1 Periodic Table and Electronic Configuration

Important Points & Activities :

- ✽ Shell : Shell is the circular pathway followed by the electrons around the nucleus of an atom. Shells are also known as orbits or principal energy levels. Shells are represented either by the letters **K,L,M,N** etc or by the numbers **1,2,3,4** etc.
- ✽ As the distance from the nucleus increases, the energy of the electrons in the shells increases and the attractive force between the nucleus and the electrons decreases.
- ✽ Principal energy levels or shells contain sub energy levels called **subshells**. Subshells are represented by the letters **s,p,d** and **f**.
- ✽ Maximum number of electrons that can be accommodated in different shells can be calculated by the expression $2n^2$, where ' **n** ' is the shell number.
- ✽ Maximum number of electrons that can be accommodated in different shells and subshells.

Shell	Subshells	No. of Electrons
K	**s**	**2**
L	**s** and **p**	2 + 6 = **8**
M	**s, p** and **d**	2 + 6 + 10 = **18**
N	**s, p, d** and **f**	2 + 6 + 10 + 14 = **32**

- ✽ Maximum number of electrons that can be accommodated in different subshells.

Subshells	s	p	d	f
No. of Electrons	2	6	10	14

- ✽ The number of subshells in each energy level is equal to its shell number.
- ✽ The subshell, which is common to all shells, is ' **s** ' subshell.

✽ **Aufbau Principle :** Electron filling in different subshells takes place in the increasing order of their energies. That is, the subshell which has the lowest energy is filled first.

✽ **Increasing order of energy of subshells :**

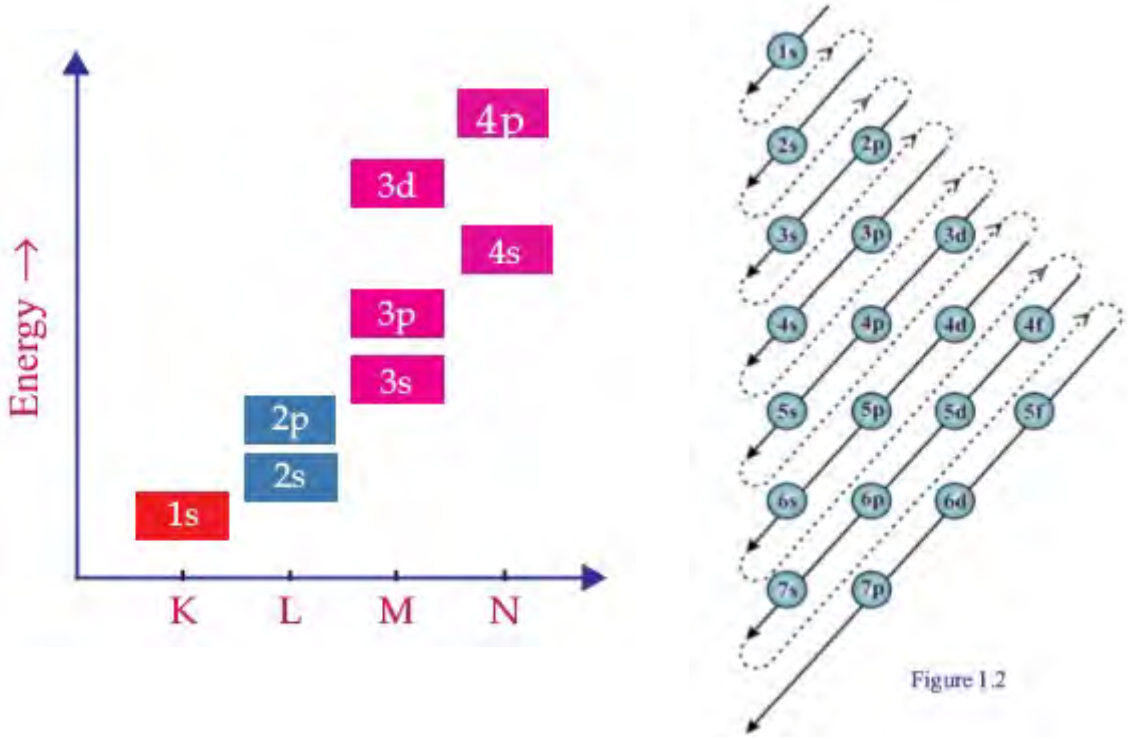


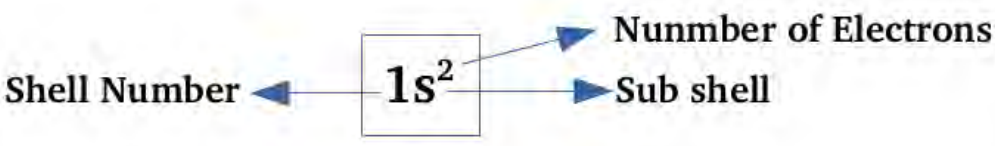
Figure 1.2

1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s <.....

✽ **Subshell Electronic Configuration** : The arrangement of electrons in different subshells in the increasing order of their energy is called the subshell electronic configuration.

✽ If we know the **total number of electrons (Atomic number), the capacity of each subshell to hold the electrons and the increasing order of energy of subshells**, we can write the subshell electronic configuration of an element.

✽ **Representation of subshell electronic configuration :**



✽ While writing the subshell electronic configuration, the number written on the left side of the subshell represents the **shell number** and the number shown as super script on the right represents the **number of electrons**.

✽ **Different ways of writing the subshell electronic configuration of an element:**

Eg: Mn (Z=25)

1) **Based on the increasing order of energy of subshells (Aufbau Principle):**

- Arrange the subshells in the increasing order of their energy.

  1s 2s 2p 3s 3p 4s 3d 4p 5s

- Fill the electrons in each subshell according to the capacity of the subshell to hold electrons.

  $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$

2) **Based on the order of the shells :**

In this method, the different subshells of the same shell are written adjacent to each other (written together).

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$

3) **Short form of subshell electronic configuration :**

While writing the short form of subshell electronic configuration of an element, the symbol of the noble gas /inert gas preceding that element is written within a square bracket followed by the electronic configuration of the remaining subshells.

$[Ar]\ 4s^2\ 3d^5$ **OR** $[Ar]\ 3d^5\ 4s^2$

[Atomic Numbers of Noble Gases ---

Helium (He) = 2, Neon (Ne) = 10, Argon (Ar) = 18 **]**

✽ **Peculiarity of the electronic configurations of Chromium (Cr) and Copper (Cu):**

The **completely filled (d^{10}) and the half filled (d^5)** configurations of **d** subshell are **more stable** than the others. So, in Chromium and Copper, in order to attain stability **1** electron is shifted from **4s to 3d** subshell.

Chromium (Cr) – (Z=24) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$

Copper (Cu) – (Z=29) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$

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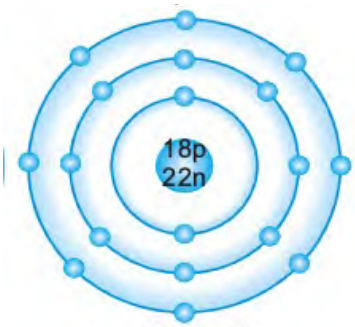
Activity - 1

The Bohr atom model of the element Argon is given below. Examine the figure and find out the following.

1. No. of Protons
2. No. of Electrons
3. No. of Neutrons
4. Atomic Number (Z)
5. Mass Number (A)
6. No. of Shells
7. No. of Valence electrons
8. No. of electrons present in each shell
9. Shell electronic configuration



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Activity - 2

Complete the Table given below.

Shell number	1	2		3			4			
Subshell	s	s	p	s	p	d	s	p	d	f
Representation of subshells	1s	-	-	-	3p	-	-	-	4d	-

Activity - 3

Complete the Table given below.

Shell number	**1**	**2**		**3**			**4**			
Maximum number of electrons that can be accommodated in each shell	2	8		18			32			
Subshell	**1s**	**2s**	**2p**	**3s**	**3p**	**3d**	**4s**	**4p**	**4d**	**4f**
Maximum number of electrons that can be accommodated in each subshell	**2**	**2**	-	-	-	-	-	-	-	-

Activity – 4

Which among the following configurations are not possible ? Justify your answer.

$2d^5$, $1s^2$, $3p^4$, $4d^3$, $3f^4$, $2s^4$, $2p^5$, $3d^{12}$

Activity – 5

Prepare a comprehensive table which contains the Atomic number, Name, Symbol, Shell Electronic Configuration, Subshell Electronic Configuration and Subshell Electronic Configuration in Short form of elements having atomic number **1 to 40.**

Atomic Number (Z)	Name	Symbol	Shell Electronic Configuration	Subshell Electronic Configuration	Short Form Configuration
1	Hydrogen	H	1	$1s^1$	--
2	Helium	He	2	$1s^2$	--
3	Lithium	Li	2,1	$1s^2\ 2s^1$	[He] $2s^1$
4					
5					
6					
7					
8					

Activity – 6

Identify the correct electronic configuration of Cu (Z=29) from those given below. Justify your answer.

a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^9$ OR $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9\ 4s^2$

b)$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$ OR $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$

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1 Periodic Table and Electronic Configuration

Important Points & Activities :

- Based on the subshell electronic configuration, elements are classified into four different blocks **s,p,d and f** in the modern periodic table.
- The block to which the element belongs will be the same as the subshell to which the last electron is added.
  - **s block –** The Elements of Group **1** & Group **2** and Helium (**14** Elements)
  - **p block** The Elements in Group **13** to Group **18** except Helium (**36** Elements)
  - **d block** The Elements in Group **3** to Group **12** (**40** Elements)
  - **f block –** The Elements placed at the bottom of the periodic table in two separate rows **(Lanthanoids & Actinoids)** (**28** Elements)
- **s block and p block** elements are collectively called **Representative elements.**
- Based on the subshell electronic configuration, we can find out the **period, block, group, atomic number, number of s,p,d electrons and valency** of elements.
  - **Period :** The **Period number** is same as the **highest shell number** (the shell number of the outer most shell) in the subshell electronic configuration**.**
  - **Block :** While writing the subshell electronic configuration of an element in the increasing order of the energy of subshells (According to Aufbau principle), **the subshell to which the last electron enters is same as the block** of that element.
  - **Group :**
    1) For **s block** elements, the **number of electrons** present in **the outermost s subshell** will be the **group number**.
    2) For **p block** elements, group number is obtained by **adding 12 to the number of electrons presesnt in the outermost p subshell**.

OR

Group number is obtained by **adding 10** to the **total number of electrons** present in the **outermost s and p subshells OR outermost shell**.

3) For **d block** elements, group number is obtained by finding the **sum of the number of electrons** present in the **outermost s subshell and the inner d subshell OR (4s + 3d).**

4) **f block** elements are **not included in any one** of the groups.

✽ **Atomic Number (Z) :** The **sum obtained by adding the numbers given as superscripts** in the subshell electronic configuration of an element will be equal to the **Atomic number(Z).**

✽ **s electrons : Sum of the number of electrons present in the s subshells** will be **equal** to the **number of s electrons**.

✽ **p electrons : Sum of the number of electrons present in the p subshells** will be **equal** to the **number of p electrons**.

✽ **d electrons : Sum of the number of electrons present in the d subshells** will be **equal** to the **number of d electrons**.

✽ **Valency :** In the case of Representative elements, by knowing the group number, the number of valence electrons (number of electrons in the outermost shell) can be calculated.

In s block elements

No. of valence electrons = Group Number. (Except Helium)

In p block elements

No. of valence electrons = Group Number – 10

For elements which contain **1 to 4** electrons in the outermost shell, **valency** will be **equal** to the number of **valence electrons**.
For elements which contain **5 to 8** electrons in the outermost shell, **valency** can be obtained by **subtracting the number of valence electrons from 8**.

Group Number	No. of Valence Electrons	Valency
1	1	1
2	2	2
13	13 – 10 = 3	3
14	14 – 10 = 4	4
15	15 – 10 = 5	8 – 5 = 3
16	16 – 10 = 6	8 – 6 = 2
17	17 – 10 = 7	8 – 7 = 1
18	18 – 10 = 8	8 – 8 = 0

✤ **Oxidation State or Oxidation Number** is a number assigned to an element in chemical combination which represents the number of electrons lost or gained by an atom of that element in the compound. Usually, **metals show positive** and **non metals show negative** oxidation states.

✤ If we know the **Group number** and **Valency** of the constituent elements, we can write the chemical formula of the compound formed by them as follows.

1) Write down the symbols of the constituent elements in the increasing order of their electronegativities. That is, write the symbol of the **less electronegative element first and then the symbol of the more electronegative element.**
2) **Interchange their valencies** and write them as **subscripts**.
3) **Simplify the subscripts** and write them in the smallest whole number ratio.

✤ **Trends in Periods and Groups : - (Excluding Noble gases)**

Periodic Trends	Down the Group (From Top to Bottom)	Across the Period (From Left to Right)
Size of atom	Increases	Decreases
Metallic character	Increases	Decreases
Non-metallic character	Decreases	Increases
Ionization energy	Decreases	Increases
Electronegativity	Decreases	Increases

Activity – 1

If the subshell wise electronic configuration of an atom is $1s^2\ 2s^2\ 2p^6\ 3s^2$, find answers to the following Questions :

1) How many shells are present in this atom?

2) Which are the subshells of each shell?

3) Which is the subshell to which the last electron was added?

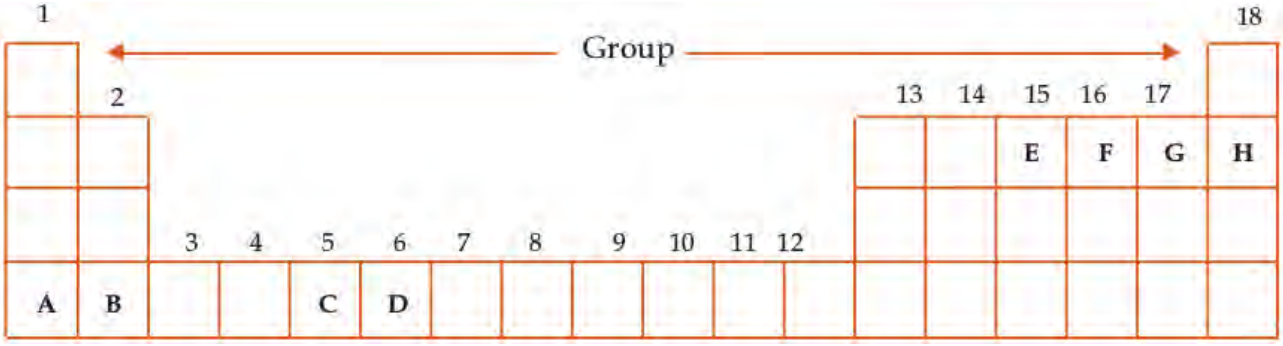
4) What is the total number of electrons in the atom?

5) What is its atomic number?

6) How can the subshell electronic configuration be written in short form?

Activity – 2

Analyse the given part of the periodic table and answer the following questions.



1) List out the **s,p and d** block elements.

2) Which element shows **valency 2** and **oxidation state +2** ?

3) Which element contains **5** electrons in the outermost shell ?

4) Which is the element that has **5 p** electrons in the outermost shell ?

5) Which are the elements in which the last electron enters into the **d** subshell ?

6) Which element has the lowest ionisation energy ?

7) Which is the highly reactive non metal ?

8) Which is the highly reactive metal ?

9) Which element shows valency **2** and oxidation state **−2** ?

10) Identify the Noble gas / Inert gas.

11) Which is the most electronegative element ?

Activity – 3

Based on the hints given, find out the atomic number and write down the subshell electronic configuration of elements (Symbols used are not real).

i) A — Period 3 , Group 17

ii) B —Period 4 , Group 6

Activity – 4

When the last electron of an atom was filled in the 3d subshell, the subshell electronic configuration was $3d^8$. Answer the following questions related to this atom.

- Complete subshell electronic configuration
- Atomic number
- Block
- Period number
- Group number

Activity – 5

Subshell electronic configurations of some elements are given below. Based on these configurations, find out the Atomic number, Period, Block, Group, Number of s, p and d electrons of these elements.

Subshell configuration	Atomic number	Period	Block	Group	No. of electrons		
					s	p	d
$1s^2\ 2s^2\ 2p^4$	8	2	p	16	4	4	0
$1s^2\ 2s^2\ 2p^6\ 3s^1$							
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$							
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$							
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$							
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$							
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^8$							
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^2$							
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$							

1 Periodic Table and Electronic Configuration

Important Points & Activities :

✤ Characteristics of 's block' Elements :-

* Elements in which the last electron enters into the **s – subshell of the outermost shell** are called **s – block** elements.
* **s – block elements** contain the elements in Group 1 & Group 2 and Helium).
* Highest **shell number** in the subshell electronic configuration is the **period** number.
* Number of electrons present in the **outermost s – subshell** is equal to the **group number.**
* **s – block** elements show **fixed valencies** and **fixed oxidation states. (** Valency of Group 1 elements is **1** and their oxidation state is **+1**. Similarly, Valency of Group 2 elements is **2** and their oxidation state is **+2)**
* Oxides and hydroxides of s – block elements are **basic** in nature.
* **s – block** elements show **low ionization energy** and **low electronegativity.**
* **s – block** elements show **Metallic character** and **lose electrons** in chemical reactions.
* Compounds of **s – block** elements are mostly **ionic in nature.**
* **Group 1 elements** of **s – block** have **greater reactivity** in their respective periods.
* Reactivity **increases** down the group**.**
* They have highest atomic radius in the respective periods.
* The outermost s – subshell of the s block elements contain **1 to 2** electrons.

✤ Characteristics of 'p block' Elements :-

* Elements in which the last electron enters into the **p – subshell of the outermost shell** are called **p** – block elements.
* **p – block elements** contain the elements of **Group 13 to Group 18 (Except Helium).**
* The outermost **p** – subshell of the **p block** elements contain **1 to 6** electrons.
* **p – block** elements contain **metals, non metals and metalloids.**
* Elements in the **solid, liquid and gaseous states** at room temperature are present in **p – block**.
* Highest **shell number** in the subshell electronic configuration is the **period** number.
* **Group number** = the no. of electrons in the **last p subshell +12**

  OR

  (The no. of electrons in the **last/outermost shell + 10)**
* Among the **p – block** elements, the highest reactivity is shown by **group 17 elements.**
* **Fluorine** is the most reactive element in Group 17.
* **p – block** elements show both **positive and negative** oxidation states.
* **Noble gases** are present in the **p – block.**
* Non metallic character **increases along a period.**
* **p – block** elements show **fixed oxidation states.**
* **Ionization energy** and **electronegativity** increases along a period.

✤ Characteristics of 'd block' Elements :-

* Elements in which the last electron enters into the **d – subshell of the penultimate shell** (the shell preceding/just inside the outermost shell) are called **d – block** elements.
* These elements are also known as **Transition Elements.**
* **d– block** elements contain the elements of 10 groups from **Group 3** to **Group 12.**
* Highest **shell number** in the subshell electronic configuration is the **period** number.

* **Group number =** Total no. of electrons in the **last s** and **d subshells OR (4s + 3d)**
* All **d – block elements** are **Metals.**
* **d – block elements** show **both vertical similarity**(similarity in a group) **and horizontal similarity** (similarity along a period) in properties.

[The no. of electrons present in the outermost shell **or** the outermost shell electronic configuration of Transition elements is generally the same in a group and also along a period. Hence, they show similarity in properties not only in a group but also in a period.**]**

* **d – block elements** show **variable valencies** and **variable oxidation states.**

  Eg :-- 1) Iron (Fe) forms two types of compounds **--- Ferrous** compounds **& Ferric** compounds**.** In Ferrous compounds, the valency of **Fe** is **2** and oxidation state of **Fe** is **+2.** Similarly, in Ferric compounds, the valency of **Fe** is **3** and oxidation state of **Fe** is **+3. eg:-- [$FeCl_2$ & $FeCl_3$]**

  2) Copper (Cu) forms two types of compounds **--- Cuprous** compounds **& Cupric** compounds**.** In Cuprous compounds, the valency of **Cu** is **1** and oxidation state of **Cu** is **+1.** Similarly, in Cupric compounds, the valency of **Cu** is **2** and oxidation state of **Cu** is **+2. eg:-- [CuCl & $CuCl_2$]**

[In the case of Transition or **d – block** elements, the difference in energy between the **outermost s – subshell and the penultimate d – subshell** is very small. Hence, under suitable conditions, in addition to the outermost **s electrons**, the electrons in the inner **d – subshell** can also take part in chemical reactions. This accounts for the **variable valencies & oxidation states** shown by the Transition or **d – block** elements.**]**

* They form **coloured compounds.**

  Eg:- Copper sulphate **--- Blue**
  Cobalt nitrate **--- Pink**
  Potassium permanganate **--- Violet**
  Ferrous sulphate **--- Green**

Uses :- **1)** Coloured compounds of **d – block** elements are used in the manufacture of **coloured glass**.

2) Coloured compounds of **d – block** elements are used as **colour pigments**.

✤ Subshell Electronic Configuration of ions :--

Subshell electronic configuration of positive ions can be written by removing the electrons, corresponding to the charge of the ion. In doing so, the electrons should be removed first from the outermost shell.

Eg :-- **Fe (Z=26)** ---- $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^6$

Fe^{2+} ---- $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$

Fe^{3+} ---- $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$

✤ Characteristics of 'f block' Elements :-

* Elements in which the last electron enters into the **f – subshell of the ante penultimate shell** (the shell preceding/just inside the penultimate shell) are called **f – block** elements.
* These elements are also known as **Inner Transition Elements.**
* These elements are placed in two separate rows at the bottom of the periodic table.
  [First row **--- Lanthanoids** and Second row **--- Actinoids**]
* Most of these elements show **variable valencies** and **variable oxidation states**.
* Most of the **Actinoids** are **artificial elements** and **radio active** in nature.
* Uranium (U), Thorium (Th), Plutonium (Pu) etc. are used as **fuels** in **nuclear reactors.**
* Many of these elements are used as **catalysts** in the **petroleum industry.**

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Activity – 1

Complete the Table given below.[Hint : X,Y (symbols are not real) **and O** are elements of the **groups 1,2 and 16 respectively)**

Group	Valency	Oxidation state	Symbol of ions	Chemical formula of oxides
1st group [X]	1	+1	-	X_2O
2nd group [Y]	2	-	Y^{2+}	-

Activity – 2

Complete the Table given below and Answer the following questions.[Hint : X and Y are not **real symbols]**

Element	Outermost electronic configuration	Complete subshell electronic configuration	Atomic number Z	Period	Group	Block
X	$3s^2$					
Y	$3s^2 3p^5$					

1) Which element has a valency 1 ?
2) Which element shows metallic character ?
3) Which element has the highest ionisation energy ?
4) Write the chemical formula of the compound formed by the combination of X and Y and label the oxidation states.

Activity – 3

Pick out the wrong subshell electronic configurations from those given below. Justify your answer

1) $1s^2\ 2s^2\ 2p^7$
2) $1s^2\ 2s^2\ 2p^2$
3) $1s^2\ 2s^2\ 2p^5\ 3s^1$
4) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^1$
5) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$

Activity – 4

The outermost electronic configuration of an element is $3s^2\ 3p^4$.

1) Write down the complete subshell electronic configuration of this element.
2) Identify the block of this element.
3) Write any two characteristics of this element.

Activity – 5

The element X in group 17 has 3 shells. If so,

1) Write down the subshell electronic configuration of X.
2) Identify the period of this element.
3) Write down the chemical formula of the compound formed, when X reacts with another element Y of the third period which contains one electron in the p subshell.

Activity – 6

Find the oxidation states of Fe and Cu in their compounds and then complete the Table given below. [The Oxidation state of chlorine is (−1)]

Compound	Oxidation state of the metal	Symbol of the metal ions
$FeCl_3$		
$CuCl_2$		
$FeCl_2$		
CuCl		

Write down the subshell electronic configuration of the ions

Activity – 7

Find the oxidation states of Mn in the given compounds of Manganese (Z=25) and then complete the Table given below. [The Oxidation state of Chlorine = −1 and Oxygen = −2]

Compound	Oxidation state of Mn	Symbol of the Mn ions	Subshell electronic configuration of the Mn ions
$MnCl_2$			
MnO_2			
Mn_2O_3			
Mn_2O_7			

Activity – 8

Match the following suitably.

Column A	Column B
s - block	Used as fuels in nuclear reactors.
d - block	Show low ionization energy and low electronegativity.
f - block	Show both positive and negative oxidation states.
p - block	Can form coloured compounds.

2 Gas Laws and Mole Concept

Important Points & Activities :

✽ Gas Laws : -

✤ Characteristic properties of Gases :-

- ❖ Each gas contains a large number of minute molecules.
- ❖ The real volume of a gas molecule is very less when compared to the total volume of the gas.
- ❖ The molecules of a gas are in a state of rapid random motion in all directions.
- ❖ During the random motion of the gas molecules, they collide with each other and also with the walls of the container in which it is kept.
- ❖ The collision of the gas molecules with the walls of the container creates the pressure of the gas.
- ❖ As the collision of molecules are perfectly elastic in nature, there is no loss of energy.
- ❖ There is no attraction between the gas molecules and the walls of the container.

✤ Molecular Arrangement in Gases :-

- ❖ Distance between the molecules is very large.
- ❖ Attractive force between the molecules is very low.
- ❖ Freedom of movement of molecules is very high.
- ❖ Energy of gas molecules is very high.
- ❖ Gases can be easily compressed by the application of Pressure.
- ❖ Gases can readily undergo Diffusion.

✤ Volume, Pressure & Temperature of a Gas :-

- ❖ **Volume of a Gas :-**

  Volume of a gas is the volume of the container which occupies the gas.

  Eg :- If a gas, which is kept in a cylinder having a volume of **1 litre**, is completely transferred to another **10 litre** cylinder then the new volume of the gas will be **10 litre**.

❖ **Pressure of a Gas :-**

Pressure of a gas is the force experienced per unit area on the inner surface of the container as a result of the collision of the gas molecules on the surface.

$$\text{Force on unit area} = \frac{\text{Total force exerted on the surface}}{\text{Surface area}}$$

❖ **Temperature of a Gas :-**

Temperature of a gas is the average kinetic energy of the molecules of that gas.

✤ **Behaviour of Gases with respect to Volume , Pressure , Temperatue & Amount :-**

Laws, which describe the behaviour of gases with respect to volume, temperature, pressure, and amount of gas are known as **Gas laws**.

The three important gas laws are,

1) Boyle's Law 2) Charle's Law and **3) Avogadro's Law.**

✤ **Relation between Volume of a gas and Pressure (Boyle's Law) :-**

Boyle's law states that at a constant temperature, the volume of a definite mass of a gas is inversely proportional to its pressure.

If **P** is the pressure and **V** the volume, then **P x V** is a constant.

Mathematical Expression :-

$V \propto 1/P$ [when **T** and **n** are constants]

Mathematical Equation :-

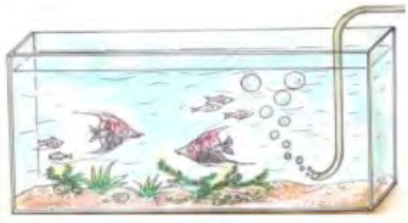
$PV = A\ Constant$

Practical Equation :-

$P_1V_1 = P_2V_2$

Situations related to Boyle's Law :-

♣ Pull the piston of a syringe backwards. Press the piston after closing the nozzle of the syringe. On pressing the piston after closing its nozzle, the volume of the gas inside the syringe decreases.



♣ The size of the air bubbles rising from the bottom of an aquarium increases.

♣ The size of the air bubbles rising from the base(bottom) of a pond **OR** any other water reservoir increases .

♣ The size of Climate balloons increases as they move in upward direction to the higher altitudes in the atmosphere.

♣ When an inflated balloon is immersed in water, its size decreases. etc

[As we move from bottom to top, the external pressure decreases. Then the volume of the air bubble or volume of the gas inside the balloon increases. Hence, their size increases. (Boyle's law).]

✤ **Relation between Volume of a gas and Temperature (Charle's Law) :-**

Charle's law states that at constant pressure, the volume of a definite mass of a gas is directly proportional to the temperature in Kelvin Scale.

If **V** is the volume and **T** the temperature, then **V/T** will be a constant.

Mathematical Expression :-

V α T [when **P** and **n** are constants]

Mathematical Equation :-

V/T = A Constant

Practical Equation :-

$V_1 / T_1 = V_2 / T_2$

Situations related to Charle's Law :-

♣ When an inflated balloon is kept in sunlight, it will burst.

♣ Vehicle tyres are not fully inflated during summer.

♣ When an inflated balloon is kept in cold water, its size decreases.

♣ An experiment using a dry injection bottle, a holed rubber stopper and a refill with a drop of ink inserted at the lower end.

[As the temperature increases, the volume of the gas/air inside the balloon/tyre increases and finally it bursts. As the temperature decreases, the volume of the gas/air inside the balloon decreases and the size of the balloon decreases.(Charle's Law)]

✤ **Relation between Volume of a gas and No.of Molecules (Avogadro's Law) :-**

Avogadro's Law states that at constant temperature and pressure, the volume of a gas is directly proportional to the number of molecules.

If **V** is the volume and **n** the no. of molecules, then **V/n** will be a constant.

OR

Under the same conditions of temperature and pressure, equal volumes of all gases will contain equal number of molecules .

Mathematical Expression :-

V α n [when **P** and **T** are constants]

Mathematical Equation :-

$V/n = A$ Constant

Practical Equation :-

$V_1/n_1 = V_2/n_2$

Situations related to Avogadro's Law :-

- ♣ The volume(size) of a balloon increases when the balloon is inflated and its volume(size) decreases when the air is removed from the balloon.
- ♣ Filling of air in the tyres of vehicles.
- ♣ Filling of air in air bed.
- ♣ The size of tyres decreases when air escapes out through the puncture . Etc.

❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖❖

Activity – 1

Pick out the correct statement from those given below.

1) The real volume of a gas molecule is very large when compared to the total volume of the gas.
2) The collision of the gas molecules with the walls of the container creates the pressure of the gas.
3) The collision of the gas molecules are not elastic in nature.
4) The force of attraction between the gas molecules is very high.

