERFORD ATOMIC MODEL

Lord Rutherford In 1911, carried out series of experiments and proposed a new atomic model.

**EXPERIMENT**

Rutherford took a thin sheet of gold and bombarded it with alpha (μ) particles obtained from a radioactive element (Like Polonium). These rays scattered from the atom and examined on a zinc sulphide (ZnS) screen.

**OBSERVATION**

- Most of the particles passed straight and undeflected through the sheet and produced illumination on the zinc sulphide screen.
- Very few alpha (μ) particles undergo small and strong deflection after passing through gold sheet.

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- A very few alpha (μ) particles (one of 8000) retraced their path.

## CONCLUSION

- According to Rutherford an atom consist of two parts nucleus and extra nuclear part.
- Majority of the alpha particles passed straight line and un-deflected, shows that most volume occupied by atom is empty.
- Alpha particles are positively charged and their deflection indicates that the spelling of atom has a positive charge, which is named as nucleus.
- The mass is concentrated in the nucleus and the electrons are distributed outside the positively charge nucleus.
- The electrons are revolving around the nucleus in extra nuclear part in orbits

## POSTULATES

- An atom consist of positively charged, dense and very small nucleus containing protons and neutron. The entire mass is concentrated in the nucleus of an atom.
- The nucleus is surrounded by large empty space which is called extra nuclear part where probability of finding electron is maximum.
- The electrons are revolving around the nucleus in circular paths with high speed (Velocity).
- These circular paths were known as orbits (Shells). An atom is electrically neutral because it has equal number of protons and electrons.
- The size of the nucleus is very small as compared to the size of its original atom.

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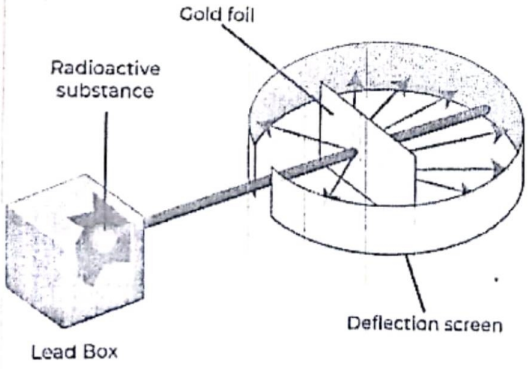
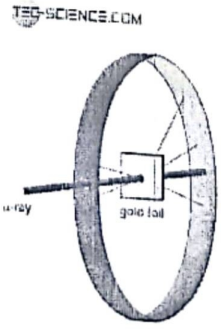
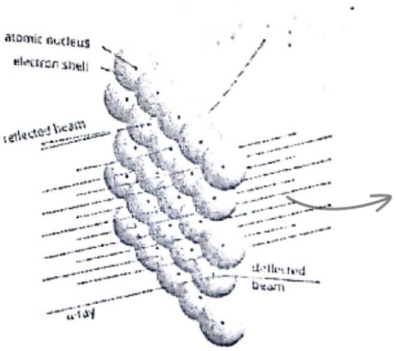
## DEFECTS OF RUTHERFORD ATOMIC MODEL

- Rutherford did not explain the stability of an atom.
- In Rutherford atomic model the negatively charged electrons revolve around the nucleus in circular path and emits energy continuously.
- Due to continuous loss of energy ultimately falls into the nucleus. 3. if the revolving electron continuous emits energy, then there would be a continuous spectrum but in contrast to it we get line spectrum from the atoms of elements.




## NEIL BOHER'S ATOMIC MODEL



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In 1913 Neil Boher proposed another atomic model. This atomic model was different in this manner that it shows two folds, first to remove the Rutherford atomic model and second explain the line spectrum of Hydrogen atom based on quantum theory of Max Planck.

## POSTULATES OF NEIL BOHER'S ATOMIC MODEL

- The atom has fixed orbits in which negatively charged electron is revolving around the positively charged nucleus.
- These orbits possess certain amount of energy which are called shells and named as K, L, M, N shells.
- The energy levels are represented by an integer (n= 1, 2, 3....) known as quantum number, this quantum range starts from nucleus side, where n=1 is lowest energy level.
- Electrons are revolving in particular orbits continuously, but they are not emits or absorb energy.
- When electron jumps from lower energy level (E1) to higher energy level (E2), it absorb energy.
- When electrons jumps from higher energy level (E2) to lower energy level (E1), it emits energy.
- The emission or absorption is discontinuous in the form of energy packet called Quantum or Photon.
- The ΔE difference in energy of higher (E1) and lower (E2) energy level.

$$\Delta E = E2 - E1$$

$$\Delta E = u\,h = 1 \text{ photon}$$

**Here h is planks constant, its value is $6.63 \times 10^{-34}$ Js and u is a frequency of light**

- Stationary state were present in those orbits in which angular moment of electron would be integral multiple of h/2p

$$mvr = nh/2p$$

**(Where n = no of orbits) h= (planks constant) m= (mass of electron)**

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## LIMITATIONS OF NEIL BOHER'S ATOMIC MODEL

- Bohr's model of an atom failed to explain the Zeeman Effect (effect of magnetic field on the spectra of atoms).
- It also failed to explain the Stark effect (effect of electric field on the spectra of atoms).
- It deviates the Heisenberg Uncertainty Principle.
- It could not explain the spectra obtained from larger atoms. +1 +2 +3



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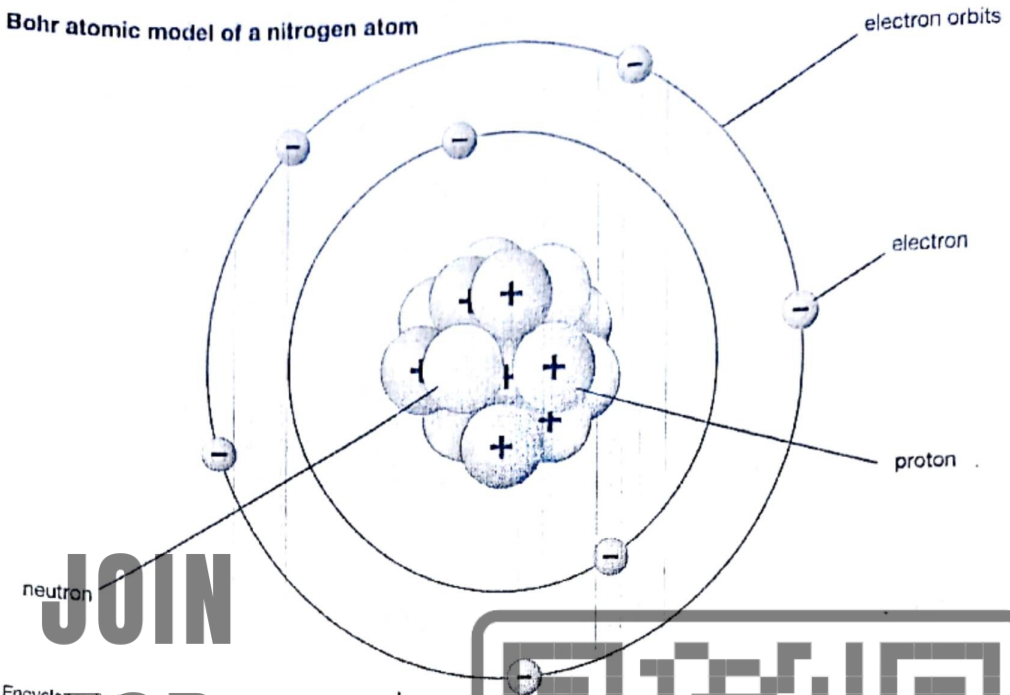
Bohr atomic model of a nitrogen atom

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## ISOTOPS

Atoms of the same elements having same atomic number but different Mass number are called isotopes.

OR

They have same atomic number and number of protons, but different number of neutrons.

- These elements have same chemical properties due to same electronic configuration but different physical properties due to difference in mass number

## Examples of Isotopes

(1) **Isotopes of Hydrogen** There are three isotopes of Hydrogen. These are known as Protium, deuterium and tritium.

(2) **Isotopes of Uranium** There are three common isotopes of uranium with atomic number 92 and mass number 234,235 and 238 respectively.

