PREFACE

- This is an interactive self learning material exclusively meant for SSLC students of Kerala State Syllabus.
- This work is meant **only for** students appearing SSLC examinations ,**march /april 2022**
- This is strictly in accordance with the Focus points suggested by SCERT
- **Scan the QR codes** given at each section to watch the video, related to the topic.
- You can also watch the videos using mobile,laptop etc by **clicking / touching the QR codes.** Make sure that the data connection is ON.
- Focus Points are marked as ♥♥♥
- Constructive suggestions for further improvement are always welcome

1 Periodic Table and Electronic Configuration

1.What is the basis of classification of elements in modern periodic table?

Answer : **Atomic number**

2. If you know the atomic number of an element, you can determine its position and nature from the periodic table.

Eg: Atomic number of sodium is 11.

Electronic configuration - 2, 8, 1

Group number – 1

Period number – 3 (= *Total number of shells*)

3. What happens to an electron as it moves away from the nucleus?

* The energy of the electron increases.

* The attraction between the nucleus and the electrons decreases.

We are familiar with writing the shell wise electronic configuration of various elements . Examples are given below.

Element	**Shells**			
	K	**L**	**M**	**N**
$_{3}$Li	2	1	-	-
$_{11}$Na	2	8	1	-
$_{18}$Ar	2	8	8	-
$_{19}$K	2	8	8	1

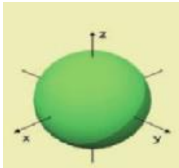
Even if the third shell (M) can accommodate a maximum of 18 electrons, **the last shell cannot accommodate more than eight electrons.**

According to The Bohr model of an atom , electrons are revolving round the nucleus through fixed circular paths called Orbits or shells. Since each electron is associated with a definite amount of energy, these orbits are also known as Main energy levels. In these main energy levels, different Sub energy levels (Sub shells)are assigned. Sub shells are named as s , p , d, f etc. (s- sharp. p -principal. d- diffuse. f- fundamental)

Orbitals: - orbitals are regions in a sub shell where the probability of finding an electron is maximum.

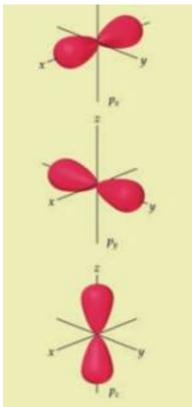
Shapes of orbitals

s Orbital is spherical



P sub shell has three orbitals. P*x* , P*y* and Pz.

They are dumb bell shaped



The following table shows the maximum number of electrons that can be accommodated in various shells and sub shells.

♥♥♥

Number of the shell	1	2		3			4			
Name of the shell	**K**	**L**		**M**			**N**			
Maximum number of electrons	2	8		18			32			
Name of sub shell	*1s*	*2s*	*2p*	*3s*	*3p*	*3d*	*4s*	*4p*	*4d*	*4f*
Maximum number of electrons	2	2	6	2	6	10	2	6	10	14

4. ♥♥♥What is the relation between the shell number and the number of sub shells

The shell number and the total number of sub shells are same .

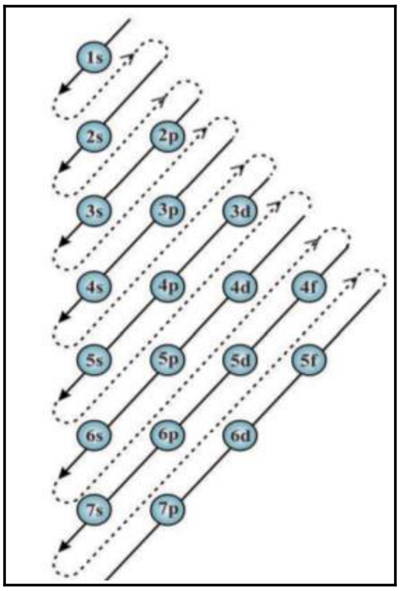
For eg: The **first shell**(K) has **only one sub shell** (1s) , the **second** shell (L) has **two sub shells** (2s ,2p) and so on.

5. ♥♥♥Which sub shell is common to all shells? ***S***

♥♥♥ Distribution of electrons in various sub shells

Electrons occupy various sub shells according to the increasing order of their energies. This is known as sub shell electronic configuration.

It can be understood from the following figure.



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

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6. ♥♥♥ Write the sub shell electronic configuration of the first 30 elements of the periodic tables.

Element	Atomic Number	Sub shell electronic Configuration	Alternate method
$_1H$	1	$1s^1$	
$_2He$	2	$1s^2$	
$_3Li$	3	$1s^2\ 2s^1$	**[He] $2s^1$**
$_4Be$	4	$1s^2\ 2s^2$	**[He] $2s^2$**
$_5B$	5	$1s^2\ 2s^2\ 2p^1$	**[He] $2s^2\ 2p^1$**
$_6C$	6	$1s^2\ 2s^2\ 2p^2$	**[He] $2s^2\ 2p^2$**
$_7N$	7	$1s^2\ 2s^2\ 2p^3$	**[He] $2s^2\ 2p^3$**
$_8O$	8	$1s^2\ 2s^2\ 2p^4$	**[He] $2s^2\ 2p^4$**
$_9F$	9	$1s^2\ 2s^2\ 2p^5$	**[He] $2s^2\ 2p^5$**
$_{10}Ne$	10	$1s^2\ 2s^2\ 2p^6$	
$_{11}Na$	11	$1s^2\ 2s^2\ 2p^6\ 3s^1$	**[Ne] $3s^1$**

$_{12}Mg$	12	$1s^2$ $2s^2$ $2p^6$ $3s^2$	**[Ne] $3s^2$**
$_{13}Al$	13	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^1$	**[Ne] $3s^2$ $3p^1$**
$_{14}Si$	14	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^2$	**[Ne] $3s^2$ $3p^2$**
$_{15}P$	15	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^3$	**[Ne] $3s^2$ $3p^3$**
$_{16}S$	16	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^4$	**[Ne] $3s^2$ $3p^4$**
$_{17}Cl$	17	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^5$	**[Ne] $3s^2$ $3p^5$**
$_{18}Ar$	18	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$	
$_{19}K$	19	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^1$	**[Ar] $4s^1$**
$_{20}Ca$	20	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$	**[Ar] $4s^2$**
$_{21}Sc$	21	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^1$ $4s^2$	**[Ar] $3d^1$ $4s^2$**
$_{22}Ti$	22	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^2$ $4s^2$	**[Ar] $3d^2$ $4s^2$**
$_{23}V$	23	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^3$ $4s^2$	**[Ar] $3d^3$ $4s^2$**
$_{24}Cr$	**24**	**$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^5$ $4s^1$**	**[Ar] $3d^5$ $4s^1$**
$_{25}Mn$	25	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^5$ $4s^2$	**[Ar] $3d^5$ $4s^2$**
$_{26}Fe$	26	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^6$ $4s^2$	**[Ar] $3d^6$ $4s^2$**
$_{27}Co$	27	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^7$ $4s^2$	**[Ar] $3d^7$ $4s^2$**
$_{28}Ni$	28	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^8$ $4s^2$	**[Ar] $3d^8$ $4s^2$**
$_{29}Cu$	**29**	**$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^{10}$ $4s^1$**	**[Ar] $3d^{10}$ $4s^1$**
$_{30}Zn$	30	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^{10}$ $4s^2$	**[Ar] $3d^{10}$ $4s^2$**

When we write the subshell wise electronic configuration, the number on the left side of the subshell denotes the shell number and the number on the top right side denotes the number of electrons.

7. ♥♥♥ Chromium and Copper show exceptional electronic configuration. Give reason

Ans:- The ***d*** sub shell can accommodate a maximum of 10 electrons.

*If it is half filled (**$3d^5$**) or completely filled (**$3d^{10}$**), it will become **more stable.***

8. ♥♥♥The sub shell electronic configuration of an element is $1s^2$ $2s^2$ $2p^6$ $3s^2$.

Find ..

* The number of shells in the atom? **3 . (K , L, M)**
* The number of sub shells in each shell? **K =1(1*s*) L =2 (2*s* , 2*p*) M= 1 (3s)**
* To which sub shell , does the last electron enter? **3s**
* The total number of electrons in the atom ? **12**
* Atomic number of the element? **12**
* The short form of sub shell electronic configuration? **[Ne] $3s^2$**

9. ♥♥♥How can the sub shell electronic configuration of Zirconium ($_{40}Zr$) be written in a short form?

$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^{10}$ $4s^2$ $4p^6$ **$4d^2$** $5s^2$ can be written as **[Kr] $4d^2$ $5s^2$**

♥♥♥ Sub shell electronic configuration and Block

*Based on the sub shell electronic configurations , the elements are arranged in four different blocks (s, p, d and f). **The block to which the element belongs will be the same asthe subshell to which the last electron is added.***

Some examples are given below:

Element	Atomic Number	Sub shell electronic configuration	The sub shell in which the last electron is present	Block of the element
$_{3}Li$	3	$1s^2$ $\mathbf{2s^1}$	*s*	*s*
$_{12}Mg$	12	$1s^2$ $2s^2$ $2p^6$ $\mathbf{3s^2}$	*s*	*s*
$_{7}N$	7	$1s^2$ $2s^2$ $\mathbf{2p^3}$	*p*	*p*
$_{21}Sc$	21	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $\mathbf{3d^1}$ $4s^2$	*d*	*d*
$_{17}Cl$	17	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $\mathbf{3p^5}$	*p*	*p*
$_{26}Fe$	26	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $\mathbf{3d^6}$ $4s^2$	*d*	*d*
$_{4}Be$	4	$1s^2$ $\mathbf{2s^2}$	*s*	*s*
$_{26}Fe$	26	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $\mathbf{3d^6}$ $4s^2$	*d*	*d*
$_{18}Ar$	18	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $\mathbf{3p^6}$	*p*	*p*

♥♥♥ Sub shell electronic configuration and Period

The period to which an element belongs in the periodic table can be determined by writing its sub shell electronic configuration**.**

The period number = highest shell number *in the* ***sub shell electronic configuration***

Examples

Element	Sub shell electronic configuration	The Highest shell number	Period
$_{4}Be$	$1s^2$ $\mathbf{2}s^2$	2	2
$_{6}C$	$1s^2$ $2s^2$ $\mathbf{2}p^2$	2	2
$_{11}Na$	$1s^2$ $2s^2$ $2p^6$ $\mathbf{3}s^1$	3	3
$_{19}K$	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $\mathbf{4}s^1$	4	4
$_{21}Sc$	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^1$ $\mathbf{4}s^2$	4	4
$_{22}Ti$	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^2$ $\mathbf{4}s^2$	4	4
$_{29}Cu$	$1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^{10}$ $\mathbf{4}s^1$	4	4

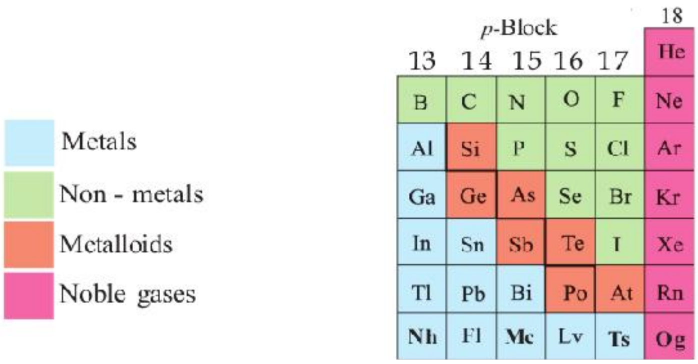
The '*s*' Block Elements

* The elements in which the last electron enters into the s sub shell of the last shell are called ***s*** block elements.

* Elements of **Group 1** (Alkali Metals) and **Group 2** (Alkaline Earth metals) of the periodic table belong to ***s*** block of the periodic table.

♥♥♥ Group number of s block elements
For **s block** elements, the number of **electrons in the outermost *s* sub shell** will be the group number.

'*p*' block elements



♥♥♥* The elements in which the last electron goes to the ***p*** subshell of the outermost shell are called ***p*** block elements.

♥♥♥* The p block consists of elements of group 13 to 18.

♥♥♥ Group number of p block elements
For **p block** elements, the number of **electrons in the outermost *p* sub shell+12** will be the group number. **Group number of p block element = (p+ *12*)** or **s+p+10**

♥♥♥ The '*d*' block elements

♥♥♥

* *The elements in which the last electron goes to the **d** sub shell of the **Penultimate** shell are called **d** block elements.*
* *The d block consists of elements of group 3 to 12.*
* *The **group number of d block** elements can be obtained by adding the total number of electrons in the **s** sub shell of the outermost shell and **d** subshell of the penultimate shell.* ***(s+d)***
* *They are also known as Transition elements.*
  (The word transition refers to a slow but steady change from one to the other)
* *These are all metals*
* *They show similarity in properties not only in a group but also in a period*
* *The show variable oxidation states.*
* *Most of their ions and compounds are coloured.*
* *Many transition metals or their compounds are good catalysts.*

10. ♥♥♥*d* Block elements show similarity in properties not only in a group but also in a period. Give reason.

In *d* Block elements, the last electron enters into the *d* sub shell of the Penultimate shell. Hence there will be no change in the number of electrons present in the last shell. The chemical properties of an element mainly depend on the number of electrons in its last shell. In *d* block elements, the number of electrons present in the last shell will be the same in a group and in a period (with a few exceptions).

Group	3	4	5	7	8	9	10	12
Element	$_{21}Sc$	$_{22}Ti$	$_{23}V$	$_{25}Mn$	$_{26}Fe$	$_{27}Co$	$_{28}Ni$	$_{30}Zn$
Electronic Configuration	[Ar] $3d^1$ $\mathbf{4s^2}$	[Ar]$3d^2$ $\mathbf{4s^2}$	[Ar]$3d^3$ $\mathbf{4s^2}$	[Ar]$3d^5$ $\mathbf{4s^2}$	[Ar]$3d^6$ $\mathbf{4s^2}$	[Ar] $3d^7$$\mathbf{4s^2}$	[Ar] $3d^8$$\mathbf{4s^2}$	[Ar] $3d^1$$\mathbf{4s^2}$

Since Chromium and Copper show exceptional electronic configuration , they have been excluded here.

11. ♥♥♥What do you mean by the term Valency?
Valency of an element is the number of electrons gained , lost or shared by an atom during chemical combinations. It is considered to be the combining capacity of the element.

12. ♥♥♥The *d* block elements show variable oxidation state. Give examples.
Two compounds of Iron (Fe) are given below.
1. Ferrous Chloride - $FeCl_2$ and
2. Ferric Chloride - $FeCl_3$
we know the oxidation state of Chlorine is -1

The oxidation state of Fe in $FeCl_2$ is +2 . Fe^{2+} ions are present in $FeCl_2$
Fe^{2+} is formed by the loss of two electrons.