Activity – 2

Examine the data given in the table (Temperature and number of molecules of the gas are kept constant). Complete the table and answer the following questions.

Pressure (P)	Volume (V)	PV
1 atm	8 L	-----
2 atm	4 L	-----
4 atm	2 L	-----
8 atm	1 L	-----

1) Calculate P x V.
2) What is the peculiarity in the value of PV ?
3) Identify the gas law related to this.
4) Write down the mathematical expression that represents this gas law.
5) What will be the volume of this gas at 16 atm pressure ?

Activity – 3

Examine the data given in the table (Pressure and number of molecules of the gas are kept constant). Complete the table and answer the following questions.

Volume (V)	Temperature (T)	V/T
546 mL	273 K	-----
600 mL	300 K	-----
700 mL	350 K	-----
800 mL	400 K	-----

1) Calculate V/T
2) What is the peculiarity in the value of V/T ?
3) Identify the gas law related to this.
4) Write down the mathematical expression that represents this gas law.
5) What will be the volume of this gas at 450 K temperature ?

Activity – 4

Examine the data given in the table (Temperature and Pressure of the gas are kept constant). Complete the table and answer the following questions.

Volume (V)	No. of Molecules (n)	V/n
10 L	x	-----
20 L	2x	-----
5 L	x/2	-----
40 L	4x	-----

1) Calculate V/n.
2) What is the peculiarity in the value of V/n ?
3) Identify the gas law related to this.
4) Write down the mathematical expression that represents this gas law.
5) What will be the no. of molecules present, when the volume of this gas is increased to 80 L ?

Activity – 5

Analyse the situations given below and explain the gas law associated with it.

a) A balloon is being inflated.

b) When an inflated balloon is immersed in water, its size decreases.

c) When an inflated balloon is kept in sunlight, it bursts.

Activity – 6

10 L of a gas M (symbol is not real) at 300 K temperature and 1 atm pressure contains 'x' molecules. Answer the following.

a) What will be the volume of **'x'** molecules of another gas **N** (symbol is not real), which is kept under the same conditions of temperature and pressure ?

b) What will be the new volume of the gas M, if the temperature of the gas is raised to 600 K without making any change in the pressure and the no. of molecules ?

c) What will be the new volume of the gas M, if the pressure of the gas is raised to 2 atm without making any change in the temperature and the no. of molecules ?

2 Gas Laws and Mole Concept

Important Points & Activities :

✽ MOLE CONCEPT : - Gram Atomic Mass(GAM)

- ✤ In all chemical reactions, there exists a fixed ratio between the reactant molecules and the product molecules.
- ✤ For a complete chemical reaction to take place, the reactants should be taken in the specified ratio. This ratio may or may not be the same for different reactions.
- ✤ A chemical reaction stops when any one of the reactants is completely used up.
- ✤ If the particles are having the same size and mass, even though they are in crores, we can determine their accurate number on the basis of mass. That is, if we can **establish a relation between mass and number**, then we can calculate the number of particles (atoms, molecules etc) from a given mass and mass of particles from the given number.
- ✤ **Relative Atomic Mass :** Nowadays, it is possible to find out the accurate or absolute mass of minute particles through the modern techniques. For example, the accurate mass of a Hydrogen atom is **1.67×10^{-27} kg.** This is an extremely small number. Such extremely small numbers are very much inconvenient for calculations.
  - ✷ To overcome this difficulty, relative mass method is used to express the mass of minute particles like atoms, molecules etc.
  - ✷ In this method, the mass of an atom is compared with the mass of another atom and expressed as a number which shows how many times it is heavier than the other atom.
- ✤ The relative atomic mass of elements is expressed by considering one-twelfth(1/12) the mass of an atom of Carbon – 12 isotope as one unit. This mass is termed as **unified mass** or '**u**'.

1 u = 1/12 x mass of a Carbon – 12 atom.

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When expressed in kilograms, **1u = 1.6606 x 10^{-27} kg**

✤ **Gram Atomic Mass (GAM) :-**

The mass of an element in gram equal to its atomic mass **OR**
The atomic mass of an element expressed in gram, is called **Gram Atomic Mass or GAM.**

Eg :- Atomic Mass of Carbon = 12 and 1 GAM of Carbon = 12g

✤ One **GAM** of any element will contain **equal no. of atoms** and it is equal to **1 Mole** atoms **or Avogadro Number** (**6.022 x 10^{23}**) of atoms.

✤ The **mass** of **6.022 x 10^{23}** atoms or **1 Mole atoms** of any element is equal to its **Gram Atomic Mass (GAM)**.

✤ **Mole** is an important unit in chemistry, which is used to express the quantity of any substance or the no. of minute particles like atoms, molecules etc.

✤ 1 Mole of any particle will contain **6.022 x 10^{23}** no. of particles.

1 Mole Atoms = **6.022 x 10^{23}** atoms
1 Mole Molecules = **6.022 x 10^{23}** molecules
1 Mole Ions = **6.022 x 10^{23}** ions

✤ **1 Mole** may be defined as the quantity of any substance which contains **6.022 x 10^{23}** particles of that substance.

✤ This number **6.022 x 10^{23}** is also known as **Avogadro's Number OR Avogadro's Constant** and it is denoted by the symbol N_A .

1 Mole = 6.022 x 10^{23} no.of particles = Avogadro Number

✤ **Relation between No. of GAM, No. of Atoms and Mass :-**

✷ If a definite mass of an element and its GAM are given, we can calculate the no. of GAM using the following relation.

$$\text{No. of GAM} = \frac{\text{Given Mass in gram}}{\text{GAM}}$$

✷ If we know the no. of **GAM** present in the given sample, we can calculate the no. of atoms present in that sample. Similarly, if we know the **GAM** of an element and the no. of **GAM** present in the given sample of that element, we can calculate the mass of that sample.

No. of Atoms = No. of GAM x Avogadro's Number (N_A)

Mass = No. of GAM x GAM

MOLE

We are familiar with some units which represent the number.

1 Pair = 2 Nos.
1 Dozen = 12 Nos.
1 Score = 20 Nos.
1 Quire = 25 Nos. (Formerly 24 Nos.)
1 Gross = 144 Nos.
1 Ream = 500 Nos. (Formerly 480 Nos.)

Mole is an important unit in chemistry, which is used to express the number of minute particles like atoms, molecules, ions etc.

1 Mole = 6.022×10^{23} no.of particles

This number is also known as Avogadro Number (N_A).

1 Mole = 6.022×10^{23} no.of particles = Avogadro Number

Can you imagine the value of this number ?

1 Mole = 602200000000000000000000 Nos.

Activity -1

Complete the Table.

Element	Atomic Mass	Gram Atomic Mass (GAM)
Hydrogen	1	1 g
Carbon	12	12 g
Nitrogen	14	*****
Oxygen	*****	16 g
Sodium	23	*****
Aluminium	*****	27 g
Calcium	40	*****
Sulphur	*****	32 g
Magnesium	24	*****

Activity -2

Complete the Table.

Element	Gram Atomic Mass (GAM)	No. of GAM	No. of Atoms
Hydrogen	1 g	1	6.022×10^{23}
Carbon	12 g	1	6.022×10^{23}
Nitrogen	14 g	1	*****
Oxygen	16 g	*****	6.022×10^{23}
Sodium	23 g	1	*****
Aluminium	27 g	*****	6.022×10^{23}
Calcium	40 g	1	*****
Sulphur	32 g	*****	6.022×10^{23}
Magnesium	24 g	1	*****

Activity -3

Complete the Table.

Element	Gram Atomic Mass (GAM)	Given Mass in gram	No. of GAM	No. of Atoms
Hydrogen	1 g	1 g	1	6.022×10^{23}
Carbon	12 g	24 g	2	$2 \times 6.022 \times 10^{23}$
Nitrogen	14 g	28 g	2	*****
Oxygen	16 g	64 g	*****	$4 \times 6.022 \times 10^{23}$
Sodium	23 g	69 g	3	*****
Aluminium	27 g	*****	2	$2 \times 6.022 \times 10^{23}$
Calcium	40 g	200 g	*****	*****
Sulphur	32 g	*****	*****	6.022×10^{23}
Magnesium	24 g	*****	2	*****

Activity -4

Calculate the no. of GAM and no. of atoms present in the given samples.

1) 10 g Hydrogen
2) 36 g Carbon
3) 48 g Oxygen
4) 92 g Sodium
5) 70 g Nitrogen
6) 120 g Calcium

[Atomic Masses :- H=1, C=12, O=16, Na=23, N=14, Ca=40]

Eg:-

1) No. of GAM present in 10 g Hydrogen = $\frac{\text{Given Mass in gram}}{\text{GAM}}$

$= 10\ g / 1g$

$= \underline{10\ GAM}$

No. of atoms $= \text{No. of GAM} \times N_A$

$= \underline{10 \times 6.022 \times 10^{23}}$ atoms

$= \underline{6.022 \times 10^{24}}$ atoms

Activity -5

Calculate the mass of the given samples.

1) **3** mole atoms (3 GAM) of Calcium.
2) **5** mole atoms (5 GAM) of Nitrogen.
3) **4** mole atoms (4 GAM) of Sodium.
4) **3** mole atoms (3 GAM) of Oxygen.
5) **3** mole atoms (3 GAM) of Carbon.
6) **10** mole atoms (10 GAM) of Hydrogen.

[Atomic Masses :- H=1, C=12, O=16, Na=23, N=14, Ca=40]

Eg:-

1) Mass of 3 mole atoms
(3 GAM) of Calcium = No. of GAM x GAM of Calcium
= 3 x 40 g
= 120 g

****

2 Gas Laws and Mole Concept

Important Points & Activities :

✽ MOLE CONCEPT : - Gram Molecular Mass(GMM)

✤ **Molecular Mass :-** In the free state, elements and compounds exist as molecules. The mass of one molecule of an element or a compound is termed as the **molecular mass (MM)**. It is also expressed in terms of unified mass '**u**'.

✤ Molecular mass of a substance can be calculated by finding the sum of the atomic masses of the individual atoms present in one molecule of that substance.

Eg :- H_2O **[Atomic masses → H=1, O=16]**

Molecular mass of H_2O = (No. of Hydrogen atoms **x** Atomic mass of Hydrogen) + (No. of Oxygen atoms **x** Atomic mass of Oxygen)

= (2 x 1) + (1 x 16)

= 2 + 16 = 18

✤ **Gram Molecular Mass (GMM) :-**

The mass of a substance in gram, equal to its molecular mass is called **Gram Molecular Mass** or **GMM** or **Gram Mole**.

OR

The molecular mass of a substance expressed in gram, is called **Gram Molecular Mass** or **GMM** or **Gram Mole**.

Eg :- Molecular Mass of Water = 18 and 1 GMM of Water = 18g

✤ One **GMM** of any element or any compound will contain **equal** no. of molecules and it is equal to **1 Mole** molecules or **Avogadro Number** (6.022×10^{23}) of molecules.

✤ The mass of 6.022×10^{23} molecules or **1 Mole** molecules of any element or any compound is equal to its **Gram Molecular Mass (GMM)**.

✤ **Relation between No. of GMM, No. of Molecules and Mass** :-

✷ If a definite mass of an element or a compound and its GMM are given, we can calculate the no. of GMM using the following relation

$$\text{No. of GMM} = \frac{\text{Given Mass in gram}}{\text{GMM}}$$

✷ If we know the no. of GMM present in the given sample, we can calculate the **no. of molecules** present in that sample. Similarly, if we know the GMM of an element or a compound and the no. of GMM present in the given sample of that element or compound, we can calculate the **mass** of that sample.

No. of molecules = No. of GMM x Avogadro's Number (N_A)

Mass = No. of GMM x GMM

✤ **Atomicity** :- **Atomicity** is defined as the total no. of atoms that constitute a molecule. (Total no. of atoms present in one molecule)

✤ **Different Types of Atomicity** :-

Monoatomic molecule – Consist of only **one** atom. **Eg:- Na, Ar, K, C etc.**

Diatomic molecules -- Consist of **two** atoms. **Eg :- H_2, O_2, N_2 etc.**

Triatomic molecules -- Consist of **three** atoms. **Eg:- O_3 , H_2O, CO_2 etc.**

Polyatomic molecules – Molecules, which consist of **three** or **more than three** atoms, are generally known as Polyatomic molecules. **Eg :- P_4 , S_8 , NH_3 etc.**

✤ **Relation between No. of Atoms, No. of Molecules and Atomicity** :-

✷ In the case of **monoatomic** molecules, the no. of molecules will be equal to the no. of atoms.

Eg:- The no. of molecules present in **12 g** Carbon(C) is **1 mole(N_A)**
The no. of atoms present in **12 g** Carbon(C) is also **1 mole(N_A)**

✷ In the case of molecules other than **monoatomic**, if we **multiply the no. of molecules** by **atomicity**, we will get the no. of atoms and, if we **divide the no. of atoms** by **atomicity**, we will get the no. of molecules.

Eg:- The no. of molecules present in **10 g** Hydrogen(H_2) is **5 mole.**
The no. of atoms present in **10 g** Hydrogen(H_2) is **10 mole.**

Activity – 1

Complete the table given below. (Atomic Mass : H=1, O=16, N=14)

Element / Compound	Chemical formula	Molecular mass
Hydrogen	H_2	1+1 = 2
Oxygen	O_2	.....
Nitrogen	N_2	.....
Water	H_2O	1+1 +16 = 18
Ammonia	NH_3	.....

Activity – 2

Calculate the molecular mass of the compounds given below.

1) Sodium Hydroxide (NaOH)
2) Sodium Chloride (NaCl)
3) Calcium carbonate ($CaCO_3$)
4) Sulphuric Acid (H_2SO_4)
5) Glucose ($C_6H_{12}O_6$)
6) Sucrose or Cane Sugar ($C_{12}H_{22}O_{11}$)

Atomic Mass

H=1	Cl=35.5
O=16	Ca=40
C=12	Na=23
S=32	

Activity – 3

Complete the Table.

Element/ Compound	Molecular Mass	Gram Molecular Mass (GMM)
Hydrogen (H_2)	2	2 g
Water (H_2O)	18	18 g
Nitrogen (N_2)	28	*****
Ammonia (NH_3)	*****	17 g
Sodium chloride (NaCl)	58.5	*****
Sulphuric acid (H_2SO_4)	*****	98 g
Methane (CH_4)	16	*****
Carbon dioxide (CO_2)	*****	44 g
Glucose ($C_6H_{12}O_6$)	180	*****

Activity – 4

Complete the Table.

Element/ Compound	Gram Molecular Mass (GMM)	No. of GMM	No. of Molecules
Hydrogen (H_2)	2 g	1	6.022×10^{23}
Water (H_2O)	18 g	1	6.022×10^{23}
Nitrogen (N_2)	28 g	1	*****
Ammonia (NH_3)	17 g	*****	6.022×10^{23}
Sodium chloride (NaCl)	58.5 g	1	*****
Sulphuric acid (H_2SO_4)	98 g	*****	6.022×10^{23}
Methane (CH_4)	16 g	1	*****
Carbon dioxide (CO_2)	44 g	*****	6.022×10^{23}
Glucose ($C_6H_{12}O_6$)	180 g	1	*****

Activity – 5

Complete the Table.

Element / Compound	Gram Molecular Mass (GMM)	Given Mass in gram	No. of GMM	No. of Molecules
Hydrogen (H_2)	2 g	2 g	1	6.022×10^{23}
Water (H_2O)	18 g	36 g	2	$2 \times 6.022 \times 10^{23}$
Nitrogen (N_2)	28 g	56 g	2	*****
Ammonia (NH_3)	17 g	68 g	*****	$4 \times 6.022 \times 10^{23}$
Sodium chloride (NaCl)	58.5 g	117 g	2	*****
Sulphuric acid (H_2SO_4)	98 g	*****	3	$3 \times 6.022 \times 10^{23}$
Methane (CH_4)	16 g	80 g	*****	*****
Carbon dioxide (CO_2)	44 g	*****	*****	$2 \times 6.022 \times 10^{23}$
Glucose ($C_6H_{12}O_6$)	180 g	*****	2	*****

Activity – 6

Calculate the no. of GMM and no. of molecules present in the given samples.

1) 10 g Hydrogen (H_2)
2) 108 g Water (H_2O)
3) 48 g Methane (CH_4)
4) 85 g Ammonia (NH_3)
5) 720 g Glucose ($C_6H_{12}O_6$)
6) 88 g Carbon dioxide (CO_2)

Molecular Mass

$H_2=2$ $H_2O=18$
$CH_4=16$ $NH_3=17$
$CO_2=44$
$C_6H_{12}O_6=180$

Eg:-

1) No. of GMM present in 10 g Hydrogen = $\frac{\text{Given mass in gram}}{\text{GMM}}$
= 10 g / 2g
= 5 GMM

No. of molecules = No. of GMM x N_A
= 5 x 6.022 x 10^{23} molecules

Activity – 7

Calculate the mass of the given samples.

1) 2 mole (2 GMM) Carbon dioxide (CO_2).
2) 4 mole (4 GMM) Glucose ($C_6H_{12}O_6$).
3) 5 mole (5 GMM) Ammonia (NH_3).
4) 3 mole (3 GMM) Methane (CH_4).
5) 6 mole (6 GMM) Water (H_2O).
6) 5 mole (5 GMM) Hydrogen (H_2).

Molecular Mass

$H_2=2$ $H_2O=18$
$CH_4=16$ $NH_3=17$
$CO_2=44$
$C_6H_{12}O_6=180$

Eg:-

1) Mass of 2 mole (2 GMM) Carbon dioxide = No. of GMM x GMM of Carbon dioxide
= 2 x 44 g
= 88 g

Activity – 8

Complete the Table.

Element / Compouond	Chemical Formula	Atomicity
Carbon	C	1
Hydrogen	H_2	•••••
Ozone	O_3	3
Sulphur	S_8	•••••
Water	H_2O	3

Activity – 9

Complete the Table.

Mass of the Element / Compound	No. of GMM	Atomicity	No. of Molecules	No. of Atoms
8 g H_2	4	2	4 x 6.022 x 10^{23}	8 x 6.022 x 10^{23}
90 g H_2O	5	3	5 x 6.022 x 10^{23}	15 x 6.022 x 10^{23}
124 g P_4	4	4	4 x 6.022 x 10^{23}	*****
51 g NH_3	3	4	*****	12 x 6.022 x 10^{23}
46 g Na	2	*****	2 x 6.022 x 10^{23}	2 x 6.022 x 10^{23}
160 g S_8	5	*****	*****	40 x 6.022 x 10^{23}
64 g CH_4	*****	5	4 x 6.022 x 10^{23}	*****
132 g CO_2	3	*****	*****	9 x 6.022 x 10^{23}
360 g $C_6H_{12}O_6$	*****	24	2 x 6.022 x 10^{23}	*****
64 g SO_2	*****	*****	*****	*****

[Molecular mass of Sulphur dioxide (SO_2) = 64]

****

2 Gas Laws and Mole Concept

Important Points & Activities :

✽ MOLE CONCEPT : - Volume of a gas and No. of Moles

✤ **Molar Volume :-**

The volume of one mole of any gas is called the **Molar Volume.**
At **STP,** the molar volume of any gas is equal to **22.4 litre.**

Molar Volume of any gas at STP = 22.4 L

✤ **273 K** Temperature and **1 atm** Pressure are known as **STP** **OR** **Standard Temperature and Pressure.**

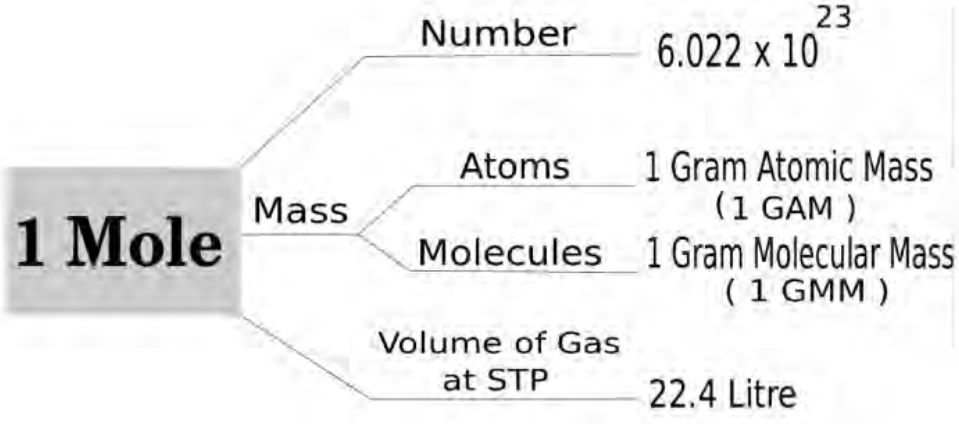
✤ Under the same conditions of Temperature and Pressure, one mole of any gas will contain the same (equal) number of molecules.

OR

Under the same conditions of Temperature and Pressure, the volume of one mole of any gas will be the same.

OR

Under the same conditions of Temperature and Pressure, equal number of molecules of all gases will have equal volumes.



✤ If we know the volume of a gas in litre at STP, we can calculate the no. of moles and no. of molecules using the relation given below.

$$\text{Number of Moles} = \frac{\text{Given Volume in litre at STP}}{22.4\ \text{L}}$$

No. of molecules = No. of moles x Avogadro's Number

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Eg :- Calculate the no. of moles and no. of molecules present in **224 L** Helium (He) gas STP.

No. of moles present in 224 L He $= \frac{\text{Given Volume in litre at STP}}{22.4\ \text{L}}$

$= 224 / 22.4$

$= \underline{10 \text{ moles.}}$

∴ No. of molecules = **No. of moles x Avogadro's Number**

$= \underline{10 \times 6.022 \times 10^{23}}$ **molecules.**

$= \underline{6.022 \times 10^{24}}$ **molecules.**

✤ If we know the no. of moles of a gas at STP, we can calculate its volume using the relation given below.

Volume of the gas at STP = No. of moles x 22.4 L

Eg :- Calculate the volume **10 mole** Helium (He) gas at STP.

Volume of the gas at STP = No. of moles x 22.4 L

= 10 x 22.4 L

= 224 L

✤ **Calculation of Number of Moles in different situations :-**

1) **If the no. of particles is given :-**

$$\text{Number of moles} = \frac{\text{Given No.of Particles}}{6.022 \times 10^{23}}$$

2) **If the Mass is given :-**

$$\text{Number of moles of Atoms} = \frac{\text{Given Mass in gram}}{\text{GAM}}$$

$$\text{Number of moles of Molecules} = \frac{\text{Given Mass in gram}}{\text{GMM}}$$

3) **If the Volume of Gas at STP is given :-**

$$\text{Number of Moles} = \frac{\text{Given Volume in litre at STP}}{22.4\ \text{L}}$$

• • • • • • • • • • • •

Activity – 1

Calculate the no. of moles and no. of molecules present in the given samples of gases at STP.

1) 44.8 L CO_2
2) 22.4 L SO_2
3) 67.2 L NH_3
4) 112 L H_2O
5) 89.6 L CH_4
6) 67.2 L O_2

Activity – 2

Calculate the volume of the given gases in litre at STP.

1) 3 mole Oxygen **(O_2)**
2) 4 mole Methane **(CH_4)**
3) 5 mole Water Vapour**(H_2O)**
4) 3 mole Ammonia **(NH_3)**
5) 1 mole Sulphur dioxide **(SO_2)**
6) 2 mole Carbon dioxide **(CO_2)**

Activity – 3

Some data regarding various gases kept at STP are given below. Complete the Table.

Gas	Volume (L)	No. of moles	No. of molecules
Hydrogen	22.4 L	1	6.022×10^{23}
Oxygen	67.2 L	3	•••••
Nitrogen	112 L	•••••	$5 \times 6.022 \times 10^{23}$
Ammonia	•••••	2	$2 \times 6.022 \times 10^{23}$
Methane	89.6 L	•••••	•••••

Activity – 4

Calculate the no. of moles present in the given samples.

1) **6.022×10^{23}** Oxygen molecules.
2) **100** Water molecules.
3) **1** molecule of Carbon dioxide.
4) **12.044×10^{23}** Hydrogen atoms.
5) **18.066×10^{23}** Sodium ions.

Activity – 5

Calculate the no. of particles present in the given samples.

1) **3** moles of Sodium ions.
2) **2** moles of Hydrogen atoms.
3) **1/ 6.022×10^{23}** moles of Carbon dioxide.
4) **100/ 6.022×10^{23}** moles of Water .
5) **1** mole Oxygen molecules.

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Activity – 6

Two samples of gases kept at STP are given below. Examine the given data and answer the following questions.

Sample A – 112 L CO_2 (Molecular mass of CO_2 = 44)

Sample B – 68 g NH_3 (Molecular mass of NH_3 = 17)

1) Calculate the no. of moles present in the samples A and B.
2) Calculate the no. of molecules present in the samples A and B.
3) Which sample contains more no. of molecules ?
4) Which sample contains more no. of atoms ?
5) Calculate the mass of sample A.
6) Calculate the volume of sample B.

Activity – 7

Some data regarding various gases kept at STP are given below. Complete the Table.

Gas	Volume (L)	No. of moles	No. of molecules	Mass (g)
Hydrogen (H_2)	22.4 L	1	6.022×10^{23}	2 g
Carbon dioxide (CO_2)	67.2 L	3	•••••	132 g
Nitrogen (N_2)	89.6 L	•••••	$4 \times 6.022 \times 10^{23}$	•••••
Ammonia (NH_3)	•••••	6	$6 \times 6.022 \times 10^{23}$	•••••
Methane (CH_4)	112 L	•••••	•••••	•••••
Oxygen (O_2)	•••••	•••••	•••••	160 g

(Molecular Masses – H_2=**2**, O_2=**32**, N_2=**28**, NH_3=**17**, CH_4=**16**, CO_2=**44**)

Activity – 8

Examine the given samples and answer the following questions.

1) 20 g He
2) 44.8 L NH_3 at STP
3) 67.2 L N_2 at STP
4) 1 mole H_2SO_4
5) 89.6 L CH_4 at STP
6) 180 g Water

1) **Arrange the samples in the increasing order (Ascending order) of molecules ?**
2) **Arrange the samples in the decreasing order (Descending order)of atoms ?**
3) **Arrange the samples in the increasing order of their masses ?**

••••••••••

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3 Reactivity series and Electrochemistry

Important Points & Activities - 1

✽ Reactivity of Metals & Reactivity Series

✤ The reactivity of different metals is different. While some metals take part in chemical reactions vigorously, certain others react sluggishly in the same reaction. Let us find out the difference in reactivity of some metals on the basis of their reactions with water, atmospheric air and dilute acids.

✤ **Reaction of metals with water :-**

Let us compare the reaction of Sodium (Na), Magnesium (Mg), Iron (Fe) and Copper (Cu) with water.

❖ **Sodium (Na) reacts with cold water to produce hydrogen.**

$$2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$$

❖ **Magnesium (Mg) reacts with hot water to produce hydrogen.**

$$Mg + 2\ H_2O \rightarrow Mg(OH)_2 + H_2$$

❖ **Iron reacts with super heated steam to produce hydrogen.**

$$3\ Fe + 4\ H_2O \rightarrow Fe_3O_4 + 4\ H_2$$

❖ **Copper has no reaction with water.**

Here, the reactivity of metals decreases in the order **Na > Mg > Fe > Cu**
[In general, the more reactive metals react vigorously with water. As the reactivity of metals decreases, the reaction rate also decreases.**]**

✤ **Reaction of Metals with Air :-**

❖ The freshly cut portion of sodium loses its lustre (shining) when kept exposed in the air for sometime. This is due to the conversion of sodium into its compounds by reacting with oxygen, moisture and carbon dioxide present in the atmosphere.

$$4\ Na + O_2 \rightarrow 2\ Na_2O$$

$$2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$$

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

❖ A fresh magnesium ribbon loses its lustre when kept exposed in the air for some days. This is also due to its reaction with atmospheric air.

$$2\ Mg + O_2 \rightarrow 2\ MgO$$

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❖ It can be seen that the lustre of Aluminium vessels diminishes as time passes by. In the case of copper vessels, it takes months for the loss of its lustre by the formation of **verdigris**. In the case of gold, the shining does not fade even after a long time.

The reactivity of these metals decreases in the order **Na> Mg> Al> Cu> Au**

[The metals **Potassium** and **Sodium** are highly reactive and react vigorously with atmospheric air and water. So, they can not be kept exposed in the air or kept in contact with water. Hence, they are kept immersed in a suitable liquid, **Kerosene**.**]**

✤ **<u>Reaction of Metals with dilute Acids</u> :-**

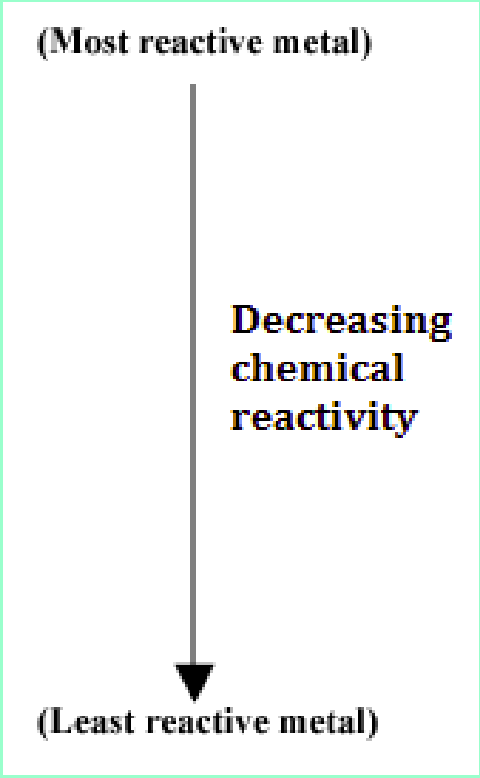
Generally metals react with dilute acids to produce **hydrogen**. In the case of reactions of metals like Mg, Pb, Zn, Fe and Cu with dilute HCl, the reactivity of these metals decreases in the order **Mg > Zn > Fe > Pb > Cu**

✤ **<u>Reactivity Series</u> :-**

The series obtained by arranging the metals in the decreasing order of their reactivity is known as the **Reactivity series**.