(3) **Isotopes of Carbon** There are two stable isotopes and one radioactive isotope of carbon. Which are shown in fig 2.22. The carbon 12 contain 6 proton and 6 neutron, Carbon 13 possess 6 proton and 7 neutron, carbon 14 contain 6 proton and 8 neutron. Carbon 12 is the most abundant (98.89%) isotope.

(4) **Isotopes of Chlorine** There are two isotopes of Chlorine with atomic number 17 and mass number 35 and 37. As shown in figure 2.23. Chlorine 35 is 75% and chlorine 37 is 25% abundant in nature.

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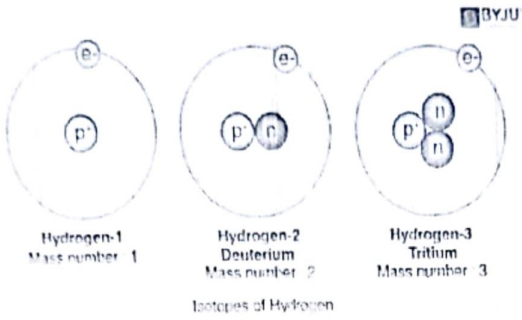
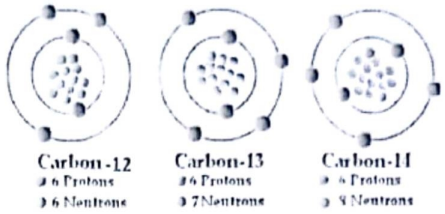
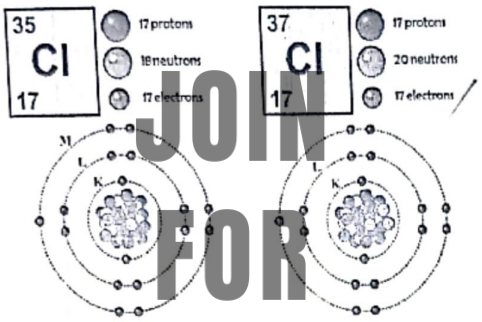



Isotopes of Hydrogen




Isotopes of Carbon

ISOTOPES OF CHLORINE

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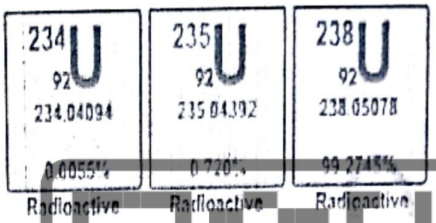
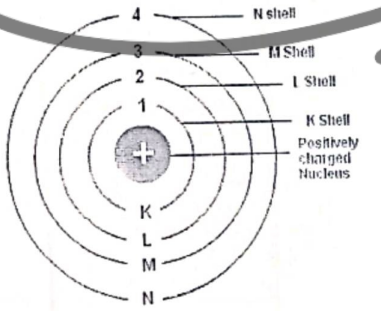



ELECTRONIC CONFIGURATION





| Shell | Subshell | Max electrons in subshell | Max electrons in shell |
|---|---|---|---|
| K | 1s | 2 | 2 |
| L | 2s | 2 | 2 + 6 = 8 |
| | 2p | 6 | |
| M | 3s | 2 | 2 + 6 + 10 = 18 |
| | 3p | 6 | |
| | 3d | 10 | |
| N | 4s | 2 | 2 + 6 + 10 + 14 = 32 |
| | 4p | 6 | |
| | 4d | 10 | |
| | 4f | 14 | |

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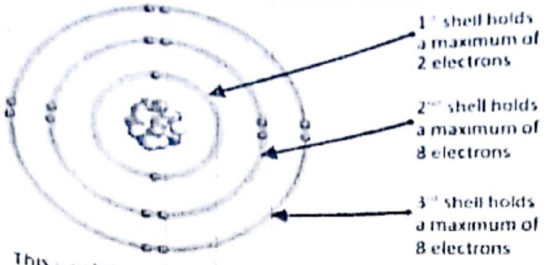
Each shell has a maximum number of electrons that it can hold
Electrons will fill the shells nearest the nucleus first.




This [illegible] is written as 2,8,8.

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## Electronic Configuration

| Atomic number | Element Symbol | Electronic configuration | Atomic number | Element Symbol | Electronic configuration |
|---|---|---|---|---|---|
| 1 | H | $1s^1$ | 11 | Na | $1s^2 2s^2 2p^6 3s^1$ |
| 2 | He | $1s^2$ | 12 | Mg | $1s^2 2s^2 2p^6 3s^2$ |
| 3 | Li | $1s^2 2s^1$ | 13 | Al | $1s^2 2s^2 2p^6 3s^2 3p^1$ |
| 4 | Be | $1s^2 2s^2$ | 14 | Si | $1s^2 2s^2 2p^6 3s^2 3p^2$ |
| 5 | B | $1s^2 2s^2 2p^1$ | 15 | P | $1s^2 2s^2 2p^6 3s^2 3p^3$ |
| 6 | C | $1s^2 2s^2 2p^2$ | 16 | S | $1s^2 2s^2 2p^6 3s^2 3p^4$ |
| 7 | N | $1s^2 2s^2 2p^3$ | 17 | Cl | $1s^2 2s^2 2p^6 3s^2 3p^5$ |
| 8 | O | $1s^2 2s^2 2p^4$ | 18 | Ar | $1s^2 2s^2 2p^6 3s^2 3p^6$ |
| 9 | F | $1s^2 2s^2 2p^5$ | 19 | K | $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$ |
| 10 | Ne | $1s^2 2s^2 2p^6$ | 20 | Ca | $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ |

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# Numericals For Chapter # 2

## Atomic Structure

Q An atom has 5 electrons in M-shell then:

(a) Find its atomic number

(b) Write electronic configuration of atom

(c) Name the element of atom.

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Solution:

part a:-

1st shell = K = $2e^-$

2nd shell = L = $8e^-$

3rd shell = M = $5e^-$

Atomic no = 2+8+5

= $15e^-$

part b:-

Electronic configuration:

$1s^2$

$2s^2$ $2p^6$

$3s^2$ $3p^3$ $3d^{10}$

$4s^2$ $4p^{15}$ $4d^{10}$ $4f^{14}$

$15e^- = 1s^2, 2s^2, 2p^6, 3s^2, 3p^3$

part c:-

Name of atom:-

Phosphorus

(in periodic table)



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Q. How many protons, neutrons and electrons are present in the following. Also determine the atomic no and mass no:-

(1) $Fe^{56}_{26}$

Solution:-

Highest no is mass no / Atomic mass = 56

Atomic no = 26

As we know that

Atomic no = no. of proton

so no. of proton = 26

As we know that

no. of proton = no. of electron

so no. of election = 26

For no. of neutrons:-

At. mass = At. no + no. of neution

56 = 26 + no. of neutron

56 - 26 = no. of neutron

No of neution = 30

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(2) $O_8^{17}$

Solution:

Mass no / At mass = 17

Atomic no = 8

no. of proton = 8

no. of electron = 8

no. of neutron = 17 - 8

= 9

(3) $Cl_{17}^{37}$

Solution:

Mass no / Atomic mass = 37

Atomic number = 17

no. of protons = 17

no. of electrons = 17

no. of neutrons = 37 - 17

= 20

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(4) $U_{92}^{235}$

(5) $C_6^{14}$ Do by yourself

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(6) $^{37}_{17}Cl^{-1}$

Atomic mass / Mass no = 37
Atomic number = 17
No. of proton = 17
no. of neution = 37 - 17
= 20

For no. of elections:-
Here -1 means chlorine accepted 1 elections
So 17 + 1
= 18e⁻

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(7) $^{24}_{12}Mg^{+2}$

Atomic mass / Mass no = 24
Atomic number = 12
No. of proton = 12
no. of neution = 12 (24-12)

For no. of election:-
Here +2 means Magnesium has donated 2 election
so:-
no. of elections = 12 - 2
= 10e⁻

(8) $^{40}_{20}Ca^{+1}$ (9) $^{27}_{13}Al^{+3}$ (10) $^{19}_{9}F^{-1}$

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## Chapter: 3

# PERIODIC TABLE AND PERIODICITY OF PROPERTIES

Q) Write statements of the following:

1. Dobereiner's classification of triads
2. Newlands law of Octaves
3. Mendeleev periodic law
4. Modern periodic law

( Short 2017, 2016, 2015)

**1) Dobereiner's classification of triads :**

German chemist Dobereiner proposed this law. It states that,

"Several groups of three elements were arranged in order of increasing their atomic masses. In Triad, central element had atomic mass average of the other two elements."