The Sub shell electronic configuration of Fe is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$

Therefore the Sub shell electronic configuration of Fe^{2+} is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^{\mathbf{0}}$
(**Two electrons are removed from the 4s orbital**)
On the other hand The oxidation state of Fe in Fe Cl_3 is **+3** . That is Fe^{3+} ions are present in $FeCl_3$
Fe^{3+} is formed by the loss of three electrons.
The Sub shell electronic configuration of Fe is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$
Therefore the Sub shell electronic configuration of Fe^{3+} is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ \mathbf{4s^0}$
(Two electrons are removed from the 4s orbital and **the third one from 3d**)

Atom/ Ion	**Sub shell electronic configuration**
Fe	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$
Fe^{2+}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$
Fe^{3+}	Fe is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ \mathbf{4s^0}$

13. ♥♥♥The d block elements show variable oxidation state. Give reason:
In d block elements, there is only a slight difference in the energy between the Outermost s subshell and the penultimate d sub shell. In some occasions , these inner d electrons may participate in chemical reactions in addition to the outermost s electrons. Hence they show variable oxidation valency (Oxidation state)

Element / Compound	**Oxidation State of Mn**	Atom / Ion of Mn	Subshell electronic configuration
$_{25}Mn$	0	Mn	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ \mathbf{4s^2}$
$MnCl_2$	2+	Mn^{2+}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ \mathbf{4s^0}$
MnO_2	4+	Mn^{4+}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ \mathbf{4s^0}$
Mn_2O_3	3+	Mn^{3+}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4\ \mathbf{4s^0}$
Mn_2O_7	7+	Mn^{7+}	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^0\ \mathbf{4s^0}$

(Oxidation state of Oxygen is -2)

14. ♥♥♥Most of the compounds of the d block elements are coloured . The colour is due to the presence of transition metal ions present in these compounds Give examples

Compound	**Colour**	
♥♥♥ *Copper* sulphate		**Blue**
♥♥♥ *Cobalt* nitrate		**Light Pink** *
♥♥♥ Potassium per*manganat*e		**Dark Purple**
♥♥♥ *Ferrous* Sulphate		**Light green**
Potassium di*chrom*ate		**Orange**
Hence compounds of transition elements are used for giving colour to glasses and in oil paintings.		

*** As per teacher text (In dilute solutions)**

2 Gas Laws and Mole Concept

Properties of gases

- Each gas contains a large number of minute particles called molecules.
- The 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 this motion, the gas molecules collide with each other and also collide with the walls of the container in which it is kept.
- ***As the collisions of molecules are perfectly elastic in nature, there is no loss of energy.***
- ***The collision of the gas molecules with the walls of the container creates the pressure of the gas.***
- The force of attraction between the gas molecules and with the wall of the container is comparatively less.
- Energy of gas molecules is very high
- Distance between the molecules is comparatively large
- Freedom of movement of molecules very high

Volume of a gas

If a gas ,kept in a cylinder having a volume of 1 litre, is completely transferred to another 5 litre cylinder, its volume becomes 5 litres.

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

1. Pull the piston of a syringe backwards. Press the piston after closing the nozzle of the syringe. What will happen to the volume of air inside the syringe?

When we press the piston after closing its nozzle, the volume of the gas inside the syringe decreases.

Temperature of a gas

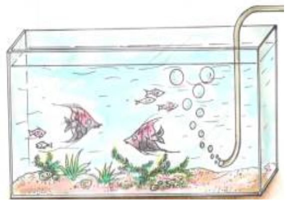
When a gas is heated , the temperature increases. The kinetic energy of the molecules increases. The average kinetic energy is a measure of the temperature of a gas.

Pressure of a gas

Force exerted per unit area is called pressure.

Force on unit area= Total force exerted on the surface / Surface area

♥♥♥ Relation between Volume of a gas and Pressure (Boyle's Law)



2.♥♥♥ The size of the air bubbles rising from the bottom of an aquarium increases. Give reason.
Here the temperature is constant. From bottom to top, the external pressure decreases.
Hence volume of the bubble increases. (Boyle's law).

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

♥♥♥ Relation between Volume of a gas and its Temperature (Charle's Law)

3.♥♥♥ Take a dry bottle (an injection bottle) having a rubber stopper. Fix an empty refill through the rubber stopper. Fill a drop of ink into in the lower end of the refill tube, then close the bottle. Dip this arrangement in luke warm water.

What do you observe?

The ink rises up.

What is the reason for the rising of the ink upwards?

When the temperature increases, the volume of the gas inside the bottle increases. This will push the ink up .

What did you observe on cooling the bottle after taking it out? Why?

On cooling the bottle, the volume of the gas decreases. Then the ink goes down.

When the temperature increases, the volume of the gas increases. When temperature decreases, volume of the gas decreases.

The table given below shows the relation between volume and temperature of a fixed mass of a gas. (Pressure is kept constant)

Volume V	Temperature T (In Kelvin scale)	V/T
900 mL	300 K	900 / 300 = **3**
960 mL	320 K	960 / 320 = **3**
819 mL	273 K	819 / 273 = **3**

[Note that the temperature is stated in kelvin scale]

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 volume and T the temperature, Then V/T will be a constant.

4. ♥♥♥ *If an inflated balloon is kept in sunlight, it will burst. What may be the reason for this?*

When the temperature increases, the volume of the gas inside the balloon increases and finally it will burst. (Charle's Law)

♥♥♥ Relation between volume of a gas and number of molecules

Avogadro's Law

At constant temperature and pressure the volume of a gas is directly proportional to number of molecules. This is Avogadro's Law

When a balloon is being inflated , the number of molecules present in it also increases. At the same time the volume of the gas also increases.

The same happens when a cylinder is being filled by a gas

These examples are i n accordance with Avogadro's Law

♥♥♥ Towards mole concept..

♥♥♥ If the relative atomic mass of an element is x grams, x grams of it contains **6.022×10^{23} atoms .**

♥♥♥ **Look at the following table for clarification**

Element	Atomic Mass	Atomic Mass in grams	Mass Actually taken	Number of Atoms
Hydrogen	**1**	**1 g**	**1 g**	**6.022×10^{23}**
Carbon	**12**	**12 g**	**12 g**	**6.022×10^{23}**
Nitrogen	**14**	**14 g**	**14 g**	**6.022×10^{23}**
Oxygen	**16**	**16 g**	**16 g**	**6.022×10^{23}**
Sodium	**23**	**23 g**	**23 g**	**6.022×10^{23}**
Magnesium	**24**	**24 g**	**24 g**	**6.022×10^{23}**
Aluminium	**27**	**27 g**	**27 g**	**6.022×10^{23}**
Chlorine	**35.5**	**35.5g**	**35.5g**	**6.022×10^{23}**
Calcium	**40**	**40 g**	**40 g**	**6.022×10^{23}**

♥♥♥ *The mass of an element in grams equal to its atomic mass is called 1 Gram Atomic Mass (1 GAM) of the element. This may also be shortened as 1 Gram Atom.*

Hence the table given above can be modified as

Element	Atomic Mass	Atomic Mass in grams	Mass Actually taken	GAM	Number of Atoms
Hydrogen	**1**	**1 g**	**1 g**	**1 GAM**	6.022×10^{23}
Carbon	**12**	**12 g**	**12 g**	**1 GAM**	6.022×10^{23}
Nitrogen	**14**	**14 g**	**14 g**	**1 GAM**	6.022×10^{23}
Oxygen	**16**	**16 g**	**16 g**	**1 GAM**	6.022×10^{23}
Sodium	**23**	**23 g**	**23 g**	**1 GAM**	6.022×10^{23}
Magnesium	**24**	**24 g**	**24 g**	**1 GAM**	6.022×10^{23}
Aluminium	**27**	**27 g**	**27 g**	**1 GAM**	6.022×10^{23}
Chlorine	**35.5**	**35.5g**	**35.5g**	**1 GAM**	6.022×10^{23}
Calcium	**40**	**40 g**	**40 g**	**1 GAM**	6.022×10^{23}

♥♥♥ ***One gram atomic mass (1 GAM) of any element contains 6.022×10^{23} atoms. This number is known as Avagadro number. This is indicated as N_A.***

♥♥♥ **Have a close look at the table given below**

Element	Atomic Mass	Atomic Mass in grams	Given mass	Number of GAM	Number of Atoms
Hydrogen	1	1 g	1 g	1 GAM	6.022×10^{23}
Hydrogen	**1**	**1 g**	**2 g**	**2 GAM**	$2 \times 6.022 \times 10^{23}$
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}
Carbon	**12**	**12 g**	**24 g**	**2 GAM**	$2 \times 6.022 \times 10^{23}$
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}
Nitrogen	**14**	**14 g**	**42 g**	**3 GAM**	$3 \times 6.022 \times 10^{23}$
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}
Oxygen	**16**	**16 g**	**80 g**	**5 GAM**	$5 \times 6.022 \times 10^{23}$
Sodium	23	23 g	23 g	1 GAM	6.022×10^{23}
Sodium	**23**	**23 g**	**230 g**	**10 GAM**	$10 \times 6.022 \times 10^{23}$

From the table given above , it is clear that

♥♥♥

Number of Gram Atomic Mass = **Given Mass in grams / GAM of element**

5 ♥♥♥ How many GAM is present in 46 g of sodium?

(Hint: 1 GAM of sodium means 23 grams of Sodium)

Answer:

Number of GAM = **Given Mass in grams / GAM of element**

= **46 g / 23 g**

= **2**

It contains 2 × 6.022 x 10^{23} atoms of sodium

6.♥♥♥ How many GAM is present in 69 g of sodium?

(Hint: 1 GAM of sodium means 23 grams of Sodium)

Answer:

Number of GAM = **Given Mass in grams / GAM of element**

= **69 g / 23 g**

= **3**

It contains 3 × 6.022 x 10^{23} atoms of sodium

Number of Atoms = **Number of GAM** x 6.022 x 10^{23}

7.♥♥♥ Calculate the number of atoms present in each of the sample?

(Atomic mass N = **14**, O = **16)**

a) 42 g Nitrogen

b) 80 g Oxygen

Answer:

a) 42 g Nitrogen

Number of GAM = **Given Mass in grams / GAM of element**

= 42 g / **14 g**

= **3**

It contains 3 x 6.022 x 10^{23} atoms of Nitrogen

b) 80 g Oxygen

Number of GAM = **Given Mass in grams / GAM of element**

= 80 g / **16 g**

= **5**

It contains 5 x 6.022 x 10^{23} atoms of Oxygen

8.♥♥♥ Complete the table given below.

Element	**Atomic Mass**	**Atomic Mass in grams**	**Given mass**	**Number of GAM**	**Number of Atoms**
Hydrogen	1	1 g	4 g	**........(a)........**	**..........(b)...........**
Carbon	**12**	**12 g**	**.........(c)..........**	**5 GAM**	**..........(d)...........**
Nitrogen	**14**	**14 g**	**42 g**	**........(e).........**	**...........(f)...........**
Oxygen	**16**	**16 g**	**........(g)..........**	**........(h).........**	**5 x 6.022 x 10^{23}**

(a) = 4 (b) = 4 x 6.022 x 10^{23} **(c) = 60 g** (d)= 5 x 6.022 x 10^{23}

(e)= 3 **(f) = 3 x 6.022 x 10^{23}** (g) = 80 g **(h) = 5**

♥♥♥ One mole of atoms

One mole of atoms = 6.022 x 10^{23} atoms = 1GAM

9. ♥♥♥ **Find the number of mole atoms of the following**

a.

Element	Atomic Mass	Atomic mass in grams	Mass taken	Number of GAM	Number of atoms	Number of mole atoms
Hydrogen	1	1 g	1 g	1 GAM	6.022×10^{23}	
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}	
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}	
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}	

Answer:

Element	Atomic Mass	Atomic mass in grams	Mass taken	Number of GAM	Number of atoms	Number of mole atoms
Hydrogen	1	1 g	1 g	1 GAM	6.022×10^{23}	1
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}	1
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}	1
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}	1

b. ♥♥♥

Element	Atomic mass	Atomic mass in grams	Given mass	Number of GAM	Number of atoms	Number of mole atoms
Hydrogen	1	1 g	1 g	1 GAM	6.022×10^{23}	
Hydrogen	1	1 g	2 g	2 GAM	$2 \times 6.022 \times 10^{23}$	
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}	
Carbon	12	12 g	24 g	2 GAM	$2 \times 6.022 \times 10^{23}$	
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}	
Nitrogen	14	14 g	42 g	3 GAM	$3 \times 6.022 \times 10^{23}$	
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}	
Oxygen	16	16 g	80 g	5 GAM	$5 \times 6.022 \times 10^{23}$	
Sodium	23	23 g	23 g	1 GAM	6.022×10^{23}	
Sodium	23	23 g	230 g	10 GAM	$10 \times 6.022 \times 10^{23}$	

Answer:

Element	Atomic mass	Atomic mass in grams	Given mass	Number of GAM	Number of atoms	Number of mole atoms
Hydrogen	1	1 g	1 g	1 GAM	$6.022x10^{23}$	1
Hydrogen	**1**	**1 g**	**2 g**	**2 GAM**	**$2 \times 6.022 \times 10^{23}$**	**2**
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}	1
Carbon	**12**	**12 g**	**24 g**	**2 GAM**	**$2 \times 6.022 \times 10^{23}$**	**2**
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}	1
Nitrogen	**14**	**14 g**	**42 g**	**3 GAM**	**$3 \times 6.022 \times 10^{23}$**	**3**
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}	1
Oxygen	**16**	**16 g**	**80 g**	**5 GAM**	**$5 \times 6.022 \times 10^{23}$**	**5**
Sodium	23	23 g	23 g	1 GAM	6.022×10^{23}	1
Sodium	**23**	**23 g**	**230 g**	**10 GAM**	**$10 \times 6.022 \times 10^{23}$**	**10**

♥♥♥ Molecular Mass and Gram Molecular Mass

10.♥♥♥The atomic masses of certain elements are given below.

(H=1 ,C =12 , N=14 , O= 16 , Na = 23 , S= 32)

Find the Molecular Mass and GMM of the following

1. H_2 **2.** O_2 **3.** N_2 **4.** H_2O **5.**NH_3

6.CO_2 **7.**NaOH **8.** $C_6H_{12}O_6$ **9.**Na_2CO_3 **10.** H_2SO_4

Sl No	Element/ Compound	Chemical Formula	Molecular Mass	GMM
1	**Hydrogen , H_2**	**H_2**	1+1 =**2**	**2 g**
2	**Oxygen , O_2**	**O_2**	16+16 =**32**	**32 g**
3	**Nitrogen , N_2**	**N_2**	14+14=**28**	**28 g**
4	**Water ,H_2O**	**H_2O**	1+1+16 = **18**	**18 g**
5	**Ammonia ,NH_3**	**NH_3**	14+1+1+1=**17**	**17 g**
6	**Carbondioxide ,CO_2**	**CO_2**	12+16+16=**44**	**44 g**
7	**Sodium hydroxide,NaOH**	**NaOH**	23+16+1=**40**	**40 g**
8	**Glucose,$C_6H_{12}O_6$**	**$C_6H_{12}O_6$**	(12 x 6) + (1 x12) + (16 x6)= 72 +12 + 96= **180**	**180 g**
9	**Sodium carbonate, Na_2CO_3**	**Na_2CO_3**	= (23 x 2) + (12 x 1) + (16 x 3) = 46 + 12 + 48 **= 106**	**106 g**
10	**Sulphuric acid, H_2SO_4**	**H_2SO_4**	(1 x 2) + (32 x 1) +(16 x 4) = 2 + 32 + 64 **= 98**	**98 g**

♥♥♥ Number of Molecules

♥♥♥ *Analyse the table given below*

Element / Compound	Molecular Mass	Mass in grams	GMM	Number of molecules
Hydrogen **(H_2)**	2	2 g	1 GMM	6.022×10^{23} H_2 molecules
Oxygen**(O_2)**	32	32 g	1 GMM	6.022×10^{23} O_2 molecules
Nitrogen**(N_2)**	28	28 g	1 GMM	6.022×10^{23} N_2 molecules
Water**(H_2O)**	18	18 g	1 GMM	6.022×10^{23} H_2O molecules
Ammonia**(NH_3)**	17	17 g	1 GMM	6.022×10^{23} NH_3 molecules
Carbon dioxide **(CO_2)**	44	44 g	1 GMM	6.022×10^{23} CO_2 molecules

♥♥♥ ***The amount** of a substance in grams **equal to its molecular mass** is called*
Gram Molecular Mass

One gram molecular mass of any substance contains Avagadro number of molecules.