Hydrogen is included in this series for the sake of comparison of chemical reactivity.

Potassium	K
Sodium	Na
Calcium	Ca
Magnesium	Mg
Aluminium	Al
Zinc	Zn
Iron	Fe
Nickel	Ni
Tin	Sn
Lead	Pb
Hydrogen	H
Copper	Cu
Silver	Ag
Gold	Au



❖ In the reactivity series, the most reactive metal is placed at the top and the least reactive metal is placed at the bottom.

❖ As we go down from top to bottom in the reactivity series, the reactivity of metals decreases.

❖ Usually, those metals which are placed below hydrogen in the reactivity series do not react with dilute acids.

••••••••••••••••

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Activity – 1

State whether the following statements are true or false. Justify your answer.

1) The shining of a freshly cut portion of sodium increases when it is kept exposed in the air for sometime.
2) Sodium metal is usually stored in kerosene.
3) Magnesium reacts with dilute acids more rapidly than Lead.
4) The gas produced in the reaction of metals with dilute acids is oxygen.

Activity – 2

Answer the following questions based on the reactivity of the given metals.

Iron (Fe), Silver (Ag), Magnesium (Mg), Potassium(K), Lead (Pb)

1) Which among the given metals is the most reactive ?
2) Which among the given metals is the least reactive ?
3) Arrange the given metals as they are seen in the reactivity series.

Activity – 3

Answer the following questions based on the reactivity of the given metals.

Iron (Fe), Silver (Ag), Magnesium (Mg), Potassium(K)

1) Name the metal that react with cold water.
2) Name the metal that react with hot water.
3) Name the metal that react with steam.
4) Name the metal that has no reaction with water and dilute acids.
5) Arrange the given metals in the increasing order of their reactivity.

Activity – 4

Choose the correct order of reactivity of metals from those given below.

1) **K > Mg > Na > Fe > Cu**
2) **Al > Fe > Sn > Cu > Ag**
3) **Fe < Ca > K < Cu > Au**
4) **Na > Zn > Ni > Pb > Cu**
5) **Cu < Pb < Fe < Mg > Al**
6) **K > Na > Mg > Fe > Cu**
7) **Au < Pb > Sn < Al < Ca**
8) **Au < Pb < Sn < Al < Ca**
9) **K < Mg > Na < Fe > Cu**
10) **Fe < Ca > Zn < Ni > Ag**

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Activity – 5

The order of reactivity of metals given below are incorrect. Arrange the metals in the correct order.

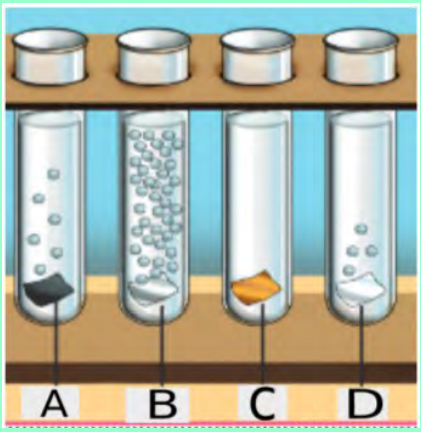
1) K > Mg > Na > Cu > Fe
2) Fe < Ca > Au > Cu > K
3) Cu > Pb < Fe > Mg > Al
4) Au < Pb > Sn < Al < Ca
5) Mg < Ca > Zn < Ni < Ag

Activity – 6

Potassium and Sodium are usually stored in kerosene. Give reason.

Activity – 7

Four different metal pieces of same mass are dipped in dilute HCl as shown in the figure (Symbols are not real). Examine the figure and answer the following questions.



1) Which among the given metals reacts vigorously with dilute HCl ?
2) Which among the given metals does not react with dilute HCl ?
3) Which is the gas evolved by the reaction of metals with dilute HCl ?
4) Write down the equation showing the reaction of metal B with HCl. (valency of B = 2)
5) Arrange the given metals in the ascending order of their reactivity.

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3 Reactivity series and Electrochemistry

Important Points & Activities - 2

✽ Reactivity Series & Displacement Reactions

✤ Displacement Reactions (Single Displacement Reactions) :-

Displacement reaction is a chemical reaction in which a more reactive element displaces a less reactive element from its compound. Generally, this type of reactions can be represented as follows.

A-x + B ⟶ A + B-x (Symbols are not real)

Characteristic features of Displacement Reactions :

- Both **metals and non-metals** take part in displacement reactions.
- Single Displacement reactions are mainly classified into two types.
  1) Cation (Positive ion) replacement reactions.

     Eg :- $Mg + Cu^{2+}SO_4^{2-} \longrightarrow Mg^{2+}SO_4^{2-} + Cu$
  2) Anion (Negative ion) replacement reactions.

     Eg :- $Cl_2 + 2\,Na^{+}Cl^{-} \longrightarrow 2\,Na^{+}Br^{-} + Br_2$

[In this Chapter, we discuss only Cation replacement reactions]

- Chemical reactivity of metals is linked with their relative positions in the reactivity series.
- A metal, which occupies a **higher position** in the reactivity series (more reactive), **can displace** another metal that occupies a **lower position** (less reactive) from the aqueous solution (solution in water) of its salt.
- A **less reactive metal** can not **displace a more reactive** metal from its salt solution.
- If a less reactive metal is added to a salt solution of a more reactive metal, nothing will happen.(Displacement reaction does not take place)
- Metals, which are **placed above hydrogen** in the reactivity series, **can displace hydrogen** from **dilute acids**. But, metals which are placed **below hydrogen** in the reactivity series **can not displace** hydrogen from dilute acids.
- Elements that form cations (Positive ions) can only displace cations and elements that form anions (Negative ions) can only displace anions.
- All **metal** displacement reactions are **cation replacement** reactions. In this type of reactions, one cation replaces another cation from its salt solution.
- All **metal** displacement reactions are **Redox** reactions.

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Let us demonstrate some examples of metal displacement reactions or cation replacement reactions.

Eg :- 1) When a **Zinc rod** is dipped in **$CuSO_4$** solution, Zinc will displace Copper from $CuSO_4$ solution (Zinc is more reactive than Copper). As a result, the **blue colour** of the **$CuSO_4$** solution **disappears** and the **zinc rod** becomes **copper rod**.

$$CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu$$

In this reaction, each zinc atom present in the zinc rod loses **2** electrons and becomes Zn^{2+} ions.

$$Zn \longrightarrow Zn^{2+} + 2\,e^- \quad (\text{Oxidation})$$

Similarly, each copper ion present in the $CuSO_4$ solution accepts **2** electrons and becomes **Copper** atoms.

$$Cu^{2+} + 2\,e^- \longrightarrow Cu \quad (\text{Reduction})$$

2) When a **Copper wire** is dipped in **$AgNO_3$** solution, Copper will displace Silver from $AgNO_3$ solution (Cu is more reactive than Ag). As a result, **the colour** of the **$AgNO_3$** solution changes to **blue** and the **copper wire** becomes **silver wire**.

$$2\,AgNO_3 + Cu \longrightarrow Cu(NO_3)_2 + 2\,Ag$$

In this reaction, each copper atom present in the copper wire loses **2** electrons and becomes Cu^{2+} ions.

$$Cu \longrightarrow Cu^{2+} + 2\,e^- \quad (\text{Oxidation})$$

Similarly, each silver ion present in the $AgNO_3$ solution accepts **1** electron and becomes **Silver** atoms.

$$Ag^+ + 1\,e^- \longrightarrow Ag \quad \text{OR}$$

$$2\,Ag^+ + 2\,e^- \longrightarrow 2\,Ag \quad (\text{Reduction})$$

✤ **<u>Oxidation</u> :-**

The process in which an atom or an ion **loses** electrons is called **Oxidation**.

OR

The process in which the **oxidation state** of an atom or an ion is **increased** is called **Oxidation**.

✤ **<u>Reduction</u> :-**

The process in which an atom or an ion **gains** electrons is called **Reduction**.

OR

The process in which the **oxidation state** of an atom or an ion is **decreased** is called **Reduction**.

OIL RIG

(Oxidation Is Loss) **(Reduction Is Gain)**

✤ **<u>Redox Reactions</u> :-**

Chemical reactions in which oxidation and reduction take place simultaneously are called **Redox Reactions**.

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✤ **Oxidizing agent (Electron Acceptor) :-**

Substances that have the ability to oxidize other substances **or** remove electrons from another substance are called **oxidizing agents.**

✤ **Reducing agent (Electron Donor) :-**

Substances that have the ability to reduce other substances **or** donate electrons to another substance are called **reducing agents.**

✤ An **oxidizing agent** always undergoes **reduction** and a **reducing agent** always undergoes **oxidation.**

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Activity – 1

Answer the following questions based on the reactivity of the metals given below.

Ag, Au, Zn, Mg

a) Which of these metals can displace Cu from $CuSO_4$ solution ?

b) Which of these metals can not displace Cu from $CuSO_4$ solution ?

c) Identify the metal that can displace all the other metals from their salt solutions ?

d) Identify the metal that can not displace all the other metals from their salt solutions ?

Activity – 2

Analyse the experimental data given below and answer the questions.

Case – I ---- A Zinc rod is dipped in $MgSO_4$ solution.

Case – II ---- A Zinc rod is dipped in $CuSO_4$ solution.

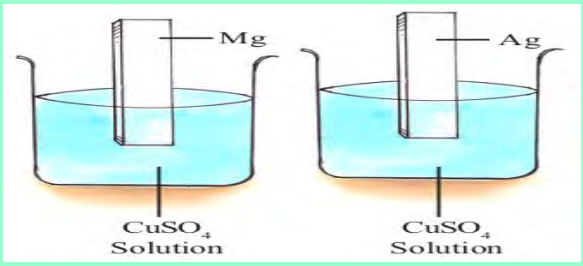
Case – III ---- A Zinc rod is dipped in $ZnSO_4$ solution.

1) In which case does the displacement reaction take place **?** Give reason.

2) Write down the chemical equation of this reaction.

Activity – 3

Observe the figure given below and answer the following questions.



1) Identify the beaker in which the displacement reaction takes place. Justify your answer.

2) Write down the chemical equation of this reaction.

3) What happens when **$CuSO_4$** is replaced by **$MgSO_4$** solution ?

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Activity – 4

The ionic equation of the reaction between Zinc and $CuSO_4$ is given below. Analyse the equation and answer the following questions.

$$Zn^0 + Cu^{2+}SO_4^{2-} \longrightarrow Zn^{2+}SO_4^{2-} + Cu^0$$

1) Which metal undergoes oxidation ?
2) Write down the equation showing oxidation.
3) Which metal ion undergoes reduction ?
4) Write down the equation showing reduction.
5) Is this a redox reaction ? Explain.

Activity – 5

The ionic equation of the reaction between Magnesium and $CuSO_4$ is given below.

$$Mg^0 + Cu^{2+}SO_4^{2-} \longrightarrow Mg^{2+}SO_4^{2-} + Cu^0$$

" This is not a redox reaction. " Do you agree with this statement ? Justify your answer.

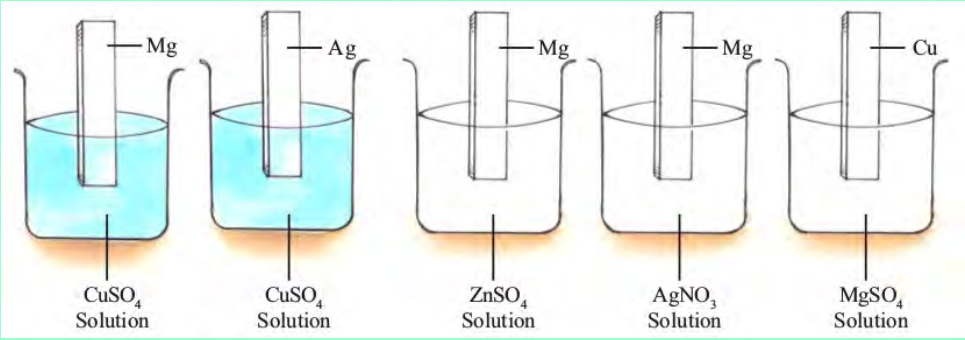
Activity – 6

Some possible observations that can be obtained on dipping a zinc rod in $CuSO_4$ solution are given below. Pick out the correct observations.

1) The colour of $CuSO_4$ solution does not change.
2) Copper gets deposited on the zinc rod.
3) Displacement reaction does not take place.
4) The colour of $CuSO_4$ solution fades or solution becomes colourless.
5) No change can be seen on the zinc rod.

Activity – 7

Analyse the figure given below and answer the following questions.



1) In which beakers does the displacement reaction take place ? Justify.
2) Write down the chemical equations of the possible displacement reactions.
3) Identify the oxidation and reduction reactions in each of the redox reactions.

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3 Reactivity series and Electrochemistry

Important Points & Activities - 3

✽ Electrochemical Cells -- Galvanic Cell (Voltaic Cell)

✤ Metals differ in their reactivity. Using some devices/arrangements, we can make use of this difference in reactivity of metals to generate electricity.

✤ **Electrochemical cells :**

An **electrochemical cell** is a device capable of either generating electrical energy from chemical reactions or using electrical energy to cause chemical reactions. These devices are capable of converting chemical energy into electrical energy, or vice versa.

✤ There are **two types** of electrochemical cells.

1) Galvanic cell or **Voltaic cell**
2) Electrolytic cell

✤ **Galvanic cell (Voltaic cell)**

Galvanic cell or **Voltaic cell (**named after **Luigi Galvani** or **Alessandro Volta** respectively **)** is an electrochemical cell in which chemical energy is converted into electrical energy by means of a redox reaction.

[Luigi Galvani is well known for the discovery of **Bioelectricity.**
Alessandro Volta is well known for the invention of **Voltaic pile,** the first electrical battery. In their experiments, both of them made use of the difference in reactivity of metals to generate electricity. **]**

✤ **Structure and Working of a Galvanic cell :**

❖ Generally, a **Galvanic cell** consists of **2 half cells / electrodes (**One **Anode** and a **Cathode --** The more reactive metal acts as Anode and the less reactive metal acts as Cathode **).** These 2 electrodes are connected to a Voltmeter externally with the help of an insulated copper wire (**Anode** is connected to the **negative** terminal of the voltmeter and **Cathode** is connected to the **positive** terminal). The solutions in the half cells are connected with each other using a salt bridge. This salt bridge ensures the continuous flow of electricity from the cell.

❖ The working of a galvanic cell is quite simple. It involves a redox reaction (simultaneous oxidation and reduction). Oxidation takes place at anode and reduction takes place at cathode. The atoms present in the anode (more reactive metal) lose electrons and enter into the solution as positive ions. These electrons will flow through the external circuit and reach the cathode (less reactive metal), where they are accepted by the positive ions present in the solution. As a result of these reactions chemical energy is converted into

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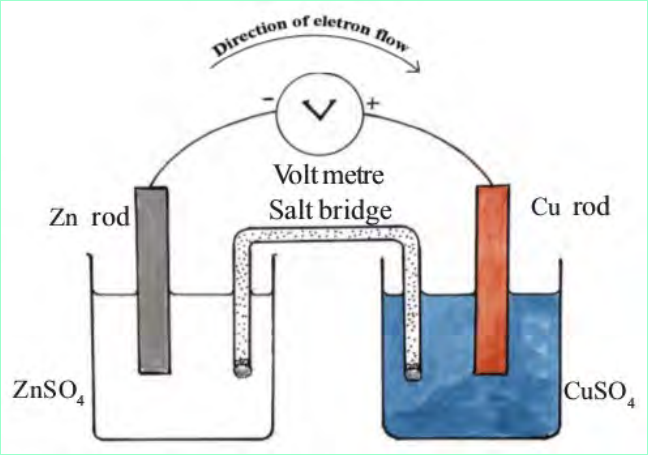
electrical energy. The salt bridge connects the oxidation and reduction half cells and allow the reaction to take place smoothly.

Eg :- Any two metals can be used to construct a galvanic cell. A typical example is **Zn – Cu galvanic cell** or **Daniel cell.**



❖ In **Zn – Cu** galvanic cell or **Daniel cell,** a Zinc rod is dipped in $ZnSO_4$ solution and a Copper rod is dipped in $CuSO_4$ solution. The two solutions in the beakers or half cells are connected using a salt bridge (A long filter paper which is moistened with KCl solution can be used instead of salt bridge). **Zn** electrode is connected to the negative terminal of the voltmeter and **Cu** electrode is connected to the positive terminal externally with the help of an insulated copper wire.

❖ In the case of **Zn – Cu** galvanic cell or **Daniel cell,** since **Zn** is more reactive than **Cu,** each **Zn** atom present in the **Zn** rod loses **2** electrons to become Zn^{2+} ion (Oxidation) and these ions enter into the solution. That is, **oxidation** takes place at **Zn** electrode or **Zn** atoms are oxidised to Zn^{2+} ions. Hence, **Zn** acts as **anode.** This reaction can be represented as follows.

Anode Reaction : $Zn \longrightarrow Zn^{2+} + 2\,e^-$ **(Oxidation)**

The electrons liberated from the **Zn** rod reach the copper electrode through the external circuit and these electrons are accepted by the Cu^{2+} ions present in the solution (Reduction) changing them into copper **(Cu)** atoms. That is, **reduction** takes place at **Cu** electrode or Cu^{2+} ions are reduced to **Cu** atoms. Hence, **Cu** acts as **cathode.** This reaction can be represented as follows.

Cathode Reaction : $Cu^{2+} + 2\,e^- \longrightarrow Cu$ **(Reduction)**

If we combine these two equations, we will get the equation for the overall cell reaction or Redox reaction. It can be written as follows.

$Zn + Cu^{2+} + 2\,e^- \longrightarrow Zn^{2+} + 2\,e^- + Cu$ **OR**

Cell Reaction : $Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$ **(Redox Reaction)**

[If both sides of the equation contain equal no. of electrons, the number of electrons should not be mentioned. **]**

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The salt bridge maintains the electrical neutrality of both the solutions in the half cells and allows the reaction to take place smoothly.

The **Zn – Cu** galvanic cell or **Daniel cell** can be summarized as follows.

Anode (Negative Electrode)	**Zinc Electrode (More reactive metal)**
Anode reaction (Oxidation)	$Zn \longrightarrow Zn^{2+} + 2\,e^-$
Cathode (Positive Electrode)	**Copper Electrode (Less Reactive metal)**
Cathode Reaction (Reduction)	$Cu^{2+} + 2\,e^- \longrightarrow Cu$
Cell Reaction (Redox Reaction)	$Zn + Cu^{2+} \longrightarrow Zn^{2+} + Cu$
Flow of Electrons	**From Anode to Cathode (From More reactive metal to Less reactive metal)**

✤ **Half cell and Electrodes** :-

- ❖ The structure that contains a metal rod dipped in its own ionic/salt solution (electrolyte solution) is termed as a **half cell.**
- ❖ The metal rods which are dipped in the electrolyte solutions are called **electrodes.**
- ❖ The electrode at which oxidation takes place is called **anode.**
- ❖ The electrode at which reduction takes place is called **cathode.**

An OX (Oxidation at Anode) **RED Cat** (Reduction at cathode)

✤ **Salt bridge** :-

- ❖ Salt bridge is a U – tube filled with a paste made by mixing gelatin or agar agar gel and a salt like KCl, KNO_3 or NH_4Cl. This arrangement connects the two half cells and allows the redox reaction to take place smoothly.
- ❖ **Functions of a Salt bridge** :
  1) Salt bridge acts as an electrical contact between the two half cells and thereby completes the electrical circuit.
  2) It maintains the electrical neutrality of the solutions in the 2 half cells by the migration of ions.
  3) It will not allow the mixing of the two solutions in the half cells.
  4) It ensures the continuous flow of electricity by allowing the redox reaction to take place smoothly.

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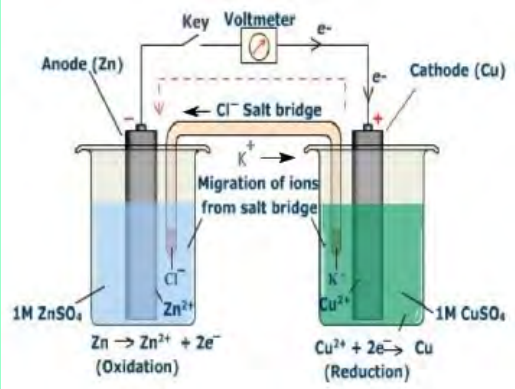
5) In a galvanic cell, the ions of the electrolyte present in the salt bridge do not participate chemically in the cell reaction.

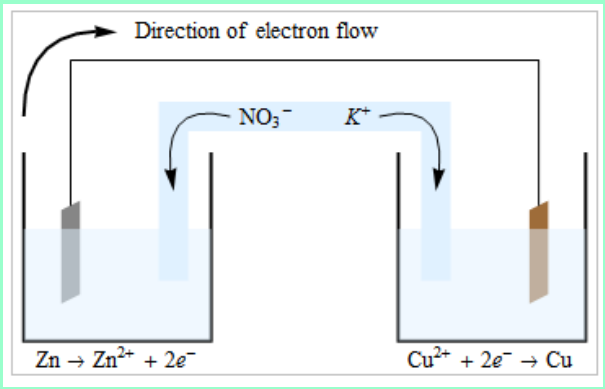
❖ **Working of a Salt bridge** :

If salt bridges are absent or if they are not used, within seconds, the solution in the anodic half cell would become positively charged and the solution in the cathodic half cell would become negatively charged. This will further result in the stoppage of the reaction and no electricity will be produced. So, in order to generate electricity continuously from a galvanic cell, the electrical neutrality of these solutions should be maintained. For this purpose we use a salt bridge.

On adding a **salt bridge**, the negative ions (anions) in the salt bridge move towards the anodic half cell and the positive ions (cations) in the salt bridge move towards the cathodic half cell. The movement of these ions completes the circuit and keeps each half cell electrically neutral.



(When KCl is used)



(When KNO_3 is used)

✤ Characteristic Features of a Galvanic cell :-

- ❖ In a galvanic cell, chemical energy is converted into electrical energy by means of a redox reaction.
- ❖ In a galvanic cell, the redox reaction takes place **spontaneously**.
- ❖ A galvanic cell consists of two half cells – one **oxidation half cell** and a **reduction half cell**.
- ❖ The electrode at which **oxidation** takes place is called **Anode** and the electrode at which **reduction** takes place is called **Cathode**.
- ❖ In a galvanic cell, the **more reactive metal** acts as **Anode** and the **less reactive metal** acts as **Cathode**.
- ❖ In a galvanic cell, **Anode** is the **negative electrode** and **Cathode** is the **positive electrode**.
- ❖ In a galvanic cell, the direction of flow of electrons is always from **anode to cathode (From More reactive metal to Less reactive metal)**
- ❖ Any two metals can be used to construct a galvanic cell. If **Zn** and **Cu** are used as electrodes then that galvanic cell is also known as **Daniel cell**.

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Activity – 1

Pick out the correct statements from those given below.

a) In a Galvanic cell, electrical energy is converted to chemical energy.

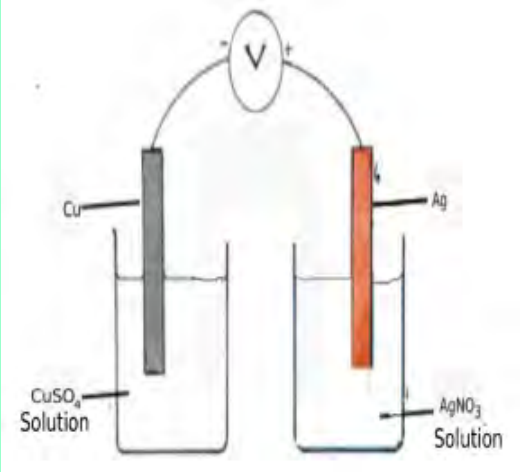
b) In a Galvanic cell, the reactivity of the cathode is less than that of the anode.

c) In a Galvanic cell, electrons will flow from cathode to anode.

d) In a Galvanic cell, oxidation takes place at anode.

Activity – 2

Diagram of a galvanic cell is given below.



1) Observe the diagram carefully and redraw, if there is any mistake.

2) Identify the anode and cathode.

3) Write down the balanced equations for the reactions taking place at anode and cathode.

4) Write down the balanced equation for the cell reaction.

Activity – 3

Consider the metals, salt solutions and the equipments given below.

1) Name the galvanic cell that can be constructed using the given materials.

2) Draw the diagram of that galvanic cell and label it suitably.

3) Identify the anode and cathode.

[Hint : Reactivity order – Mg > Zn > Cu > Ag]

4) Write down the balanced equation for the redox reaction.

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Activity – 4

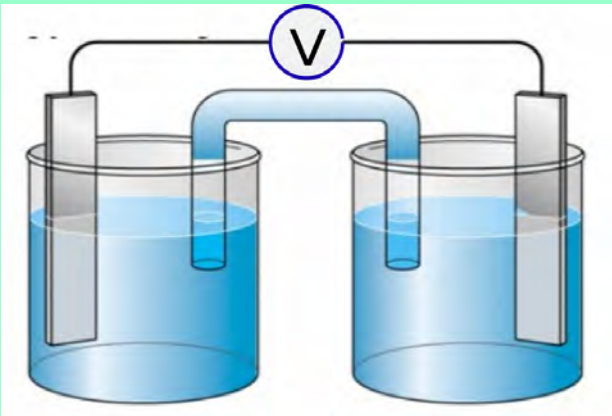
The galvanic cell shown in the figure is constructed using the two metals and their salt solutions given below.

Metals --- A and B (symbols are not real)

Salt solutions --- Ax solution and Bx solution

[Hint : B is more reactive than A.

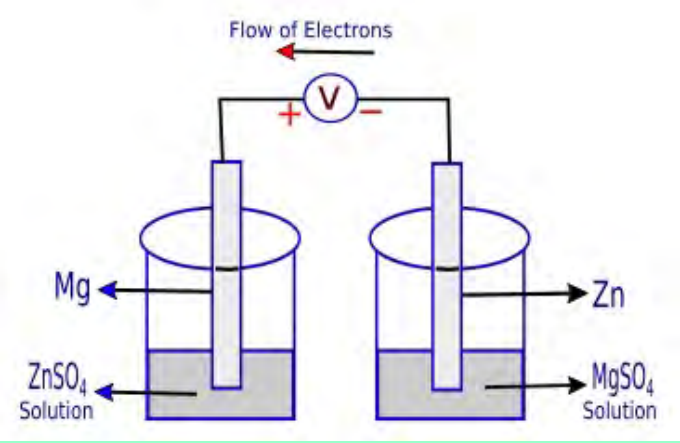
The ions of A and B are dipositive (carry 2 positive charges).]



1) Draw and label the diagram.
2) Identify the positive and negative electrodes.
3) Indicate the direction of flow of electrons.
4) Write down the balanced equations for the electrodes and the overall cell reaction.

Activity – 5

The diagram of Mg-Zn galvanic cell drawn by Anil is given below. He has made some mistakes while drawing the diagram. Observe the diagram carefully and answer the following questions.



1) List out the mistakes seen in the above diagram.
2) What changes are to be made in the above diagram in order to correct the mistakes ?
3) Redraw the diagram with the corrections.

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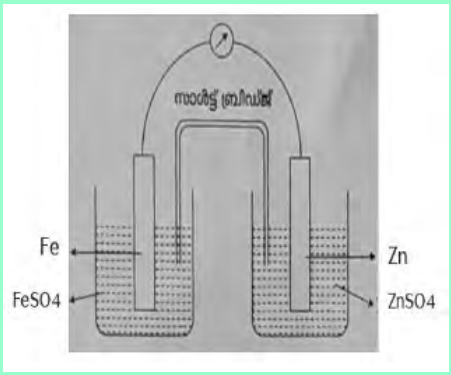
Activity – 6

Diagram of a galvanic cell is given below.



a) At which electrode oxidation takes place ?
b) Which electrode acts as the positive electrode ?
c) Write down the chemical equation for the redox reaction taking place in the given galvanic cell.
d) If the Zn electrode is replaced by Cu electrode in the above cell, Which metal will act as the anode ?

(Hint : Reactivity order --- Mg > Zn > Fe > Pb > Cu)

Activity – 7

Four metals are given below. Answer the following questions.

Mg, Cu, Zn, Ag

(Hint : Reactivity order --- Mg > Zn > Cu > Ag)

Ions of the metals --- Mg^{2+}, Zn^{2+}, Cu^{2+}, Ag^{+})

a) List out the galvanic cells that can be constructed using the given metals.
b) Draw the diagram of each galvanic cell and prepare a table in the given format.

Anode (Negative Electrode)	
Anode reaction (Oxidation)	
Cathode (Positive Electrode)	
Cathode Reaction (Reduction)	
Cell Reaction (Redox Reaction)	

c) In these galvanic cells, which metal can act only as anode and which metal can act only as cathode ?

.....

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3 Reactivity series and Electrochemistry

Important Points & Activities - 4

✽ Electrochemical Cells – Electrolytic Cell

✤ Electrolytic Cell :-

Electrolytic cell is an electrochemical cell capable of using electrical energy to cause chemical reactions. In electrolytic cells, electrical energy is converted into chemical energy by means of a redox reaction.

✤ Electrolysis :-

The process in which an electrolyte undergoes a chemical change by the passage of electricity through it is known as **Electrolysis.**

✤ Electrolytes :-

Substances which can conduct electricity in the molten state or in aqueous solution and undergo chemical changes are called **Electrolytes**.

Eg :- Acids, Alkalies and Salts are good electrolytes in their molten states or in aqueous solutions.

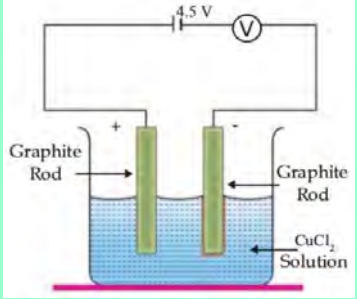
✤ Structure and Working of an Electrolytic cell :-

❖ An electrolytic cell consists of **2** electrodes (Anode & Cathode — usually, 2 carbon rods are used as electrodes) dipped in the same electrolyte solution taken in a beaker. These electrodes are connected to a battery by means of an insulated copper wire **(** The electrode which is connected to the positive terminal of the battery is called **Anode** and the electrode which is connected to the negative terminal of the battery is called **Cathode)**.