**2)Newlands law of Octaves:**

British chemist Newland put forwarded this law. It states that,

"If the elements are arranged in order of increasing their atomic masses, then eighth element has similar properties as the first element."

**3)Mendeleev periodic law:**

In 1869 Mendeleev Proposed a periodic law which states that,

"The Properties of the elements are a periodic function of their atomic weight".

**4) Modern periodic law :**

In 1913 Moseley discovered that Atomic number is the basic property of an atom. He proposed a modern periodic law. The Moseley states that, " The Physical and chemical properties of the elements are a periodic function of their atomic numbers."

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Q) Describe in detail long form of periodic table? Or Describe periods in periodic table?

A) **Periods in periodic table :**

The seven horizontal lines in periodic table are known as periods. There are 7 periods in periodic table which are:

**First period (shortest period) :**

- This period contains 2 elements Hydrogen and Helium.
- K shell is filled in this period.

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**Second and third period (short period) :**

- Each period contain 8 elements.
- In these Periods L and M shells are being filled by electrons.
- Second period contains Li, Be, B, C, N, O,F and Ne.
- Third period contains Na, Mg, Al, Si, P,S, Cl, and Ar.

**Fourth and Fifth period (long period) :**

- Each period contain 18 elements.
- In these periods M and N shells are being filled by electrons.
- Fourth period starts from Potassium (K) and ends on Krypton (Kr).
- Fifth period starts from Rubidium (Rb) and ends on Xenon (Xe).

**Sixth period ( longest period) :**

- This period contains 32 elements.
- The 14 elements in the bottom are named as Lanthanides.
- Sixth periods starts from Caesium (Cs) and ends with Radon (Rn).

**Seventh period (incomplete period) :**

- This period starts from Francium (Fr)
- This period is consider as incomplete.
- This period contains a group of 14 elements known as Actinides.

JOIN FOR MORE!!!

Q) Define periodicity of properties? (short 2012)

A) **Periodicity of properties :**

"The repetition of properties of elements after some period is called periodicity of properties."

Q) Define the following : (short 2018,2014)

**1) Ionization energy :**

"The amount of energy required to remove an electron from gaseous state is called ionization energy."

**2) Electron affinity :**

"The amount of energy released when an electron is added in the outermost shell of a gaseous atom is called electron affinity."

**3) Atomic radius :**

"Half of the distance between two bonded atoms of elements is called atomic radius."

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**4) Electronegativity :**

"The ability of an atom to attract the shared pair of electrons towards itself in a molecule is called electronegativity."

Q) Why ionization energy increases from left to right in a period and decreases in group?

A) **Along the period:**

Ionization energy increases from left to right in a period because size of the atoms reduces and electrons are held strongly by electrostatic forces of nucleus.

**Along the group:**

Ionization energy decreases down the group because of addition of shells. These shells reduce the electrostatic force between valence electrons and nucleus.

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Q) Describe the trend of Electronegativity within a group and period in periodic table?

A) **Along the group:**

In group, electronegativity decreases because size of the atom increases and attraction for shared pair of electrons decreases.

**Along the period:**

In period, electronegativity increases due to increase in nuclear charge which decreases the distance from nucleus to shared electron pair.

Q) What are the elements of Group I-A called? Write the names of elements. Also write it's properties? (long 2021, 2016)

A) **Group I-A:**

This group elements are called Alkali metals. It includes Lithium, Sodium, Potassium, Rubidium, Cesium and Francium.

**Properties :**

- Their valence shell contain one electron.
- They form univalent positive ion.
- They are highly reactive.
- They have low melting point.

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Q) Describe the trend of electron affinity in periodic table?

A) **Along the period:**

In period, electron affinity increases due to decrease of atomic size. Because when size of the atom decreases, the attraction between nucleus and incoming electrons increases and more energy is released.

**Along the group:**

In group, electron affinity decreases due to increase in atomic size. Because when size of atom increases, the attraction between nucleus and incoming electrons decreases and less energy is released.

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**Book Exercise:**

Identify the electronic configuration of the following elements.

Na, Ca, F, Si

s:

| Elements | Atomic Number | Electronic Configuration |
|---|---|---|
| Na | 11 | $1s^2, 2s^2, 2p^6, 3s^1$ |
| Ca | 20 | $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$ |
| F | 9 | $1s^2, 2s^2, 2p^5$ |
| Si | 14 | $1s^2, 2s^2, 2p^6, 3s^2, 3p^2$ |

# Chapter : 4

## CHEMICAL BONDING

Q) Define the following terms:

1) **Chemical Bond:** (short 2016,2015,2014,2012)

"An interaction that holds two atoms together is called chemical bond."

2) **Ionic Bond:** (short 2015,2014,2012) (long 2022)

"The force of attraction that holds the oppositely charged ions together is called ionic bond."

3) **Covalent Bond:** (short 2015,2012)

"The bond that is formed by mutual sharing of electrons between two atoms is called a covalent bond."

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**4) Coordinate Covalent Bond OR Dative Bond:** (short 2015)

"The bond in which bond pair of electrons is contributed by one atom only is called coordinate covalent bond or dative bond."

**Q)** Define ionic bond. Illustrate bond formation in Sodium Chloride (NaCl). (long 2022,2013)

**A) Ionic Bond:** Six m

"The force of attraction that holds the oppositely charged ions together is called ionic bond."

**Bond formation between Sodium and Chlorine:**

- Sodium is a metal of Group I-A and has one electron in the outermost shell. By losing that one electron, sodium forms cation($Na^+$).
- Chlorine is a non metal of Group VII-A and has seven electrons in the outermost shell. It only needs one electron to complete its octet.
- By gaining one electron from sodium, chlorine forms anion($Cl^-$).
- Both these atoms are now oppositely charged ions. Therefore $Na^+$ and $Cl^-$ ions are attracted to each other and form NaCl.
- Thus $Na^+$ and $Cl^-$ ions are joint by ionic bond to form sodium chloride.

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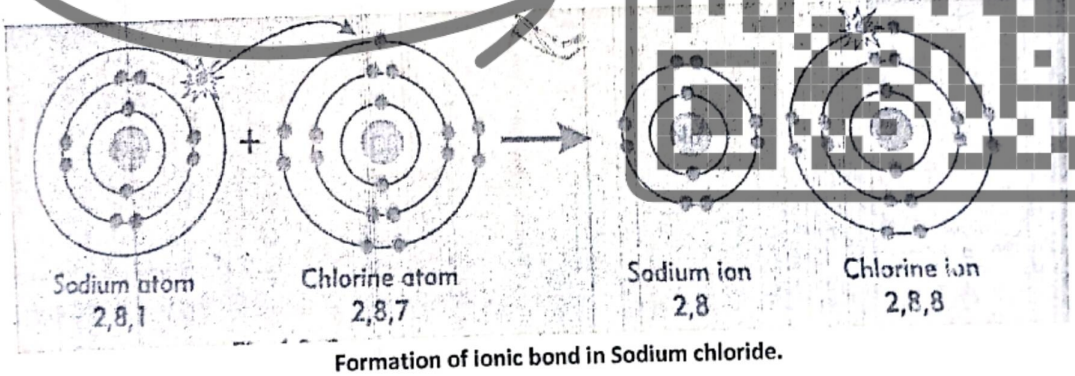


**Formation of ionic bond in Sodium chloride.**

**Q)** What is octet and duplet rule? (for understanding purpose)

**A) Duplet rule:**

Atoms to acquire two electrons in the valence shell is called duplet rule.

**Octet rule:**

Atoms to acquire eight electrons in the valence shell is called octet rule.

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**Q)** Define covalent bond. Explain Polar Covalent Bond and Non Polar Covalent Bond. (long 2012)

**A) Covalent Bond:**

"The bond that is formed by mutual sharing of electrons between two atoms is called a covalent bond."

**Non Polar Covalent Bond:**

" The covalent bond formed between identical atoms is called non-polar covalent bond." **Example:**

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In the above example, each H atom has an equal electronegativity value of 2.1,therefore the covalent bond between them is non-polar.

**Polar Covalent Bond:**

" The covalent bond formed between different atoms or non-identical atoms is called polar covalent bond." **Example:**

In Hydrogen chloride, Cl is more electronegative than hydrogen. This causes Cl atom to acquire a slight negative charge and H atom a slight positive charge.