11. ♥♥♥One GMM oxygen is 32g Oxygen. This contains 6.022×10^{23} oxygen molecules.

(a) How many GMM are there in 64g oxygen?
(b) How many molecules are present in it?

Answer:

(a) One GMM oxygen is 32g Oxygen.
Hence ,
Number of GMM in 64 g oxygen = 64g/32g
=2

(b)

Number of molecules in 64g Oxygen = Number of GMM x 6.022×10^{23}
= 2 x 6.022×10^{23}

♥♥♥

Number of G**ram** M**olecular** M**ass** = Mass given in grams / Gram Molecular Mass **(GMM)**

12. ♥♥♥ Calculate the number of GMM and number of ,molecules in each of the following samples

(a) 360 g glucose (Molecular mass = 180)
(b) 90 g Water (Molecular mass = 18)

Answer:

<u>**(a) 360 g glucose**</u>

Number of G**ram** M**olecular** M**ass** = Mass given in grams / Gram Molecular Mass **(GMM)**
= 360 g / 180 g
= 2

Number of molecules = Number of GMM x 6.022×10^{23}
= 2 x 6.022×10^{23}

(b) 90 g glucose

Number of **G**ram **M**olecular **M**ass = Mass given in grams / Gram Molecular Mass **(GMM)**

= 90 g / 18 g

= 5

Number of molecules = Number of GMM x 6.022 x 10^{23}

= 5 x 6.022 x 10^{23}

♥♥♥

Number of Molecules = Number of GMM x 6.022 x 10^{23}

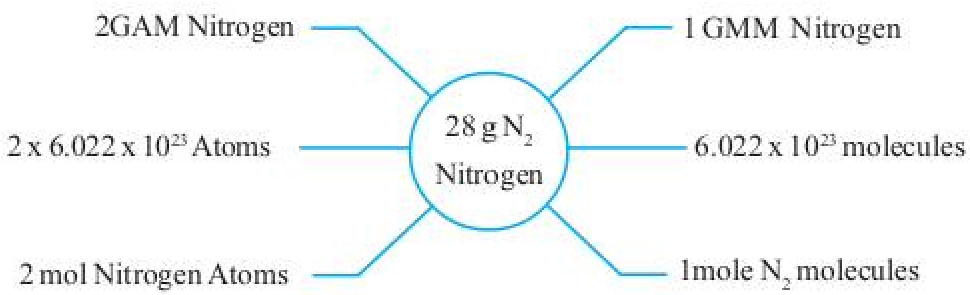
♥♥♥ One Mole of molecules

♥♥♥ ***6.022 x10^{23} molecules are called one mole molecule.***

1 GMM = 1 Mole = 6.022 x10^{23} molecules.

ARGGIY

♥♥♥ N_2 is a diatomic molecule. The molecular mass of nitrogen is 28. Look at the word diagram given below.



Problem Part – Quick Review	
♥♥♥ **For Atoms**	♥♥♥**For Molecules**
Number of GAM = Given mass in grams / GAM of the element	**Number of GMM = Given mass in grams / GMM**
Number of Atoms = Number of GAM x 6.022 x10^{23}	**Number of Molecules = Number of GMM x 6.022 x10^{23}**

3 Reactivity series and Electrochemistry

Some metals engage in chemical reactions vigorously, certain others react sluggishly in the same reaction.

♥♥♥Reaction of Metals with Water

1. Take three beakers having the same quantity of water. Take pieces of sodium, magnesium and copper of same size and drop each one to each beaker. Observe the reactions.

Observation

Metal	In cold water	In hot water
Sodium	Reacts vigorously with the evolution of a gas	
Magnesium	No reaction	Reaction occurs. A gas evolves
Copper	No reaction	No reaction

The gas formed is hydrogen

2. Based on the above observations, arrange the these metals in the decreasing order of reactivity

Answer **: Sodium > Magnesium > Copper**

♥♥♥Reaction of Metals with Air

3. Cut a piece of sodium using a knife. Observe the freshly cut portion. Give reason

Answer : This is due to the conversion of sodium into its compounds by reacting with oxygen, moisture and carbon dioxide in the atmosphere.

4.A fresh magnesium ribbon losing its lustre when kept exposed in the air for some days. Give reason?

This is also due the formation of magnesium oxide by the reaction with atmospheric air.

This will act as a black coating over magnesium

$$2\,Mg_{(s)} + O_{2\,(g)} \rightarrow 2MgO_{(s)}$$

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. These are examples of reaction of metals with air But the shining of gold does not fade even after a long time .Gold does not react with air. This indicates that metals react with air at different rates.

5.(a) Which metal among magnesium, copper, gold, sodium and aluminium, loses its lustre at a faster rate?

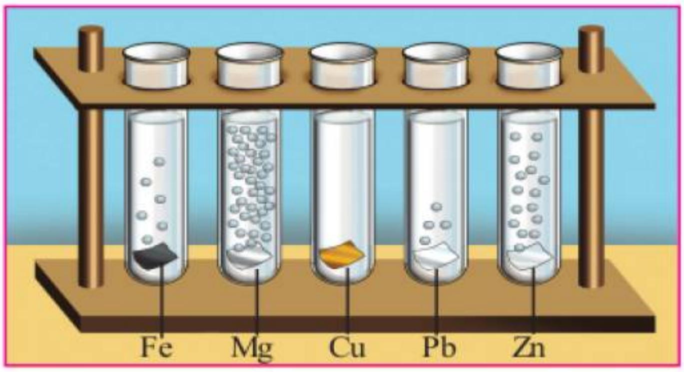
Sodium

(b) List the above metals in the decreasing order of their reactivity with air and thereby losing lustre.

Sodium > Magnesium > Aluminium > Copper > Gold

♥♥♥Reaction of Metals with Acids

The image given below shows the reaction of some metals with dilute HCl



This indicates that metals react with dilute HCl at different rates.

6.♥♥♥ What is reactivity series?

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

Note that hydrogen is also 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

React with dil acids and displace hydrogen

Do not displace hydrogen from dil. acids

♥♥♥Reactivity series and displacement reactions

7.♥♥♥Prepare some $CuSO_4$ solution in a beaker and dip a Zn rod in it. Observe the changes after sometime and write down the observations.

Observation	Before the experiment	After the experiment
Colour of Zinc rod	Grey	Covered with copper
Colour of $CuSO_4$ solution	Blue	**Colourless**

The blue colour of $CuSO_4$ solution is due to the presence of Cu^{2+} ions. When the Zn rod is dipped in $CuSO_4$ solution, the Cu^{2+} ions in the solution get deposited at the Zn rod as Cu atoms. The chemical reaction taking place here is given below.

$$\mathbf{Zn + CuSO_4 \rightarrow ZnSO_4 + Cu}$$

Zinc is more reactive than copper. Hence zinc will displace copper from the solution. As a result, $ZnSO_4$ and Copper are formed. The blue colour of the solution diminishes and disappears. The displaced copper gets deposited at the zinc rod.(The colour of the solution changes to the colour of the newly formed compound(solution).

$$Zn_{(s)} + CuSO_{4(aq)} \rightarrow \mathbf{ZnSO_4}_{(aq)} + Cu_{(s)}$$

The ionic form of the above reaction is given below.

$$Zn^0{}_{(s)} + Cu^{2+}SO_4{}^{2-}{}_{(aq)} \rightarrow Zn^{2+}SO_4{}^{2-}{}_{(aq)} + Cu^0{}_{(s)}$$

Here Zinc undergoes the following reaction,

$$\mathbf{Zn^0{}_{(s)} \rightarrow Zn^{2+} + 2\,\bar{e}}$$

Each ***Zinc atom loses two electrons*** . That is , ***Zinc undergoes Oxidation .***

At the same time ,Cu^{2+} ions receive two electrons to become Cu atoms

$$\mathbf{Cu^{2+} + 2\,\bar{e} \rightarrow Cu^0{}_{(s)}}$$

Each ***Zinc Copper ion gains two electrons*** . That is , Copper ions ***undergo Reduction.***

Since oxidation and redox reactions occur simultaneously , this is a redox reaction.

8.♥♥♥ A copper plate is immersed in $AgNO_3$ solution,

(a) Identify and record the changes.

Answer: Copper is more reactive than Silver. Hence copper will displace silver from silver nitrate solution. Silver gets deposited at the copper plate. Since copper nitrate solution is formed, the colour of the solution becomes blue.

$$Cu_{(s)} + AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2\,(aq)} + Ag_{(s)}$$

(b) Write the reaction in ionic form to show that it is a redox reaction

$$Cu_{(s)} + AgNO_{3(aq)} \rightarrow Cu(NO_3)_{2\,(aq)} + Ag_{(s)}$$

$$[Cu^0{}_{(s)} \rightarrow Cu^{2+} + 2\,\bar{e}$$
$$2Ag^+ + 2\,\bar{e} \rightarrow 2\,Ag^0{}_{(s)}]$$

$$Cu^0{}_{(s)} + 2Ag^+ + \rightarrow Cu^{2+} + 2\,Ag^0{}_{(s)}$$

Each Copper atom loses two electrons . That is , ***Copper undergoes Oxidation .***

Each Ag^+ ***ion gains one electron*** . Hence Silver ions ***undergo Reduction.***

Since oxidation and redox reactions occur simultaneously , this is a redox reaction.

♥♥♥ Displacement reactions

Highly reactive metals can displace less reactive metals from their salt solutions . Such reactions are called displacement reactions. **Displacement reactions are redox reactions.**

9.♥♥♥Certain metals and the salt solutions in which they are dipped are given below.
Identify displacement reaction occurs.

Metal/ Solution	**Mg**	**Cu**	**Zn**	**Fe**	**Ag**	**Al**
Magnesium sulphate						
Copper sulphate						
Zinc sulphate						
Ferrous sulphate						
Silver nitrate						
Aluminium nitrate						

Answer:

Metal/ Solution	**Mg**	**Cu**	**Zn**	**Fe**	**Ag**	**Al**
Magnesium sulphate	**No reaction**	**No reaction**	**No reaction**	**No reaction**	**No reaction**	**No reaction**
Copper sulphate	**Reaction occurs**	**No reaction**	**Reaction occurs**	**Reaction occurs**	**No reaction**	**Reaction occurs**
Zinc sulphate	**Reaction occurs**	**No reaction**	**No reaction**	പ്രവർത്തനമില്ല	**No reaction**	**Reaction occurs**
Ferrous sulphate	**Reaction occurs**	**No reaction**	**Reaction occurs**	പ്രവർത്തനമില്ല	**No reaction**	**Reaction occurs**
Silver nitrate	**Reaction occurs**	**Reaction occurs**	**Reaction occurs**	**Reaction occurs**	**No reaction**	**Reaction occurs**
Aluminium nitrate	**Reaction occurs**	**No reaction**	**No reaction**	**No reaction**	**No reaction**	**No reaction**

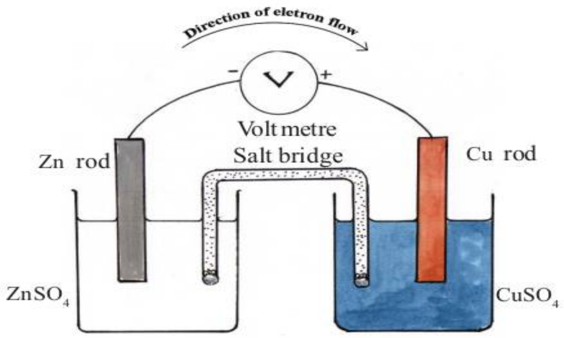
10. ♥♥♥Arrange the above metals in the decreasing order of their reactivity.

Answer: Mg > Al > Zn > Fe > Cu > Ag

♥♥♥ Galvanic cell

We have learned that metals differ in their reactivity. Galvanic cell is an arrangement in which the difference in reactivity of metals is used to produce electricity.

Arrange the apparatus as shown in the picture. Take two beakers, one containing 100mL $ZnSO_4$ solution and the second containing the same amount of $CuSO_4$ solution with the same concentration.



Connection details

Zn rod in $ZnSO_4$ solution , Cu rod in $CuSO_4$ solution.
Negative terminal of voltmeter is connected to the Zn rod and the positive terminal to the Cu rod.
Two solutions in the beakers are connected using a salt bridge
(A long filter paper moistened with KCl solution can be used instead of salt bridge).

Observation

The reading of the voltmeter changes. We can produce electricity using such arrangements.
Here electricity is produced due to chemical change.

Galvanic cell or voltaic cell is an arrangement in which chemical energy is converted into electrical energy by means of a redox reaction.

11. ♥♥♥ We have understood from the reactivity series that Zn has higher reactivity than Cu.

a. Which electrode has the ability to donate electrons in a cell constructed using these metals?

Answer: Zn

b. Which one can gain electrons?

Answer: Cu

c. Identify the chemical reaction that takes place at the Zn electrode.

(i) $Zn \rightarrow Zn^{2+} + 2\bar{e}$
(ii) $Zn^{2+} + 2\bar{e} \rightarrow Zn$

Answer: **(i) $Zn \rightarrow Zn^{2+} + 2\bar{e}$**

d. Which reaction takes place here? Oxidation/Reduction

Answer: Oxidation

That is, Zn loses two electrons and becomes Zn^{2+} . This process is known as oxidation.
An electrode at which oxidation occurs is called anode. **Anode has negative charge in this case.**
The electrons liberated from Zn rod reach the copper electrode through the external circuit . These electrons are received by copper ions in the solution changing them into copper.

a. Write the chemical equation for the reaction taking place at the Cu electrode.

Answer: $Cu^{2+} + 2\bar{e} \rightarrow Cu$

b. Which reaction takes place here? Oxidation/Reduction

Answer: Reduction

That is, Cu gains two electrons and becomes Cu .
An electrode at which reduction occurs is called cathode.
Cathode has positive charge in this case.