❖ When electricity is passed through the electrolyte solution, it undergoes ionization and **2** ions are formed **(** one positive ion and a negative ion **)**. Then, these two ions move towards the oppositely charged electrodes and get discharged to form the products.

❖ In electrolysis, the ions which move towards the anode are called **Anions** (negative ions) and the ions which move towards the cathode are called **Cations** (positive ions).

Eg :- The Electrolytic cell used for the electrolysis of Cupric chloride **($CuCl_2$)** solution is shown in the figure given below.



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✤ **Electrolysis of Molten Sodium chloride (NaCl) :-**

When electricity is passed through the molten sodium chloride, it dissociates into sodium ions (Na^+) and chloride ions (Cl^-).

$$NaCl \longrightarrow Na^+ + Cl^-$$

The negatively charged chloride ions (Cl^-) will move towards the positively charged anode, donate one electron to the anode and become chlorine atoms. Since chlorine atoms are unstable, two chlorine atoms combine together to form chlorine molecule. Thus, **Chlorine** gas is liberated at the **anode**.

Anode Reaction :-

$$2\,Cl^- \longrightarrow Cl_2 + 2\,e^- \qquad (\text{Oxidation})$$

Similarly, the positively charged sodium ions will move towards the negatively charged cathode, accept 1 electron from the cathode and become sodium atoms. These **Sodium** atoms are deposited on the **cathode**.

Cathode Reaction :-

$$Na^+ + 1\,e^- \longrightarrow Na \qquad (\text{Reduction})$$

Thus, by the electrolysis of molten sodium chloride we get **two** products — **Chlorine** at **Anode** and **Sodium** at **Cathode**.

✤ **Electrolysis of Sodium chloride solution (NaCl solution):-**

When electricity is passed through the sodium chloride solution, sodium chloride dissociates into sodium ions (Na^+) and chloride ions (Cl^-).

$$NaCl \longrightarrow Na^+ + Cl^-$$

While comparing Cl^- ions (chloride ions) and water, Cl^- has a greater tendency to get oxidised. Hence, Cl^- ions undergo oxidation at anode and **chlorine** gas is liberated at the anode.

Anode Reaction :-

$$2\,Cl^- \longrightarrow Cl_2 + 2\,e^- \qquad (\text{Oxidation})$$

While comparing Na^+ ions (sodium ions) and water, **water** has a greater tendency to get reduced. Hence, water undergoes reduction at cathode and **hydrogen** gas is liberated at the cathode.

Cathode Reaction :-

$$2\,H_2O + 2\,e^- \longrightarrow H_2 + 2\,OH^- \qquad (\text{Reduction})$$

Thus, by the electrolysis of sodium chloride solution, we get **two** products at the electrodes — **Chlorine** at **Anode** and **Hydrogen** at **Cathode**.

In addition to the two products formed at the electrodes, the sodium ions (Na^+) and hydroxide ions (OH^-) present in the solution combine together to give the **third** product in the form of **sodium hydroxide (NaOH)**.

✤ Products of Electrolysis of molten NaCl and NaCl solution) :-

Name of the Electrolyte	At Anode	At Cathode
Molten Sodium Chloride (NaCl)	Chlorine (Cl_2) $2Cl^- \longrightarrow Cl_2 + 2e^-$	Sodium (Na) $Na^+ + 1\ e^- \longrightarrow Na$
Sodium Chloride solution (NaCl solution)	Chlorine (Cl_2) $2Cl^- \longrightarrow Cl_2 + 2e^-$	Hydrogen (H_2) $2\ H_2O + 2e^- \longrightarrow H_2 + 2\ OH^-$
	In addition to the two products formed at the electrodes, **sodium hydroxide (NaOH)** is also formed in the solution as a third product.	

✤ Characteristic Features of an Electrolytic cell :-

- ❖ In an electrolytic cell, **electrical energy** is converted into **chemical energy** by means of a redox reaction.
- ❖ The redox reaction that takes place in an electrolytic cell is **non-spontaneous** (energy is to be supplied) in nature.
- ❖ An electrolytic cell consists of two electrodes — one **anode** and a **cathode**.
- ❖ The electrode at which **oxidation** takes place is called **Anode** and the electrode at which **reduction** takes place is called **Cathode**.
- ❖ In an electrolytic cell, **Anode** is the **positive electrode** and **Cathode** is the **negative electrode**.
- ❖ Usually, two **inert electrodes** are used in an electrolytic cell. (The electrodes which do not take part or interfere in the redox reaction but serve as a source of electrons are called **inert** electrodes). **Graphite** (a form of **carbon**) and **platinum** are commonly used to make inert electrodes.

✤ Galvanic cell versus Electrolytic cell :-

❖ Similarities :-

1) Both Galvanic and Electrolytic cells are **electrochemical cells.**
2) The working of both the cells is based upon a **redox reaction.**
3) In both the cells, **oxidation** occurs at **anode** and **reduction** occurs at **cathode.**

❖ Differences :-

Galvanic cell	Electrolytic cell
1) Converts chemical energy into electrical energy. (C ⟶ E)	1) Converts electrical energy into chemical energy. (E ⟶ C)

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2) Anode is the **negative** electrode and Cathode is the **positive** electrode.	2) Anode is the **positive** electrode and Cathode is the **negative** electrode.
3) The redox reaction is **spontaneous.**	3) The redox reaction is **non-spontaneous.**
4) Do not require external electrical energy sources.	4) Require external electrical energy sources.
5) Both the electrolytes and the electrodes taken in the two beakers are different.	5) Only one electrolyte is taken and the electrodes taken may be of the same or different material.
6) Generally, a salt bridge is required.	6) No salt bridge is required.

✤ In the molten state or in aqueous solution, ions of the electrolytes can move freely. These ions are responsible for the conduction of electricity by the electrolytes. But in the solid state, these ions are not free to move. Hence, electrolytes in the solid state usually do not conduct electricity.

✤ Pure water ionizes only to a very small extent. Since the no.of ions in pure water is very less, it does not allow the passage of electricity. In order to make water a good conductor, a little dilute sulphuric acid is added to water before electrolysis.

✤ **Applications of Electrolysis :-**

✴ **Production of Metals :-** Metals like Potassium**(K)**, Calcium**(Ca)**, Sodium**(Na)**, Aluminium**(Al)** etc. are produced by the electrolysis of their compounds.

✴ **Production of Non metals :-** Electrolysis can be utilised for the bulk production of non metals like Hydrogen**(H_2)**, Oxygen**(O_2)**, Chlorine**(Cl_2)** etc

✴ **Production of Compounds :-** Electrolysis can be employed to produce compounds like Sodium hydroxide**(NaOH)**, Potassium hydroxide**(KOH)** etc.

✴ **Purification (Refining) of Metals :-** Metals such as copper **(Cu)**, gold **(Au)** etc. are refined by electrolysis.

✴ **Electroplating :-** The process of obtaining a coating of one metal over another metal using electrolysis is known as **Electro plating**.

✤ **Electro plating :-**

The process of obtaining a coating of one metal over another metal using electrolysis is known as **Electro plating**.

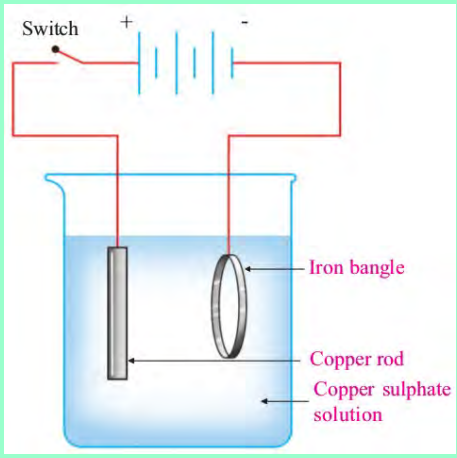
✤ **Chemistry of Electroplating :-**

During Electroplating, the cleaned article to be coated is connected to the negative terminal (Cathode) of the battery. The metal to be plated is connected to the positive terminal (Anode) of the battery. A suitable salt solution of the metal to be plated is taken as the electrolyte.

Eg :- Electroplating of **Copper** on an **Iron bangle.**

In order to plate copper on an iron bangle, electrolysis is done using **copper rod** as anode, **iron bangle** as cathode and **copper sulphate** solution as electrolyte.

When electricity is passed through the electrolyte solution, Cu^{2+} ions in the solution are attracted towards the cathode (iron bangle) and get reduced at cathode to form copper atoms. These copper atoms are deposited on the iron bangle as a coating.



$$Cu^{2+} + 2e^- \longrightarrow Cu \text{ (Reduction)}$$

At the same time, copper atoms present in the copper rod (anode) undergo oxidation at anode, and enter into the solution as Cu^{2+} ions .

$$Cu \longrightarrow Cu^{2+} + 2e^- \text{ (Oxidation)}$$

As a result of these two simultaneous reactions, the concentration of ions in the solution remains constant during electrolysis.

✤ **Advantages of Electroplating :-**

- ❖ It is helpful in preventing metallic corrosion.
- ❖ It is helpful for improving the appearance of the metal.

✤ **Examples for Electroplating :-**

- ❖ Gold plated ornaments.
- ❖ Silver plated Utensils.
- ❖ Chromium plated taps & fittings. etc
- ❖ Chromium plated iron handle bars.
- ❖ Gold plated cups & trophies.

✤ Some metals and electrolytes used for electroplating are given below.

Metal to be coated	Name of the electrolyte used
Copper (Cu)	Copper sulphate solution
Silver (Ag)	Silver nitrate solution. OR Sodium cyanide + Silver cyanide solution.
Gold (Au)	Sodium cyanide + Gold cyanide solution.

.....

Activity – 1

Pick out the correct statements from those given below.

a) In an electrolytic cell, electrical energy is converted to chemical energy.
b) In an electrolytic cell, cathode is positively charged.
c) In an electrolytic cell, electrodes are dipped in two different electrolyte solutions.
d) In an electrolytic cell, oxidation take place at anode.

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Activity – 2

Classify the ions given below into anions and cations.

Cu^{2+}, CO_3^{2-}, Zn^{2+}, Cl^-, Na^+, OH^-

Mg^{2+}, SO_4^{2-}, NO_3^-, K^+, Br^-, H^+

Activity – 3

Answer the questions given below.

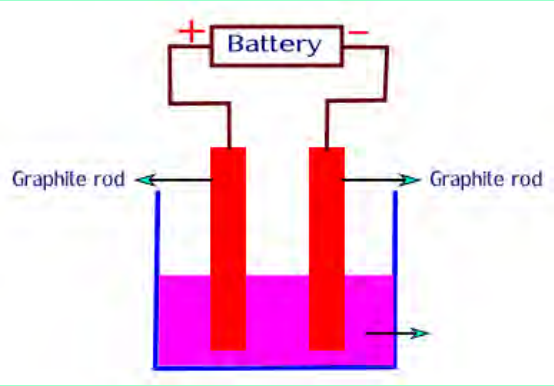
1) Draw and label the diagram of an electrolytic cell that can be used for the electrolysis of molten sodium chloride (NaCl).
2) Name the products obtained by the electrolysis of molten sodium chloride (NaCl).
3) Write down the balanced equations for the electrode reactions.
4) What changes can be observed if NaCl solution is used instead of molten NaCl.

Activity – 4

NaCl crystals, molten NaCl, aqueous solution of NaCl are given. Which of the above does not conduct electricity ? Give reason.

Activity – 5

The diagram of an electrolytic cell used for the electrolysis of KCl solution is given below. Observe the diagram and answer the following questions. (Hint : Electrolysis is similar to that of NaCl solution)



1) Draw the above diagram and label anode, cathode and electrolyte.
2) Name the electrolyte used.
3) Write down the balanced equations for the electrode reactions.
4) Name the products obtained by the electrolysis of KCl solution.
5) What will be the products formed if molten KCl is used instead of KCl solution ?
6) Give any two practical applications of electrolysis.

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Activity – 6

Ravi wants to coat silver on a copper ring by electrolytic method.

a) Name this process.
b) List out the materials required to carry out this process.
c) Draw a labelled diagram of the electrolytic cell that is used for this purpose.
d) Name the anode, cathode and electrolyte of this cell.
e) Write down the equations for the reactions taking place at anode and cathode.

Activity – 7

Answer the following questions.

a) What is meant by electroplating ?
b) Write down two advantages of electroplating.
c) Give any two instances where electroplating is made use of.

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4 Production of Metals

Important Points & Activities - 1

✽ Metallurgical Processes

✤ The chemically reactive metals are found in the combined state while the relatively unreactive metals like platinum, gold etc. are found in the native state in the earth's crust.

✤ **Minerals :-** The metallic compounds generally seen in the earth's crust are called **minerals**. The same metal can be seen in many minerals.

Eg :- Bauxite – $Al_2O_3 . 2H_2O$, **Cryolite** – Na_3AlF_6 and

Clay – $Al_2O_3 . 2SiO_2 . 2H_2O$ are minerals of Aluminium.

✤ **Ores :-** A mineral from which a metal is easily, quickly and economically extracted is called the ore of the metal.

Eg :- Bauxite – **$Al_2O_3 . 2H_2O$** is the ore of Aluminium.

✤ All minerals are not ores, but all ores are minerals.

✤ **Criteria used for the selection of an ore from the minerals :-**

- ❖ **Abundance** – The mineral should be readily or easily available.
- ❖ **Metallic content**– The metallic content present in the mineral should be very high.
- ❖ **Easily and cheaply separable** – There should be an economical and easy method to separate the metal from the mineral.

✤ **Some important metals and their ores are given below :-**

Metal	Ores	Chemical formula
Aluminium	Bauxite	$Al_2O_3.2H_2O$
Iron	Haematite, Magnetite	Fe_2O_3 Fe_3O_4
Copper	Copper pyrites Cuprite	$CuFeS_2$ Cu_2O
Zinc	Zinc blende Calamine	ZnS $ZnCO_3$

✤ **Metallurgy :-** All the processes involved in the separation of pure metals from their ores are collectively called **Metallurgy**.

✤ The **3** important stages in metallurgy are the following.

- ❖ Concentration of Ores.
- ❖ Extraction of metal from the concentrated ore.
- ❖ Refining of metals.

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✤ **Concentration of Ores** :-

The process of removing the impurities (Gangue) from the ore obtained from the earth's crust is termed **concentration** of the ore. The concentrated ore will have a higher metal content and will be more or less free from impurities.

✤ Depending on the nature of the ore and the impurities, different methods are used for the concentration of the ore. The important methods are the following.

1) Levigation or Hydraulic Washing. **2)** Froth Floatation
3) Magnetic Separation **4)** Leaching

✤ **Important methods used for the Concentration of Ores** :-

Ore	Impurities	Method of Concentration	Example
High Density. **(Heavier)**	Low Density. **(Lighter)**	**Levigation** or **Hydraulic Washing.** (The powdered ore is mixed with an upward stream of running water. The lighter impurities are washed away in the running water. The heavier ore particles will settle down and can be separated easily.)	Concentration of **Oxide ores** and **Ores of Gold.**
Low Density. **(Lighter)**	High Density. **(Heavier)**	**Froth Floatation.** (A mixture of the powdered ore, water and pine oil is strongly agitated by passing compressed air. Then the ore particles, which are wetted by the pine oil, stick to the froth of the oil formed during the mixing process and float on the surface of water. The heavier impurities, wetted by water, will sink to the bottom. Then, the ore is separated from the froth.)	Concentration of **sulphide** ores. **(Eg :- Copper pyrites)**
Either **Magnetic** or **Non Magnetic.**	Either **Non Magnetic** or **Magnetic.**	**Magnetic Separation.** (The powdered ore is fed into a conveyor belt which is moving over a magnetic wheel. Then the ore or impurity, which is magnetic in nature, is attracted by the magnetic wheel and get separated from the other.)	Concentration of **Magnetite**, the ore of **Iron**. It is also used to separate the magnetic impurity **Iron tungstate** from **Tin stone**, the non magnetic ore of **Tin**.

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Dissolve in a suitable solvent.	**Do not dissolve** in that solvent.	**Leaching.** (The powdered ore is added to a suitable solvent. Then, the ore dissolves in the solvent and the impurities will remain insoluble. The insoluble impurities are filtered off and the pure ore is separated from the filtrate by a chemical reaction.)	Concentration of **Bauxite** (the ore of **Aluminium**) is done by this method.

✤ **Extraction of Metals from the Concentrated Ore :-** There are **2** Stages.

1) Conversion of the concentrated ore into its oxide.

2) Reduction of the Oxide.

✤ **Conversion of the concentrated ore into its oxide :-**

The **2** important methods used for the conversion of the concentrated ore into its oxide are the following.

1) Calcination.

2) Roasting.

✤ **Difference between Calcination and Roasting :-**

Calcination	Roasting
❖ **Calcination** is the process of heating the concentrated ore at a temperature below its melting point in the **absence of air**.	❖ **Roasting** is the process of heating the concentrated ore at a temperature below its melting point in the **presence of air**.
❖ During **calcination,** impurities like moisture, organic matter and other volatile impurities are expelled from the ore and the ore decomposes to form its oxide.	❖ During **roasting**, moisture and volatile impurities are expelled from the ore and other impurities like phosphorous, sulphur etc. are oxidised and removed as their oxides. The ore gets converted into its oxide.
❖ **Calcination** is suitable for **metal carbonates** and **hydroxides.** **Eg :-** $ZnCO_3$ ore is converted to **ZnO** by calcination.	❖ **Roasting** is suitable for **sulphide** ores. **Eg :-** Cu_2S ore is converted to Cu_2O by roasting.

✤ **Reduction of the oxide :-** The process of extraction of metals from their oxides is Reduction [Metals have a tendency to lose electrons to become positive ions. So, the metals exist in their compounds as positive ions. Hence, a reducing agent is needed for the separation or extraction of metals from their compounds]. Suitable reducing agents are used for this purpose.

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✤ Highly reactive metals (From potassium to aluminium in the reactivity series) are extracted from their ores by the electrolysis of their molten compounds using the strongest reducing agent, electricity. (Because, their compounds are highly stable).

✤ Comparatively less reactive metals (From zinc to lead in the reactivity series) are extracted from their ores by the reduction of their metal oxides using ordinary reducing agents like carbon and carbon monoxide.

Eg :- Carbon monoxide is used as the reducing agent to extract iron (Fe) from haematite, and carbon to extract zinc (Zn) from zinc oxide.

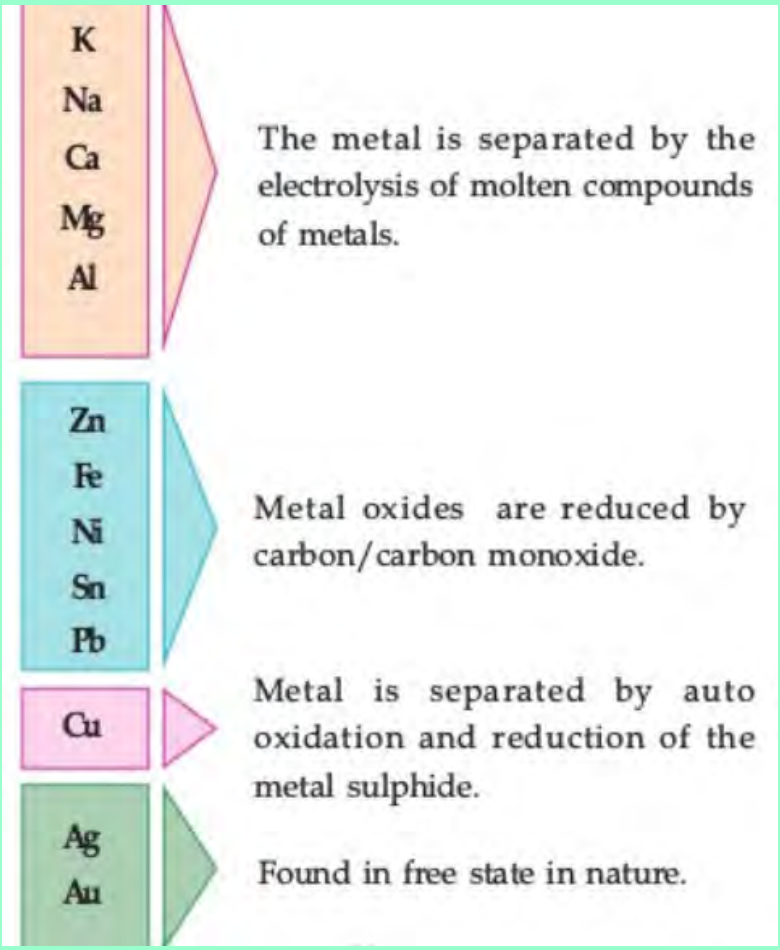
$$Fe_2O_3 + 3\,CO \longrightarrow 2\,Fe + 3\,CO_2$$

$$ZnO + C \longrightarrow Zn + CO$$

✤ Copper is separated by the auto oxidation and reduction of the metal sulphide

✤ Metals with very low reactivity (Silver, Gold and Platinum in the reactivity series) are found in free state in nature.

✤ **Extraction of Metals :-**



✤ **Refining of Metals :-** The metal obtained by reduction may contain **other metals, metal oxides and small quantities of non metals** as impurities.

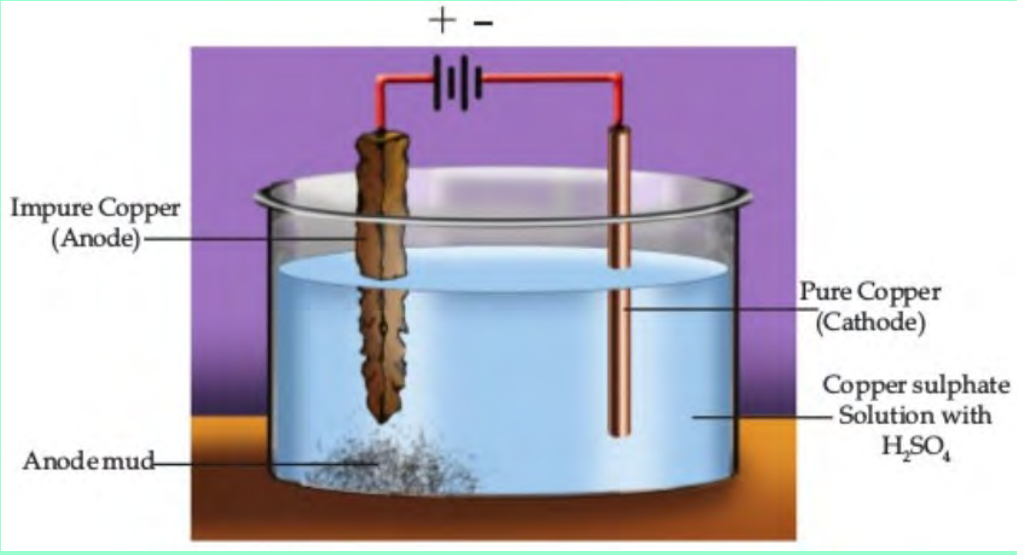
Refining is the process of removal of the impurities present in the metal even after its extraction.

Depending on the nature of metal and the impurities present in them, different methods are used. The important methods are the following.

Name of Process	Particulars	Examples
Liquation [When the impure metals are heated on the inclined surface of a furnace, the pure metal flows down leaving the impurities behind. This process is known as **Liquation**.]	Metals with **low melting points** (metals which easily melt) are purified by this method.	Tin **(Sn)**, Lead **(Pb)** etc.
Distillation [When the impure metals are heated in a retort, the pure metal alone vaporizes. These vapours are condensed to get the pure metal. This process is known as **Distillation.]**	Metals with **low boiling points** (metals which easily vaporize) are purified by this method.	Zinc **(Zn)** Mercury **(Hg)** Cadmium **(Cd)** etc.
Electrolytic Refining [The process of refining a metal by the electrolysis of a suitable salt solution (electrolyte) of the metal is known as **electrolytic refining**.] In this method, a small piece of **pure metal** is used as the negative electrode (Cathode) and **impure metal** is used as the positive electrode (Anode).	This is one of the most common and widely used methods because it is applicable to most metals. The different **electrochemical properties** of the metals and the impurities are used in this method.	Copper **(Cu)**, Silver **(Ag)**, Gold **(Au)** etc.

✤ **Electrolytic Refining of Copper :-**

Copper extracted from its ore is not pure. It is refined by the electrolytic method.



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In the electrolytic cell used for the electrolytic refining of copper, a thin plate of **pure copper** is used as the negative electrode **(Cathode**) and a big piece of **impure copper** is used as the positive electrode **(Anode)**. **Acidified solution of copper sulphate** is used as the electrolyte.

During electrolysis, metal **(Cu)** atoms from the anode donate **2** electrons to the anode and enters into the solution as positive ions **(Cu^{2+})**. These ions will move towards the cathode and accepts **2** electrons from the cathode and get discharged to form **Cu** atoms. These **Cu** atoms are deposited on the cathode.

At Anode :-

$$Cu \longrightarrow Cu^{2+} + 2e^{-} \quad \text{(Oxidation)}$$

At Cathode :-

$$Cu^{2+} + 2e^{-} \longrightarrow Cu \quad \text{(Reduction)}$$

Anode	**Impure copper**
Cathode	**Pure copper**
Electrolyte	**Copper sulphate solution acidified with dilute H_2SO_4**
Anode Reaction	**$Cu \longrightarrow Cu^{2+} + 2e^{-}$**
Cathode Reaction	**$Cu^{2+} + 2e^{-} \longrightarrow Cu$**

✤ **Anode mud :-**

During the electrolytic refining of copper, the insoluble impurities will get deposited below the anode. This is known as **Anode mud**. This may contain precious metals like platinum, gold, silver etc.

.....

Activity – 1

Answer the questions given below.

a) What is the difference between minerals and ores ?
b) What are the factors to be considered for the selection of an ore from the minerals ?
c) What is meant by the term metallurgy ? Write down the different stages involved in metallurgy.

Activity – 2

Answer the questions given below.

a) Write the name and chemical formula of the ore of Aluminium.
b) Which method is used for the concentration of this ore ?

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Activity – 3

Match the following suitably.

Metal	Ore	Chemical Formula
Aluminium	Calamine	Fe_3O_4
Iron	Cuprite	$Al_2O_3 . 2H_2O$
Copper	Bauxite	$ZnCO_3$
Zinc	Magnetite	Cu_2O

Activity – 4

Match the entries of column A with the appropriate entries of columns B and C.

A	B	C
Ore of gold	Ore and gangue do not dissolve in same solvent	Magnetic separation
Iron tungstate	the ore is lighter than the gangue	Leaching
Zinc blende	magnetic impurity	Hydraulic washing
Bauxite	the ore is heavier than the gangue	Froth floatation

Activity – 5

Calamine ($ZnCO_3$) and Zinc blende (ZnS) are the two ores of Zinc (Zn). The equations that indicate the conversion of these ores into their oxides are given below.

i. $ZnCO_3 + Heat \longrightarrow ZnO + CO_2$

ii. $ZnS + O_2 + Heat \longrightarrow ZnO + SO_2$

1) Which method is used for the concentration of zinc blende ?
2) Which of the above equations represent calcination ?
3) Write any two differences between roasting and calcination.

Activity – 6

Answer the questions given below.

a) Name the methods used for the refining of Lead (Pb) and Mercury (Hg).
b) Which property of metals is made use of in the refining of lead and mercury ?

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Activity – 7

Complete the table given below.

Ore	Method of concentration
Magnetite	
Bauxite	
Zinc blende	
Tin stone	
Copper pyrites	
Ore of gold	

Activity – 8

Answer the questions given below.

1) Draw a labelled diagram of the electrolytic cell used for the refining of copper.
2) Name the anode, cathode and electrolyte of the electrolytic cell mentioned above.
3) Write down the equations for the reactions taking place at anode and cathode.

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4 Production of Metals

Important Points & Activities - 2

✽ Industrial production of Iron (Fe)

✤ **Iron** is the second most abundant metal in the Earth's crust and the fourth most abundant element in that layer (after oxygen, silicon and aluminium).

✤ **Haematite (Fe_2O_3), Magnetite (Fe_3O_4), Iron pyrites (FeS_2)** etc. are some of the minerals of iron. But the **ores** of iron are **Haematite** and **Magnetite.**

✤ **Iron pyrites** has a brass-yellow colour and metallic lustre similar to gold. As it resembles gold in appearance, it is also called **"Fool's Gold"** .

✤ **Some important terms used in metallurgy :-**

❖ **Gangue :-** The earthly impurities present along with the ore of a metal are called **gangue**.

❖ **Flux :-** The substance, which is added to the ore during the extraction stage to remove the impurities **(** gangue **)** still present after the concentration, is called **flux**.

Selection of the flux is done based on the nature of the gangue present in the ore.

✷ If the gangue present in the ore is **acidic** in nature (**Eg :-** Silica/Sand or SiO_2), a **basic flux** is to be used (**Eg :-** CaO, FeO etc).

✷ If the gangue present in the ore is **basic** in nature (**Eg :-** CaO, FeO etc), an **acidic flux** is to be used (**Eg :-** Silica/Sand or SiO_2).

❖ **Slag :-** The fusible product formed by the reaction between gangue and flux is called **slag**. Usually slags are seen in the molten state and they are less denser.

✤ **Industrial Production of Iron (Fe) :-**

❖ The principal ore of Iron is **Haematite**. The raw materials used for the industrial production of iron are **haematite, lime stone ($CaCO_3$)** and **coke (C)**.

❖ Since the impurities are less denser than the ore, **hydraulic washing** or **levigation** is used for the concentration of the powdered ore (**magnetic separation** can also be employed for this purpose). The concentrated ore is then subjected to **roasting**. During roasting, impurities like sulphur, phosphorous, arsenic etc. are removed as their gaseous oxides and water is expelled. But the gangue (silicon dioxide) present in the ore is not removed.