**Q)** What is metallic bond? (short 2016)

**A) Metallic bond:**

"Metallic bonds are formed by the attraction between metal ions and delocalized or "mobile" electrons."

**OR**

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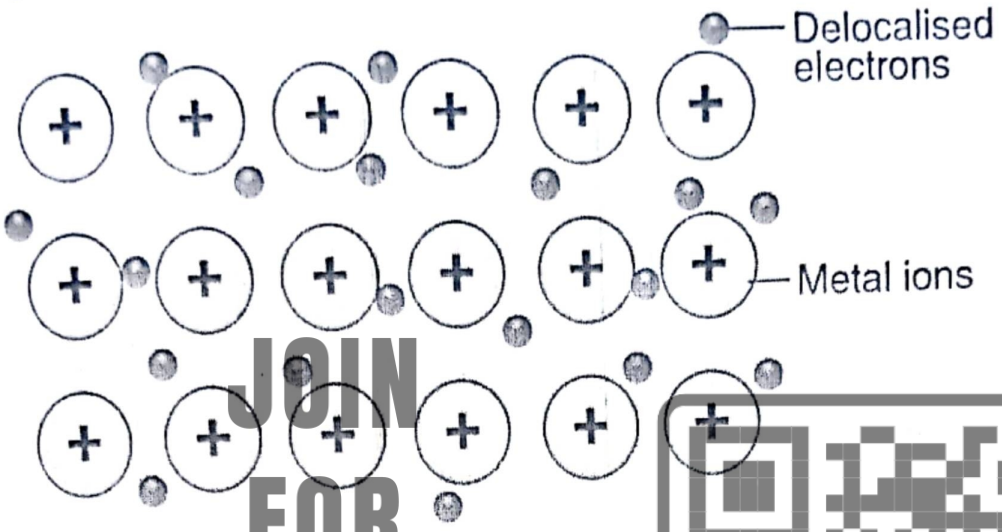
"Metallic bond' is a term used to describe the collective sharing of a sea of valence electrons between several positively charged metal ions."

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Q) What is hydrogen bonding?(2016)

**A) Hydrogen Bond:**

It is a type of dipole dipole interaction. "The interaction between partially positive charged hydrogen atom of one molecule with electronegative atom of other molecule is called hydrogen bond."

**Example:**

$$\overset{\delta^+}{N}\!-\!\overset{\delta^-}{H} \qquad \overset{\delta^+}{O}\!-\!\overset{\delta^-}{H} \qquad \overset{\delta^+}{F}\!-\!\overset{\delta^-}{H}$$

Q) Write some characteristics of ionic compounds? (short + long 2017,2012,2022)

**A) Characteristics of ionic compounds:**

The ionic compounds exhibit following properties :

i. Ionic compounds form crystals. Sit m

ii. Ionic compounds tend to be hard and brittle. Sit m.

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iii. The have high melting points.

iv. Aqueous solution of ionic compounds conduct electricity.

v. Ionic compounds usually dissolve in polar solvents like water and are insoluble in nonpolar solvents like oil, petrol, etc.

**Q)** Write some of Covalent compounds? (short + long 2012,2015)

**A) Characteristics of covalent compounds :**

The covalent compounds have following properties :

i. Covalent compounds exist as crystals like sugar, diamond.

ii. They have low melting and boiling points.

iii. They are bad conductors of electricity.

iv. They are insoluble in water but soluble in non-polar solvents like oil, petrol, etc.

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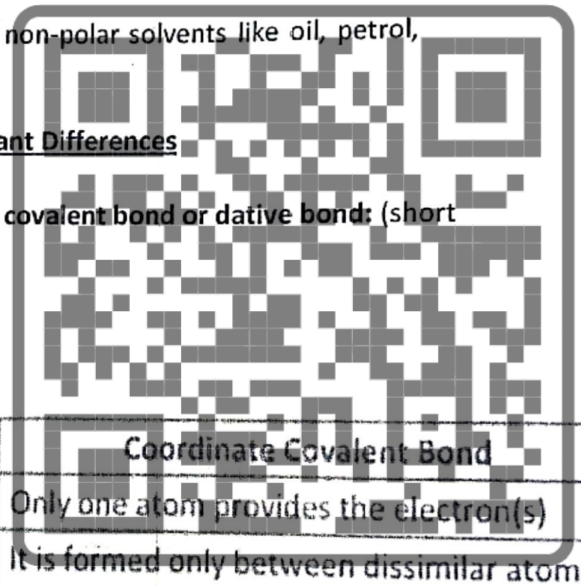

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**Important Differences**

**Difference between Covalent bond and Coordinate covalent bond or dative bond:** (short 2021,2019,2013,2012)

| Covalent Bond | Coordinate Covalent Bond |
|---|---|
| Both the bonding atoms provide electron(s) | Only one atom provides the electron(s) |
| It is formed between both similar and dissimilar atoms | It is formed only between dissimilar atoms |
| It is represented by single, double or triple short lines showing the sharing between one, two or three electron pairs | It is represented by an arrow pointing from the donor to the acceptor atom |
| Covalent bond may be polar or non-polar | Coordinate covalent bond is always polar |
| Covalent compounds are usually insoluble in water. | Coordinate covalent compounds are sparingly soluble in water. |

**Difference between bond pair and lone pair:**

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| Bond Pair | Lone Pair |
|---|---|
| Bond pair is a pair of electrons that are in a bond. | Lone pair is a pair of electrons that are not in a bond. |
| They are always in bonds. | They are not in bonds but can form bonds by donating the lone pairs. |
| In a bond pair, the two electrons belong to two atoms. | In a lone pair, the two electrons belong to the same atom. |
| A bond pair is created due to sharing of electrons by two atoms. | Alone pair is created due to the absence of empty orbitals. |

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Chapter : 5

# PYSICAL STATES OF MATTER

**Important Terms**

1) **Diffusion:** (short 2016,2014,2013,2012)

**"The movement of particles from an area of high concentration to an area of lowconcentration is called diffusion."**

**Example:**

- Perfume diffuses into the air.
- Smoke diffuses into the air.

2) **Effusion:**

**"The Effusion is escaping of gas molecules through a tiny hole into a space withlesser pressure."**

**Examples:**

- Leakage of air through tyre hole.
- Leakage of helium through gas balloons.

3) **Pressure :**

**" The force exerted by gaseous particles per unit area is called pressure."**

**Formula:**

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**Pressure =**

**Force/Area P =**

**$F/A = N/m^2$**

Unit: $Nm^{-2}$ or Pascal (Pa).

4) **Compressibility :**

**"The capacity of something to be flattened or reduced in size by pressure is called compressibility."**

5) **Mobility :**

**"The ability to move freely is known as mobility."**

6) **Density**

**" The degree of compactness or closeness of a molecule is called density." OR "Itis defined as mass per unit volume."**

Formula: D = M/V

Unit: grams/$dm^3$

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**Q) What is Boyle's law? Also write its mathematical expression.**

**A) Boyle's law:**

**In 1662 Robert Boyle proposed this law.**

**Statement:**

**"The volume of a given mass of a gas is inversely proportional to its pressure, at constanttemperature."**

**Mathematical expression:**

**According to Boyle's law, the volume of a gas decreases with the increase of pressure, so,**

$V \propto 1/P$ Or $V = K/P$ where K= is the constant

$PV = K$

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At initial pressure, At final pressure,

Combining both equations,

$$P_1V_1 = K$$

$$P_2V_2 = K$$

$$P_1V_1 = P_2V_2$$

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Q) What is Charle's law? Also write its mathematical expression.

A) Charle's law:

In 1787 French scientist J. Charles proposed this law.

Statement:

"The volume of a given mass of a gas is directly proportional to the absolute temperature if thepressure is kept constant."

Mathematical expression:

According to Charle's law if temperature of a gas is increased, its volume will also increase,

so,

$$V \propto T$$

$$\text{Or} \quad V = KT$$

$$\frac{V}{T} = K$$

At initial temperature, $\frac{V}{T} = K$

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$T_1$

**At final**

**temperature,**

$\frac{V_2}{T_2} = K$

**Combining both equations,**

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

**Q) What is Evaporation?** Sitmuneer

**A) Evaporation :** (short 2017,2016,2012)

**" The process by which a liquid changes to a gas is called evaporation."**

**Factors Affecting Evaporation :**

- **Surface area:** Greater the surface area greater is evaporation.
- **Temperature:** The rate of evaporation increases with the increase in temperature.
- **Intermolecular forces:** Evaporation increases with less Intermolecular forces and decreases with strong Intermolecular forces.