Normally highly reactive metals donate electrons

*The electrode at which **oxidation** occurs is the **anode** and that at which **reduction** occurs is the **cathode. Anode** attains **negative** charge and **cathode** gets **positive** charge.*

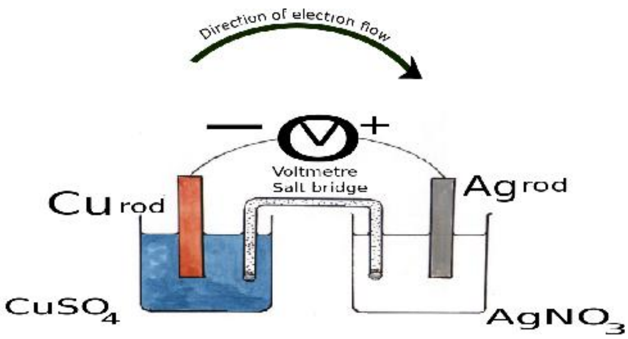
This redox reaction can be written as

$$\mathbf{Zn_{(s)} \rightarrow Zn^{2+} + 2\bar{e}}$$
$$\mathbf{Cu^{2+} + 2\bar{e} \rightarrow Cu_{(s)}}$$

♥♥♥ $\mathbf{Zn_{(s)} + Cu^{2+} \rightarrow Zn^{2+} + Cu_{(s)}}$

Since oxidation and reduction occur at the same time, it is a redox reaction.
The transfer of electrons produced by this redox reaction causes the flow of electric current in the cell. The direction of electron flow is from anode to cathode.

12. ♥♥♥ Construct a galvanic cell using silver and copper electrodes.



<table>
<tr><td>Anode</td><td>Cu</td><td rowspan="2">Cu is more reactive than Ag</td></tr>
<tr><td>Cathode</td><td>Ag</td></tr>
<tr><td>Reaction at anode</td><td>$\mathbf{Cu \rightarrow Cu^{2+} + 2\bar{e}}$</td><td rowspan="2">2 Ag^{+} ions receive the two electrons</td></tr>
<tr><td>Reaction at cathode</td><td>$\mathbf{Ag^{+} + \bar{e} \rightarrow Ag}$</td></tr>
</table>

13. ♥♥♥ How many cells can be constructed using Zn , Cu and Ag ?
Find the cathode and anode of the cell.

Answer:

Cell	*Anode*	*Cathode*
Zn – Cu	Zn	Cu
Zn – Ag	Zn	Ag
Ag - Cu	Cu	Ag

4 Production of Metals

Iron is used in making equipments ranging from pins to aeroplanes. Copper and aluminium have various uses in our daily life. Gold, silver and platinum used for making jewellery.

The chemically reactive metals are found in the combined state while the relatively unreactive metals (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.
Example : Bauxite ($Al_2O_3 2H_2O$), Cryolite (Na_3AlF_6), Clay ($Al_2O_3 2SiO_2 2H_2O$) etc. are some of the minerals of aluminium.

1. What are the characteristics possessed, by minerals that are used for the extraction of metals?

• Abundance • Easily and cheaply separable •High metal content

♥♥♥ **Ore**

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

♥♥♥ Some metals and their ores are given below.

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

2.♥♥♥ All ores are minerals, but are all minerals ores. Justify.

The metallic compounds generally seen in the earth's crust are called minerals. But ore is a mineral from which the metal is economically, easily and quickly extracted.

Metallurgy
It involves all the processes leading to the separation of a pure metal from its ore.

There are three important stages in metallurgy.

1. Concentration of ores
2. Extraction of metal from concentrated ore
3. Refining of metals

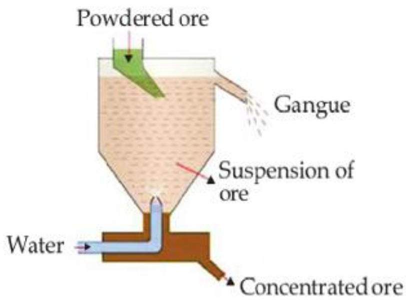
I. ♥♥♥ Concentration of ores

The process of removing the impurities (*gangue*) from the ore obtained from the earth's crust is termed concentration of the ore. Depending on the nature of the ore and the impurities, there are different methods of concentration.

1.♥♥♥ Levigation or hydraulic washing

When the ***impurities are lighter and the ore particles are heavier***,the lighter impurities are removed by washing in a current of water

e.g.concentration of oxide ores, concentration of the ores of gold.



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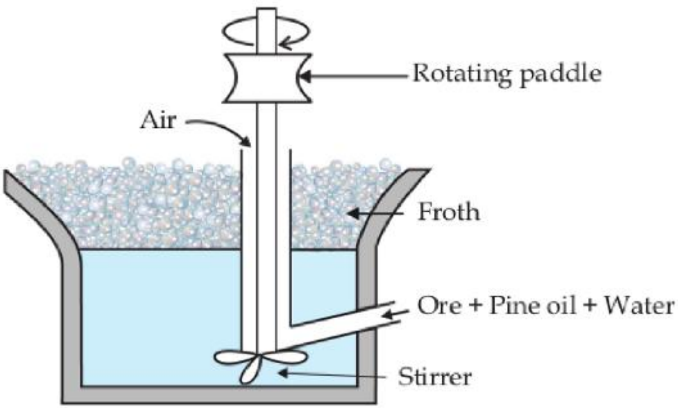
2. ♥♥♥ Froth floatation

This process is used when the ***impurities are heavier and the ore particles are lighter*** .
Sulphide ores are usually concentrated by this method.



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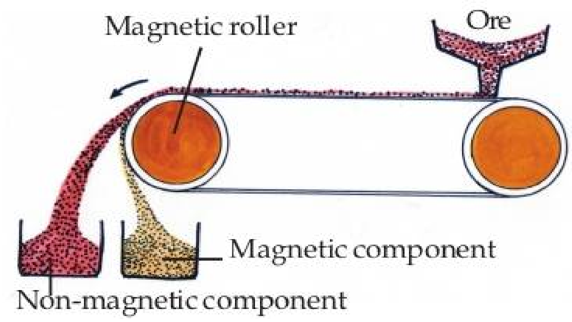
3.♥♥♥ Magnetic separation

If ***either the ore or the impurity has magnetic nature***, concentration is done by this method. This method is used for the concentration of ***magnetite***, ore of iron and also to separate ***iron tungstate,*** the magnetic impurity from ***tin stone (SnO_2), the non-magnetic ore of tin.***



4.♥♥♥ Leaching

On adding the ore ***to a suitable solution***, a chemical reaction takes place and ***the ore dissolves. The insoluble impurities are filtered off.*** The pure ore is separated from the filtrate by a chemical reaction.

Bauxite, the ore of aluminium is concentrated by this method.

3.♥♥♥ Complete the table given below

Properties of ores	Properties of the impurities present in the ore	The method of concentration
High density	Low density	....
Magnetic in nature	Non - magnetic nature	....
Lighter sulphide ores	High density	....
Aluminium ores that get dissolved in a solution	Insoluble in the same solution	....

Answer:

Properties of ores	Properties of the impurities present in the ore	The method of concentration
High density	Low density	Levigation
Magnetic in nature	Non - magnetic nature	Magnetic separation
Lighter sulphide ores	High density	Froth floatation
Aluminium ores that get dissolved in a solution	Insoluble in the same solution	Leaching

4.♥♥♥Write the suitable method of concentration of the following.

1.Tinstone 2. Bauxite 3.Zinc Blende

Answer:

Tinstone	Magnetic separation
Bauxite	Leaching
Zinc Blende (Zn**S**)	Froth floatation

(Why froth floatation for Zinc blende? . Answer: It is the sulphide ore)

II.♥♥♥ Extraction of metals from concentrated ore

It has usually two stages.

a) Conversion of the concentrated ore into its oxide.

b) Reduction of the oxide.

(a)♥♥♥ Conversion of concentrated ore into its oxide

i)♥♥♥ ***Calcination :*** *Calcination* ***is the process of heating the concentrated ore in the absence of air at temperature below its melting point. Carbonates and hydroxides of metals decompose to form their oxides.***

ii) ♥♥♥ Roasting : *Roasting* ***is the process of heating the concentrated ore in a current of air at a temperature below its melting point. When the concentrated ore is subjected to roasting, the moisture present in it is removed as vapour. Sulphide ore combines with oxygen to form oxide.***
e.g. Cu_2S ***ore is converted to*** Cu_2O ***by roasting.***

b) ♥♥♥ Reduction of the oxide

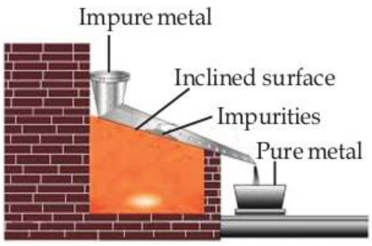
The process of extraction of metal from the oxide is reduction. Suitable reducing agents can be used for this purpose.
During the process of the production of metal, ***electricity, carbon, carbon monoxide etc. are used as reducing agents*** on the **basis of the reactivity** of the metal.
Electricity is used as the reducing agen***t to extract highly reactive metals like sodium, potassium and calcium*** from their ores.

III. ♥♥♥ Refining of metals

The metal obtained by reduction may contain other metals, metal oxides and small quantities of non metals as impurities. Refining of metals is the process of removal of these impurities to get the pure metal. Depending on the nature of metals and the impurities present in them, different methods are used for the refining of metals. Some methods are given below.

a.♥♥♥ Liquation

Low melting metals like tin and lead may contain other high melting metals or metal oxides as impurities. On heating such metals on the inclined surface of a furnace, the pure metal melts and flows down leaving the impurities behind. This process is termed liquation.



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b. ♥♥♥ Distillation

This method is used for the refining of metals with ***low boiling points such as zinc, cadmium and mercury.*** When the impure metal is heated in a retort, the pure metal alone vapourises. The vapours are condensed to get the pure metal. This method is termed distillation.

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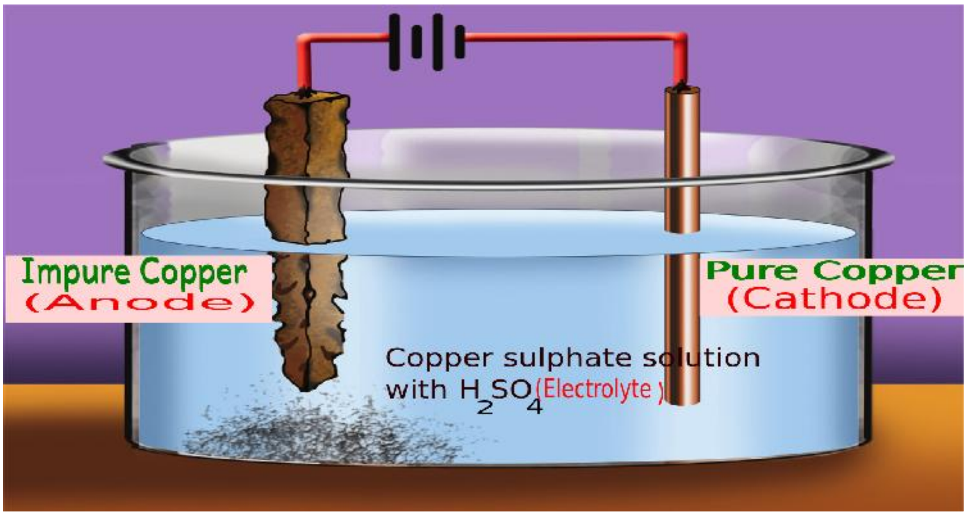
c.♥♥♥ Electrolytic refining

Electrolytic refining is the process of refining a metal by the electrolysis of a solution of the salt of the metal, using a small piece of pure metal as the negative electrode and the impure metal as the positive electrode. Copper can be refined by this method.



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5. ♥♥♥ Observe the above picture and complete the following table.

Anode	
Cathode	
Electrolyte	
Equation of the chemical reaction taking place at anode	
Equation of the chemical reaction taking place at cathode	

Answer:

Anode	Impure Copper
Cathode	Pure Copper
Electrolyte	Copper sulphate solution
Equation of the chemical reaction taking place at anode	$Cu \longrightarrow Cu^{2+} + 2\bar{e}$
Equation of the chemical reaction taking place at cathode	$Cu^{2+} + 2\bar{e} \longrightarrow Cu$

♥♥♥ Industrial production of iron

Have a look at a student's science diary related to the production of iron.

♥♥♥ September 15

Today's class

Industrial production of iron(Day 1)

AUUY6D

• Minerals of iron- Haematite, magnetite, iron pyrites etc.

• Iron pyrites - fool's gold. Reason : It has a yellow brazen colour which resembles gold.

• Ores of iron- Haematite(Fe_2O_3) , Magnetite(Fe_3O_4)

Iron is industrially prepared **mainly from** haematite.

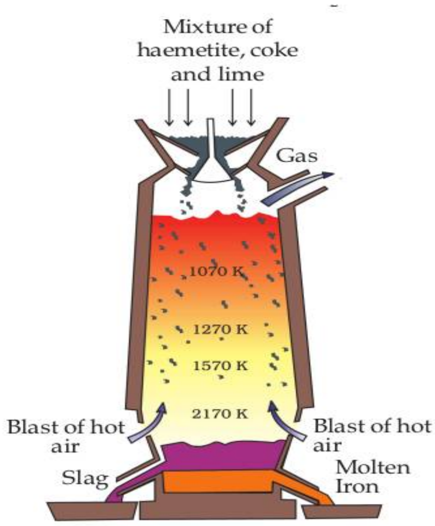
Impurities having low density are removed by **washing**.

Magnetic separation is also employed .

Roasting . During roasting , impurities like sulphur, arsenic, phosphorous etc. are removed as their gaseous oxides. Water is also expelled along with this.

[Washing. Magnetic separation. Roasting]

*But the **gangue, silica (silicon dioxide)** present in the ore is not removed.*



Haematite is converted into iron by using the blast furnace.

Blast of hot air is passed through the bottom of the furnace.

That is why this furnace is called blast furnace.

September 16

Today's class

Industrial production of iron (Day 2)

♥♥♥

Process

Raw materials : **Haematite(Fe_2O_3), limestone($CaCO_3$) and coke(C).**

Hematite, limestone and coke are fed into the furnace through a special arrangement at the top of the furnace.

Reactions

$$C + O_2 \rightarrow CO_2 + Heat$$

$$CO_2 + C + Heat \rightarrow 2CO$$

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

The reduction of haematite into iron is done mainly by this carbon monoxide.

(CO is the reducing agent)

Calcium carbonate decomposes to give calcium oxide and carbon dioxide at high temperature in the furnace.

$$CaCO_3 \rightarrow CaO + CO_2$$

This calcium oxide (flux) reacts with SiO_2 (gangue) in the ore to form easily melting calcium silicate(slag).

$$CaO + SiO_2 \rightarrow CaSiO_3$$

Flux + Gangue → Slag

If the gangue is acidic in nature, basic flux is to be used.

If the gangue is basic in nature, acidic flux is to be used.