❖ A mixture of the roasted **haematite, coke** and **lime stone** is fed into the **blast furnace** through a special arrangement at the top of the furnace. At the same time a blast of hot air is passed through the bottom of the furnace. That

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is why this furnace is called blast furnace. Then, Iron (Fe) gets separated from the ore as a result of the following chemical reactions taking place inside the blast furnace.

A **blast furnace** is a type of metallurgical furnace used for the production of industrial metals like Iron. Blast furnace is usually built with a steel case, the inside of which is lined with bricks made of a refractory material. The furnace can be up to 60 meters (200 ft) tall and 15 meters (49 ft) in diameter. It is cylindrical in shape and the diameter decreases from bottom to top.

- Oxygen in the hot air reacts with coke to give carbon dioxide.

$$C\,(s) + O_2\,(g) \longrightarrow CO_2\,(g)$$

- The limestone breaks down (decomposes) to form carbon dioxide.

$$CaCO_3\,(s) \longrightarrow CO_2\,(g) + CaO\,(s)$$

- Carbon dioxide produced in the above two reactions, react with more coke to produce carbon monoxide.

$$CO_2\,(g) + C\,(s) \longrightarrow 2\,CO\,(g)$$

- This carbon monoxide reduces the ore to give molten iron.

$$3\,CO\,(g) + Fe_2O_3\,(s) \longrightarrow 2\,Fe\,(l) + 3\,CO_2\,(g)$$

- The calcium oxide (lime / CaO) formed by the decomposition of limestone reacts with the sand (silica) to form slag (calcium silicate).

$$CaO\,(s) + SiO_2\,(s) \longrightarrow CaSiO_3\,(l)$$

- Both the slag and iron are in the molten state. Being less dense, the molten slag floats on the top of the molten iron. Slag and Iron are tapped at regular intervals through separate tap holes.

✤ 1) Role of Lime stone or Calcium carbonate ($CaCO_3$) :-

At a high temperature inside the furnace, the **limestone** (calcium carbonate), which is mixed with the haematite, decomposes into **calcium oxide** and **carbon dioxide.**

$$CaCO_3 \longrightarrow CaO + CO_2$$

The **calcium oxide (CaO)** formed by the above reaction acts as the **flux.** It combines with the impurities or gangue (**Silica/Sand or SiO_2**) present in the ore to form the slag, **calcium silicate ($CaSiO_3$)**. The molten slag flows down to the bottom of the furnace.

$$\underset{\text{(Flux)}}{CaO} + \underset{\text{(Gangue)}}{SiO_2} \longrightarrow \underset{\text{(Slag)}}{CaSiO_3}$$

[Lime stone is mixed with the haematite ore to get **calcium oxide (lime)** which acts as the **basic flux** to remove the **acidic gangue]**

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✤ 2) **Role of Coke (C) :-**

At the bottom of the blast furnace, coke combines with the oxygen in the hot current of air to form carbon dioxide. Since this is an exothermic reaction, the temperature at the bottom of the furnace rises upto 1800 ^{0}C.

$$C + O_2 \longrightarrow CO_2 + Heat$$

The CO_2 rises up along with the hot current of air and is reduced by coke to form carbon monoxide (CO).

$$CO_2 + C + Heat \longrightarrow 2\,CO$$

[This **carbon monoxide** acts as the **reducing agent** which reduces the **haematite** ore to separate **Iron**.]

✤ 3) **Reduction of the Haematite ore :-**

The carbon monoxide (CO) formed by the reaction between CO_2 and coke, reduces the haematite ore to produce Iron.

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

Due to the high temperature inside the furnace, the separated Iron will be in the molten state. It moves down the furnace and gets collected as a molten liquid at the bottom of the furnace. Being less dense, the slag floats on the top of the molten iron. Slag and Iron are tapped at regular intervals through separate tap holes. This slag is mainly used to **build roads**. It is also used as a raw material for the **production of cement**.

✤ **Pig Iron :-** The molten iron taken out from the blast furnace may contain 4% carbon and other impurities like manganese, silicon, phosphorous etc. This impure form (crude) of iron is called **Pig Iron**. It is used for making steel, cast iron, wrought iron etc.

[The molten iron taken out from the blast furnace is solidified by pouring it into separate moulds. As a result, iron blocks or ingots called **pigs** are formed. Hence, the name **pig iron**.]

Industrial production of Iron (Fe) at a glance

Ore of iron	**Haematite (Fe_2O_3)**
Production	In a **Blast Furnace**
Raw materials fed into the blast furnace	A mixture containing the **iron ore (haematite), limestone** and **coke.**
Reducing Agent	**Carbon monoxide (CO)**
Gangue (Acidic in nature)	**Silica /Silicon dioxide /Sand / SiO_2**
Flux (Basic in nature)	**Calcium Oxide (Lime/Quick lime/CaO)** (formed by the decomposition of limestone. $CaCO_3 \longrightarrow CaO + CO_2$)
Slag	**Calcium silicate ($CaSiO_3$)**
Equation of formation of slag	$CaO + SiO_2 \longrightarrow CaSiO_3$

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✤ **Alloys** :-

An alloy is a substance formed by the combination of a metal with at least one other metal or non metal. **Eg :- Steel** is an alloy of **iron** and **carbon.**

In order to improve the mechanical properties, **Alloy steels** are prepared by adding other elements to steel. A table containing different types of alloys, their components, properties and uses is given below.

Alloy steels	Constituent elements	Properties	Uses
Stainless steel	Fe, Cr, Ni, C	Hard	For the manufacture of utensils, parts of vehicles
Alnico	Fe, Al, Ni, Co	Magnetic nature	For the manufacture of permanent magnets
Nichrome	Fe, Ni, Cr, C	High resistance	For making heating coils

✤ Different alloys are prepared either by changing the component elements or by varying the proportion of the component elements.

Eg :- Stainless steel and **Nichrome.**

.....

Activity – 1

Answer the questions given below.

1) Briefly explain the terms given below.
a) Gangue b) Flux c) Slag

2) What is the criterion used for the selection of flux ?

Activity – 2

Answer the questions given below.

1) Which mineral of iron is known as " fool's gold " ?
2) Which are the ores of iron ?
3) Which method is used for the concentration of haematite ?

Activity – 3

Iron is produced in a blast furnace.

1) Why this furnace is called blast furnace ?
2) Explain the chemical reactions taking place inside the blast furnace.
3) What is pig iron ?

Activity – 4

Explain the role of coke and limestone in the production of iron.

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Activity – 5

Iron is produced in a blast furnace.

1) What are the raw materials used for the production of iron in the blast furnace?
2) Which compound acts as the reducing agent ? Write down the equation for the reduction of iron ore.
3) Name the flux used. How it is formed ?
4) Name the slag formed.

Activity – 6

Answer the questions given below.

1) Write down the name and chemical formula of the slag obtained from the blast furnace.
2) Write down the equation for the reaction that represents the slag formation.
3) Give an important use of the slag.

Activity – 7

Examine the given equations and answer the following questions.

$$CaCO_3 \longrightarrow \underline{A} + CO_2$$

$$CaO + \underline{B} \longrightarrow \underline{C}$$

1) Identify A, B and C
2) What is the role of A, B and C in the production of iron.

Activity – 8

Match the following suitably.

Alloys	Properties	Uses
Stainless steel	High resistance	For the manufacture of permanent magnets
Alnico	Hard	For making heating coils
Nichrome	Magnetic nature	For the manufacture of utensils

Activity – 9

Give reason for the following.

1) Constituent elements of Stainless steel and Nichrome are the same, but they show different properties.
2) Alnico is used for the manufacture of permanent magnets.
3) Nichrome is used for making heating coils.

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Activity – 10

Analyse the given table and answer the following questions.

Alloy steels	Constituent elements	Properties	Uses
Stainless steel	Fe, Cr, Ni, C	Hard	For the manufacture of utensils, parts of vehicles
Alnico	Fe, Al, Ni, Co	Magnetic nature	For the manufacture of permanent magnets
Nichrome	Fe, Ni, Cr, C	High resistance	For making heating coils

1) Which metal is the common component of the given alloys ?
2) Name the alloys with the same constituent elements.
3) What is the similarity and difference between Stainless steel and Nichrome.
4) Which property of Alnico is made use of in its use as permanent magnets ?
5) Which property of Nichrome is made use of in its use as heating coils ?

.....

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4 Production of Metals

Important Points & Activities - 3

✽ Industrial production of Aluminium (Al)

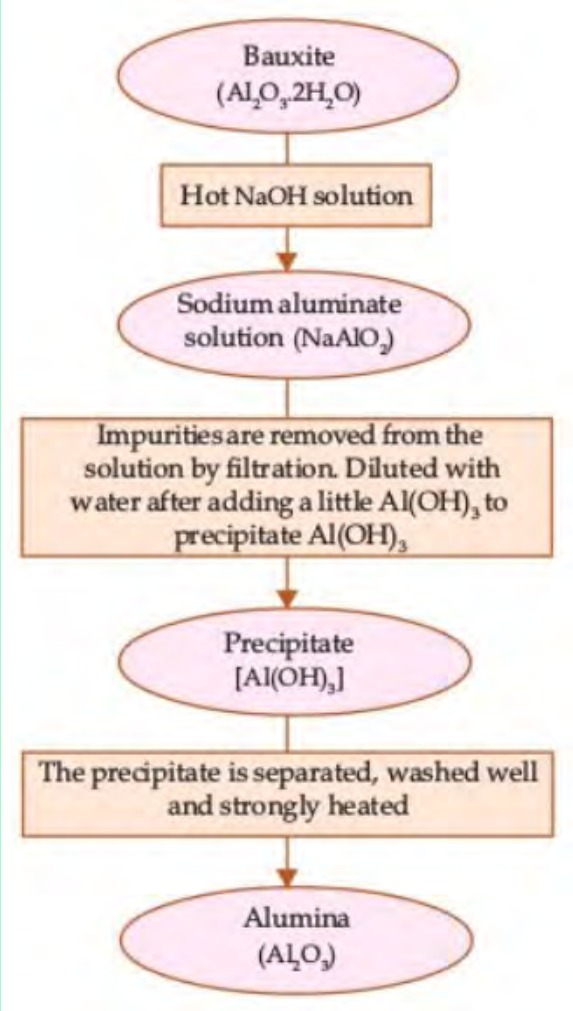
✤ **Aluminium** is the most abundant **metal** in the Earth's crust and the third most abundant element in that layer (after oxygen and silicon).

✤ Bauxite ($Al_2O_3.\ 2\ H_2O$), Cryolite (Na_3AlF_6), Clay ($Al_2O_3.\ 2\ SiO_2.\ 2\ H_2O$) etc. are some of the minerals of Aluminium. But the main ore of Aluminium is **Bauxite (Hydrated aluminium oxide --- $Al_2O_3.\ 2\ H_2O$).**

✤ The industrial production of Aluminium is known as **Hall – Heroult** process. It involves two important stages. The first stage is the concentration of the bauxite ore through **Leaching** and the second stage is the **electrolysis** of the concentrated ore **(Alumina).**

1) Concentration of the Bauxite ore through Leaching :-

Bauxite is concentrated through the **leaching** process. The main impurity present in the bauxite ore is Silica / Sand or SiO_2 .When powdered bauxite ore is mixed with hot concentrated solution of NaOH (sodium hydroxide), bauxite dissolves in it to form **sodium aluminate** ($NaAlO_2$) and the impurities will remain undissolved. The undissolved impurities are removed from the solution by filtration. Then, a small quantity of freshly prepared aluminium hydroxide [$Al(OH)_3$] is added and diluted with water to precipitate the entire aluminium hydroxide [$Al(OH)_3$].
The precipitate of aluminium hydroxide [$Al(OH)_3$] is separated, washed well and heated strongly. Then, it decomposes to give **Alumina (Anhydrous Aluminium oxide - Al_2O_3).**



$$2\ Al(OH)_3 \longrightarrow Al_2O_3 + 3\ H_2O$$

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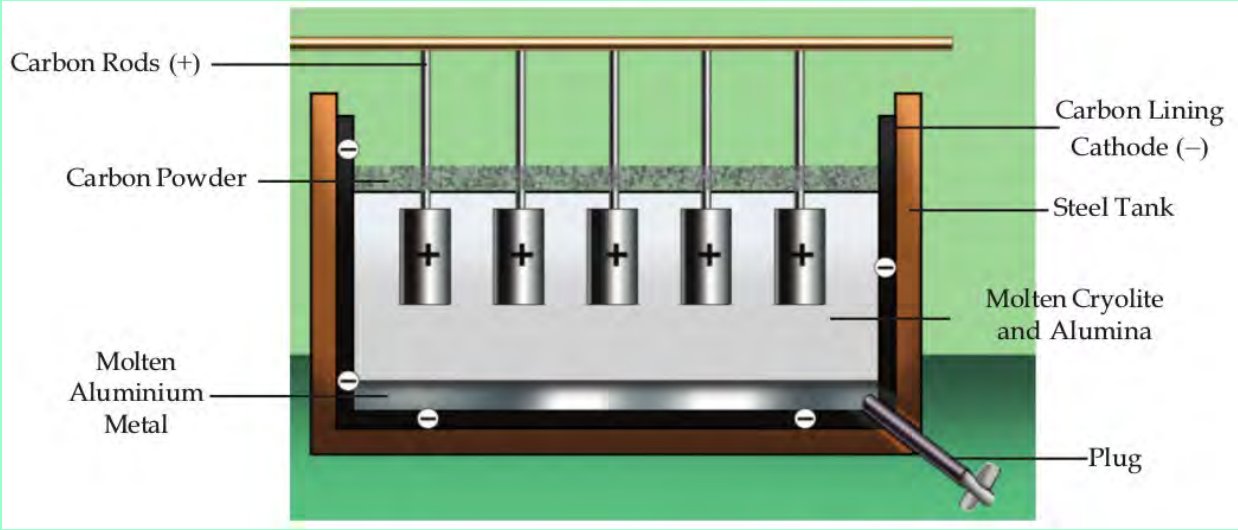
2) Electrolysis of Alumina (Al_2O_3) :-

Since the reactivity of aluminium is very high, aluminium is manufactured by the **reduction of alumina** using the strongest reducing agent, **electricity.** The **alumina** obtained by the concentration of bauxite is mixed with **molten cryolite** (Na_3AlF_6) and subjected to **electrolysis**. The diagram of the cell used for the electrolysis of alumina is shown below.



When electricity is passed through this mixture, it gets heated, alumina dissolves in cryolite and dissociates into aluminium ions **(Al^{3+})** and oxide ions **(O^{2-})**.

$$Al_2O_3 \longrightarrow 2\,Al^{3+} + 3\,O^{2-}$$

These ions will move towards the oppositely charged electrodes and get discharged to form the products.

At Anode :-

$$2\,O^{2-} \longrightarrow O_2 + 4\,e^- \qquad \textbf{(Oxidation)}$$

At Cathode :-

$$Al^{3+} + 3\,e^- \longrightarrow Al \qquad \textbf{(Reduction)}$$

[By the electrolysis of alumina, we get **2** Products **--- Aluminium** at **Cathode** and **Oxygen** at **Anode]**

✷ **Role of Cryolite :-** The melting point of Alumina is very high. At a very high temperature it is difficult to carry out the electrolysis. So, **Cryolite** is added to alumina **to reduce its melting point** and **increase its electrical conductivity.**

✷ The oxygen liberated at anode reacts with the anode (Carbon blocks) to form carbon dioxide and anode gets corroded gradually. So the carbon blocks, used as anode in this cell, are replaced from time to time.

$$C + O_2 \longrightarrow CO_2$$

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✤ Industrial production of Aluminium (Al) at a glance

Ore of Aluminium	Bauxite (Al_2O_3. 2 H_2O)
Method of concentration	Leaching
Method of Production	Reduction using electricity (Electrolysis)
Reducing Agent	Electricity
Anode	Carbon rods (Carbon blocks)
Cathode	Carbon lining (Graphite lining)
Electrolyte	A mixture containing Alumina and molten Cryolite
Anode Reaction	$2\ O^{2-} \longrightarrow O_2 + 4\ e^-$
Cathode Reaction	$Al^{3+} + 3\ e^- \longrightarrow Al$

.....

Activity – 1

Some important uses of Aluminium are shown in the table given below. Which properties of Aluminium are made use of in its uses ?

Uses	Characteristics
Transmission of electricity	
Kitchen utensils	
Reflectors	
Vehicle parts	

Activity – 2

Answer the questions given below.

1) Write down the name and chemical formula of the ore of aluminium.
2) Name the method used for the concentration of this ore.
3) Name the process by which aluminium is produced industrially.

Activity – 3

Explain the process of producing alumina from bauxite through leaching.

OR

Explain the process of concentration of bauxite through leaching.

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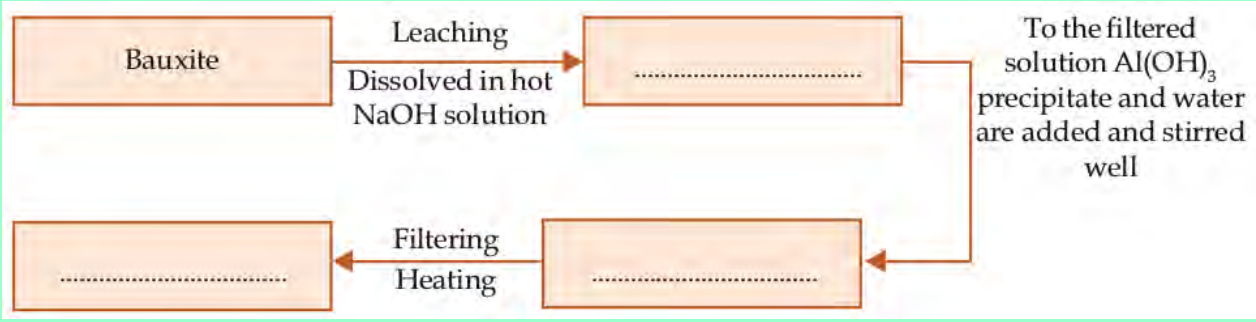
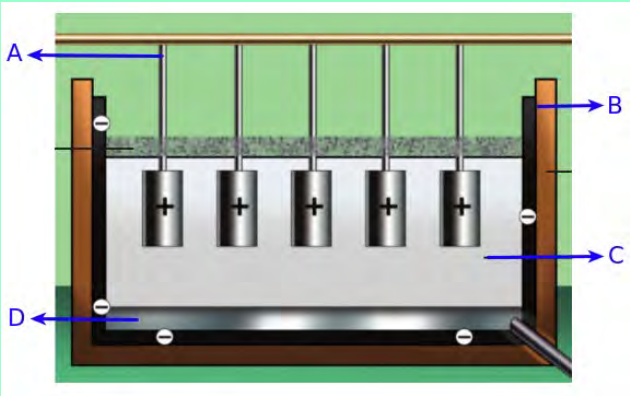
Activity – 4

Complete the flow diagram, related to the concentration of bauxite, which is given below.



Activity – 5

The electrolytic cell used for the production of Aluminium is shown in the figure given below.



1) Label the diagram appropriately, indicating the electrodes and the electrolyte.
2) Name the anode, cathode and electrolyte of the cell.
3) Explain the process of obtaining aluminium from alumina by electrolysis.
4) Name the products obtained at anode and cathode.
5) Write down the chemical equations for the reactions taking place at anode and cathode.

Activity – 6

Give reason for the following.

1) The strongest reducing agent, electricity, is required for the reduction of alumina to produce aluminium.
2) During the electrolysis, cryolite is added to alumina.
3) During the electrolysis of alumina carbon anodes are replaced from time to time (occasionally).

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5 Compounds of Non - Metals

Important Points & Activities - 1

✽ Ammonia (NH_3)

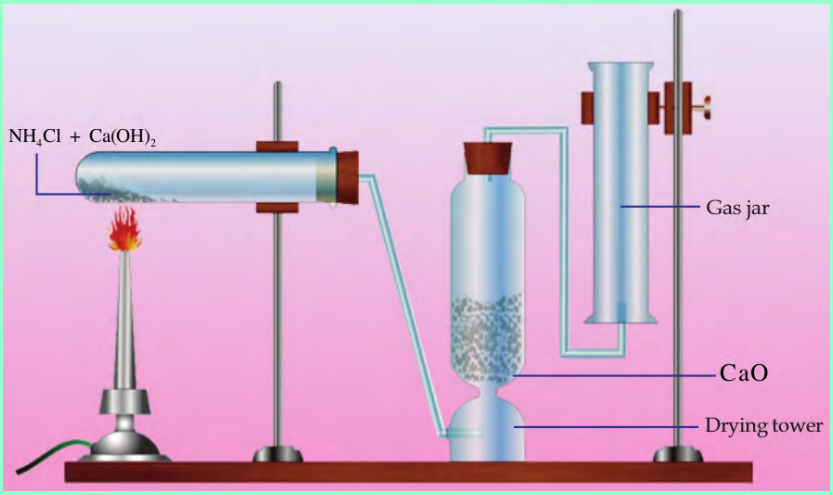
✤ **Ammonia** is an industrially important compound of nitrogen and hydrogen with the formula NH_3.

✤ **Preparation of Ammonia (NH_3) :-**

❖ **1) Class room preparation :-**

Ammonia is prepared in the classroom by adding a little calcium hydroxide ($Ca(OH)_2$) to a little ammonium chloride (NH_4Cl) taken in a watch glass. Stir the mixture well. Then, we can sense the **pungent smell** of ammonia. If wet blue and red litmus papers are shown over the watch glass one by one, then the **red litmus turns blue**. This shows the **basic nature** of ammonia.

❖ **2) Laboratory preparation :-**



Ammonia is prepared in the laboratory by heating a mixture of **ammonium chloride (NH_4Cl) and calcium hydroxide $Ca(OH)_2$** .

$$2\,NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2\,H_2O + 2\,NH_3$$

The ammonia gas, formed by this reaction, is passed through a **drying tower** containing **lime / quick lime / calcium oxide (CaO)** and collected in a gas jar by the **downward displacement** of air.

❖ **2) Industrial Preparation :-**

Ammonia is industrially prepared by **Haber Process** . In Haber Process, **nitrogen** and **hydrogen** taken in the **ratio 1:3**, are made to combine at a very high pressure **(150-300 atm)** and a temperature of **450^0 C** to produce ammonia. In this process, **spongy iron** is used as the catalyst.

$$N_2 + 3H_2 \rightleftharpoons 2\,NH_3$$

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✤ **Drying Agent :-**

Drying agents are substances capable of absorbing the moisture present in a substance.

Eg :- Calcium Oxide **(CaO),** Concentrated Sulphuric acid **(H_2SO_4)** etc.

- **Calcium Oxide (CaO) / lime / Quick lime** is used as a **drying agent** in the preparation of ammonia. **[** Ammonia gas is passed through a drying tower containing quick lime (CaO) to **remove the moisture** present in it.**]**
- Concentrated Sulphuric acid **(H_2SO_4)** is a good drying agent, but it **undergoes chemical reaction with ammonia** to form products. Hence, it can not be used as a drying agent in the preparation of ammonia.
- In the laboratory preparation of ammonia, ammonia gas formed is collected in a gas jar by the **downward displacement of air (** Gas jar should be kept inverted **)** because ammonia is **less denser than air**.

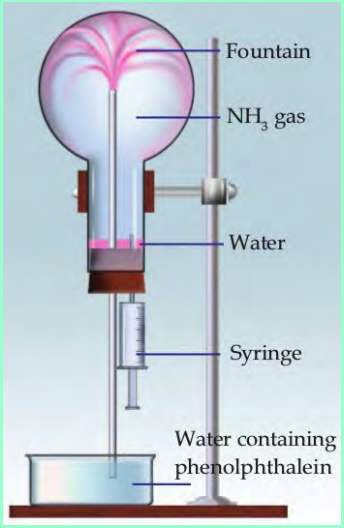
✤ **Preparation of Ammonia (NH_3) at a glance :-**

Laboratory Preparation	
Chemicals used	**Ammonium chloride (NH_4Cl) and Calcium hydroxide ($Ca(OH)_2$)**
Chemical Equation	**$2\ NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2\ H_2O + 2\ NH_3$**
Drying Agent	**Calcium Oxide (CaO) / lime / Quick lime**
Method of collection	**Downward displacement of air (Gas jar should be kept inverted --- ammonia is less denser than air)**
Industrial Preparation	
Name of Process	**Haber Process**
Chemicals used	**Nitrogen and Hydrogen taken in the ratio 1:3**
Temperature & Pressure	**A temperature of 450^0 C & a pressure of 150-300 atm**
Catalyst used	**Spongy iron**
Chemical Equation	**$N_2 + 3H_2 \rightleftharpoons 2\ NH_3$**

✤ **Fountain Experiment (Experiment to prove the high solubility of ammonia in water) :-**

Procedure :- Collect dry ammonia gas in a round bottomed flask (RB flask). The flask is then corked with a two holed cork. Through one hole, one jet tube and through the other hole, a syringe containing small quantity of water are connected. Dip the jet tube in the beaker containing water, in which some phenolphthalein is added. Using the syringe add a few drops of water into the flask in which ammonia is taken.

Observation :-



On adding a few drops of water into the flask from the syringe, water from the beaker rushes into the flask through the jet tube making a fountain. When water enters into the flask, the solution inside the flask becomes pink in colour.

Inference :-

- On adding a few drops of water into the flask from the syringe, due to the high solubility of ammonia in water, almost the entire ammonia gas filled in the flask dissolves in it to form ammonium hydroxide (NH_4OH), which is an alkali. Also, the **gaseous pressure** inside the flask **decreases suddenly**. As a result, due to the atmospheric pressure, the water from the beaker rushes into the flask through the jet tube making a fountain.
- On adding a few drops of water into the flask from the syringe, almost the entire ammonia gas filled in the flask dissolves in it to form **ammonium hydroxide** (NH_4OH), **which is an alkali.**

$$NH_3 + H_2O \longrightarrow NH_4OH \text{ (Ammonium hydroxide)}$$

As the water containing phenolphthalein enters into the flask, the solution inside the flask becomes pink in colour because, **phenolphthalein imparts pink colour to alkaline solutions**.

- Due to the extremely high solubility of ammonia in water, a large quantity of ammonia will be dissolved in a very small quantity of water. Thus, the intensity of spreading of ammonia gas can be prevented by spraying water. Hence, when an ammonia tanker leaks, water is sprayed to reduce its intensity.

- **Liquor ammonia & Liquid ammonia :-**
  - A highly concentrated aqueous solution of ammonia is called **liquor ammonia**.
  - Ammonia gas can be liquefied easily by applying pressure. This liquefied ammonia gas is known as **liquid ammonia**.

- **Important Properties of Ammonia (NH_3) :-**
  - Ammonia is a colourless gas.
  - It has a pungent smell.
  - It is basic in nature.
  - It is highly soluble in water.
  - Ammonia is less denser than air.
  - Ammonia is a poisonous gas.

- **Important Uses of Ammonia :-**
  - For the manufacture of chemical fertilisers like ammonium sulphate, ammonium phosphate, urea etc.
  - As a refrigerant in ice plants.
  - To clean tiles and window panes.
  - For the manufacture of chemicals.
  - For the manufacture of explosives. etc

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✤ **Detection (Identification Test) of NH_3 gas :-**

When a glass rod **dipped in concentrated hydrochloric acid** is introduced in the jar containing ammonia gas, **dense white fumes** are formed on the glass rod. The formation of this dense white fumes shows the presence of ammonia gas. This is due to the formation of **ammonium chloride (NH_4Cl)** by the reaction between HCl gas and ammonia.

$$NH_3 + HCl \longrightarrow NH_4Cl$$

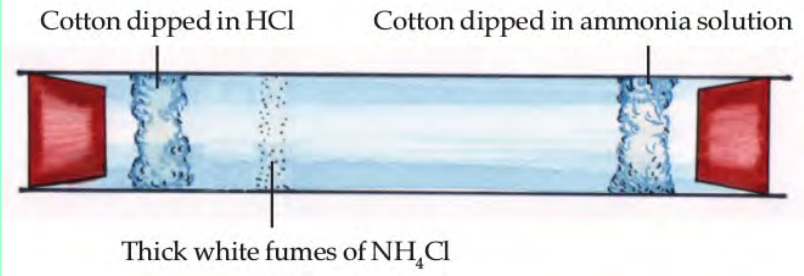
✤ On heating a boiling tube containing ammonium chloride, ammonium chloride undergoes decomposition to form **ammonia** and **hydrogen chloride**.

$$NH_4Cl \longrightarrow NH_3 + HCl$$

When a wet red litmus paper is shown at the mouth of the boiling tube, it **turns blue**. On keeping the litmus paper for some more time at the mouth of the boiling tube, it again **turns red**. When ammonium chloride (NH_4Cl) is heated, lighter NH_3 comes out first, followed by the denser HCl. Ammonia, which is basic in nature, turns red litmus blue and the HCl, which is acidic in nature, turns blue litmus red. The NH_3 and HCl gases, which come out of the boiling tube, combine together to form ammonium chloride and it sticks on to the sides of the boiling tube as white powder.

$$NH_3 + HCl \longrightarrow NH_4Cl$$

✤ Place a piece of cotton dipped in HCl at one end of an elongated glass tube and another piece dipped in ammonia solution at the other end such that these are well inside the glass tube. Close both ends of the glass tube tightly using corks. Then dense white fumes are formed in between the two cotton pieces. This is due to the formation of ammonium chloride by the reaction between ammonia and hydrogen chloride. These fumes condenses and sticks on to the inner sides of the glass tube as a ring of white powder. When this portion of the glass tube is heated, the ring of white powder disappears due to the decomposition of ammonium chloride.



The ring usually forms nearer to the hydrochloric acid end of the glass tube because, ammonia diffuses more rapidly than hydrogen chloride (hydrogen chloride diffuses more slowly than ammonia).

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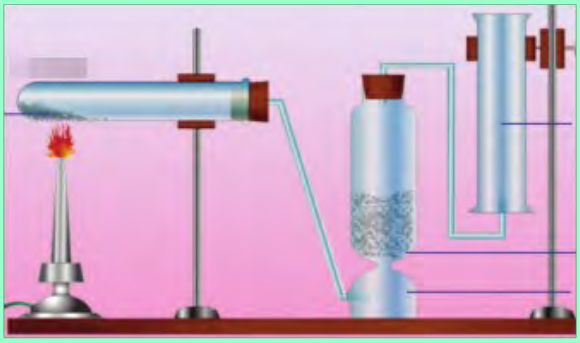
Activity – 1

Observe the figure that shows the the laboratory preparation of ammonia and answer the following questions.