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- **Q)** What is Boiling point?

Sitmuneer

**A) Boiling point:** (short 2016 2014,2012)

**"The temperature at which vapour pressure of a liquid becomes equal to atmosphericpressure is called boiling point."**

**Factors Affecting Boiling point:**

- **Atmospheric pressure:** Boiling point increases with increased atmospheric pressure.
- **Nature of liquid:** Polar liquids have high boiling point than nonpolar liquids.
- **Intermolecular forces:** Boiling point increases with strong Intermolecular forces and decreases with weak Intermolecular forces.

**Q) What is Freezing point?**

**A) Freezing point:** ( short 2014)

**" The temperature at which the vapour pressure of a liquid state becomes**

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equal to the vapourpressure of its solid state is called as freezing point."

**Q) Explain some types of solid?**

**A) Types of Solids:**

**There are two types of solids which are:**

1) **Crystalline Solid:** Sib muneeb

**"The solids in which molecules are arranged in three dimensional geometrical patternis called Crystalline solids."**

Example: Salt, Diamond, etc.

2) **Amorphous Solid:** Sib muneeb

**" The solids in which molecules are not arranged in geometrical pattern are calledamorphous solids."**

Example: Plastic, Rubber, Glass, etc.

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**Q) What is Allotropy?**

**A) Allotropy:**

**" The existence of an element in more than one crystalline forms is known as allotropy."**

Example: The allotropes of carbon include, Diamond

1) Graphite
2) Graphene
3) Fullerenes



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## SOLVED BOOK NUMERICALS

1. Convert the following units:

(a) 100°C to K (b) 150°C to K (c) 780K to °C (d) 170K to °C

**(a) 100°C to K**

**Data:**

T°C = 100°C

T(k) = ?

**Calculation:**

We know that

(T) K = (T) °C + 273

Therefore,

(T) K = 100 + 273

= 373 K Ans.

**(b) 150°C to K**

**Data:**

T°C = 150°C

T(k) = ?

**Calculation:**

We know that

(T) K = (T)°C + 273

Therefore,

(T) K = 150 + 273

= 423 K Ans.

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**(c) 780 K to °C**

**Data:**

T(k) = 780K

T°C = ?

**Calculation:**

We know that

T°C = (T) K – 273

Therefore,

T°C = 780 – 273

= 507 °C Ans.

**(d) 170 K to °C**

**Data:**

T(k) = 170 K

T°C = ?

**Calculation:**

We know that

T°C = (T) K – 273

Therefore,

T°C = 170 – 273

= –103 °C Ans.

2. It is desired to increase the volume of a fixed amount of gas from 90.5 to 120 $cm^3$ while holding the pressure constant. What would be the final temperature if the initial temperature is 33°C.

**Solution:**

**Data:**

$T_1$ = 33°C = 33 + 273 K = 306 K

$V_1$ = 90.5 $cm^3$

$V_2$ = 120 $cm^3$

$T_2$ = ?

**Calculations :**

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By Using Charles' law equation:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

or $T_2 = \frac{V_2 T_1}{V_1}$

By putting the values

$$T_2 = \frac{120 \times 306}{90.5} = \frac{36720}{90.5}$$

$$T_2 = 405.74\ K$$

or $(T)°C = (T)K - 273$

$(T)°C = 405.74 - 273$

$(T)°C = \boxed{132.74°C}$ Ans.

3. A 78ml sample of gas is heated from 35°C to 80°C at constant pressure. What is the final volume?

**Solution:**

**Data:**

$T_1 = 35°C = 35 + 273\ K = 308\ K$

$T_1 = 80°C = 80 + 273\ K = 353\ K$

$V_1 = 78\ ml$

**Calculations :**

By Using the equation:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

or $V_2 = \frac{V_1 T_2}{T_1}$.

By putting the values in equation

$$V_2 = \frac{78 \times 353}{308}$$

$V_2 = \boxed{89.39\ ml}$ Ans.

*The volume will become 89.39 ml, which shows the increase in volume with raising the temperature.*

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4. A gas occupies a volume of 40.0 $dm^3$ at standard temperature (0°C) and pressure (1 atm), when pressure is increased up to 3 atm unchanged temperature what would be the new volume?

**Solution:**

**Data:**

$V_1 = 40.0\ dm^3$

$P_1 = 1\ atm$

$P_2 = 3\ atm$

$V_2 = ?$

**Calculations :**

$P_1 V_1 = P_2 V_2$

$V_2 = \frac{P_1 V_1}{P_2}$

$V_2 = \frac{1 \times 40}{3} = \frac{40}{3}$

$V_2 = \boxed{13.33\ dm^3}$ Ans.

5. The 800 $cm^3$ of a gas is enclosed in a container under a pressure of 750 mm. If the volume is reduced to 250 $cm^3$, what will be the pressure?

**Solution:**

**Data:**

$V_1 = 800\ cm^3$

$V_2 = 250\ cm^3$

$P_1 = 750\ mm$

$P_2 = ?$

**Calculations :**

$P_2 = \frac{P_1 V_1}{V_2}$

$P_2 = \frac{750 \times 800}{250} = \frac{600000}{250}$

$P_2 = \boxed{2400\ mm^3}$ Ans.

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6. The pressure of a sample gas is 8 atm and the volume is 15 litres. If the pressure is reduced to 6 atm, what is the volume?

**Solution:**

**Data:**

$V_1 = 15$ liters

$P_1 = 8$ atm

$P_2 = 6$ atm

$V_2 = ?$

**Calculations:**

$$P_1 V_1 = P_2 V_2$$

$$V_2 = \frac{P_1 V_1}{P_2}$$

$$V_2 = \frac{8 \times 15}{6} = \frac{120}{6}$$

$V_2 =$ 20 liters Ans.

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# SOLUTIONS

## Important Terms

1) Aqueous solution: (2022)

"An Aqueous solution is a solution in which the solvent is water." e.g. Sugar in water,salt water, etc.

2) Solute:

"The component in solution which is present in smaller amount is called solute." e.g.

Sugar, salt, etc.

3) Solvent:

"The component in solution which is present in larger amount is called solvent." e.g.

Water, etc.

4) Saturated solution : (2012)

"The solution which cannot dissolve more solute in it at particular temperature iscalled saturated solution."

5) Unsaturated solution: (2012)

"A solution which contains lesser amount of solute than is required at a particular temperature is called unsaturated solution."

6) Supersaturated solution: (2012)

"A solution that can dissolve more solute than it contained in the saturated solution after heating is called Supersaturated solution."

7) Dilute solution:

"A solution which contains small amount of solute in a large amount of solvent iscalled dilute solution." Like adding water to milk.

8) Concentrated solution:

"A solution which contains a large amount of solute in a small amount of solvent iscalled concentrated solution."

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**Concentration:**

**"Concentration is the amount of solute present in a given amount of solvent or solution."**

Unit: $g/dm^3$

**Formula:**

$$\text{Concentration in } g/m^3 = \frac{\text{Mass of solute in gram}}{\text{Volume of Solution in } dm^3}$$

**Percentage:**

**It is a unit of concentration. It can be expressed as:**

- Mass by mass percent: (% m/m)

**It is the mass of solute dissolve in 100 gram of solution.**

$$\text{Percent solution } (\frac{m}{m})\% = \frac{\text{Mass of solute (g)}}{\text{Mass of solute + mass of solution (g)}} \times 100$$

$$\text{Percent solution } (\frac{m}{m})\% = \frac{\text{Mass of solute (g)}}{\text{Mass of solution (g)}} \times 100$$

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- **Mass by volume percent:** (%m/v)

**It is the mass of solute dissolved per 100cm $^3$ of solution.**

- **Volume by mass percent:** (%v/m)

**It is the volume of solute in cm $^3$ dissolved in 100gm of solution.**

$$\text{Percent of the solution } (\frac{V}{m}) = \frac{\text{Volume of Solute}(cm^3)}{\text{Mass of solution (g)}} \times 100$$

- Volume by volume percent: (% v/v)