The molten slag being less dense, floats over the molten iron.

Pig iron

The molten iron obtained from the blast furnace is called pig iron.

It contains 4% carbon and other impurities like manganese, silicon, phosphorus etc.

♥♥♥

Ore of iron	Haematite(Fe_2O_3)
Raw materials fed into the blast furnace	Haematite(Fe_2O_3), limestone($CaCO_3$) and coke(C)
The compound used for reducing haematite	Carbon monoxide (CO)
Gangue	SiO_2
Flux	CaO
Slag	$CaSiO_3$
Equation of formation of slag	$CaO + SiO_2 \rightarrow CaSiO_3$ Flux + Gangue → Slag

♥♥♥ Different types of Alloy steels

Alloy steels are prepared by adding other metals to steel. The properties and uses of different types of alloy steels are 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

The components of stainless steel and nichrome are same . But the proportion of components is different

Different types of alloys are prepared by changing the constituent elements and also by varying their proportion.

5 Compounds of Non - Metals

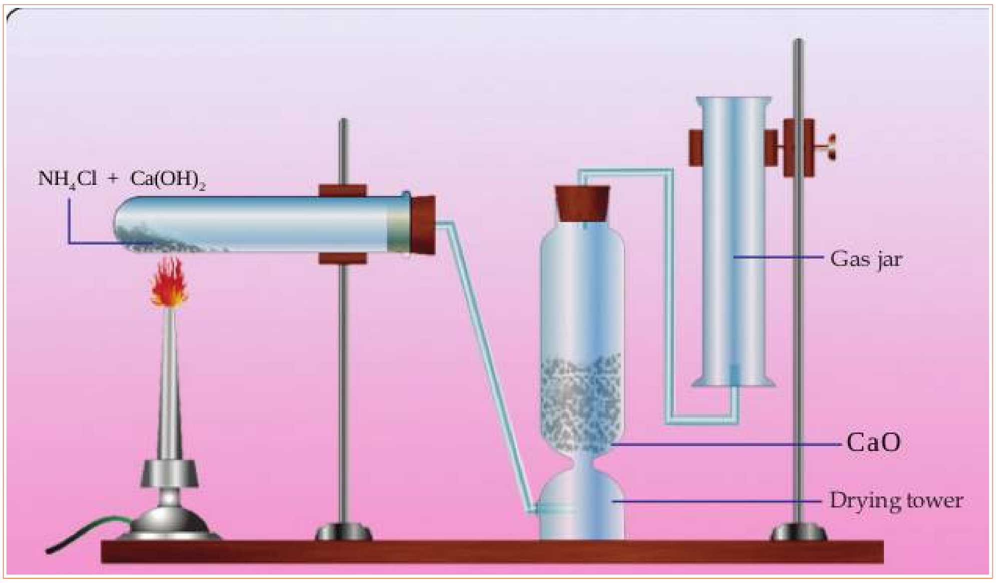
♥♥♥Ammonia (NH_3)

Ammonia is an important raw material for the production of nitrogenous fertilisers which are essential for the growth of plants.

1.♥♥♥ Preparation of Ammonia in the class room.

Experiment	Observation	Inference
Take a little ammonium chloride (NH_4Cl) in a watch glass and add a little calcium hydroxide ($Ca(OH)_2$) to it. Stir well.	Pungent smell	A Colourless pungent smelling gas is produced
Show wet blue and red litmus papers over the watch glass one by one.	Red litmus paper turns blue	The gas is basic

2. ♥♥♥ Preparation of Ammonia in the Laboratory



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

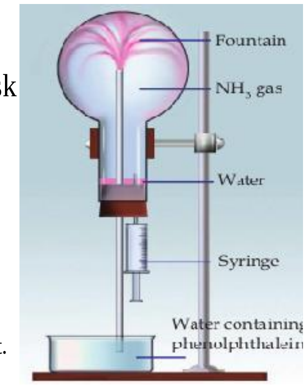
1. Why is ammonia gas passed through quick lime (CaO) ?

Answer : It is passed through a drying tower containing quick lime (CaO) ***to remove the moisture present in it.***

2. Note that the gas jar used for collecting ammonia is kept inverted. Give reason.

Answer : Ammonia is lighter than air(Density of ammonia is less than that of air)

♥♥♥ Properties of Ammonia



Arrange the apparatus as shown in the figure. Dip the jet tube in the beaker containing water, in which some phenolphthalein is added. Using a syringe add a few drops of water into the flask in which ammonia is taken.

(a) What do you observe?

Answer : Water rushes into the flask and spreads like a fountain. The entering water changes its colour to pink.

(b) What inference can be made about the solubility of ammonia in water ?

Answer : Ammonia is highly soluble in water.

(c) Why does water rush into the flask?

Answer : When ammonia dissolves in water , the pressure inside the flask decreases. Hence water rushes into it.

(d) Why does water entering the flask change its colour?

Answer : Ammonia dissolves in water forming a basic compound called ammonium hydroxide . Phenolphthalein shows pink colour in basic / alkaline solutions.

(e) Which property of ammonia is responsible for this change in colour?

Answer : Basic property

(f) Complete the chemical equation given below and find the product obtained when ammonia is dissolved in water.

$NH_3 + H_2O \rightarrow$ ....

Answer : $NH_3 + H_2O \rightarrow NH_4OH$

3.♥♥♥ Put a tick mark to those which are applicable to ammonia in the table given below.

Colour	Yes/No
Odour	Pungent smell/No smell
Nature	Acidic/Basic
Solubility in water	Less/Very high
Density of Ammonia	Less than that of air/More than that of air

Answer :

Colour	Yes/ **No** √
Odour	**Pungent smell** √ /No smell
Nature	Acidic / **Basic** √
Solubility in water	Less/**Very high** √
Density of Ammonia	**Less than that of air** √ / More than that of air

4. ♥♥♥ When an Ammonia tanker leaks, water is sprayed to reduce its intensity. What is the reason for this?

Answer : Ammonia gas is highly soluble in water. It prevents the spreading of ammonia .
Direct inhalation of ammonia is dangerous **.**

5. ♥♥♥ What is the difference between liquid ammonia and liquor ammonia ?

Answer :

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

6. ♥♥♥ List the important ***uses of ammonia.***

- For the manufacture of chemical fertilisers like ammonium sulphate, ammonium phosphate, urea etc.
  (About 80% of the ammonia produced by industry is used in **agriculture** as **fertilizer**)
- As a refrigerant in ice plants.
- To clean tiles and window panes.
- For purification of **water** supplies
- In the manufacture of plastics, explosives, textiles, **pesticides**, dyes and other chemicals.

7. ♥♥♥ a. Identify the pungent smelling gas evolved, when ammonium chloride is heated ?

Answer : The ***pungent smelling gas*** evolved ***is ammonia***. It turns a wet ***red litmus blue.***
This shows that ***ammonia is basic*** in nature.

b. After a while , the wet litmus paper changes again to red . Give reason.

Answer : When ammonium chloride is heated , ammonia and hydrogen chloride are formed . Ammonia , being lighter and basic , comes out first . It turns the wet ***red litmus blue.*** Then the **denser HCl** comes out . **It is acidic** in nature. It ***turns the blue litmus paper red .***

c. Identify the white powder sticking to the sides of the test-tube. Justify your answer.

It is ammonium chloride. It is formed due to the reaction between NH_3 and HCl gases which come out.

8.♥♥♥ Let us do another experiment to make this clear. A glass rod dipped in concentrated hydrochloric acid is shown inside
a jar which is filled with ammonia gas.

- What have you observed?

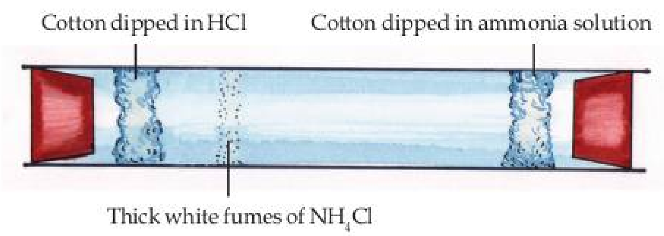
Answer : Dense white fumes are formed . This is due to the formation of ammonium chloride.

- Complete the chemical equation and find out the product.

$NH_3 + HCl \rightarrow$ .....

Answer : $NH_3 + HCl \rightarrow$ **NH_4Cl** (Ammonium chloride)

9.♥♥♥ Take a glass tube. Place a piece of cotton dipped in HCl at one end and another piece dipped in ammonia solution at the other end of the glass tube, such that these are well inside the glass tube. Close both ends of the glass tube tightly using corks. Observe the changes inside the glass tube.



Do you observe the thick white fumes? It is due to the combination of HCl gas and NH_3 gas.
Heat the region of the glass tube where the white powder of ammonium chloride has been stuck.The white powder disappears . It is due to the decomposition of ammonium chloride to ammonia and hydrogen chloride.

Summary

- **When ammonium chloride is heated , ammonia gas and hydrogen chloride gas are formed.**

$$NH_{3\,(g)} + HCl_{\,(g)} \rightarrow NH_4Cl_{(s)}$$

- When ammonia gas and hydrogen chloride gas are cooled , they combine to form ammonium chloride.

$$NH_4Cl_{\,(s)} \rightarrow NH_{3\,(g)} + HCl_{\,(g)}$$

- We can combine these equations into

$$NH_4Cl_{(s)} \rightleftharpoons NH_{3\,(g)} + HCl_{\,(g)}$$

This sign $\rightleftharpoons$ is to be read as reversible is to be read as reversible

Reactions taking place in both directions are called **reversible reactions.**

In a reversible reaction the reaction in which the ***reactants change to products is called the forward reaction*** and that in which the ***products change back to reactants is called the backward reaction.***

10♥♥♥.Examine the chemical equations given below and write the forward and backward reactions in each.

$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$
$2SO_2\,(g) + O_2\,(g) \leftrightarrow 2SO_3\,(g)$
$H_2\,(g) + I_2\,(g) \leftrightarrow 2HI\,(g)$

Answer :

Reaction	**Forward reaction**	**Backward reaction**	
$N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$	$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$	$N_2(g) + 3H_2(g) \leftarrow 2NH_3(g)$	$2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$
$2SO_2\,(g) + O_2\,(g) \leftrightarrow 2SO_3\,(g)$	$2SO_2\,(g) + O_2\,(g) \rightarrow 2SO_3\,(g)$	$2SO_2\,(g) + O_2\,(g) \leftarrow 2SO_3\,(g)$	$2SO_3\,(g) \rightarrow 2SO_2\,(g) + O_2\,(g)$
$H_2\,(g) + I_2\,(g) \leftrightarrow 2HI\,(g)$	$H_2\,(g) + I_2\,(g) \rightarrow 2HI\,(g)$	$H_2\,(g) + I_2\,(g) \leftarrow 2HI\,(g)$	$2HI\,(g) \rightarrow H_2\,(g) + I_2\,(g)$

The chemical equation of the neutralisation reaction between sodium hydroxide and hydrochloric acid is given below.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Here the products cannot be converted into reactants. Such ***chemical reactions in which reactants give products, but the products do not give back the reactants are called irreversible reactions.***

More examples:

$C + O_2 \rightarrow CO_2$

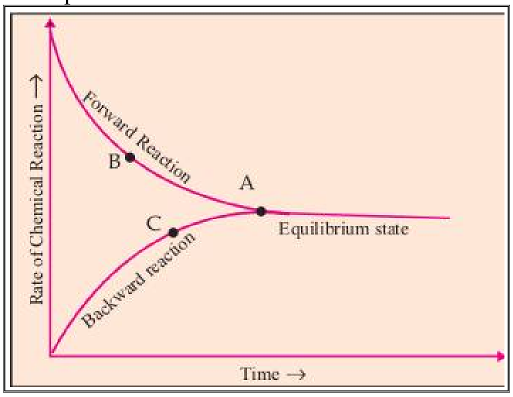
$NaCl + AgNO_3 \rightarrow NaNO_3 + AgCl$

$MgSO_4 + BaCl_2 \rightarrow BaSO_4 + MgCl_2$

$KOH + HCl \rightarrow KCl + H_2O$

♥♥♥ Chemical Equilibrium

Analyse the following graph of a reversible process.



●What happens to the rates of forward and backward reactions as time progresses?

Answer : As time progresses , the rate of forward reaction decreases and that of backward reaction increases

●Identify the point from the graph at which the rates of both forward and backward reactions become equal.

Answer : A

♥♥♥ ***Chemical equilibrium*** is the stage at which the rate of the forward reaction becomes equal to the rate of the backward reaction in a reversible chemical reaction.

♥♥♥ ***The characteristics of equilibrium*** identified through the experimental observations conducted so far are given below:

- 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 in closed systems.
- ♥♥♥ At equilibrium forward and backward reaction occur simultaneously at the same rate.

Hence, chemical equilibrium is said to be dynamic at the molecular level .

♥♥♥ ***Le Chateliers' Principle***

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.

♥♥♥ Influence of concentration on Equilibrium

Ammonia is industrially prepared by Haber process. Its chemical equation is given below

$N_2 (g) + 3H_2 (g) \rightarrow 2NH_3 (g)$

Observe carefully the action and change in the rate of the reaction , under the following conditions .

♥♥♥ **(Each raw should carefully be analysed)**

Action	Change in concentration	Change in rate*		
More nitrogen is added	Increases the concentration of reactant	Rate of forward reaction increases	OR	Rate of backward reaction decreases
More hydrogen is added	Increases the concentration of reactant	Rate of forward reaction increases	OR	Rate of backward reaction decreases
More ammonia is added	Increases the concentration of product	Rate of forward reaction decreases	OR	Rate of backward reaction increases
Nitrogen is removed	Decreases the concentration of reactant	Rate of forward reaction decreases	OR	Rate of backward reaction increases
Hydrogen is removed	Decreases the concentration of reactant	Rate of forward reaction decreases	OR	Rate of backward reaction increases
Ammonia is removed	Decreases the concentration of product	Rate of forward reaction increases	OR	Rate of backward reaction decreases

*** Comparitive change**

Given below is the stage of a reaction for the preparation of Sulphuric acid.

$2SO_2 (g) + O_2 (g) \rightarrow 2SO_3 (g)$

♥♥♥ Observe carefully the action and change in the rate of the reaction , under the following conditions .

Action	Change in concentration	Change in rate*		
More SO_2 is added	Increases the concentration of reactant	Rate of forward reaction increases	OR	Rate of backward reaction decreases
More O_2 is added	Increases the concentration of reactant	Rate of forward reaction increases	OR	Rate of backward reaction decreases
More SO_3 is added	Increases the concentration of product	Rate of forward reaction decreases	OR	Rate of backward reaction increases
SO_2 is removed	Decreases the concentration of reactant	Rate of forward reaction decreases	OR	Rate of backward reaction increases
O_2 is removed	Decreases the concentration of reactant	Rate of forward reaction decreases	OR	Rate of backward reaction increases
SO_3 is removed	Decreases the concentration of product	Rate of forward reaction increases	OR	Rate of backward reaction decreases

* Comparitive change

Action	Change in concentration	Change in rate*	
Reactants are added	Increases the concentration of reactants	Rate of forward reaction increases	Rate of backward reaction decreases
Products are removed	Decreases the concentration of products		
Reactants are removed	Decreases the concentration of reactants	Rate of forward reaction decreases	Rate of backward reaction increases
Products are added	Increases the concentration of products	Rate of forward reaction decreases	

* Comparitive change

♥♥♥ Pressure and Chemical Equilibrium

Pressure has a significant influence in the case of ***gases only.***
Let us examine the influence of pressure in the manufacture of ammonia.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

Here, both reactants and products are gases.