1) Name the chemicals used for the laboratory preparation of ammonia.
2) Complete the equation given below.

$$2\ NH_4Cl + \ldots\ldots\ldots\ldots \longrightarrow \ldots\ldots\ldots\ldots + 2\ H_2O + \ldots\ldots\ldots\ldots$$

3) Ammonia gas is passed through a drying tower containing quick lime. Why ?
4) Ammonia is collected by the downward displacement of air (in an inverted gas jar). Why?

Activity – 2

Answer the questions given below.

1) What is meant by 'drying agent' ?
2) Name the drying agent used in the laboratory preparation of ammonia.
3) Can sulphuric acid be used as a drying agent in the preparation of ammonia ? Justify your answer.

Activity – 3

Answer the questions given below.

1) Fountain experiment is carried out to prove an important property of ammonia. Which is that property ?
2) Write down the observations of fountain experiment.
3) Why does water rush into the flask making a fountain ?
4) As the water containing phenolphthalein enters into the flask, the solution inside the flask becomes pink in colour. Why ?

Activity – 4

Answer the questions given below.

1) Name the product, which is formed by the dissolution of ammonia in water.
2) Complete the equation given below.

$$NH_3 + H_2O \longrightarrow \ldots\ldots\ldots\ldots$$

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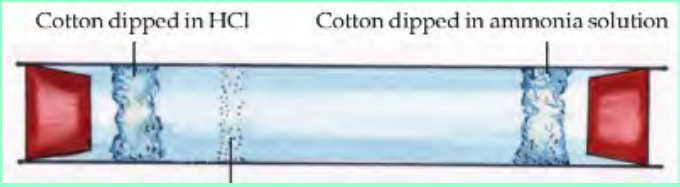
Activity – 5

Answer the questions given below.

1) What is the characteristic smell of ammonia ?
2) When an ammonia tanker leaks, water is sprayed to reduce its intensity. Give reason.
3) What is the difference between liquor ammonia and liquid ammonia ?

Activity – 6

Observe the figure given below and answer the following questions.



1) What is the reason for the formation of a ring of white powder inside the tube ?
2) What happens to the ring of white powder on heating ?
3) The ring usually forms nearer to the hydrochloric acid end of the glass tube. Why ?

Activity – 7

The chemical equation for the industrial preparation of ammonia is given below.

$$N_2 + 3H_2 \rightleftharpoons 2\,NH_3$$

1) What is the name of this process ?
2) Which is the catalyst used in this process ?
3) Give any two uses of ammonia.
4) Write down the identification test for ammonia.

Activity – 8

Some statements related to the characteristic properties of ammonia are given below.

a) Colourless gas.
b) Odourless gas.
c) Ammonia is denser than air.
d) Ammonia is basic in nature.
f) Ammonia is insoluble in water.

1) Pick out the correct statements from those given above.
2) Correct the wrong statements, if any ?

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5 Compounds of Non - Metals

Important Points & Activities - 2

✽ Chemical Equilibrium

✤ Irreversible Reactions :-

Chemical Reactions in which the reactants give products, but the products do not give back the reactants are called **Irreversible Reactions**. These reactions will take place only in **one** direction.

Eg :- $NaOH + HCl \longrightarrow NaCl + H_2O$

$Zn + 2\,HCl \longrightarrow ZnCl_2 + H_2$

$NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$

$C + O_2 \longrightarrow CO_2$

$Mg + 2\,HCl \longrightarrow MgCl_2 + H_2$

✤ Reversible Reactions :-

Chemical Reactions in which the reactants give products and the products give back the reactants are called **Reversible Reactions.** Reversible reactions will take place in **both** directions.

Eg :- $NH_4Cl \rightleftharpoons NH_3 + HCl$

$N_2 + O_2 \rightleftharpoons 2\,NO$

$N_2 + 3\,H_2 \rightleftharpoons 2\,NH_3$

$H_2 + I_2 \rightleftharpoons 2\,HI$

$2\,SO_2 + O_2 \rightleftharpoons 2\,SO_3$

✤ In a reversible reaction, the reaction in which the reactants are converted to the products is called the **Forward reaction** and the reaction in which the products are converted back to the reactants is called the **Backward reaction.**

✤ Chemical equilibrium :-

In a reversible reaction, the stage at which the rate of forward reaction becomes equal to the rate of backward reaction is called the **Equilibrium state** or **Chemical Equilibrium**.

✤ Characteristics of Equilibrium :-

- ✸ At the equilibrium both the reactants and the products **coexist**.
- ✸ The rates of forward and backward reactions **become equal** at equilibrium.
- ✸ Chemical equilibrium is **dynamic** at the molecular level.
- ✸ Chemical equilibrium is attained only in **closed systems.**
- ✸ At the equilibrium there will be **no visible change** in the **concentrations** of both reactants and products.

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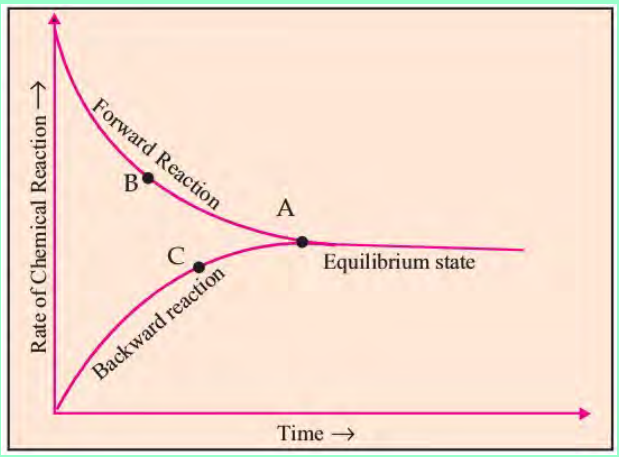
✤ **Closed System** :-

If nothing new is added to a system and nothing is removed from the system, then the system is said to be a closed system.

✤ **Graphical Representation of a Reversible Reaction** :-



BA – Forward Reaction
CA – Backward Reaction
A – Equilibrium state

✤ **Chemical Equilibrium -- Dynamic Equilibrium** :-

A system reaches equilibrium not because the reaction stops but because the rates of forward and backward reactions become equal. Even at equilibrium, the reactant molecules react to form product molecules and the product molecules react to form reactant molecules. Hence, the chemical equilibrium is said to be **dynamic** at the molecular level.

✤ **Le Chatelier Principle** :-

Le Chatelier Principle states that when the concentration, pressure or temperature of a system at equilibrium is changed, the system will readjust itself so as to nullify the effect of that change and attain a new state of equilibrium.

✤ **Factors influencing the state of equilibrium** :-

1) Effect of the change in Concentration :-

There are **4** possibilities for changing the **concentration.**

- ✸ If we **increase** the concentration of the **reactants** (adding more reactants), the rate of **forward reaction increases**. (rate of backward reaction decreases)
- ✸ If we **decrease** the concentration of the **reactants** (removing the reactants), the **rate** of **forward reaction decreases**. (rate of backward reaction increases)
- ✸ If we **increase** the concentration of the **products** (adding more products), the **rate** of **forward** reaction **decreases**. (rate of backward reaction increases)
- ✸ If we **decrease** the concentration of the **products** (removing the products), the **rate** of **forward** reaction **increases**. (rate of backward reaction decreases)

[According to **Le Chatelier**, when the concentration of either reactants or products is **increased**, the system will attain a new state of equilibrium by **increasing the speed of the reaction** by which the concentration is

decreased. Similarly, when the concentration of either reactants or products is **decreased**, the system will attain a new state of equilibrium by **increasing the speed of the reaction** by which the concentration is **increased.]**

2) <u>Effect of the change in Pressure</u> :-

In a gaseous system, a decrease in the no. of molecules helps to decrease pressure and an increase in the no. of molecules helps to increase pressure. There are **2** possibilities for changing the **pressure.**

- In reactions involving gases, if we **increase** the **pressure**, the reaction by which the **no. of molecules decreases** will be favoured. **OR** the **rate** of **that reaction increases**.
- In reactions involving gases, if we **decrease** the **pressure,** the reaction by which the **no. of molecules increases** will be favoured. **OR** the **rate** of **that reaction increases**.
- **Pressure** has a significant influence only in systems which involve the **gaseous reactants** and **products.** Similarly, in gaseous systems, if there is **no change** in the **no. of reactant molecules and product molecules** as a result of forward and backward reactions, **(OR** If the **total** no. of **reactant molecules** is **equal** to the **total** no. of **product molecules), pressure will not have any effect** on that equilibrium.

[According to **Le Chatelier,** when the pressure of a system at equilibrium is **increased,** the system will try to attain a new state of equilibrium by **increasing the speed of the reaction** by which the pressure is **reduced**. Similarly, when the pressure of a system at equilibrium is **decreased,** the system will try to attain a new state of equilibrium by **increasing the speed of the reaction** by which the pressure is **increased**.

3) <u>Effect of the change in Temperature</u> :-

There are **2** possibilities for changing the **temperature.**

- If we **increase** the temperature, the rate of **endothermic** reaction **increases.**
- If we **decrease** the temperature, the rate of **exothermic** reaction **increases.**
- If there is an **optimum temperature** for the reaction, **allow** the **reaction** to **take place** at **that temperature.**

[According to **Le Chatelier,** when the temperature of a system at equilibrium is **increased,** the system will try to attain a new state of equilibrium by **increasing the speed of endothermic reaction.** Similarly, when the temperature of a system at equilibrium is **decreased,** the system will try to attain a new state of equilibrium by **increasing the speed of exothermic reaction.]**

- **<u>Optimum Temperature</u> :-**

The suitable and most favourable temperature at which a chemical reaction is best carried out is known as the **optimum temperature.** The optimum temperature for the manufacture of ammonia by **Haber Process** is **450^0 C.**

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4) Effect of Catalyst :-

- **Catalysts** are substances which can alter or change the rate of a chemical reaction without being consumed in the process. The substances which increase the rate of reactions are called **positive catalysts** and the substances which decrease the rate of reactions are called **negative catalysts.**
- If a **positive catalyst** is added in the beginning of a reversible reaction, it increases the rates of both forward and backward reactions to the same extent. As a result the system **reaches the equilibrium at a faster rate.** Once equilibrium has been reached, the rate of chemical reaction can be controlled by altering other factors.
- If a **catalyst** is added in a system which has already attained equilibrium, it does not disturb or change the state of equilibrium.

✤ **The influence of Concentration, Pressure, Temperature and Catalyst in the manufacture of Ammonia by Haber Process :-**

Ammonia is industrially prepared by **Haber process.**

$$N_2\ (g) + 3\ H_2\ (g) \rightleftharpoons 2\ NH_3\ (g) + Heat$$

1) Effect of change in Concentration :-

- In this reaction, when the **concentration** of the **reactants is increased** (When more Hydrogen or Nitrogen is added), according to Le Chatelier principle, the system will try to decrease the concentration by converting the reactants into products. That is, the rate of **forward reaction increases** and more Ammonia will be formed. (Rate of backward reaction decreases)
- In this reaction, when the **concentration** of the **reactants is decreased** (When Hydrogen or Nitrogen is removed), according to Le Chatelier principle, the system will try to increase the concentration by converting the products into reactants.That is, the rate of **forward reaction decreases** and Ammonia decomposes. (Rate of backward reaction increases)
- In this reaction, when the **concentration** of the **products is increased** (When more Ammonia is added), according to Le Chatelier principle, the system will try to decrease the concentration by converting the products into reactants. That is, the rate of **forward reaction decreases** and Ammonia decomposes. (Rate of backward reaction increases)
- In this reaction, when the **concentration** of the **products is decreased** (When Ammonia is removed from the system), according to Le Chatelier principle, the system will try to increase the concentration by converting the reactants into products. That is, the rate of **forward reaction increases** and more Ammonia will be formed. (Rate of backward reaction decreases)

2) Effect of change in Pressure :-

[In gaseous systems, the decrease in the no. of molecules helps to decrease pressure and an increase in the no. of molecules helps to increase the pressure.]

- In this reaction, when the **pressure** of the system at equilibrium is **increased**, according to Le Chatelier principle the system will try to

decrease the pressure by **increasing the rate of forward reaction** by which the **no.of molecules decreases**. As a result, more ammonia will be formed.

✸ In this reaction, when the **pressure** of the system at equilibrium is **decreased**, according to Le Chatelier principle the system will try to increase the pressure by **increasing the rate of backward reaction** by which the **no. of molecules increases**. As a result, ammonia will be decomposed.

3) Effect of change in Temperature :-

✸ When the **temperature is increased**, according to Le Chatelier principle the system will try to reduce the temperature by **increasing the rate of endothermic reaction.** In this reaction, the backward reaction is the endothermic reaction. Hence, the rate of **backward reaction increases** and Ammonia decomposes.

✸ When the **temperature is decreased**, according to Le Chatelier principle the system will try to increase the temperature by **increasing the rate of exothermic reaction** . In this reaction, the forward reaction is the exothermic reaction. Hence, the rate of **forward reaction has to be increased**. But at low temperature, the rates of both the forward and backward reactions get very much reduced. Hence, in this reaction, an **optimum temperature** of **450^0 C** is used.

4) Effect of Catalyst :-

In this reaction, the positive catalyst **spongy iron** helps the system to reach the equilibrium very quickly. Once equilibrium has been reached, the rate of chemical reaction can be controlled by altering other factors.

✤ **Measures to be taken to increase the yield of products of a reversible reaction at equilibrium :-**

- ✸ Increase the concentration of any one of the reactants. **(Add more reactants)**
- ✸ Decrease the concentration of any one of the products. **(Remove the product from the system).**
- ✸ In gaseous systems, if the forward reaction is the one by which the no.of molecules is increased, decrease the pressure and if the forward reaction is the one by which the no.of molecules is decreased, increase the pressure.
- ✸ If the forward reaction is endothermic, increase the temperature and if the forward reaction is exothermic, decrease the temperature.
- ✸ If there is an optimum temperature for the reaction, allow the reaction to take place at that temperature.
- ✸ Use suitable positive catalysts which help the reaction to reach the equilibrium at a faster rate.

.....

Activity – 1

Pick out the chemical equations that represent reversible reactions, from those given below.

a) $N_2\ (g) + 3\ H_2\ (g) \rightleftharpoons 2\ NH_3\ (g)$

b) $NaOH + HCl \longrightarrow NaCl + H_2O$

c) $2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ SO_3\ (g)$

d) $C + O_2 \longrightarrow CO_2$

e) $NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$

f) $H_2\ (g) + I_2\ (g) \rightleftharpoons 2\ HI\ (g)$

Activity – 2

Chemical equations of some reversible reactions are given below. Write down the forward and backward reactions of each reversible reaction.

a) $N_2\ (g) + 3\ H_2\ (g) \rightleftharpoons 2\ NH_3\ (g)$

b) $2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ SO_3\ (g)$

c) $H_2\ (g) + I_2\ (g) \rightleftharpoons 2\ HI\ (g)$

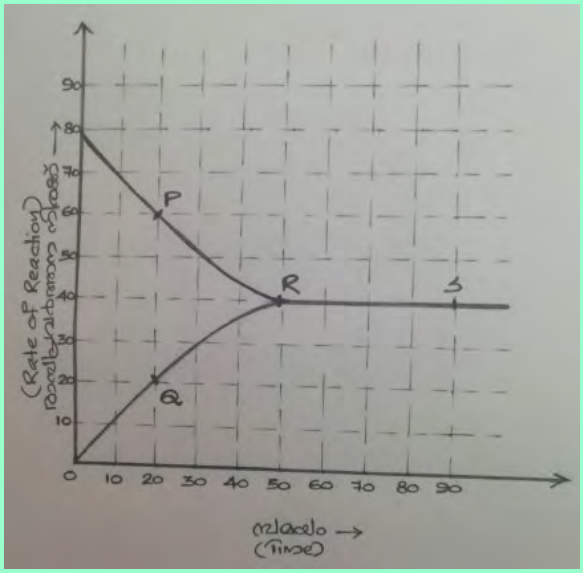
Activity – 3

Explain the terms given below.

a) Reversible reaction
b) Irreversible reaction
c) Forward reaction
d) Backward reaction
e) Closed system
f) Equilibrium state

Activity – 4

Graphical representation of a reversible reaction is given below. Analyse the graph and answer the following questions.



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1) Identify the graph that represents the forward reaction.
2) Identify the graph that represents the backward reaction.
3) Identify the point in the graph that represents the equilibrium state.
4) What happens to the position of the point of equilibrium in the graph when a positive catalyst is used in the beginning of this reaction ? Redraw the graph accordingly.

Activity – 5

Answer the questions given below.

1) State Le Chatelier Principle.
2) Write down any two characteristics of chemical equilibrium.
3) "Chemical equilibrium is always dynamic, not static ". Explain.

Activity – 6

Pick out the statements suitable for chemical equilibrium from those given below.

1) At the equilibrium both the reactants and the products coexist.
2) The rate of forward reaction is greater than that of backward reaction.
3) Chemical equilibrium can not be attained in closed systems.
4) Chemical equilibrium is dynamic at the molecular level.

Activity – 7

$$2\ NO\ (g) + O_2\ (g) \rightleftharpoons 2\ NO_2\ (g) + Heat$$

In this reaction, how do the following changes influence the amount of the product?

1) Decrease in temperature.
2) Increase in pressure.
3) Increase in the concentration of oxygen.

Activity – 8

The chemical equation of one of the different stages of manufacturing sulphuric acid by contact process is given below. Find out the influence of the following factors in this reaction.

$$2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ SO_3\ (g) + Heat$$

1) Amount of oxygen is increased.
2) Pressure is increased.
3) Catalyst vanadium pentoxide (V_2O_5) is added.
4) SO_3 is removed.

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Activity – 9

Answer the questions given below.

1) In which of the following reversible reactions the change in pressure does not influence the equilibrium? Give reason.

a) $N_2\ (g) + 3\ H_2\ (g) \rightleftharpoons 2\ NH_3\ (g)$

b) $H_2\ (g) + I_2\ (g) \rightleftharpoons 2\ HI\ (g)$

2) How do the following conditions influence a reversible reaction ?

a) Concentration of reactants is increased.

b) Pressure is increased.

c) Products are removed from the system.

d) Temperature is increased.

Activity – 10

The chemical equation given below represents the industrial production of ammonia.

$$N_2\ (g) + 3\ H_2\ (g) \rightleftharpoons 2\ NH_3\ (g) + \text{Heat}$$

1) What happens to the forward reaction under the following conditions ?

a) Concentration of Nitrogen is increased.

b) Pressure is decreased.

c) Ammonia is removed from the system.

d) Temperature is increased.

2) Suggest any two measures to be taken to get maximum yield of ammonia.

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5 Compounds of Non - Metals

Important Points & Activities – 3

✽ Sulphuric Acid

✣ **Sulphuric acid** is a chemical compound of utmost importance in industry. Its chemical formula is H_2SO_4.

✣ **Important Uses of Sulphuric acid :-**

- ✸ Manufacture of fertilisers.
- ✸ Manufacture of paints.
- ✸ Manufacture of explosives
- ✸ Used as a Dehydrating agent
- ✸ Refining of petroleum.
- ✸ Manufacture of fibres.
- ✸ Manufacture of other chemicals.
- ✸ Used as a Drying agent.

Because of these wide uses of sulphuric acid, it is called the **King of Chemicals.**

✣ **Industrial Preparation of Sulphuric Acid :-**

Sulphuric acid is industrially prepared by the **Contact Process**. The different stages in the contact process are the following.

I. Sulphur is burnt in air to produce **sulphur dioxide (SO_2).**

$$S + O_2 \longrightarrow SO_2$$

II. The SO_2 thus formed is allowed to combine with oxygen in the presence of **Vanadium pentoxide (V_2O_5)** as catalyst to produce **sulphur trioxide (SO_3).**

$$2\,SO_2 + O_2 \underset{450^{\circ}C}{\overset{V_2O_5}{\rightleftharpoons}} 2\,SO_3$$

III. SO_3 is now dissolved in concentrated sulphuric acid to form **Oleum**.

$$SO_3 + H_2SO_4 \longrightarrow H_2S_2O_7 \text{ (Oleum)}$$

IV. Oleum is then dissolved in water to form **Sulphuric acid.**

$$H_2S_2O_7 + H_2O \longrightarrow 2\,H_2SO_4$$

✣ Sulphuric acid is also formed by the direct dissolution of sulphur trioxide in water. But, it is not done. The dissolution of sulphur trioxide in water is an **exothermic process**. It may turn sulphuric acid initially formed into fine fog like particles (smog) which will **hinder further dissolution of sulphur trioxide.** That is why sulphur trioxide is dissolved in concentrated sulphuric acid to make oleum.

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✤ Physical Properties of Sulphuric acid :-

- ✸ It is a colourless liquid.
- ✸ It is odourless.
- ✸ It has comparatively high viscosity.
- ✸ It is highly corrosive.
- ✸ It is denser than water.
- ✸ It dissolves in water.

✤ Chemical Properties of Sulphuric acid :-

✸ Dilution of Concentrated Sulphuric acid :-

While diluting concentrated sulphuric acid, the acid should be added to water in very small quantities and stirred well. Since the reaction is highly exothermic, if water is added to the acid, it will result in spurting and may cause burns to our body.

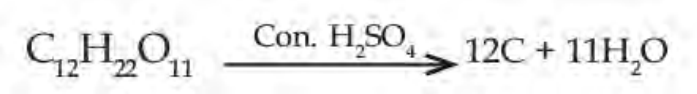
✸ Dehydrating nature :-

The process of absorbing chemically combined water, or hydrogen and oxygen from substances in the ratio corresponding to that of water is known as **dehydration**.

The substances which absorb chemically combined water, or hydrogen and oxygen from other substances in the ratio corresponding to that of water are called **dehydrating agents**. **Concentrated sulphuric acid** is a **strong dehydrating agent**.

Eg :-

1) When a few drops of concentrated sulphuric acid is added to a watch glass which contains some sugar, the colour of sugar gets converted into black due to the formation of carbon. Here, concentrated sulphuric acid acts as dehydrating agent and absorbs hydrogen and oxygen from sugar in the ratio 2:1. The black carbon is left behind.



2) When a few drops of concentrated sulphuric acid is added to a watch glass which contains some copper sulphate crystals, the blue colour of the copper sulphate crystals disappears and it becomes a white powder. Here, concentrated sulphuric acid acts as dehydrating agent and removes the water of crystallization from the hydrated copper sulphate (blue in colour) to produce anhydrous copper sulphate (white powder).

✸ Drying nature :-

Drying agents are substances capable of absorbing the moisture present in a substance. **Concentrated sulphuric acid** is a good **drying agent**.

Eg :- It is used as a drying agent in the preparation of Cl_2 , SO_2 and HCl.

All drying agents are not dehydrating agents but all dehydrating agents are drying agents.

✸ Reaction with salts :-

Concentrated sulphuric acid can displace **volatile acids** like **hydrochloric acid** and **nitric acid** from their salts. This method is employed in the preparation of these acids.

Eg :- Concentrated sulphuric acid forms hydrogen chloride on reaction with chlorides and nitric acid on reaction with nitrates.

$$NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$$

$$KNO_3 + H_2SO_4 \longrightarrow KHSO_4 + HNO_3$$

✸ **Oxidising nature :-**

Concentrated sulphuric acid reacts with metals and non metals and oxidises them.

Eg :-

1) Reaction with metals :- Reaction between concentrated **sulphuric acid** and **copper** is given below.

$$Cu + 2\,H_2SO_4 \longrightarrow CuSO_4 + SO_2 + 2\,H_2O$$

When **Cu** becomes $CuSO_4$, the oxidation state of **Cu** increases from **0** to **+2**. Hence, **Cu** is said to be oxidised to $CuSO_4$. Similarly, when H_2SO_4 becomes SO_2, the oxidation state of **S** in H_2SO_4 decreases from **+6** to **+4**. Hence, H_2SO_4 is said to be reduced to SO_2. In this reaction, **Cu** undergoes **oxidation** and it acts as the **reducing agent**. Similarly, H_2SO_4 undergoes **reduction** and it acts as the **oxidising agent**.

2) Reaction with non metals :- Reaction between concentrated **sulphuric acid** and **carbon** is given below.

$$C + 2\,H_2SO_4 \longrightarrow CO_2 + 2\,H_2O + 2\,SO_2$$

When **C** becomes CO_2, the oxidation state of **C** increases from **0** to **+4**. Hence, **C** is said to be oxidised to CO_2. Similarly, when H_2SO_4 becomes SO_2 , the oxidation state of **S** in H_2SO_4 decreases from **+6** to **+4**. Hence, H_2SO_4 is said to be reduced to SO_2. In this reaction, **C** undergoes **oxidation** and it acts as the **reducing agent**. Similarly, H_2SO_4 undergoes **reduction** and it acts as the **oxidising agent**.

[❖ The oxidation state of **any element** in the elemental state is **zero**.
❖ The **sum of the oxidation states of the constituent elements** of a compound will always be **zero**.
❖ An **increase in the oxidation state** of an atom, through a chemical reaction, is known as **oxidation** and a **decrease in the oxidation state** is known as **reduction**.
❖ An **oxidising agent** will always undergo **reduction** and a **reducing agent** will always undergo **oxidation**. **]**

✸ **Identification of sulphate ions :-**

Take a little of the given salt solution in a test tube and add a few drops of **barium chloride** ($BaCl_2$) solution to it. If a **white precipitate** is obtained by the reaction, add a few drops of dilute hydrochloric acid to it. If the white precipitate is **not dissolved** in dilute hydrochloric acid, then the given salt is a **sulphate**.

Eg :-

$$Na_2SO_4 + BaCl_2 \longrightarrow BaSO_4 + 2\,NaCl$$

- The **white precipitate** obtained by the addition of **barium chloride** solution **($BaCl_2$)** to the sulphate solution, is **barium sulphate ($BaSO_4$).**
- If no white precipitate is obtained by the addition of barium chloride ($BaCl_2$) to the given salt solution, the given salt will not be a sulphate. **Sulphate salts** react with **Barium chloride** to form a **white precipitate** of **Barium sulphate.** It is **not soluble** in **dilute hydrochloric acid.**

.....

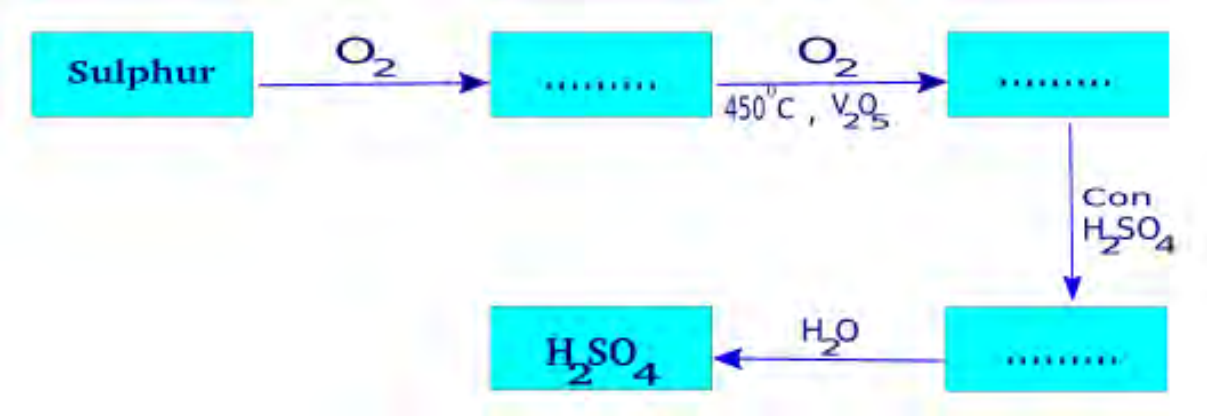
Activity – 1

Answer the questions given below.

1) Name the process of industrial preparation of sulphuric acid.
2) Which is the catalyst used in this process ?
3) What is the optimum temperature of this reaction ?
4) Name the product formed by the dissolution of SO_3 in concentrated sulphuric acid ?
5) Explain the different stages involved in the industrial preparation of sulphuric acid.

Activity – 2

Complete the flow chart given below.



Activity – 3

Pick out the correct statements from those given below.

1) Sulphuric acid is a colourless liquid.
2) Sulphuric acid is insoluble in water.
3) Sulphuric acid is highly corrosive.
4) Sulphuric acid is less denser than water.
5) Viscosity of sulphuric acid is comparatively high.

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Activity – 4

Give reason for the following.

1) Sulphuric acid can be produced by the direct dissolution of sulphur trioxide (SO_3) in water. But, sulphur trioxide is not directly dissolved in water to produce sulphuric acid.
2) Concentrated sulphuric acid is diluted not by adding water to the acid but by adding acid to water in very small quantities.
3) When concentrated sulphuric acid is added to $CuSO_4$ crystals, the blue colour of $CuSO_4$ disappears and it becomes a white powder.
4) Concentrated sulphuric acid not used as a drying agent in the preparation of ammonia.

Activity – 5

Explain the terms given below.

1) Dehydrating agent.
2) Drying agent
3) Oxidising agent.
4) Reducing agent

Activity – 6

When concentrated sulphuric acid is added to some sugar taken in a watch glass, the reaction takes place as per the equation given below.

$$C_{12}H_{22}O_{11} \xrightarrow{\text{Con. } H_2SO_4} 12C + 11H_2O$$

1) Which are the constituent elements of sugar ?
2) What is the ratio of hydrogen and oxygen in sugar ?
3) Write down the observation of this reaction.
4) Give reason for your observation.
5) Which property of concentrated sulphuric acid is made use of in this reaction ?

Activity – 7

Which property of concentrated sulphuric acid is made use of in each of the following reactions.