**The volume of solute in cm $^3$ dissolved per 100cm $^3$ of solution.**



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$$\text{Percent of the solution } \left(\frac{V}{V}\right) = \frac{\text{Volume of Solute } (cm^3)}{\text{Volume of Solution } (cm^3)} \times 100$$

**MOLARITY:** (2015,2012)

**" It is defined as the number of moles of solute dissolved in one $dm^3$ of solution."**

**Denoted:** by "M"

**Unit:** $mol/dm^3$

**Formula:**

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$$\text{Molarity (M)} = \frac{\text{Number of moles of solute}}{\text{Volume of solution in } dm^3}$$

$$\text{Number of moles of solute} = \frac{\text{mass of solute}}{\text{molar mass of the solute } (gmol^{-1})}$$

$$\text{The volume of solution in } dm^3 = \frac{\text{Volume of solution } (cm^3)}{1000}$$

$$\text{Molarity} = \frac{\text{Mass of solute (g)}}{\text{Molar mass of the solute } (gmol^{-1})} \times \frac{1000}{\text{Volume of Solution } (cm^3)}$$

Six M

**SOLUBILITY:** (2018,2016,2015)

**" It is defined as the maximum quantity of solute that can be dissolved in 100gm of solvent toprepare saturated solution at particular temperature."**

**Factors Affecting Solubility:** (2018,2016)

- **Temperature :** Solubility is directly proportional to temperature in solid and liquid. Solubility increases with increase in temperature as hot water molecules have greaterkinetic energy. For gases, solubility decreases as temperature increases.
- **Pressure:** When the pressure of gaseous substance increases, its solubility also increases.This is not applied to solids or liquids.



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- **Like dissolve like rule:** Principle of solubility is "like dissolve like". Means that two substances with similar Intermolecular forces likely to have more solubility than unlikesubstances.

Sir muneeb

**SUSPENSION:** (2017 with four examples)

**"A suspension is a heterogeneous mixture of solute and solvent in which solute particlesdo not dissolve." These particles settle to the bottom after sometime.**

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**Examples:**

1) Mud in water
2) Chalk in water
3) Paints
4) Sand particles in water

**Q) Air is a mixture of gases then why Nitrogen gas is considered as solvent? (2022 reasoning)**

**A) Air is mixture of many gases namely oxygen, nitrogen, carbon dioxide, etc. Nitrogen gas makes up almost 78% of total air composition. Since Nitrogen gas is present in large amount that's why it is considered as solvent in air.**

**Important Differences**

**Difference between saturated, unsaturated and super saturated solution**

**Difference between solution and suspension** (short 2016,2012,2016 long)



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...saturated, Unsaturated and Supersaturated solution

| Saturated | Unsaturated | Supersaturated |
|---|---|---|
| In saturated solution maximum amount of solute that can be dissolved at particular temperature. | In unsaturated solution more amount of solute that can be dissolved at particular temperature. | In super saturated solutio more amount of solute h been dissolved than maximum capacity. |
| The solution has high concentration than unsaturated solution. | The solution has low concentration than saturated solution. | The solution has m concentration th saturated solution. |
| There is no formation of precipitation at the bottom of container. | There is also no precipitation at the bottom of container. | There is formation precipitation at the bo of container. |
| A solution having 20.9 gram of sodium sulphate salt per 100cm³ of water at 20°C is the example of saturated solutions. | A solution having less than 20.9 gram per 100cm³ of water at 20°C is the example of unsaturated solution. | A solution having amount than 20.9 g salt per 100cm³ of w 20°C is the exam supersaturated soluti |

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| Particle size less than 1 nm | Particle size greater than 1000 nm | Particle size 1 to 100 nm |
|---|---|---|
| Homogeneous (particles dissolve uniformly) | Heterogeneous (particles settle down after sometimes) | Homogeneous and heterogeneous (Particles do not settle down for a long time) |
| Particles cannot be distinctly seen with the naked eye | Particles are big enough but can be seen with naked eyes | Colloidal particles cannot be seen with the naked eye but can be seen through ultra microscope |
| Clear, transparent and homogeneous | Cloudy, but uniform and homogeneous | Cloudy, heterogeneous, at least two substances visible |
| Transparent but often colored | Translucent and often opaque but can be transparent | Often opaque, but can be transparent |
| Cannot be separated | Cannot be separated | Can be separated easily |
| Do not scatter light | Scatter light, but are not transparent | Scatter light (Tyndall effect) |
| Particles can pass through filter paper | Particles pass through filter paper | Particles do not pass through filter paper |

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# CHP # 06 SOLUTIONS
## Solved Numericals

Q1) 10M $HNO_3$ solution is available in laboratory. How would you prepare 500 $cm^3$ of 0.1M solution?

**Data :-**

$M_1$ = 10M $HNO_3$
$M_2$ = 0.1M $HNO_3$
$V_2$ = 500 $cm^3$
$V_1$ = ?

**Solution :-**

In a laboratory we can make a dilute solution from concentrated solution by using formula :

$M_1V_1 = M_2V_2$

Concentrated = Dilute

$10 \times V_1 = 0.1 \times 500$

$V_1 = \frac{0.1 \times 500}{10}$

$V_1 = 5 cm^3$

Take 5 $cm^3$ of concentrated $HNO_3$ and dilute it by using water to prepare 0.1M solution of $HNO_3$.

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Q2) Determine the percentage concentration of solution obtained by dissolving 10g sugar in 140g water?

**Data :-**

Mass of solute = 10g
Mass of solvent = 140g
Total mass of solution = 10 + 140 = 150g
M/M % = ?

**Solution :-**

$\frac{m}{m}\% = \frac{\text{Mass of solute}}{\text{Total mass of solution}} \times 100$

$\frac{m}{m}\% = \frac{10}{150} \times 100$

$\frac{m}{m}\% = 6.66\%$

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Q1) A solution of NaOH has concentration of the solution 1.2M, calculate the mass of NaOH in g/dm³ in this solution?

Data:-

Molarity = 1.2M

Volume = 1dm³

Molar mass of NaOH = 23 + 16 + 1 = 40 g/mol

Mass of NaOH = ?

Calculation:-

$$\text{Molarity} = \frac{\text{Mass of solute}}{\text{Molar mass of solute}} \times \frac{1}{\text{Volume of solution(dm)}}$$

$$1.2 = \frac{\text{Mass of solute}}{40} \times \frac{1}{1}$$

Mass of NaOH = 1.2 × 40 × 1

= 48 g/dm³

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What is the molarity of the solution prepared by dissolving 1.25 g of HCl gas into enough water to make 30 cm³ of the solution?

**Solution:**

**Data:**

| | | |
|---|---|---|
| Mass of solute | = | 1.25g |
| Molar mass of HCl | = | 1 + 35.5 = 36.5 g/mol |
| Volume of solution | = | 30 cm³ |
| Molarity (M) | = | ? |

**Formula :**

$$\text{Molarity} = \frac{\text{Mass of solute}}{\text{Molar mass of solute (g)}} \times \frac{1000}{\text{Volume of solution (cm}^3\text{)}}$$

**Calculation:-**

$$\text{Molarity} = \frac{1.25\text{ g}}{36.5\text{ g/mol}} \times \frac{1000}{30}$$

$$\text{Molarity} = \boxed{1.14\text{ mole/ dm}^3}$$

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A solution of potassium chloride was prepared by dissolving 2.5 g of potassium chloride (KCl) in water and making the volume up to 100cm³. Find the concentration of the solution in mol/dm³.

**Solution:**

**Data:**

Mass of solute = 2.5 g

Molar mass of KCl = 39.09 + 35.5 = 74.59 g/mol

Volume of solution = 100 cm³

**Calculation:**

We know that

$$\text{Molarity} = \frac{\text{Mass of solute}}{\text{Molar mass of solute (g)}} \times \frac{1000}{\text{Volume of solution (cm}^3\text{)}}$$

$$\text{Molarity} = \frac{2.5\,g}{74.59\,g/mol} \times \frac{1000}{100}$$

$$\text{Molarity} = \boxed{0.335 \text{ mole/ dm}^3}$$

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A flask contains 0·25M NaOH solution. What mass of NaOH is present per dm³ of solution?

Data :-

Molarity = 0·25M

Volume = 1 dm³

Molar mass of NaOH = 40 g/mol

Mass of NaOH = ?