● In this equation what is the total number of moles of the reactant molecules?

Answer :

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

$$1 + 3 = 4$$

● What about the products?

Answer :

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

$$\text{Answer} = 2$$

Forward reaction	: 4 mole reactant molecules → 2 mole product molecules (volume decreases)
Backward reaction	: 2 mole product molecules → 4 mole reactant molecules (volume increases)

In a gaseous system, decrease in the number of molecules helps to decrease the pressure.
According to Le Chateliers' principle, when pressure of a system at equilibrium is increased the system will try to attain equilibrium by reducing pressure.

● In the manufacture of ammonia, the reaction in which direction results in the decrease in the number of molecules?

Answer : From left to right (Forward direction)

● What happens when the pressure of the system is increased?

Answer : *According to Le Chateliers' principle, when pressure of a system at equilibrium is increased, the system will try to attain equilibrium by reducing pressure.* ***Here*** *it is done by increasing the rate of forward reaction (By decreasing the rate of backward reaction)*

● What happens if the pressure of the system is decreased?

Answer : *According to Le Chateliers' principle, when pressure of a system at equilibrium is decreased, the system will try to attain equilibrium by increasing pressure.* ***Here*** *it is done by decreasing the rate of forward reaction.(By increasing the rate of backward reaction)*

● In the manufacture of ammonia, why is a high pressure of 150-300 atm used?

Answer : To increase the rate of production of ammonia . *According to Le Chateliers' principle, when pressure of a system at equilibrium is increased ,the system will try to attain equilibrium by reducing pressure.* ***Here*** *it is done by increasing the rate of forward reaction (By decreasing the rate of backward reaction)*

◘ Analyse the chemical equation for the gaseous reaction given below:

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

● What is the total number of moles of reactants?

Answer : 1+1 = 2

● What about the products

Answer : 2

Here there is no change in the number of moles of the reactants and the products.

In a reversible reaction ***if there is no change in the number of gaseous molecules in the reactant and product side, pressure will not have any effect*** *on the chemical equilibrium.*

11. ♥♥♥ What happens when pressure in the following system at equilibrium is changed?

$$2\ SO_3(g) \rightarrow 2\ SO_2(g) + O_2(g)$$

Answer:

Total number of gaseous moles of reactants	2
Total number of gaseous moles of products	2+1 =3
What happens when pressure is increased	***The reaction proceeds faster to the side having lesser number of gaseous moles.*** *According to Le Chateliers' principle, when pressure of a system at equilibrium is increased, the system will try to attain equilibrium by reducing pressure. Here it is done by increasing the rate of backward reaction (By decreasing the rate of forward reaction)*
What happens when pressure is decreased	***The reaction proceeds faster to the side having greater number of gaseous moles.*** *According to Le Chateliers' principle, when pressure of a system at equilibrium is decreased, the system will try to attain equilibrium by increasing pressure. Here it is done by increasing the rate of forward reaction (By decreasing the rate of backward reaction)*

♥♥♥ Temperature and Equilibrium

Consider the reaction

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

● Which is the endothermic reaction in this? (Forward reaction/Backward reaction) ?

Answer : Backward reaction

On ***increasing the temperature***, the system tries to reduce it by ***increasing the rate of endothermic reaction***. As a result the product ammonia decomposes to form N_2 and H_2 .

Hence, according to Le Chateliers' principle, for the formation of a larger amount of NH_3 , the temperature has to be reduced. But ***at low temperature the number of molecules having threshold energy will be less***. Therefore ***the rates*** of forward and backward reactions ***get very much reduced***, the ***system will take more time to reach equilibrium***. Hence in the manufacture of ***ammonia, 450°C*** is taken as the ***optimum temperature.***

♥♥♥Catalyst and Equilibrium

Catalysts are substances which alter the rate of reaction without undergoing a permanent chemical change to itself. Positive catalysts increase the rate of reaction. (Negative catalysts decrease the rate of reactions)

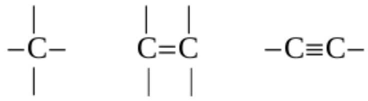
In a reversible reaction , a catalyst accelerates the forward and backward reactions simultaneously . Hence the system attains equilibrium quickly.

It is not beneficial to add a catalyst in a system which has already attained equilibrium.
At equilibrium,the rate of forward reaction is equal to the rate of backward reaction. Since the catalyst accelerates the forward and backward reactions simultaneously it does not have any effect in equilibrium

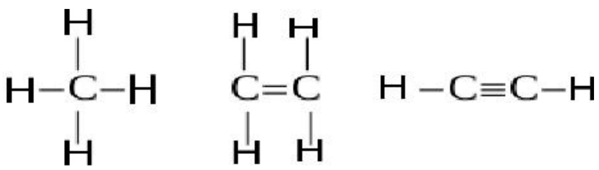
6 Nomenclature of organic compounds and isomerism

* Carbon has very high tendency of *catenation* (Ability to make bonds with other carbon atoms).
* The valency of carbon is 4.
* It has the ability to form different types of chemical bonds with other elements.

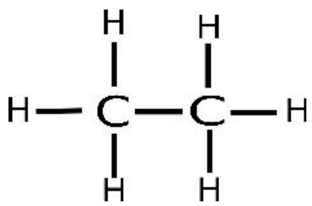
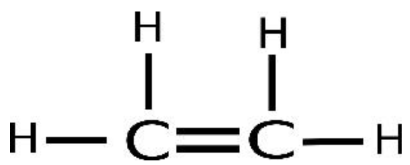
Look at the representation given below.



Imagine that hydrogen atoms are added to these structures. Then we will get the following structures.



Certain organic compounds and their molecular formulae are given here.

Structure of the compound	Molecular Formula
	C_2H_6
	C_2H_4
	C_2H_2

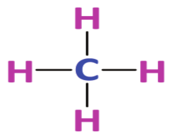
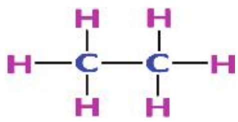
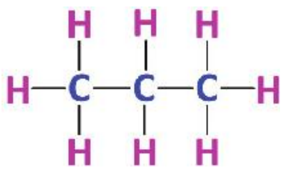
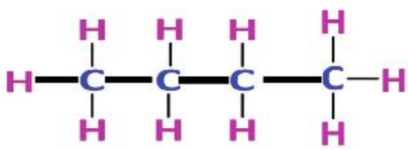
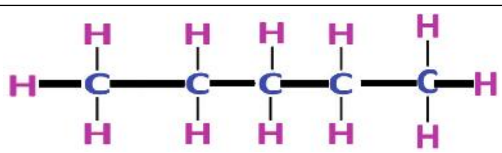
*What are the characteristics of the compounds given in the table?
They contain carbon and hydrogen only. Hence they are hydrocarbons.
There are compounds having single bond, double bond and triple bond between the carbon atoms.The structure of these compounds can also be written in condensed way as $CH_3 - CH_3$, $CH_2 = CH_2$, $CH \equiv CH$. Such a representation is known as **condensed formula.**

♥♥♥ Alkanes

The open chain hydrocarbons having only ***single bond*** between the carbon atoms are included in the ***Alkane*** category.

In alkanes, as all the four valencies of each carbon atom are satisfied by single bonds, they are known as ***saturated hydrocarbons.***

1. ♥♥♥ Complete the following table.

Number of Carbon atoms	**Structure of Alkanes**	**Condensed formula**	**Molecular formula**
1		CH_4	CH_4
2		CH_3-CH_3	C_2H_6
3		CH_3-CH_2-CH_3	C_3H_8
4		CH_3-CH_2- CH_2-CH_3	C_4H_{10}
5		CH_3-CH_2- CH_2-CH_2-CH_3	-----------------
6	---	-----------------------------	C_6H_{14}
7	---	------------------------------	-----------------

2. With the help of the table given above, find relationship between the number of atoms of carbon and hydrogen in alkanes.

Number of hydrogen atoms = (2 x number of carbon atoms) +2

3. If an alkane contains '*n*' carbon atoms, how many hydrogen atoms will be there?

(**2** × ***n***) +**2**

4. If so, can you deduce a general formula for alkanes? C_nH_{2n+2}

5. Analyse the following compounds

CH_4 , C_2H_6,C_3H_8 ,C_4H_{10} , C_5H_{12}

Certain characteristics of these compounds are given below.

- They 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.

A series of such compounds is called a **homologous series.**

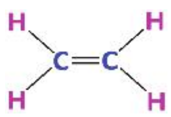
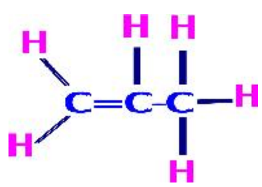
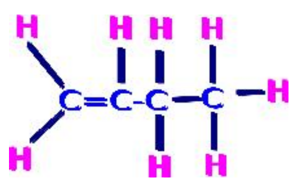
6. What are unsaturated hydrocarbons?

Hydro carbons having one or more double bond or triple bond between carbon atoms are commonly known as unsaturated hydrocarbons.

Alkenes

Hydro carbons having a double bond between any two carbon atoms are considered as Alkenes.

7. Complete the table given below.

No of Carbon atoms	Structure of the Alkene	Condensed formula	Molecular formula
2		CH_2=CH_2	C_2H_4
3		CH_2=CH-CH_3	C_3H_6
4		CH_2=CH-CH_2-CH_3	C_4H_8
5		CH_2=CH-CH_2-CH_2-CH_3	
6		CH_2=CH-CH_2-CH_2-CH_2-CH_3	

8. Analyse the table above and find the number of hydrogen atoms in an alkene with 'n' carbon atoms.

$2 \times n$

9. If so, can a general formula of alkenes be deduced ? Try to write it.

C_nH_{2n}

Alkenes given in the above table are also members of a homologous series.

Alkynes

Look at the structure of a hydrocarbon carrying a triple bond between two carbon atoms

Hydrocarbons having a triple bond between any two carbon atoms are named as alkynes.

10. Complete the table given below.

No of Carbon atoms	Structure of the Alkyne	Condensed formula	Molecular formula
2		$CH\equiv CH$	C_2H_2
3		$CH\equiv C-CH_3$	C_3H_4
4		$CH\equiv C-CH_2-CH_3$	C_4H_6
5		$CH\equiv C-CH_2-CH_2-CH_3$	
6		$CH\equiv C-CH_2-CH_2-CH_2-CH_3$	

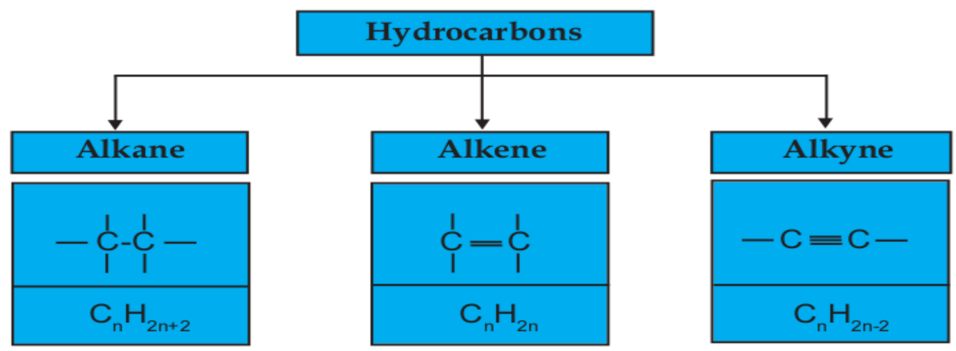
11. Analyse the table above and find the number of hydrogen atoms in an alkyne with 'n' carbon atoms.

$(2 \times n) - 2$

12. If so, can a general formula of alkenes be deduced ? Try to write it.

C_nH_{2n-2}

Alkynes given in the above table are also members of a homologous series.



♥♥♥ *Nomenclature of hydrocarbons*

IUPAC has put forward some rules for the naming of organic compounds. While naming hydrocarbons , the following basic points should be considered

1. Number of carbon atoms

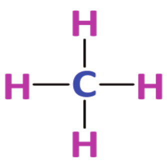
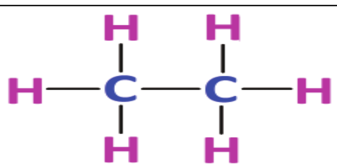
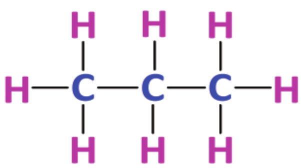
2. Nature of the chemical bond between the carbon atoms.

Word roots are selected based on the number of carbon atoms.

Number of carbon atoms	Word Root
C_1	*Meth*
C_2	**Eth**
C_3	*Prop*
C_4	**But**
C_5	*Pent*
C_6	**Hex**
C_7	*Hept*
C_8	**Oct**
C_9	*Non*
C_{10}	**Dec**

♥♥♥ *Nomenclature of Unbranched Alkanes.*

Examine the given structural formula, molecular formula and IUPAC names of some alkanes.

Structural formula	Molecular formula	IUPAC name
	CH_4	Methane
	C_2H_6	Ethane
	C_3H_8	Propane

► How are the names derived from the word roots?

Alkanes are named by adding the suffix 'ane' along with the word root that denotes the number of carbon atoms.

Meth + ane → Methane
Eth + ane → Ethane
Prop + ane → Propane

Word root + ane → Alkane

13. ♥♥♥ Write the IUPAC name of the following alkanes.

Condensed formula	**IUPAC Name**
CH_3-CH_2-CH_2-CH_3	
CH_3-CH_2-CH_2-CH_2-CH_3	
CH_3-CH_2-CH_2-CH_2-CH_2-CH_3	
CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3	
CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3	
CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3	

Answer:

Condensed formula	**IUPAC Name**
CH_3-CH_2-CH_2-CH_3	Butane
CH_3-CH_2-CH_2-CH_2-CH_3	Pentane
CH_3-CH_2-CH_2-CH_2-CH_2-CH_3	Hexane
CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3	Heptane
CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3	Nonane
CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3	Decane

14.♥♥♥ Complete the following table

Condensed formula	**IUPAC Name**
....	Propane
....	Octane
CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3	....