1) In the laboratory preparation of Cl_2 gas, Cl_2 gas is passed through concentrated sulphuric acid before collection.
2) $C_{12}H_{22}O_{11} + \text{Con. } H_2SO_4 \longrightarrow 12\ C + 11\ H_2O$
3) $NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$
4) $C + 2\ H_2SO_4 \longrightarrow CO_2 + 2\ SO_2 + 2\ H_2O$

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Activity – 8

Give one example each for the given properties of concentrated sulphuric acid.

1) Dehydrating property. **2)** Drying property.
3) Oxidising property.
4) Ability to displace volatile acids from their salts.

Activity – 9

Based on the equation given below, answer the following questions.

$$Cu^{0} + 2\,H_2{}^{+1}S^{+6}O_4{}^{-2} \longrightarrow Cu^{+2}S^{+6}O_4{}^{-2} + S^{+4}O_2{}^{-2} + 2\,H_2{}^{+1}O^{-2}$$

1) Which substance undergoes oxidation ?
2) Which substance undergoes reduction ?
3) Which is the oxidising agent ?
4) Which is the reducing agent ?

Activity – 10

Suggest an experiment for the identification sulphate ions.

a) Which is the reagent used for the identification of sulphates ?
b) Write down the procedure of the reaction.
c) What is your observation ?

Activity – 11

When a few drops of barium chloride ($BaCl_2$) solution is added to sodium sulphate (Na_2SO_4) solution, a white precipitate is formed.

a) Write down the chemical equation of this reaction.
b) Identify the white precipitate formed on the addition of $BaCl_2$.
c) What happens to the white precipitate when dilute HCl is added to it ?

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6 Nomenclature of organic compounds and isomerism

Important Points & Activities – 1

✽ IUPAC Nomenclature of Hydrocarbons

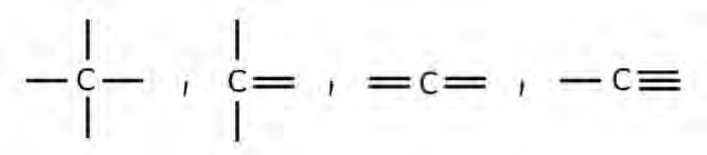
✤ **Organic Chemistry** is the branch of chemistry which deals with the study of carbon and its compounds.

✤ **Characteristic Properties of Carbon :-**

Symbol -- **C**	Atomic Number -- **6**
Period -- **2**	Valency -- **4**
Group -- **14**	Electro negativity – **2.55**

- ✷ All carbon compounds are **covalent** compounds .
- ✷ Carbon exhibits the unique property of **Catenation**. Carbon atoms can link with other carbon atoms through covalent bonds (single, double and triple bonds) to form long chain or ring like structures. This is known as **catenation.**
- ✷ Carbon compounds can exhibit **Isomerism**.

✤ In organic compounds, carbon satisfies its **4** valencies through any one of the following methods.



✤ **Hydrocarbons :-**
Organic compounds that are made of only hydrogen and carbon atoms are called **Hydrocarbons**.
Eg :- Methane **(CH_4)**, Ethane **(C_2H_6)** etc.

✤ Based on the structure, hydrocarbons are classified as follows.
1) Open chain hydrocarbons (Aliphatic hydrocarbons/Acyclic hydrocarbons)
2) Closed chain hydrocarbons (Ring hydrocarbons / Cyclic hydrocarbons).

✤ **Saturated hydrocarbons and Unsaturated hydrocarbons :-**
Saturated hydrocarbons are hydrocarbons which contain only single bonds between carbon atoms. **Eg :- Alkanes**
Unsaturated hydrocarbons are hydrocarbons which contain at least one double or triple bond between the carbon atoms. **Eg :- Alkenes** and **Alkynes**

✤ **Alkanes, Alkenes and Alkynes :-**
- ✷ Open chain hydrocarbons which contain **only single bonds** between carbon atoms are called **Alkanes**.
Eg :- Methane **(CH_4)**, Ethane **(C_2H_6)** etc.

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✷ Open chain hydrocarbons which contain at least **one double bond** between carbon atoms are called **Alkenes**.
Eg :- Ethene **(C_2H_4)**, Propene **(C_3H_6)** etc.

✷ Open chain hydrocarbons which contain at least **one triple bond** between carbon atoms are called **Alkynes.**
Eg :- Ethyne **(C_2H_2)**, Propyne **(C_3H_4)** etc.

✷ Alkanes are **Saturated** compounds whereas Alkenes and Alkynes are **Unsaturated** compounds.

✤ **General Formula of Alkanes, Alkenes and Alkynes :-**

Alkanes -- C_nH_{2n+2}

Alkenes -- C_nH_{2n}

Alkynes -- C_nH_{2n-2}

✤ **Word root :-** Word root is the word which represents the number of carbon atoms present in the carbon chain.

No. of Carbon atoms in the Main chain	Word Root	No. of Carbon atoms in the Main chain	Word Root
1 Carbon	meth	6 Carbon	hex
2 Carbon	eth	7 Carbon	hept
3 Carbon	prop	8 Carbon	oct
4 Carbon	but	9 Carbon	non
5 Carbon	pent	10 Carbon	dec

✤ **Homologous Series :-**
Compounds, which can be represented by a general formula and the successive members differ by a **CH_2** group, are called **homologues** and a series of such compounds is called **homologous series**.

Characteristics of a homologous series :-
- ✷ The members can be represented by a general formula.
- ✷ Successive members differ by a **CH_2** group.
- ✷ Members show similarity in chemical properties.
- ✷ There is a regular gradation in their physical properties.

✤ **IUPAC Nomenclature of Hydrocarbons :-**

1) **Nomenclature of Unbranched Hydrocarbons :-**
- ✷ Choose the appropriate **word root** according to the **no. of carbon atoms** present in the hydrocarbon.
- ✷ **Add** the **suitable suffix** to the **word root** based on the **bonding** between the **carbon atoms**.(If there exists **only single bonds** between the carbon atoms, use the suffix **"ane"**. If there exists at least a **double bond** between the carbon atoms, use the suffix **"ene"** and if there exists at least a **triple bond** between the carbon atoms, use the suffix **"yne"**.) **OR**

[In **Alkanes** the suffix **" ane "**, in **Alkenes** the suffix **" ene "** and in **Alkynes** the suffix **" yne "** are used .]

- In Alkenes and in Alkynes, the numbering of carbon atoms should be done in such a way that the **carbon atoms** linked by **double or triple** bond gets the **lowest number**.
- In the case of Alkenes and Alkynes with more than **3** carbon atoms,the **position number of the carbon** atom, which carries the double or triple bond, should be written in **between the word root and the suffix**.
- **Alphabets and numerals** should be separated by a **hyphen (–)**.

Eg :-

1) IUPAC name of a hydrocarbon with **5 carbon** atoms and only **single bonds** between carbon atoms is **pent + ane ⟶ pentane.**

2) IUPAC name of a hydrocarbon with **5 carbon** atoms and a **double** bond in between the second and third carbon atoms is **pent-2-ene.**

3) IUPAC name of a hydrocarbon with **5 carbon** atoms and a **triple** bond in between the second and third carbon atoms is **pent-2-yne.**

IUPAC Nomenclature of Unbranched Hydrocarbons

Alkanes ⟶ Word root + 'ane'
Alkenes ⟶ Word root + position no.of double bond + 'ene'
Alkynes ⟶ Word root + position no.of triple bond + 'yne'

2) Nomenclature of Branched Alkanes :-

1) Choose the **longest carbon chain** (the chain with the maximum no. of carbon atoms) and number the carbon atoms as per the IUPAC rules.

[a) Numbering of the carbon atoms in the main chain should be done in such a way that the **carbon atom which carries the branch gets the lowest number.**

b) If **more than one branch** is present, numbering should be done either from left to right or from right to left so as to get the **lowest number for the branch coming first in the longest chain**.

c) If the position number of the **first branch** is the **same**, while numbering the carbon atoms from left to right and from right to left, consider the position of the **second branch**. If that also is the same, then consider the position of the **third branch**. **]**

2) Write the **name** of the **Alkane** (parent hydrocarbon) based on the no. of carbon atoms in the main chain.

3) Write the **name of the branch / branches** on the **left side** of the name of Alkane.

[To find the **name of the branch**, choose the appropriate **word root** based on the no. of carbon atoms present in the **branch** and add the suffix ' **yl** ' to the **word root**.

Eg :- If only **one carbon** atom is present in the branch, then the name will be **meth + yl ⟶ methyl**. If **2** carbon atoms are present in the branch, then the name will be **eth + yl ⟶ ethyl**. **]**

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4) If the **same branch appears more than once** in a carbon chain, the **number of branches** should be indicated by the prefixes like **di (two), tri (three), tetra (four)** etc.

5) If **two identical branches** are present on the **same carbon** atom, their **position number** should be **repeated**.

6) If **different branches** are present in the main chain, the **names of these branches** should be written in the **alphabetical order**.

7) Write the **position numbers** of the branches on the **left side of the name of each branch**.

8) **Alphabets and numerals** should be separated by a **hyphen (–)**. Similarly, **numbers** should be separated by a **comma (,)**.

Name of a branched Alkane ⟶ Position number of the branch + hyphen + Name of the branch + Name of Alkane

[If there are more than one identical branches, the prefix indicating the number of branches should be written on the left side of the name of branch and if there are different branches, their names should be written in the alphabetical order. **]**

✤ **Method of writing the structural formula of Alkanes based on their IUPAC names :-**

1) Write the main carbon chain first.
[Based on the last part (alkane) of the name **]**

2) Complete the carbon chain by including the carbon atoms present in the branch / branches at proper positions in the main carbon chain.

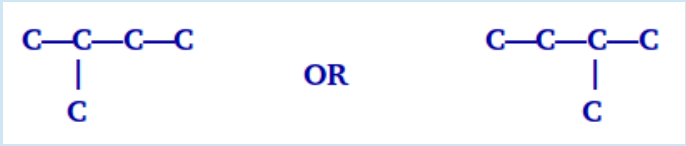
3) Then complete the structure by filling all the four valencies of each carbon atom with hydrogen atoms.

Eg :- Method of writing the structure of 2-methylbutane.

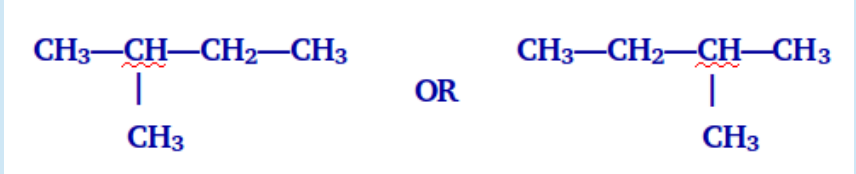
Step -1 (Write the **Main carbon chain**)

C—C—C—C **[** Parent alkane (last part of the name) is **butane.]**

Step -2 (Include the carbon atoms present in the branch / branches to the **Main carbon chain** at proper positions.)

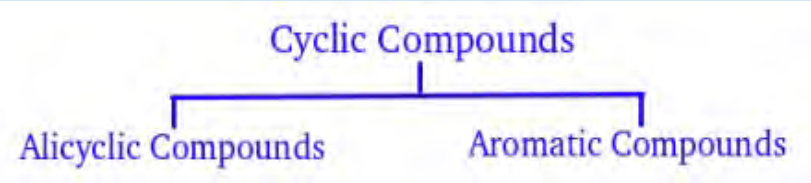


Step -3 (Complete the **four** valencies of each **carbon** atom with **hydrogen** atoms)



✤ Cyclic or Ring Compounds :-

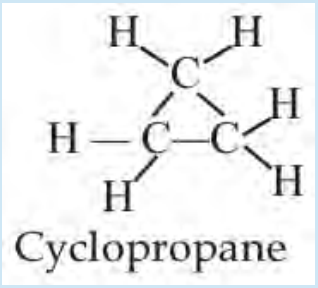
Cyclic or ring compounds are classified into two.

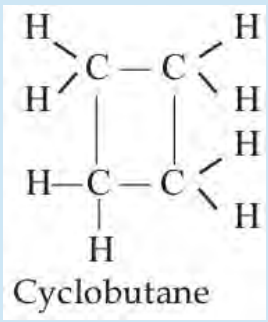


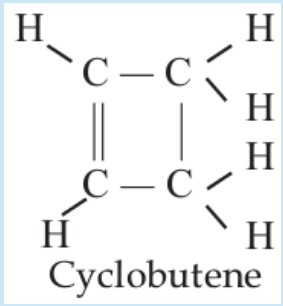
✷ Alicyclic Hydrocarbons :-

Alicyclic hydrocarbons are cyclic hydrocarbons which contain a ring of **3** or more carbon atoms. They resemble open chain hydrocarbons or aliphatic (acyclic) hydrocarbons like alkane, alkene and alkyne in their properties.

Eg :- Structure of some alicyclic hydrocarbons and their IUPAC names are given below.



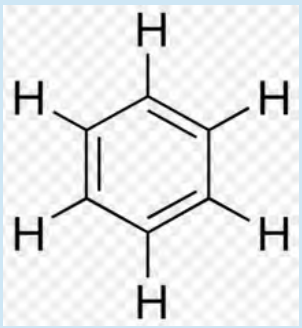




✷ Aromatic Hydrocarbons :-

Aromatic compounds are cyclic compounds having their own aroma(smell).

Benzene (C_6H_6) is an industrially important aromatic compound.



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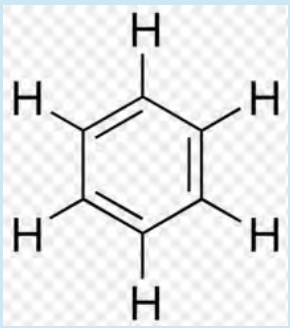

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Activity – 1

Explain the terms given below.

1) Alkanes **2)** Alkenes

3) Alkynes **4)** Homologous series

Activity – 2

Classify and tabulate the following compounds into alkanes, alkenes and alkynes.

C_5H_{10} , C_6H_{10} , C_2H_4 , C_5H_{12} , C_6H_{12} , C_7H_{12} , $C_{10}H_{22}$, C_4H_{10} , C_4H_8 , C_4H_6

Activity – 3

Pick out the homologues from the compounds given below.

CH_4 , C_2H_4 , C_3H_4 , C_2H_6 , C_7H_{14} , C_3H_6 , C_4H_6 , C_4H_8 , C_5H_{12}

Activity – 4

Pick out the statements that are suitable for a homologous series from those given below.

1) The members can be represented by a general formula.
2) Members differ in their chemical properties.
3) Successive members differ by a CH_2 group.
4) Members show similarity in physical properties.

Activity – 5

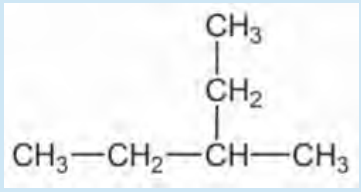
Answer the following questions.

1) Write down the chemical formula of an alkane, alkene and an alkyne which contain **6** carbon atoms.
2) Identify the homologues of the above mentioned alkane, alkene and alkyne.

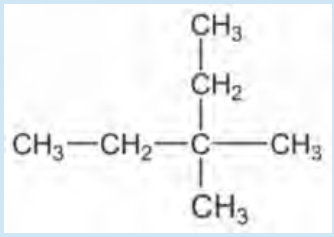
Activity – 6

Mark the main chains of the compounds given below.

1)



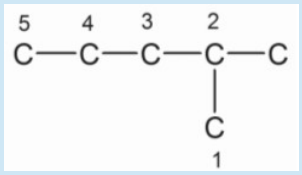
2)



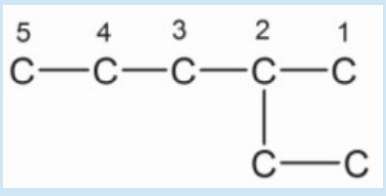
Activity – 7

Identify the wrongly numbered carbon chains from those given below and correct them.

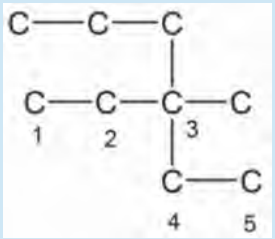
1)



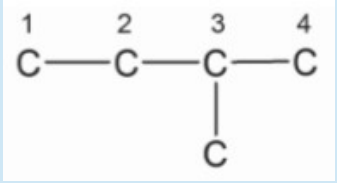
2)



3)

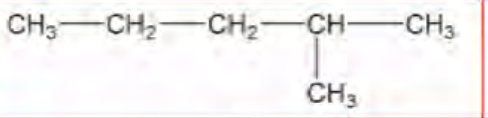
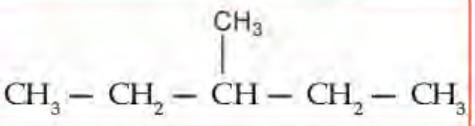
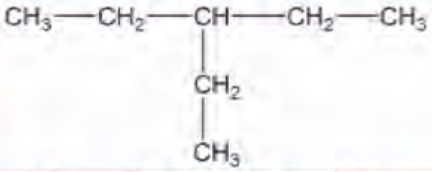
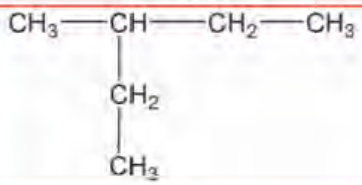


4)



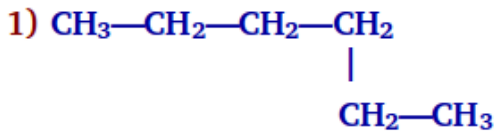
Activity – 8

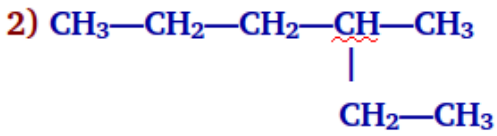
Complete the table given below.

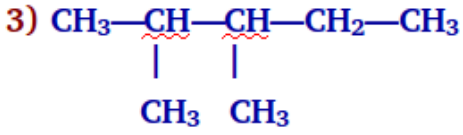
Compound	Number of carbon atoms in the longest chain	Name of branch	Position of branch	IUPAC name
	.....	.....	.....	.....
	.....	.....	.....	.....
	.....	.....	.....	.....
	.....	.....	.....	.....

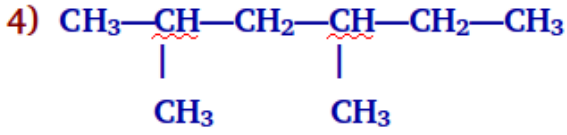
Activity – 9

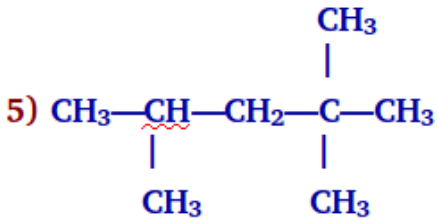
Write down the IUPAC names of the compounds given below.

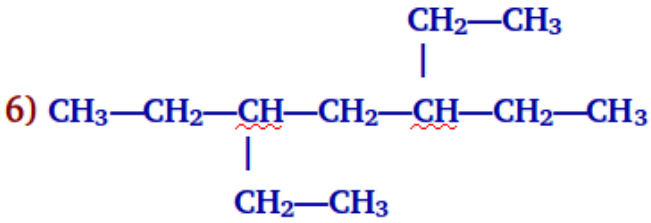
1) 

2) 

3) 

4) 

5) 

6) 

Activity – 10

Write down the structural formulae of the compounds given below.

1) Hexane
2) 3-methylpentane
3) 3-ethylpentane
4) 2,2-dimethylhexane
5) 2,2,4-dimethylpentane
6) 3,5-diethylheptane

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Activity – 11

Write down the IUPAC names of the compounds given below.

1) $CH_2=CH-CH_2-CH_3$

2) $CH_3-CH=CH-CH_2-CH_3$

3) $CH_3-C\equiv C-CH_3$

4) $CH_3-CH_2-CH_2-C\equiv CH$

5) $CH_3-CH_2-CH=CH-CH_2-CH_3$

6) $CH_3-CH_2-CH_2-CH(CH_3)-CH=CH_2$

Activity – 12

Write down the structural formulae of the compounds given below.

1) But-2-ene
2) Pent-3-ene
3) But-1-yne
4) Pent-2-yne
5) Hex-2-ene
6) 3-methylhex-2-ene

Activity – 13

Certain hints about a hydrocarbon are given below.

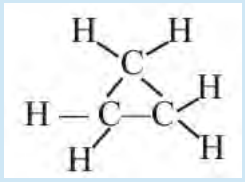
- **The molecular formula is C_5H_{12}**
- **It has a methyl radical as branch on second carbon.**

1) Write down the structural formula of this compound.
2) Write down its IUPAC name.

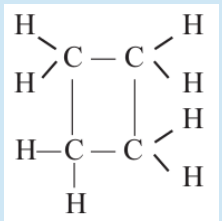
Activity – 14

Write down the IUPAC names of the following cyclic hydrocarbons.

1)



2)



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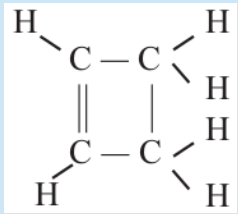

Activity – 15

Write down the structural formulae of the compounds given below.

1) Cyclobutane
2) Cyclopentane
3) Cyclobutyne
4) Benzene

.....

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6 Nomenclature of organic compounds and isomerism

Important Points & Activities – 2

✽ Functional Groups & Isomerism

✤ Functional Groups :-

In organic chemistry, **a functional group** is a **specific group of atoms** within a compound that is responsible for the characteristic properties of that compound.

✤ Some Important Functional Groups :-

Name of Functional group	Symbol	Category of Compounds
Hydroxyl group	– OH	Alcohols
Alkoxy group	– O – R	Ethers
Carboxylic group	– COOH	Carboxylic Acids
Halo group [fluoro (–F), chloro (–Cl), bromo (–Br), iodo (–I)]	– F, – Cl, –Br, –I	Halo Compounds
Ester group	– COO –	Esters

✤ IUPAC Nomenclature of Alcohols :-

Organic compounds which contain **Hydroxyl group (– OH)** as the functional group are called **Alcohols**.

Naming :-

1) Write the name of the corresponding **alkane** based on the no. of carbon atoms present in the carbon chain.

2) Replace the last letter ' **e** ' from the name of the **alkane** with ' **ol** '.

3) If there are more than **2** carbon atoms, the **position number** of the **– OH** group should be written in **between** the name of the **alkane** and the suffix ' **ol** '.

[Number the carbon atoms in the carbon chain in such a way that the **carbon atom** which carries the **– OH group** should get the **lowest number.]**

Alkane – e + ol ⟶ Alkanol

Eg :- CH_3-CH_2-OH **[Ethane – e + ol ⟶ Ethanol]**

Prepared by Muraleedharan. K, GVHSS Vattenad

✤ IUPAC Nomenclature of Ethers :-

Organic compounds which contain **Alkoxy group (– O – R)** as the functional group are called **Ethers**.

Naming :-

1) Among the **alkyl** groups on either side of the **– O –** group, the **longest alkyl group (** the group with maximum no. of carbon atoms **)** is taken as **alkane** and the name of that **alkane** is written based on the no. of carbon atoms present.
2) Find the name of the **alkoxy** group by adding the suffix ' **oxy** ' to the **word root** of the **smallest alkyl group**.
3) Write the name of the **alkoxy** group on the **left side** of the name of **alkane**

Word root of the smallest alkyl group + oxy +
Word root of the longest alkyl group + ane ⟶ Alkoxyalkane
OR
Name of alkoxy group + Name of alkane ⟶ Alkoxyalkane

Eg :- CH_3-CH_2-O-CH_3 **[Meth + oxy + eth + ane ⟶ Methoxyethane]**

✤ IUPAC Nomenclature of Carboxylic Acids :-

Organic compounds which contain **Carboxylic group (– COOH)** as the functional group are called **Carboxylic acids**.

Naming :-

1) Write the name of the corresponding **alkane** based on the no. of carbon atoms (including the carbon atom present in the **– COOH** group) present in the carbon chain.
2) **Replace** the last letter ' **e** ' from the name of the **alkane** with ' **oic acid** '.

[Number the carbon atoms in the carbon chain in such a way that the **carbon atom** of the **– COOH** group should get the **lowest number**.**]**

Alkane – e + oic acid ⟶ Alkanoic acid

Eg :- CH_3-CH_2-COOH **[Propane – e + oic acid ⟶ Propanoic acid]**

✤ IUPAC Nomenclature of Halo Compounds :-

Organic compounds which contain **Halo group (fluoro,chloro,bromo and iodo)** as the functional group are called **Halo Compounds**.

Naming :-

1) Write the name of the corresponding **alkane** based on the no. of carbon atoms present in the carbon chain.
2) Write the name of the **halo group (fluoro,chloro,bromo** and **iodo)** on the **left side** of the **name of alkane**.
3) If the **same halo group** appears **more than once** in a carbon chain, the **number** of **halo groups** should be indicated by the prefixes like **di (two)**, **tri (three)**, **tetra (four)** etc.

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4) If **different halo groups** are present in the main chain, the **names** of these **halo groups** should be written in the **alphabetical order**.

5) If there are more than **2 carbon** atoms and more than **one halo group** in the carbon chain, the **position number** of the **halo group** should be written on the **left side** of the **name** of each **halo group**.

Position number of halo group + hyphen + Name of halo group + Name of alkane ⟶ Halo alkane

Eg :- CH_3-CH_2-CH_2-Cl [1-chloropropane]

CH_3-CH_2-CH_2-Br [1-bromopropane]

✤ Isomerism :-

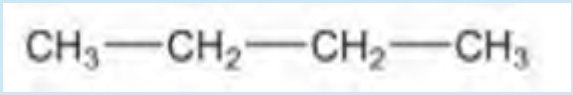
Compounds having the same molecular formula but different chemical and physical properties (different structural formula) are called **Isomers**. This phenomenon is called **Isomerism**.

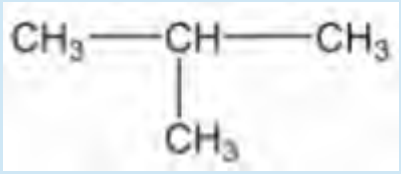
Eg :- CH_3-CH_2-OH (Ethanol) & CH_3-O-CH_3 (Methoxymethane) are isomers with the same molecular formula **(C_2H_6O)** and different structural formulae.

✤ Different Types of Isomerism :-

1) **Chain Isomerism :-** Compounds with the same molecular formula, but **different main chain structures** are called **Chain isomers** and the phenomenon is called **Chain isomerism**.

Eg :-





[Butane & 2-Methylpropane are **chain isomers** with the same molecular formula **(C_4H_{10}),** but different main chain structures. **]**

2) **Functional Isomerism :-** Compounds having the same molecular formula, but having a **difference in their functional groups** are called **Functional isomers** and the phenomenon is called **Functional isomerism**.

Eg :- CH_3-CH_2-OH (Ethanol) & CH_3-O-CH_3 (Methoxymethane) are functional isomers with the same molecular formula **(C_2H_6O)** and different functional groups.

3) **Position Isomerism :-** Compounds having the same molecular formula, but having a difference in the **position** of the **functional group / double or triple bond / branches** are called **Position isomers** and the phenomenon is called **Position isomerism**.

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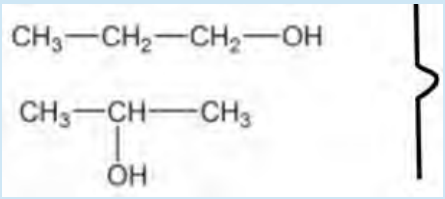
Eg :-

1)

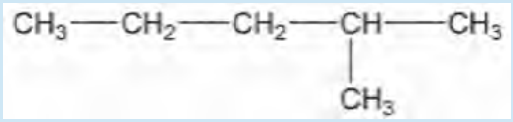


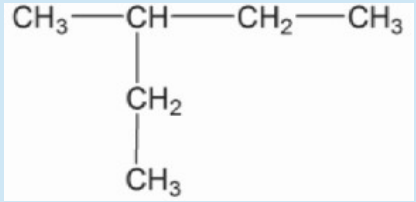
Propan-1-ol & Propan-2-ol are position isomers with the same molecular formula. **(C_3H_8O)**

2) **CH_3-CH_2- CH=CH_2 (But-1-ene) &**
CH_3-CH= CH-CH_3 (But-2-ene) are position isomers with the same molecular formula **(C_4H_8)**

3) **CH_3-CH_2- C≡CH (But-1-yne) &**
CH_3-C≡C-CH_3 (But-2-yne) are position isomers with the same molecular formula **(C_4H_6)**

4)





2-Methylpentane & 3-Methylpentane are position isomers with the same molecular formula **(C_6H_{14})**

• • • • • • • • • • • • • • • • • •

Activity – 1

Identify the functional groups present in the compounds given below.

1) CH_3-CH_2-CH_2-CH_2- Cl **2) CH_3-CH_2-CH_2-COOH**

3) CH_3-O-CH_2-CH_2-CH_3 **4) CH_3-CH_2-CH_2-OH**

Activity – 2

Examine the given structure and answer the following questions.

CH_3-O-CH_2-CH_2-CH_3

(a) Name the functional group present in this compound.
(b) Name the category of compounds which contains this functional group.
(c) Give the IUPAC name of the compound.

Activity – 3

Examine the given structure and answer the following questions.

CH_3-CH_2-CH_2-OH

(a) Name the functional group present in this compound.
(b) Name the category of compounds which contains this functional group.
(c) Give the IUPAC name of the compound.

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Activity – 4

Match the items given in columns A,B and C suitably.

A	B	C
Hydroxyl group	– Cl	Carboxylic Acids
Alkoxy group	– COOH	Halo Compounds
Carboxylic group	– COO –	Alcohols
Halo group	– O – R	Esters
Ester group	– OH	Ethers

Activity – 5

Complete the table given below.

Functional group	Compounds with this functional groups	IUPAC Name
•••••••	CH_3-CH_2-CH_2-CH_2-OH	•••••••
– O – R	•••••••	Ethoxypropane
•••••••	CH_3-CH_2-COOH	•••••••
–Cl	•••••••	2-chloropentane

Activity – 6

Write a short note on each of the following.

1) Isomerism
2) Chain isomerism
3) Functional isomerism
4) Position isomerism

Activity – 7

Write down the IUPAC names of the compounds given below.