Calculation :-

$$\text{Molarity} = \frac{\text{Mass of solute}}{\text{molar Mass of solute}} \times \frac{1}{\text{Volume of solution(dm}^3\text{)}}$$

$$0.25 = \frac{\text{Mass of NaOH}}{40} \times \frac{1}{1}$$

$$\text{Mass of NaOH} = 0.25 \times 40 \times 1$$

$$= 10\ g/dm^3$$

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Chapter: 7

# ELECTROCHEMISTRY

**Important Terms :**

1) **Electrochemistry:** (short 2014)

**"The branch of chemistry which deals with electro chemical reactions, electrolyte andelectrochemical cells is called electrochemistry."**

**Or**

**"It deals with the conversion of electrical energy into chemical energy and chemicalenergy into electrical."**

2) **Electrochemical Equivalent:** (short 2015,2014)

**"It is the weight of the substance collected at the electrodes when one coulomb ofelectric charge is passed through electrolyte."**

3) **Electrolysis:** (short 2017,2014)

**"Electrolysis is a chemical reaction that occurs when an electric current is passedthrough a substance."**

4) **Electroplating:** (long 2022,2018)

**"The coating of metal at the surface of other metal by electrolytic process is calledelectroplating."**

5) **Faraday:** (short 2015)

**"Quantity of charge which deposits or liberates 1gm equivalent weight of a substanceis called 1 Faraday."**

**1 Faraday= 96500 Coulombs**

**Q) State Faraday's 1st law of electrolysis and explain it. (short 2022,2017) (long 2019,2012)**

**A) Faraday's 1st law of Electrolysis:**

**Michel Faraday, a British chemist proposed this law.**

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**Statement:**

**"The amount of substance that is deposited at an electrode during electrolysis is directlyproporti to the quantity of electricity passed through the electrolyte."**

**Mathematical expression,**

$$W \propto A \times t$$

$$W = Zat$$

Or

In this equation, W = weight of the substance deposited or liberated at the electrode,

A = Current in Ampere and t = Time in second

Ampere (A) × time(t) = Coulomb (C)

If A = 1 amp, t = 1 sec then W = Z (Electrochemical equivalent)

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**Q) State Faraday's 2nd law of Electrolysis and explain it. (short 2017)(long 2019,2012)**

**A) Faraday's 2nd law of Electrolysis:**

**Michel Faraday, a British chemist proposed this law.**

**Statement:**

**"The amount of different substances deposited due to passage of same quantity of currentthrough different electrolytes are proportional to their chemical equivalent masses."**

**For an element,**

$$\text{Equivalent mass} = \frac{\text{Atomic weight}}{\text{Valency}}$$

**Example:**

**Chemical equivalent of Al**

$$= \frac{27}{3} = 9g$$



**Q) With the help of a labeled diagram, explain the construction and working of a lead storagebattery. (long 2013)**

**A) Lead Storage Battery:** ✓ Done Sir Muneeb

**Lead storage battery is an example of secondary cell in which chemical**



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changes can bereversed.

**Construction:**

It has several voltaic cells connected in series. It contains lead plates which serve as anodeand lead oxide $PbO_2$ which acts as cathode. These electrodes are immersed in electrolytic solution of dilute sulphuric acid $H_2SO_4$.

**Working:**

Chemical changes during charging and discharging processes can be shown as,

$$Pb + PbO_2 + 2H_2SO_4 \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} 2PbSO_4 + 2H_2O$$

**Diagram:**


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**Q) What is an alloy? Write names of alloys of copper with their composition. (short 2016)**

**A) Alloy:**

**" Alloy is the mixture of metal with metal or metal with non metal."**

**Alloys of Copper:**

1) **Brass:** It is an alloy of Copper (Cu) and Zinc (Zn).
2) **Bell metal:** It is an alloy of Copper (Cu) and Tin (Sn).
3) **Bronze:** It is an alloy of Copper (Cu) with Zinc (Zn) and Tin (Sn).

**Q) Write advantages of electroplating? (long 2012)**

**Advantages of Electroplating:**



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Six marks

- **It is used to coat metal surfaces with desired metal coatings for decorative purposes.**
- It saves metal surfaces from rusting.
- It saves metals from corrosion.
- It also gives lustre or shine to metals.

**Q) Explain what are electrolytes and non electrolytes and how are they classified? (long 2021)**

**A) Electrolyte:**

**"The substance which contains free moving ions and conduct electricity is called anelectrolyte."**

**Types of Electrolytes:**

- **Strong electrolyte:** Electrolyte that dissociate or ionize completely in their aqueoussolution. **E. G.** HCl, KOH, NaCl, NaOH, etc.
- **Weak electrolyte:** Electrolyte that do not dissociate or ionize completely in aqueoussolution. **E. G.** PbI, AgCl, $H_2CO_3$, etc.

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**Non Electrolyte:**

**"The substances which are unable to conduct electricity in molten state or aqueoussolution are called non electrolytes." E. G. Benzene, Glucose, Sucrose, etc.**

**Q) Define Oxidation by three different ways with one suitable example for each. (short 2015)**

**A) Oxidation :**

- Oxidation may involve introduction of oxygen. **E. G.**

$C + O_2 \text{ - - - > } CO_2$ **(burning of coal)**

- Oxidation may involve removal of hydrogen. **E. G.**

$N_2H_4 + O_2 \text{ - - - > } N_2 + 2H_2O$ **(removal of hydrogen from Hydrazine)**

- The electrochemical reaction in which atom or ion loses electron and its oxidationnumber increases is called oxidation reaction. **E. G.**

$Cu \text{ -----> } Cu^{2+} + 2e^-$

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**Q) How can a steel spoon be electroplated with chromium? Explain with diagram. (long 2022)**

**A) Chromium plating on Steel spoon:**

**" The process in which chromium is coated eletrolytically at the surface of other metal is called chromium plating."**

**Construction:**

**Acidified chromium sulphate $Cr_2(SO_4)_3$ is taken as electrolyte.**

**Chromium metal serves asanode and steel spoon is used as cathode.**

**Working:**

Following chemical changes take place in chromium plating.

$$Cr_2(SO_4)_{3(aq)} \rightleftharpoons 2Cr^{3+}_{(aq)} + 3SO^{2-}_{4(aq)}$$

Reaction at anode: $Cr \rightleftharpoons Cr^{3+} + 3e^-$

Reaction at cathode: $Cr^{3+} + 3e^- \rightleftharpoons Cr$

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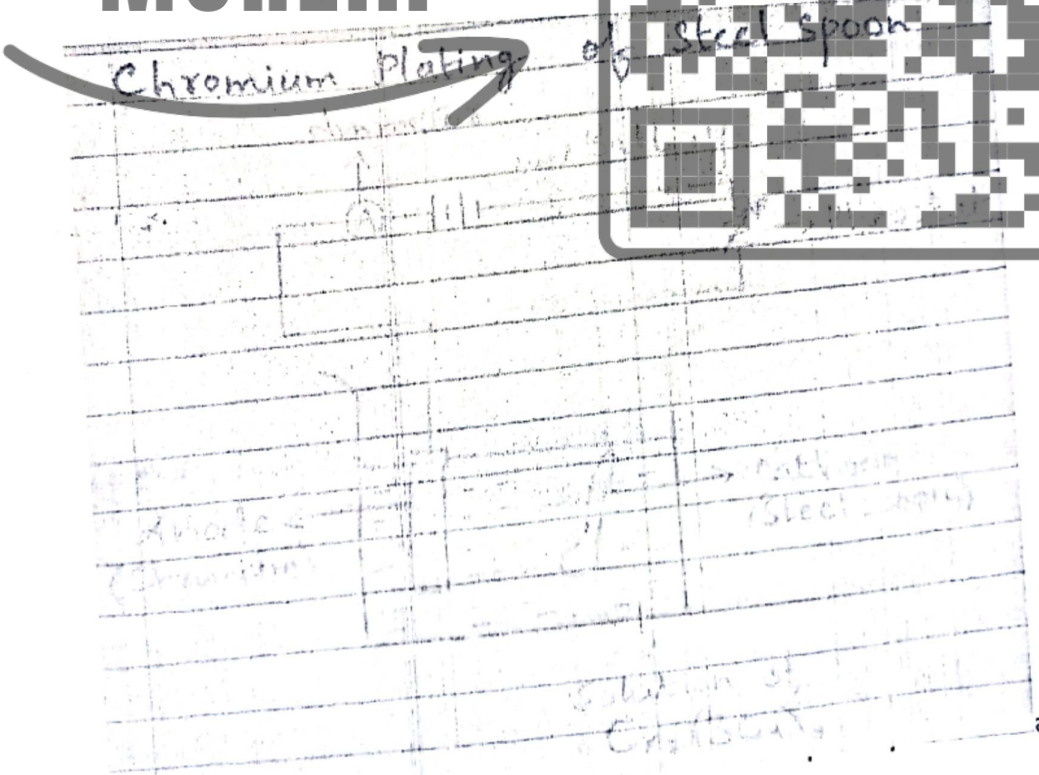
**Diagram:**