Answer:

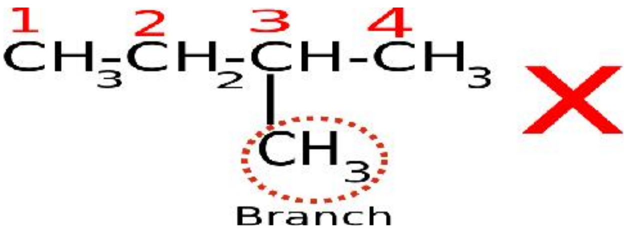
Condensed formula	**IUPAC Name**
CH_3-CH_2-CH_3	Propane
CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3	Octane
CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3	Decane

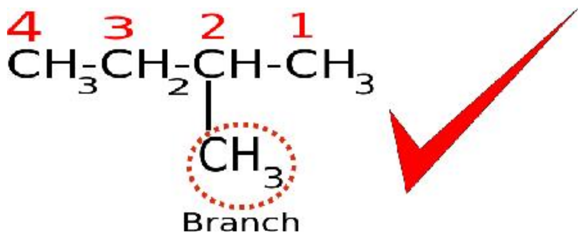
♥♥♥ Nomenclature of Branched Hydrocarbons

Consider the following compound

$CH_3-CH_2-CH-CH_3$
|
CH_3

According to the IUPAC rules of nomenclature, the longest chain (with the maximum number of carbon atoms) should be considered as the main chain and the remaining carbon atoms are treated as branches. The position of the branches can be found out by numbering carbon atoms in the main chain.
Numbering of the carbon atoms in the chain should be done in such a way that the carbon atom carrying the branch gets the lowest number.
Hence the numbering should be done in the following way.





After understanding the correct numbering , go through the following points.

a) Number of carbon atoms in the main chain : 4
b) Word root : But
c) Suffix ***: ane***
d) Name of the alkyl radical coming as branch : Methyl
***e)* Position of the branch** **: 2**
f) IUPAC name : 2-Methyl butane

Position number of branch + hyphen + name of radical(branch) + word root + suffix.

A hyphen (-) is used to separate numerals and alphabets while writing the IUPAC name.

15. ♥♥♥ Write IUPAC names of the hydrocarbons given below.

Compound	Number of carbon atoms in the longest chain	Name of branch	Position of branch	IUPAC name
$CH_3-CH_2-CH_2-CH(CH_3)-CH_3$	....	....	....	....
$CH_3-CH_2-CH(CH_3)-CH_2-CH_3$	....	....	....	....
$CH_3-CH_2-CH(CH_2CH_3)-CH_2-CH_3$	....	....	....	....
$CH_3-CH(CH_2CH_3)-CH_2-CH_3$	....	....	....	....

Answer:

Compound	Number of carbon atoms in the longest chain	Name of branch	Position of branch	IUPAC name
$CH_3-CH_2-CH_2-CH(CH_3)-CH_3$	5	Methyl	2	2- Methylpentane
$CH_3-CH_2-CH(CH_3)-CH_2-CH_3$	5	Methyl	3	3- Methyl pentane
$CH_3-CH_2-CH(CH_2CH_3)-CH_2-CH_3$	5	Ethyl	3	3- Ethyl pentane
$CH_3-CH(CH_2CH_3)-CH_2-CH_3$	5	Methyl	3	3- Methylpentane

More practice questions.

16. ♥♥♥Write the IUPAC names of the following .

Compound	Number of carbon atoms in the longest chain	Name of branch	Position of Branch	IUPAC Name
$CH_3-CH-CH_2-CH_3$ | CH_3				
$CH_3-CH_2-CH_2-CH-CH_3$ | CH_3				
$CH_3-CH_2-CH_2-CH_2-CH-CH_3$ | CH_3				
$CH_3-CH_2-CH_2-CH-CH_2-CH_3$ | CH_3				
$CH_3-CH_2-CH-CH_2-CH_2-CH_3$ | CH_3				
$CH_3-CH_2-CH-CH_2-CH_2-CH_3$ | CH_2-CH_3				
$CH_3-CH_2-CH_2-CH-CH_2-CH_3$ | CH_2 | CH_3				

While naming a branch it is better to have knowledge about alkyl groups.
Alkyl groups are obtained by removing a hydrogen atom from alkanes

Alkane	Alkyl group
Methane CH_4	Methyl CH_3-
Ethane C_2H_6	Ethyl C_2H_5- or CH_3-CH_2-
Propane C_3H_8	Propyl C_3H_7- or $CH_3-CH_2-CH_2-$

Answer:

Compound	Number of carbon atoms in the longest chain	Name of branch	Position of Branch	IUPAC Name
CH_3-CH-CH_2-CH_3 | CH_3	4	Methyl	2	2-Methylbutane
CH_3-CH_2-CH_2-CH-CH_3 | CH_3	5	Methyl	2	2-Methylpentane
CH_3-CH_2-CH_2-CH_2-CH-CH_3 | CH_3	6	Methyl	2	2-Methylhexane
CH_3-CH_2-CH_2-CH-CH_2-CH_3 | CH_3	6	Methyl	3	3-Methylhexane
CH_3-CH_2-CH-CH_2-CH_2-CH_3 | CH_3	6	Methyl	3	3-Methylhexane
CH_3-CH_2-CH-CH_2-CH_2-CH_3 | CH_2-CH_3	6	Ethyl	3	3-Ethylhexane
CH_3-CH_2-CH_2-CH-CH_2-CH_3 | CH_2 | CH_3	6	Ethyl	3	3-Ethyl hexane

17.♥♥♥ Complete the table.

IUPAC Name	Structural formula
2 – Methyl Propane	
3 – Methyl heptane	
3 – Ethyl Octane	
4– Ethyl Decane	

Answer:

IUPAC Name	Structural formula
2 – MethylPropane	CH_3 | $CH_3\text{-}CH\text{-}CH_3$
3 – Methylheptane	CH_3 | $CH_3\text{-}CH_2\text{-}CH\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$
3 – Ethyloctane	$CH_2\text{-}CH_3$ | $CH_3\text{-}CH_2\text{-}CH\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$
4– Ethyldecane	$CH_2\text{-}CH_3$ | $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

Recommendations for the nomenclature of branched hydrocarbons

- Find out the main chain and identify the branch/branches.
- Numbering should be done from the end in which the branch occurs.

♥♥♥Nomenclature of hydrocarbons with more than one branch

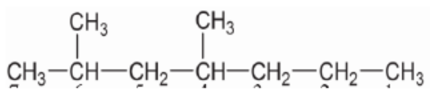
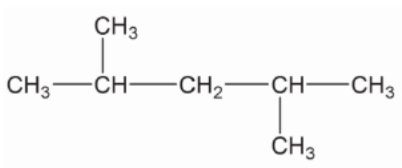
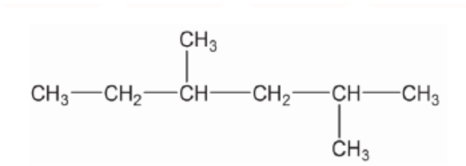
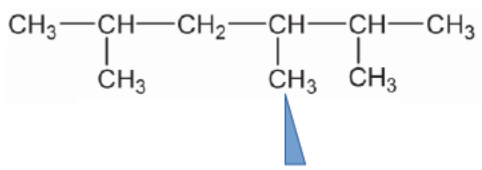
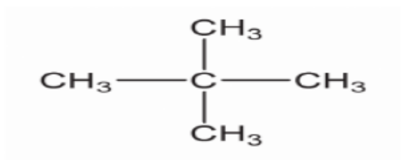
If the same type of branch is present more than once,
as per rule,
***numbering should be done either from left to right or from right to left so as to get the lowest number for the branch coming first** in the longest chain.*

Recommendations for the nomenclature of branched hydrocarbons

- Find out the main chain and identify the branch/branches.
- Numbering should be done from the end in which the branch occurs.
- In case of hydrocarbons with more than one branch, the main chain should be numbered from the end nearest to the first branch.
- If the number of the first branch becomes equal from both sides the next branch is to be considered consecutively.

To students...

Some compounds are given .Name them your own. Look at the answers after that.If there is a discrepancy with the answer given, please understand the explanation.

Compound	IUPAC Name	Explanation
	2,4-Dimethylheptane	***The number of the first branch is 2 when numbered from left to right.*** The number of the first branch is 4 when the number is given from right to left. ***The position number of the first branch should get the smallest possible number***
	2,4- Dimethylpentane	Total two branches. ***The position of the first branch is 2*** even if the number is given from left to right or from right to left
	2,4- Dimethylhexane	The number of the first branch is 3 when numbered from left to right. ***The number of the first branch is 2 when the number is given from right to left.*** ***The position number of the first branch should get the smallest possible number***
	2,3,5-Trimethylhexane	There are 3 branches in total .The first branch is at the same distance from the two ends **So the next branch should be considered and numbered. This branch is marked as** 
	2,2-Dimethylpropane	If a ***carbon atom has two identical branches, the number of their position should be repeated.***

♥♥♥ Nomenclature of unsaturated Hydrocarbons

18.♥♥♥ 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 ,C_2H_6 , C_3H_6 ,C_2H_2 , C_3H_4 C_3H_8

Answer:

Alkane	Alkene	Alkyne
C_5H_{12} $C_{10}H_{22}$ C_4H_{10} C_2H_6 C_3H_8	C_5H_{10} C_2H_4 C_6H_{12} C_4H_8 C_3H_6	C_6H_{10} C_7H_{12} C_4H_6 C_2H_2 C_3H_4

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26.Write the structural formula of the compound C_2H_4

Answer: $CH_2=CH_2$

19.♥♥♥ What is the IUPAC name of the compound **$CH_2=CH_2$** ?

(Hint : Replace the 'ane' in the IUPAC name of the alkane with 'ene'. Alk + ene = alkene)

Answer: The IUPAC name of the compound is Ethene.

More examples:

20.♥♥♥ What is the IUPAC name of the compound **$CH_3-CH=CH_2$** ?

Answer: Propene.

21.♥♥♥ What is the IUPAC name of the compound **$CH_2=CH-CH_2-CH_3$** ?

If your answer is Butene, then ,what is the IUPAC name of **$CH_3-CH=CH-CH_3$? Is it Butene? Look at the difference in the position of the double bond .**

For unbranched, unsaturated hydrocarbons with four or more carbon atoms, position number of the doubly bonded carbon atom should be indicated.

Then ,

What is the IUPAC name of the compound $CH_3-CH_2-CH=CH_2$?

Let's go through this example

$$\overset{1}{C}H_2=\overset{2}{C}H-\overset{3}{C}H_2-\overset{4}{C}H_3 \quad \text{(Method 1)}$$

$$\overset{4}{C}H_2=\overset{3}{C}H-\overset{2}{C}H_2-\overset{1}{C}H_3 \quad \text{(Method 2)}$$

While numbering the carbon atoms, during IUPAC naming, ***the carbon atoms linked by double bond should be given the lowest position number.***

Accordingly, it is in ***method (1)*** *that the lowest position numbers are given to the doubly bonded carbon atoms. What will be the IUPAC name of the compound then?*

Answer: But-1-ene

22.♥♥♥ What is the structure of **But-2-ene ?**

Answer: CH_3-CH=CH-CH_3

23.♥♥♥.What is the IUPAC name of **CH_3-CH_2 - CH=CH-CH_3 ?**

Answer: Pent-2-ene

24.♥♥♥What is the IUPAC name of **CH_3-CH=CH-CH_2-CH_3 ?**

Answer: Pent-2-ene.

For naming alkynes , the same method has to be followed . Alk + yne = Alkyne.

25.♥♥♥ What is the IUPAC name of **CH≡CH ?**

Answer: Ethyne

26.♥♥♥ What is the IUPAC name of **CH_3-C≡CH ?**

Answer: Propyne

27.♥♥♥ What is the IUPAC name of **CH_3-CH_2- C≡CH ?**

Answer: But-1-yne

28.♥♥♥ What is the structure of **But-2-yne ?**

Answer: CH_3-C≡C-CH_3

29.♥♥♥ What is the structure of Pent**-2-yne ?**

Answer: CH_3-CH_2-C≡C-CH_3 **OR** CH_3-C≡C-CH_2 -CH_3

♥♥♥ Functional groups.

Carbon and hydrogen are not the only elements present in organic compounds. There are other atoms and groups of atoms present in the place of hydrogen atoms in organic compounds.

The presence of certain atoms or groups imparts certain characteristic properties to organic compounds. They are called functional groups. Some important functional groups are given below.

Sl No	Functional group	Structure	Name	IUPAC Name
1	♥♥♥ Hydroxyl group	-OH	Alcohol	Alkanol
2	♥♥♥ Alkoxy group	- O - R	Ether	Alkoxyalkane

(R – Alkyl groups like CH_3-, CH_3-CH_2-, CH_3-CH_2-CH_2- or Aryl groups like C_6H_5-)

1.♥♥♥ Hydroxyl Group (- OH)

IUPAC Name : Alkane - e + ol → Alkanol

30.♥♥♥ What is the IUPAC name of CH_3-OH?

Answer: Methane-e+ ol = **Methanol**

39.♥♥♥ What is the IUPAC name of CH_3-CH_2-OH?

Answer: Ethanol

31.♥♥♥ What is the IUPAC name of CH_3-CH_2-CH_2-OH?

Is it Propanol ? If yes, then , what is the IUPAC name of CH_3-CH-CH_3 ?
|
OH

CH_3-CH_2-CH_2-OH is Propan-1-ol

CH_3-CH-CH_3
|
OH
is Propan-2-ol

32. ♥♥♥What is the IUPAC name of CH_3-CH_2-CH_2-CH_2-OH?

Answer : Butan-1-ol

33. ♥♥♥What is the IUPAC name of CH_3-CH-CH_2-CH_3?
|
OH

Answer : Butan-2-ol

34. ♥♥♥ What is the IUPAC name of CH_3-CH_2-CH-CH_3?
|
OH

Answer : Butan-2-ol

(The main chain should be numbered from the end nearest to the functional group.)

35. ♥♥♥ What is the structural difference between CH_3-CH_2-CH_2-OH and CH_3-CH-CH_3 ?
|
OH

Answer: The position of functional group is different.

2.♥♥♥Carboxylic Group

Carboxylic acids are compounds containing -COOH group.

Look at the IUPAC names of some compounds

Compound	IUPAC Name
H-COOH	**Methanoic acid**
CH_3-COOH	**Ethanoic acid**
CH_3-CH_2-COOH	**Propanoic acid**
CH_3-CH_2-CH_2 -COOH	**Butanoic acid**

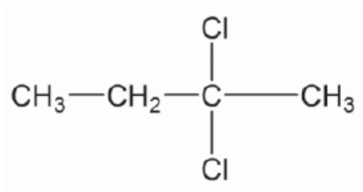
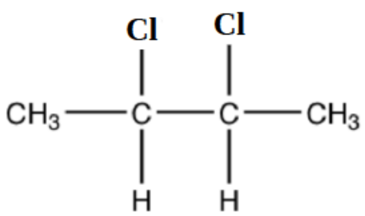
While writing IUPAC names of these compounds, the name of the main chain is terminated with the suffix 'oic acid'.**alkane - e + oic acid**

Vinegar contains acetic acid (CH_3-COOH)**.Its IUPAC name is ethanoic acid**

3.♥♥♥Halo Group

The position of the halo group + - + name of halo group + name of alkane.

Organic compounds with functional groups fluro (-F), chloro (-Cl), bromo (-Br) and iodo (- I) are called Halo compounds. The method of giving IUPAC names to these compounds is given below.