1) $CH_3-\underset{\underset{OH}{|}}{CH}-CH_2-CH_3$
2) $CH_3-CH_2-CH_2-CH_2-OH$
3) $CH_3-CH_2-\underset{\underset{OH}{|}}{CH}-CH_2-CH_3$
4) $CH_3-CH_2-CH_2-CH_2-CH_2-OH$
5) $CH_3-O-CH_2-CH_3$
6) $CH_3-CH_2-O-CH_2-CH_2-CH_3$
7) $CH_3-CH_2-O-CH_2-CH_3$
8) $CH_3-CH_2-CH_2-CH_2Cl$
9) $CH_3-CH_2-CH_2-COOH$
10) CH_3-CH_2-COOH

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Activity – 8

Write down the structural formula of the compounds given below.

1) Propan-2-ol
2) Methoxypropane
3) Ethanoic acid
4) Pentan-2-ol
5) 2-chlorobutane
6) Methoxymethane

Activity – 9

Examine the two compounds given below.

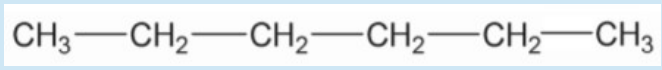
1) CH_3-CH_2-OH **2)** CH_3-O-CH_3

(a) Write down the molecular formula of these compounds.
(b) Identify the functional groups present in these compounds.
(b) What is the similarity between these two compounds ?
(c) What is the difference between these two compounds ?
(d) Do they belong to the same category of compounds.
(e) Find out whether they are isomers or not.

Activity – 10

The structural formulae of various compounds are given below. Tabulate them into different pairs of isomers.Write down their IUPAC names also.

1)



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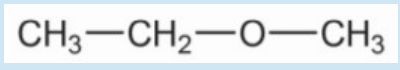

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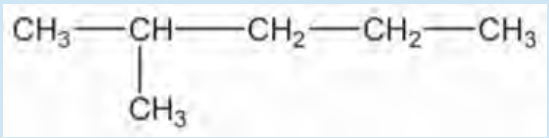
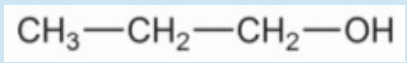


4)



Activity – 11

The structural formulae of two organic compounds are given.

1) CH_3-CH_2-CH_2-OH **2)** CH_3-O-CH_2-CH_3

a) Write down the IUPAC names of these compounds.
b) Write one similarity and one difference between these two compounds.
c) Identify the type of isomerism to which these compounds belong.
d) Write down the structural formula and IUPAC name of the isomer of these 2 compounds.

Activity – 12

Write down the structural formula of the compound C_5H_{10}.
Write down the structural formula of one of its isomers which is an alicyclic compound.

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Activity – 13

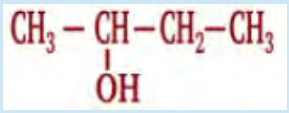
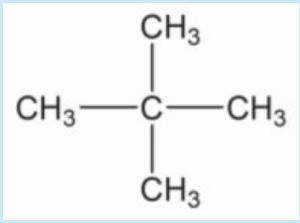
Certain hints about a hydrocarbon are given below.

- **The molecular formula is C_5H_{12}**
- **It has a methyl radical as branch on second carbon.**

1) Write down the structural formula of this compound.
2) Write down the structural formulae of the possible chain isomers of this compound.
3) Write down the IUPAC names of these chain isomers.

Activity – 14

Examine the compounds given below and find out the isomeric pairs. Also, identify the type of isomerism to which each pair belongs.

1) $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}OH$
2) $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$
3) $CH_3\text{-}CH_2\text{-}CH_2\text{-}OH$
4) $CH_3\text{-}O\text{-}CH_2\text{-}CH_3$
5) 
6) 
7) $CH_3\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_3$

Activity – 15

The structural formula of an organic compound is given below.

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}OH$

1) How many position isomers are possible for this compound ?
2) Write down the structure and IUPAC names of these isomers.

Activity – 16

The structural formula of an organic compound is given below.

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

1) How many chain isomers are possible for this compound ?
2) Write down the structure and IUPAC names of these isomers.

Activity – 17

The structural formula of an organic compound is given below.

$CH_3\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_3$

1) How many functional isomers are possible for this compound ?
2) Write down the structure and IUPAC names of these isomers.

Activity – 18

Find three pairs of isomers from the compounds given below. Identify the type of isomerism to which each pair belongs.

a) Propan-1-ol b) 2,2,3,3-Tetramethylbutane
c) Octane d) Propan-2-ol e) Methoxyethane

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7 Chemical Reactions of Organic Compounds

Important Points & Activities – 1

✽ Basic Chemical Reactions of Hydrocarbons

✤ Substitution Reactions :-

Reactions in which an atom or atom group in a compound is replaced by another atom or atom group are called **Substitution Reactions.**

Eg :- Reaction of **methane (CH_4)** with **chlorine** in presence of **sunlight**. When methane reacts with chlorine in presence of sunlight, each hydrogen atom of methane is replaced successively by chlorine atoms. As a result, a mixture of compounds **[CH_3Cl (chloromethane)**, **CH_2Cl_2 (dichloromethane)**, **$CHCl_3$ (trichloromethane** OR **chloroform)** and **CCl_4 (tetrachloromethane** OR **carbon tetrachloride)]** is formed.

$$CH_4 + Cl_2 \xrightarrow{\text{Sunlight}} CH_3Cl + HCl$$

$$CH_3Cl + Cl_2 \longrightarrow CH_2Cl_2 + HCl$$

$$CH_2Cl_2 + Cl_2 \longrightarrow CHCl_3 + HCl$$

$$CHCl_3 + Cl_2 \longrightarrow CCl_4 + HCl$$

[Only **Alkanes** undergo **substitution** reactions. **Alkenes and Alkynes do not undergo** substitution reactions. **]**

[In **substitution** reactions, the **reactant part** will be an **alkane / halo alkane + Cl_2** and the **product part** will be a **halo alkane + HCl]**

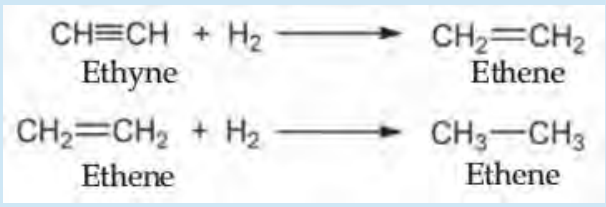
✤ Addition Reactions :-

Reactions in which unsaturated hydrocarbons (Alkenes and Alkynes) react with other molecules like **H_2, Cl_2, Br_2, HCl, HBr** etc to form saturated compounds are called **Addition Reactions**.

Eg :- a) Reaction between **Ethene** and **Hydrogen** to form **Ethane**.

$$CH_2 = CH_2 + H_2 \longrightarrow CH_3 - CH_3 \quad \text{(Ethane)}$$

b) Reaction between **Ethyne** and **Hydrogen** to form **Ethane**.



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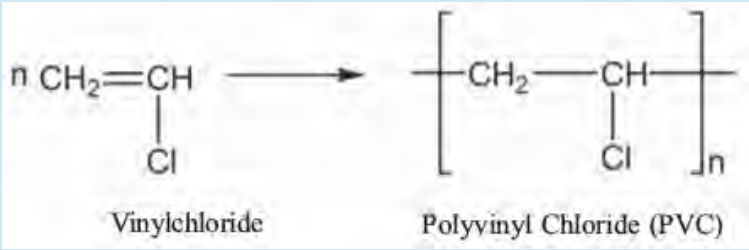
[In addition reactions of **alkenes**, they are **directly converted** to saturated compounds. But, in addition reactions of **alkynes**, they are first converted to **unsaturated compounds having double bond** and in the second step these compounds are converted to **saturated compounds**.]

[Only **unsaturated hydrocarbons (Alkenes and Alkynes) undergo** addition reactions. **Alkanes do not undergo** addition reactions.
In **Addition reactions**, the **reactant part** will be an **alkene / alkyne + Cl2 / H2 / Br2 / HCl / HBr** and the **product part** will be a **saturated compound** (only a **single product** is formed).]

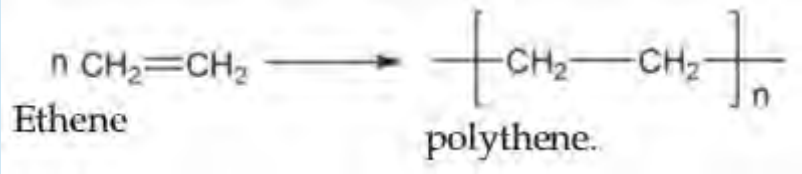
✤ Polymerisation Reactions :-

Polymerisation is the process in which a large no. of simple molecules combine under suitable conditions (high temperature, pressure and in the presence of a catalyst) to form complex molecules.
In **Polymerisation reaction**, the simple molecules which combine together to form a complex molecule are called **Monomers** and the complex molecule formed by this reaction is called **Polymer**.

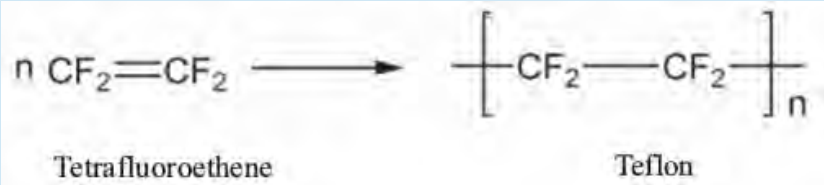
Eg :- a) Polymerisation of **vinylchloride** (chloroethene) molecules to form **Polyvinylchloride (PVC)**.



b) Polymerisation of **ethene** molecules to form **Polythene (PE)**.



c) Polymerisation of **tetrafluoroethene** molecules to form **Polytetrafluoroethene (PTFE)** OR **Teflon**.



[Only **Alkenes, substituted alkenes** and **Alkynes undergo polymerisation**. **Alkanes do not undergo** polymerisation. In **polymerisation** reactions, the **reactant part** will be '**n**' **molecules** of an **alkene / substituted alkene / an alkyne** and the **product part** will be a **polymer** molecule within **square brackets**.]

Monomer	Polymer	Uses
Ethene	**Polythene (PE)**	It is used for making carry bags, packing covers, toys, electrical insulation etc.
Vinylchloride (chloroethene)	**Polyvinylchloride (PVC)**	It is used for making pipes, doors and windows, blood bags and tubings, wire and cable insulation etc.
Isoprene	**Polyisoprene (Natural Rubber)**	It is used for making vehicle tyres and tubes, surgical gloves, mats etc.
Tetrafluoroethene	**Polytetrafluoroethene (PTFE) OR Teflon**	It is used as a non-stick coating for pans and other cookware.

✤ **Combustion Reactions :-**

When hydrocarbons burn, they combine with the oxygen in the air to form carbon dioxide (CO_2) and water (H_2O) along with heat and light. This process is called **Combustion**.

Eg :- Combustion of **Methane (CH_4)**

$$CH_4 + 2\,O_2 \longrightarrow CO_2 + 2\,H_2O + \text{Heat}$$

✷ Combustion of hydrocarbons is an **exothermic reaction**. That is, during combustion large amount of heat energy is liberated. Hence, most of the hydrocarbons are used as fuels. **Eg :-** Kerosene, Petrol, LPG etc.

[In Combustion reactions, the **reactant part** will be a **hydrocarbon + O_2 (oxygen)** and the **product part** will be **carbon dioxide (CO_2) and water (H_2O)]**

✤ **Thermal Cracking :-**

Some hydrocarbons with high molecular masses, when heated in the absence of air, undergo decomposition to form hydrocarbons with lower molecular masses. This process is called **Thermal cracking**.

Eg :- Propane is one of the simplest hydrocarbons which has the capacity to undergo thermal cracking.

$$\underset{\text{Propane}}{CH_3 - CH_2 - CH_3} \rightarrow \underset{\text{Ethane}}{CH_2 = CH_2} + \underset{\text{Methane}}{CH_4}$$

✷ The products formed as a result of thermal cracking depend on the **nature** of the **hydrocarbons** getting cracked, their **temperature** and **pressure**.

✷ When **saturated** hydrocarbons are subjected to **thermal cracking,** the products formed contain both **saturated and unsaturated** hydrocarbons.

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[In **Thermal Cracking,** the **reactant part** will be a **single hydrocarbon** and the **product part** will contain **more than one hydrocarbons.]**

Applications of Thermal Cracking :-

1) **Butane**, the **main component of LPG**, can be prepared by the thermal cracking of **higher hydrocarbons**.
2) **Plastic wastes**, which are hydrocarbon polymers can be converted to simpler hydrocarbons by thermal cracking. This helps to control pollution to some extent.

.....

Activity – 1

Write a note on the basic chemical reactions of hydrocarbons. Give one example for each.

Activity – 2

Answer the following questions.

a) Write the chemical formula of ethane.

b) Write down the chemical equations that represent the different stages of the substitution reaction between **ethane (CH_3-CH_3)** and **chlorine**.

Activity – 3

Write the chemical formula of propane. Write the structural formulae and IUPAC names of any two compounds that may be formed during its substitution reaction with chlorine.

Activity – 4

Two chemical equations are given below.

a) $CH_2 = CH_2 + H_2 \xrightarrow[\text{Sunlight}]{} A$

b) $A + Cl_2 \longrightarrow B + HCl$

a) Identify the compounds '**A**' and '**B**'.

b) Name these reactions.

Activity – 5

Identify the products in the following addition reactions and complete the table.

Chemical reaction	Product	IUPAC name of the product
$CH_2=CH_2 + Cl_2$	.....	.....
$CH_2=CH_2 + HCl$	.....	.....
$CH_3–CH=CH_2 + H_2$	.....	.....
$CH_3–CH=CH–CH_3 + HBr$	.....	.....

Activity – 6

Complete the given table suitably.

Monomer	Polymer	Use
.....	PVC	.....
Ethene	.....	.....
Isoprene	Natural rubber (Polyisoprene)	.....
.....	Teflon	.....

Activity – 7

Answer the questions given below.

1) Name the polymer that is used as a coating in non-stick cookwares.
2) Name the monomer of this polymer.
3) Write down the chemical equation which shows the polymerisation of this monomer.

Activity – 8

Answer the questions given below.

1) Which is the major component of LPG ?
2) Write down the balanced chemical equation for the combustion of butane (C_4H_{10}).
3) Most of the hydrocarbons are used as fuels. Give reason.

Activity – 9

Complete the table given below.

$CH{\equiv}CH + H_2$	→	.....
$CH_3Cl + Cl_2$	→	..... + HCl
.....	→	$+CH_2—CH_2+_n$
CH_4 + ...	→	$CO_2 + H_2O$
..... + H_2	→	$CH_3—CH_3$

Activity – 10

Answer the questions given below.

1) What is thermal cracking ?
2) Name the factors that influence the formation of products during thermal cracking.
3) Give any one application of thermal cracking.

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Activity – 11

Find out the appropriate reactions and match the columns A, B and C suitably.

Reactants (A)	Products (B)	Name of the reaction (C)
$CH_3–CH_3 + Cl_2$	$CO_2 + H_2O$	Addition reaction
$C_2H_6 + O_2$	$CH_2=CH_2$	Thermal cracking
$nCH_2=CH_2$	$CH_2=CH_2 + CH_4$	Substitution reaction
$CH_3–CH_2–CH_3$	$CH_3–CH_2Cl + HCl$	Polymerisation
$CH\equiv CH + H_2$	$\left[CH_2—CH_2\right]_n$	Combustion

Activity – 12

Some reactions are given below.

Reaction-A : $CH\equiv CH + H_2 \longrightarrow X$

Reaction-B : $X + H_2 \longrightarrow Y$

Reaction-C : $Y + Cl_2 \longrightarrow Z + HCl$

1) Write the molecular formula of the compounds **X, Y** and **Z.**

2) Write the names of the reactions **B** and **C.**

Activity – 13

Some hydrocarbons are given below.

Butane, Propene, Methane, Hexene, Pentane

$CH_2=CH_2$, CH_3-CH_2-CH_3, CH_3-CH_2-$CH=CH_2$

1) Which of the given molecules can undergo addition reactions ?

2) Which of the given molecules can undergo substitution reactions ?

3) Which of the given molecules can form polymers ?

.....

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7 Chemical Reactions of Organic Compounds

Important Points & Activities – 2

✽ Some Important Organic Compounds

✤ Alcohols :-

1) Methanol (Methyl alcohol) :-

Methanol is an industrially important alcohol. It is the simplest alcohol and it is also known as **Wood Spirit.** Methanol is a highly poisonous substance.

Industrial Preparation :

Methanol is industrially prepared by treating **carbon monoxide (CO) with hydrogen** in the presence of a catalyst at high temperature and pressure.

(Catalytic hydrogenation of Carbon monoxide)

$$CO + 2H_2 \xrightarrow[573\,K,\ 200\,atm]{\text{Catalyst}} \underset{\text{Methanol}}{CH_3 — OH}$$

Uses :

1) It is used as a **solvent** in the manufacture of **paints**.

2) It is used as a **reactant** in the manufacture of **varnish and formalin** .

3) It is used for the **denaturing** of Ethanol .

4) It is used for the **production of bio diesel** via **Trans esterification** reaction. Etc.

2) Ethanol (Ethyl alcohol) :-

Ethanol also is an industrially important alcohol. It is also known as **Grape spirit.**

Industrial Preparation :

Ethanol is industrially prepared by the **fermentation** of the dilute **molasses** (OR **10%** sugar solution) by the addition of **yeast**.

Fermentation of molasses takes place in the presence of two enzymes **Invertase** and **Zymase** present in the yeast and within a few days it changes to ethanol.

$$\underset{\text{Sucrose (Sugar)}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} \underset{\text{Ethanol}}{2C_2H_5\text{-}OH} + 2CO_2$$

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✷ **Molasses :-** Molasses is the concentrated solution of sugar (mother liquor) left behind after the separation of sugar crystals during the manufacture of sugar.

✷ **Fermentation :-** Fermentation is the slow decomposition of complex organic compounds into simple compounds by the action of biological catalysts called enzymes.

Uses :-

1) It is used as **beverage**.
2) It is used as an **organic solvent** for **medicines**.
3) Used in the **manufacture of various organic compounds** and paints.
4) Used as a **preservative**.
5) It can be used as a **fuel** by itself or in combination with other compounds.
6) Used as a **disinfectant.** Etc.

✤ **Different Types of Ethanol mixtures :-**

Wash	The **8 – 10 %** strong ethanol solution obtained by the fermentation of molasses is called **Wash.**
Rectified spirit	The **95.6 %** strong ethanol solution obtained by the **fractional distillation of wash** is known as **Rectified spirit**. It is used for medicinal purposes, as a household solvent etc.
Absolute Alcohol	**99 %** or **more than 99 % pure ethanol** obtained by the purification of rectified spirit is known as **Absolute alcohol.**
Power Alcohol	A mixture of **Absolute alcohol and petrol** is known as **Power alcohol**. It is used as fuel in automobiles.
Denatured spirit	The **Ethanol** (ethyl alcohol) made unfit for human consumption by the **addition** of one or more **poisonous substances** (**denaturants**) to it is called **Denatured spirit. [A mixture of ethanol and poisonous substances.]**
Methylated spirit	A mixture of **Ethanol** and **Methanol is known as Methylated spirit.**

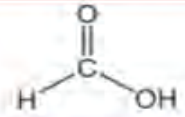
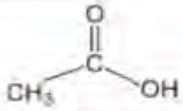
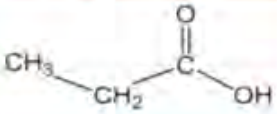
✤ **Denaturing :-** The process of adding **poisonous substances / chemicals** (denaturants) such as **methanol, pyridine, rubber distillate** etc to ethanol meant for industrial purposes to prevent its misuse as beverage is known as **Denaturing.**

The product (a mixture of ethanol and poisonous substances) formed by denaturing is called **Denatured spirit.** It is suitable for other industrial or domestic purposes.

✤ **Methylating :-** If **methanol** is used as a **poison for denaturing** then the process is also called **Methylating** and the product (a mixture of ethanol and methanol) is called **Methylated spirit.**

✤ **Carboxylic Acids :-**

Most of the substances obtained from nature contain carboxylic acids. Some examples are given below.

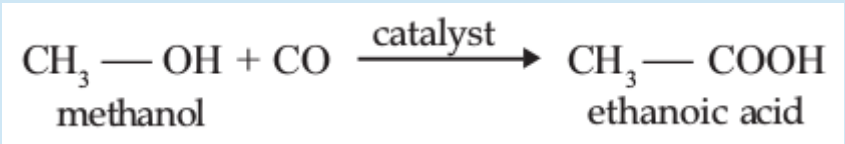
Condensed Formula	Structural Formula	IUPAC name	Common name
H—COOH		methanoic acid	formic acid
CH_3—COOH		Ethanoic acid	Acetic acid
CH_3—CH_2—COOH		Propanoic acid	Propionic acid

✶ **Fatty acids :-** Carboxylic acids containing **more no. of carbon atoms** are called **Fatty acids**. (**Eg :-** Palmitic acid, Stearic acid, Oleic acid etc.)

✶ **Acetic acid** is formed by the **fermentation of fruits**. Carboxylic acids are usually prepared by the **oxidation of alcohols**.

Industrial Preparation :-

Ethanoic acid (Acetic acid) is industrially prepared by the reaction between **methanol** and **carbon monoxide** in the presence of catalyst.



✶ **5 – 8 %** strong **ethanoic acid** (Acetic acid) is known as **Vinegar**. **Vinegar** is obtained by the **fermentation of ethanol** in the presence of air using the bacteria **Acetobactor**.

Uses of Ethanoic acid (Acetic acid) :-

1) Ethanoic acid is used in the **manufacture of Rayon**.
2) It is used in the **rubber and silk** industry.
3) It is used as a **reactant** in the preparation of **esters**.(Ethyl ethanoate)
4) Vinegar is used as a **preservative.**
5) Vinegar is used as a **food additive** to impart taste to the food materials.

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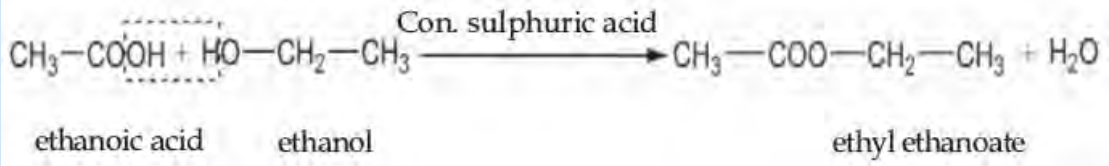
✤ Esters :-

Esters are the **c**ompounds obtained by the reaction between **carboxylic acids** and **alcohols** with the elimination of water molecule. This process is known as **Esterification.**

Eg :- When **ethanoic acid** reacts with **ethanol** in the presence of concentrated sulphuric acid, the ester **ethyl ethanoate** is formed.



✷ The ester group is **– COO –**

✷ Esters have the **pleasant smell of fruits and flowers**. Hence, esters are used as a **constituent** of perfumes, food flavourings, cosmetics, etc. Esters are also used as **organic solvents**.

✷ **How to find out the name of Carboxylic acid and Alcohol from the Structure / Name of the ester :-**

1) If the Structure is given :- Divide the molecule by drawing a **vertical line in between the two oxygen atoms** of the **– COO –** group. Then add **OH** on the left side and **H** on the right side. Then we will get acid on the left hand side and alcohol on the right hand side.

2) If the Name is given :- The name of an ester has two parts. The **first part represents the alcohol** and the **second part represents the acid**. Divide the name by drawing a vertical line in between these two parts. Then on adding ' **alcohol** ' on the **left side**, we will get the name of the **alcohol**. Similarly, remove the suffix ' **ate** ' from the **right hand side** and add ' **ic acid** '. Then we will get the name of the acid.

✷ **How to write the Chemical equation of Esterification reaction :-** Write the structure of acid first followed by the structure of alcohol in the reverse order. Then remove **OH** from **COOH group of acid** and **H** from **OH group of alcohol** as water molecule and join the remaining parts together as it is to get the ester.

✤ Soaps :-

Soaps are cleansing agents.They are sodium or potassium salts of **fatty acids**.

✷ Oils and fats are esters formed by the reaction between **Glycerol** (alcohol) with **fatty acids** such as **Palmitic acid**, **Stearic acid** and **Oleic acid**.

✷ When these **oils and fats** react with alkalies like **NaOH** and **KOH**, salts like sodium palmitate, potassium palmitate etc are formed. These sodium or potassium salts are called **soaps**.

✷ **Glycerol**, is obtained as the by product in the industrial production of soap (Hot process). It is used for the preparation of several products like medicines and cosmetic materials.

✷ **Cleansing action of soaps :-**

Most of the dirt is oily in nature and oil does not dissolve in water.Soap molecule has an **oil soluble non polar end** and a **water soluble polar end**. The hydro carbon part (non polar end) of the soap molecule dissolves in oil and the ionic part (polar end) dissolves in water. When **soap** is dissolved in water, its non polar ends attach themselves to dirt and remove it from the cloth. Moreover, soap reduces the surface tension of water and as a result, the surface of the cloth is wetted thoroughly. Soap molecules act as a link between water and dirt particles and the dirt particles can be easily removed by rinsing with water.

✤ **Detergents :-**

Cleansing agents other than soaps are usually known as **detergents**.

✷ Similar to soaps, detergents also have an **oil soluble non polar end** and a **water soluble polar end**. Detergents are made from **hydrocarbons** obtained from coal and petroleum. Most detergents are salts of **sulphonic acids**.

✷ Soap does **not lather** well in **hard water**. The hardness of water is due to the presence of dissolved calcium and magnesium salts (sulphates, chlorides and bicarbonates) in it. These salts react with soap to form insoluble compounds resulting in the decrease of lather. But detergents do not give insoluble compounds on reaction with these salts. Hence, **detergents are more effective than soaps in hard water.**

✷ The **excessive use** of the detergents causes **environmental problems**. The micro organisms in water cannot decompose the components of detergents. Hence the detergents released into water leads to the destruction of aquatic life. For example, the detergents which contain phosphate increases the growth of algae and limits the quantity of oxygen. Therefore, it decreases the quantity of oxygen for the breath of the organisms in water and causes their destruction.

✤ **Comparison between Soaps & Detergents :-**

Soaps	Detergents
1) Soaps are sodium or potassium salts of **fatty acids**.	**1)** Detergents are sodium or potassium salts of **sulphonic acids**.
2) Soaps **do not work well** with **hard water, acidic solutions and saline water**.	**2)** Detergents **work well** with hard **water, acidic solutions and saline water**.

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3) They are fully **biodegradable**.	**3)** Some detergents having branched hydrocarbon chain are **non biodegradable.**
Eg :- ✷ Sodium palmitate. ✷ Potassium palmitate. ✷ Sodium stearate. ✷ Potassium stearate.	**Eg :-** ✷ Sodium alkylsulphate. ✷ Sodium alkylbenzenesulphonate.

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Activity – 1

Answer the questions given below.

a) Which alcohol is known as " **Wood spirit** " ?

b) How is this alcohol prepared industrially ?

c) Give any two uses of this alcohol.

Activity – 2

Answer the questions given below.

a) Which alcohol is known as " **Grape spirit** " ?

b) How is this alcohol prepared industrially ?

c) Name the enzymes that involved in the industrial preparation of this alcohol.

d) Give any two uses of this alcohol.

Activity – 3

The equations which are given below, represent the industrial preparation of ethanol from molasses.

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{A} C_6H_{12}O_6 + C_6H_{12}O_6$$

$$C_6H_{12}O_6 \xrightarrow{B} C + 2\,CO_2$$

a) What is meant by molasses ?

b) What is the name of this process by which ethanol is produced ?

c) Identify **A, B** and **C**.

d) Name the ethanol that is obtained by this process.

Activity – 4

Match the following suitably.

Column A	Column B
8 – 10 % ethanol	Methylated Spirit
99.5 % ethanol	Rectified Spirit
A mixture of absolute alcohol & petrol	Wash
95.6 % ethanol	Denatured Spirit
A mixture of ethanol & methanol	Power alcohol
A mixture of ethanol & poisonous substance	Absolute alcohol

Activity – 5

Answer the questions given below.

a) What is meant by denaturing ?
b) What is the purpose of denaturing ?
c) Name the product obtained by denaturing ?
d) How is ethanol converted to methylated spirit ?

Activity – 6

a) What is Vinegar ?
b) How is ethanoic acid prepared industrially ?
c) Give any two uses of ethanoic acid.

Activity – 7

Answer the following questions based on the given structures.

$CH_3–CH_2–O–CH_3$, $CH_3–OH$, $CH_3–CH_2–COO–CH_3$,
$CH_3–CH_2–COOH$, $CH_3–CH_2–OH$

a) Which among the given compounds represents an ester ?
b) Choose the compounds required to prepare this ester, from the given.
c) Write the chemical equation of this ester formation.
d) Which characteristic property of esters is made use of in the preparation of perfumes ?

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Activity – 8

Uses of some organic compounds are given below. Choose the appropriate compound from the bracket according to each use.

[Teflon , Ester, Ethanoic acid, ethanol, power alcohol]

1) Used as a solvent and in the production of different organic compounds.
2) Used in the production of artificial perfumes.
3) Used as fuel in automobiles.
4) Used in the manufacture of rayon.

Activity – 9

Soaps and detergents are cleansing agents.

1) Give any two differences between soaps and detergents.
2) Name the by product obtained in the industrial production of soap.
3) How does the excessive use of the detergents cause environmental problems ?

Activity – 10

Examine the structural formulae given below and answer the following questions.

1. $CH_3–CH_2–COO–CH_3$
2. $CH_3–CH_2–COOH$
3. $CH_3–CH_2–CO–CH_3$
4. $CH_3–OH$
5. $CH_3–CH_2–CH_2OH$
6. $CH_3–COOH$
7. $CH_3–COO–CH_2–CH_2–CH_3$

1) Pick out the esters from the given compounds and name them.
2) Identify the compounds required to prepare these esters.
3) Write down the chemical equations that represent the esterification reactions.

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