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Ficals :

(Q) A current of 5 ampere was passed through an electrolytic solution of copper sulphate for an hour. Find the mass of copper metal deposited at cathode.
(The electrochemical equivalent of copper is 0.000329 g/c)

**Data:-**

1) A = Current = 5 ampere
2) Time = t = 1 hour = 60 minutes
   t = 60 × 60 = 3600 sec
3) Amount of deposit = W = ?
4) Z = $\frac{0.000329}{1000}$ g/c = $3.29 \times 10^{-7}$ kg/c

**Solution:-**

$W = Z \times A \times t$

$W = 3.29 \times 10^{-7} \times 5 \times 3600$

$[W = 0.005922 \text{ kg}]$

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Q) A current of 5 ampere was passed through an electrolytic solution of Copper sulphate for an hour. Find the mass of copper metal deposited at Cathode. 2018
(The electrochemical equivalent of copper is 0.000329 g/c)

Data:-

1) A = Current = 5 ampere
2) Time = t = 1 hour = 60 minutes
t = 60 × 60 = 3600 sec
3) Amount deposit = W = ?
4) Z = 0.000329 / 1000 g/c = 3.29 × 10⁻⁷ kg/c

Solution:-

W = Z × A × t
W = 3.29 × 10⁻⁷ × 5 × 3600
W = 0.005922 kg

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**Practice Numericals :**

Q) Calculate the amount of silver (Ag) Deposited at Cathode, when 10 Ampere of Electric current is passed for 1 hour through the solution of AgNO₃.
(Z of Ag = 0.001118 g/c) 2016
(Ans: 0.0402 kg)

Q) A current of 5 ampere was passed through a solution of AgNO₃ for 5 minutes. Calculate mass of Silver (Ag) deposited on cathode. (Z of Ag = 0.00118 g/c) 2014
(Ans: 0.001677 kg)

**Difference between Oxidation and Reduction : (2017,2013)**



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| Oxidation | Reduction |
|---|---|
| Addition of oxygen | Addition of Hydrogen |
| Removal of Hydrogen | Removal of oxygen |
| Loss of electron by a substance | Gain of electrons by a substance |
| Increase in oxidation number of a substance | Decrease in oxidation number of a substance |

A mineral water bottle contains 28 mg of calcium in 100 $cm^3$ of solution. What is the concentration in $g/dm^3$?

**Solution:**

**Data:**

Mass of solute = 28 mg = $\frac{28}{1000}$ g = 0.028 g

Volume of solution = 100 $cm^3$ = $\frac{100}{1000}$ $dm^3$ = 0.1 $dm^3$

**Calculation:**

$$\text{Concentration in g / dm}^3 = \frac{\text{Mass of solute in gram}}{\text{volume of solution in dm}^3}$$

$$= \frac{0.028}{0.1}$$

$$= \boxed{0.28\ g/dm^3}$$

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A solution of 20 $cm^3$ of alcohol is dissolved in 80 $cm^3$ of water. Calculate the concentration (v/v) of this solution.

**Solution:**

**Data:**

Volume of solute = 20 $cm^3$

Volume of solution = 80 $cm^3$

Volume / volume percent = ?

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$$\text{Percent of the solution } \left(\frac{v}{v}\right) = \frac{\text{volume of Solute } (cm^3)}{\text{volume of Solution } (cm^3)} \times 100$$

$$= \frac{20}{80} \times 100$$

$$= \boxed{25\%}$$

Thus the concentration of a solution is 25% by volume.

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How much sodium hydroxide (NaOH) is required to prepare 400 $cm^3$ of 0.3M solution?

**Solution:**

**Data:**

Molarity = 0.3 $mol/dm^3$

Volume in $cm^3$ = 400

Molar mass of sodium hydroxide (NaOH) = 23 + 16 + 1 = 40 g/mol

Mass of solute = ?

**Formula :**

$$\text{Molarity} = \frac{\text{Mass of Solute}}{\text{Molar mass of solute(g)}} \times \frac{1000}{\text{Volume of solution } (cm^3)}$$

**Calculation:-**

$$0.3 = \frac{\text{Mass of Solute}}{40} \times \frac{1000}{400}$$

$$\text{Mass of solute} = \frac{0.3 \times 40 \times 400}{1000}$$

$$= \boxed{4.8 gm}$$



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Chapter : 08

# CHEMICAL REACTIVITY

Q) Write physical and chemical differences between metals and non metals? (2014)

| | |
|---|---|
| ❖ Tend to lose electrons in reactions<br>❖ Good conductors of heat and electricity<br>❖ Ductile<br>❖ Lustrous<br>❖ Strong<br>❖ Malleable<br>❖ Sonorous<br>❖ Oxides are basic in nature e.g. ($Li_2O$, $Na_2O_2$, $KO_2$, MgO). | ❖ Tend to gain electrons in reactions with metals.<br>❖ Poor-conductors of heat and electricity<br>❖ Not ductile<br>❖ Often have dull appearance<br>❖ Oxides are acidic in nature ($CO_2$, $SO_3$, $NO_2$). |

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Q) What are halogens? Also write its characteristics. (2017, 2016)

**A) Halogens:**

" Halogens are the elements which belong to group 7A of periodic table. Halogen is a Greek word which means "salt formation." As they are helpful in generating salts with metals." **Elements :** Fluorine, Chlorine, Bromine, Iodine and Astatine.

**Characteristics :**

- They have seven valence electrons.
- They have high electronegativity values.
- They ate highly reactive.
- They cannot exist as pure elements in the environment due to high rate of reactivity.
- They have low melting and boiling points.

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- They are poor conductors of heat and electricity.

**Q)** Write difference between Alkali and Alkaline Earth metals?

| Alkali Metals (IA) | Alkaline Earth Metals (IIA) |
|---|---|
| They are highly reactive than (IIA) group elements due to low ionization energy. | They are less reactive than (IA) group elements due to high ionization energy. |
| They form monovalent cation($M^+$) | They form divalent cation($M^{++}$) |
| They immediately tarnish in air and form metal oxide. $K + O_2 \rightarrow KO_2$ | They react with oxygen on heating. $2Mg + O_2 \rightarrow 2MgO$ |
| They react violently with halogens $2Na + Cl_2 \rightarrow 2NaCl$ | They react slowly with halogens $Ca + Cl_2 \rightarrow CaCl_2$ |
| They react with water vigorously at room temperature and form strong alkaline solution $2K + 2H_2O \rightarrow 2KOH + H_2$ | They react with water less vigorously and form alkaline solution $Mg + H_2O \rightarrow MgO + H_2$ $MgO + H_2O \rightarrow Mg(OH)_2$ |
| Their oxides and hydroxides are more basic than those of IIA group elements. | Their oxides and hydroxides are less basic than those of IA group elememts. |
| They do not form metal carbides. | They form metal carbides on heating. $Ca + 2C \rightarrow CaC_2$ |

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**Q)** Write chemical formulae of the following compounds:

i. **Caustic Soda:** NaOH
ii. **Sodium Nitrate:** $NaNO_3$
iii. **Ammonium Chloride:** $NH_4Cl$
iv. **Table salt:** NaCl
v. **Baking Soda:** $NaHCO_3$
vi. **Soda Ash:** $Na_2CO_3$

**Q)** Write some properties and uses of Sodium?

**A) Properties of Sodium:**

- It is a silvery white Alkali metal.
- It is very soft and can be cut with a knife due to weak metallic bonding.
- It has a shining surface.

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- Sodium reacts with halogens to form halides.
- It also reacts with sulphuric acid to form hydrogen gas.

**Uses of Sodium:**

- It is used as coolent in nuclear reactors.
- It is used in detergent preparation.
- It is used as street light and gives yellow colour.
- It is used as reducing agent in extraction of Calcium, Zirconium and Titanium.

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