Compound	IUPAC name
CH_3-Cl	**Chloromethane**
CH_3-CH_2-Cl	**Chloroethane**
CH_3-CH_2-CH_2-Cl	**1-Chloropropane**
	**2,2- Dichlorobutane**
	**2,3- Dichlorobutane**

4. ♥♥♥Alkoxy Group (- R-O)

Ethers are compounds with an alkoxy group.

IUPAC Name: Alkoxy alkane

Examples are given below.

Sl No	Ether	IUPAC name
1	CH_3-O -CH_3	Methoxymethane
2	CH_3-CH_2 -O -CH_2-CH_3	Ethoxyethane
3	CH_3-CH_2-CH_2-O-CH_2-CH_2-CH_3	Propoxypropane
4	CH_3-O-CH_2-CH_3	*Methoxyethane*
5	CH_3-CH_2-O-CH_3	*Methoxyethane*
6	CH_3-CH_2-O-CH_2-CH_2-CH_3	Ethoxypropane
7	CH_3-O-CH_2-CH_2-CH_2 -CH_3	Methoxybutane
8	CH_3-CH_2-O-CH_2-CH_2-CH_3	Ethoxypropane
9	CH_3-CH_2-CH_2-CH_2-O-CH_2-CH_3	Ethoxybutane
10	CH_3-CH_2-CH_2-CH_2-O-CH_3	Methoxybutane

*Here among the alkyl radicals on either side of the -O- group , the **longest alkyl group is taken as alkane** and the other as alkoxy group. Look at the above table one again and verify*

7 Chemical Reactions of Organic Compounds

♥♥♥Some important Chemical reactions of organic compounds are given below.

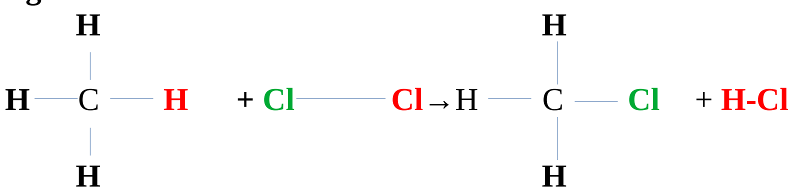
Sl No	Reaction
1	Substitution Reactions
2	Addition Reactions
3	Polymerisation
4	Combustion of Hydrocarbons
5	Thermal Cracking

♥♥♥1. Substitution Reactions

8ATGLC

♥♥♥Examine the different stages of the reaction of methane (CH_4) with chlorine **in the presence of sunlight.**

Stage 1

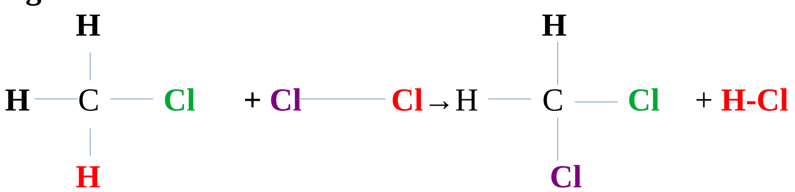


Chloromethane

(CH_4 + Cl_2 → CH_3-Cl + HCl)

Here, one hydrogen atom of methane molecule is replaced by one chlorine atom.
If this process continues..

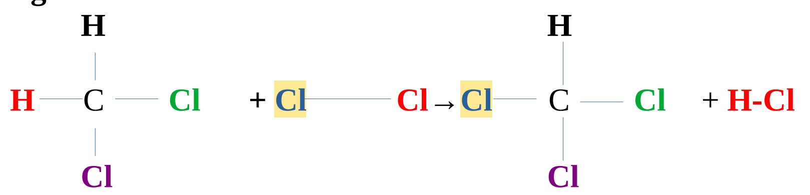
Stage 2



Dichloro methane

(CH_3Cl + Cl_2 → CH_2-Cl_2 + HCl)

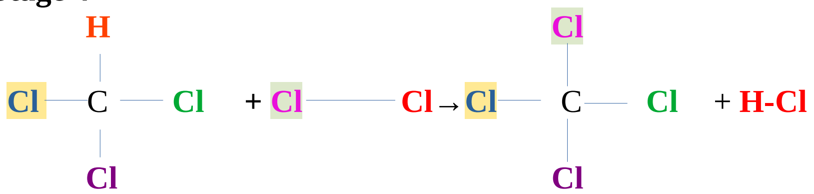
Stage 3



Trichloromethane
(Chloroform)

(CH_2Cl_2 + Cl_2 → $CH\text{-}Cl_3$ + HCl)

Stage 4



Tetrachloromethane
(Carbon tetra chloride)

($CHCl_3$ + Cl_2 → CCl_4 + HCl)

When methane reacts with chlorine each hydrogen atom of methane is replaced successively by chlorine atom. As a result, a mixture ofCH_3Cl (Chloromethane), CH_2Cl_2 (dichloromethane), $CHCl_3$(trichloromethane) and CCl_4 (Tetrachloromethane) is formed.

Such reactions are called Substitution reactions.

> A reaction in which an atom or a group in a compound is replaced by another atom or a group is called substitution reaction

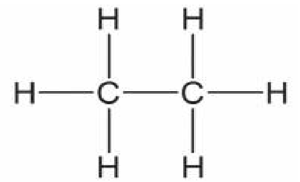
1.What are the compounds formed when CH_3 -CH_3 (C_2H_6 ,ethane)undergoes substitution reaction with chlorine?

Answer:

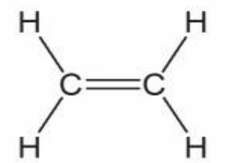
C_2H_6	+	Cl_2	→	C_2H_5Cl	+	HCl
C_2H_5Cl	+	Cl_2	→	$C_2H_4Cl_2$	+	HCl
$C_2H_4Cl_2$	+	Cl_2	→	$C_2H_3Cl_3$	+	HCl
$C_2H_3Cl_3$	+	Cl_2	→	$C_2H_2Cl_4$	+	HCl
$C_2H_2Cl_4$	+	Cl_2	→	C_2HCl_5	+	HCl
C_2HCl_5	+	Cl_2	→	C_2Cl_6	+	HCl

♥♥♥ 2. Addition Reactions

Look at the structural formulae of ethane and ethene.



Ethane



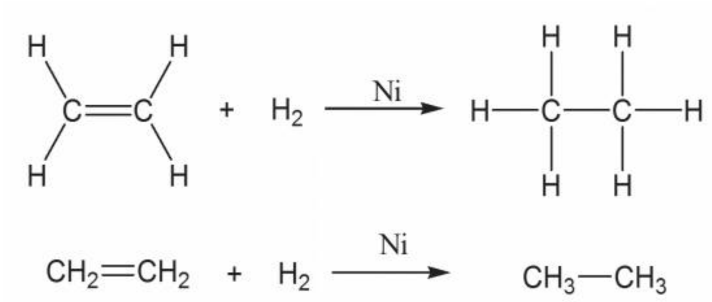
Ethene

*What is the peculiarity of the carbon - carbon bond in ethene?

Ethene is an ***unsaturated*** compound due to the presence of the carbon - carbon ***double bond.*** When unsaturated compounds take part in chemical reactions they tend to form saturated compounds

Let us examine a chemical reaction of ethene molecule.

The chemical equation of ***ethene reacting with hydrogen in the presence of the nickel (Ni)*** catalyst at high temperature is given.

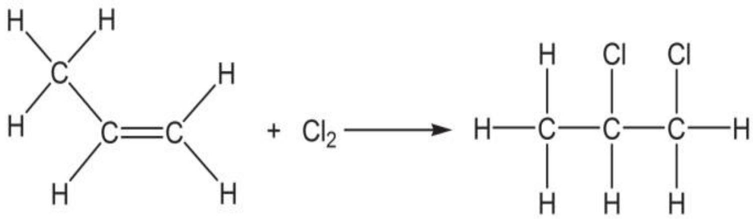


Ethene Ethane

* What do we get as the product?

Answer: Ethane (CH_3-CH_3 or C_2H_6)

Let us examine another similar reaction.



$$CH_3{-}CH{=}CH_2 + Cl_2 \longrightarrow CH_3{-}CHCl{-}CH_2Cl$$

Propene 1, 2 - Dichloropropane

* Which hydrocarbon is the reactant here?
Answer: Propene (CH_3-CH=CH_2)
* Is the product saturated or unsaturated?
Answer: Saturated

2. ♥♥♥ Identify the products in the following addition reactions and complete table

Chemical reaction	Product	IUPAC name of the product
$CH_2{=}CH_2 + Cl_2$	....	....
$CH_2{=}CH_2 + HCl$	....	....
$CH_3{-}CH{=}CH_2 + H_2$	....	....
$CH_3{-}CH{=}CH{-}CH_3 + HBr$	....	....

Answer:

<table>
<tr><th>Chemical reaction</th><th colspan="2">Product</th><th>IUPAC name of the product</th></tr>
<tr><td>CH_2=CH_2 +Cl_2</td><td colspan="2">CH_2-CH_2
| |
Cl Cl</td><td>1,2-Dichloroethane</td></tr>
<tr><td>CH_2=CH_2 +HCl</td><td>CH_3-CH_2-Cl</td><td>Cl-CH_2-CH_3</td><td>Chloroethane</td></tr>
<tr><td>CH_3-CH=CH_2 +H_2</td><td colspan="2">CH_3-CH_2-CH_3</td><td>Propane</td></tr>
<tr><td>CH_3-CH=CH-CH_3 +HBr</td><td>CH_3-CH_2-CH-CH_3
Br</td><td>CH_3-CH-CH_2-CH_3
Br</td><td>2-Bromobutane</td></tr>
</table>

♥♥♥ Similarly, take note of the following chemical reactions

Chemical reaction	Product
$CH \equiv CH + H_2$ Ethyne	$CH_2=CH_2$ Ethene
$CH_2=CH_2 + H_2$ Ethene	CH_3-CH_3 Ethane
$CH_3-C \equiv CH + H_2$ Propyne	$CH_3-CH=CH_2$ Propene
$CH_3-CH=CH_2 + H_2$ Propene	$CH_3-CH_2-CH_3$ Propane

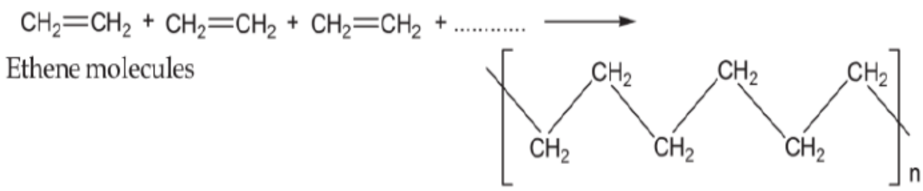
Reactions in which unsaturated organic compounds with double bond or triple bond react with other molecules to form saturated compounds are called addition reactions

♥♥♥ 3. Polymerisation

8BC8PM

We have learned that ethene molecules undergo addition reaction to form saturated compounds.

Consider the reaction in which a ***large number of ethene molecules combine under high pressure and temperature in the presence of a catalyst***. The ***product*** formed here ***is polythene***.



Ethene molecules

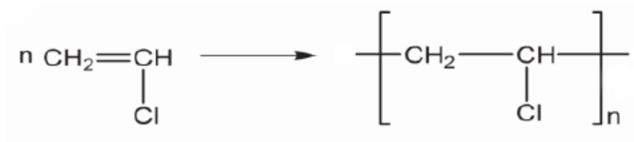
$$n\ CH_2{=}CH_2 \longrightarrow \left[-CH_2-CH_2- \right]_n$$

Ethene polythene.

Polymerisation is the process in which a large number of simple molecules combine under suitable conditions to form complex molecules. The product molecules are called polymers

The simple molecules which combine in this manner are called monomers.

We use a number of natural and man - made polymers in our daily life.
PVC (Polyvinyl Chloride) is a polymer commonly used for making pipes. It is formed by the polymerisation of a large number of chloroethene (Vinyl chloride) molecules.



Vinylchloride Polyvinyl Chloride (PVC)

Teflon is a polymer which is familiar to us. It is used ***for coating on the inner surface of non-stick cookware. Its monomer is tetrafluoroethene.***

$$n\ CF_2{=}CF_2 \longrightarrow \left[-CF_2-CF_2- \right]_n$$

Tetrafluoroethene Teflon

3.♥♥♥ Complete the following table suitably.

Monomer	Polymer	Use
. . . .	PVC	. . . .
Ethene	. . . .	. . . .
Isoprene	Natural rubber (Polyisoprene)	. . . .
. . . .	Teflon	. . . .

Answer:

Monomer	**Polymer**	**Use**
Vinyl Chloride (Chloroethene)	PVC	For making pipes,electronic equipments ,buckets, vinyl flooring, table cloths etc
Ethene	Polythene	For making Polythene bags,rain coats etc.
Isoprene	Natural Rubber (Poly Isoprene)	For making tyres, foot wares etc
Tetra Fluoroethene	Teflon (Poly Tetra Fluoroethene)	For coating on the inner surface of non-stick cookware

♥♥♥ 4. Combustion of Hydrocarbons*

8BL4RA

Most of the hydrocarbons are used as fuels.
Examples: Kerosene, Petrol, LPG

When hydrocarbons burn they combine with the oxygen in the air to form CO_2 and H_2O along with heat and light. This process is called combustion

***Complete combustion**

Example: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ **+ Heat + Light**

Hydrocarbons are used as fuels because of the exothermic nature of the combustion process.

♥♥♥ More worked out examples.

1.

Unbalanced	Balanced
$CH_4 + O_2 \rightarrow CO_2 + H_2O$	**$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ + Heat + Light**
$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$	$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ + Heat + Light
$C_5H_{12} + O_2 \rightarrow CO_2 + H_2O$	**$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ + Heat + Light**
$C_7H_{16} + O_2 \rightarrow CO_2 + H_2O$	$C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$ + Heat + Light
$C_6H_{12} + O_2 \rightarrow CO_2 + H_2O$	**$2\ C_6H_{12} + 9\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ + Heat + Light**

2♥♥♥

Unbalanced	Balanced
$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$	**$2\ C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$ + Heat + Light**
$C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$	**$2\ C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$ + Heat + Light**
$C_6H_{14} + O_2 \rightarrow CO_2 + H_2O$	**$2\ C_6H_{14} + 19\ O_2 \rightarrow 12CO_2 + 14H_2O$ + Heat + Light**
$C_6H_6 + O_2 \rightarrow CO_2 + H_2O$	**$2\ C_6H_6 + 15\ O_2 \rightarrow 12CO_2 + 6H_2O$ + Heat + Light**
$C_3H_6 + O_2 \rightarrow CO_2 + H_2O$	**$2\ C_3H_6 + 9\ O_2 \rightarrow 6CO_2 + 6H_2O$ + Heat + Light**

Hint: Balance Hydrogen atoms first,then balance carbon atoms . ***Finally balance Oxygen atoms.***
If It is a fraction like 5/2 , 7/2 ,15/2 etc, multiply all by 2 , like a mathematical equation.

Explanation

Example

$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$

a. Balancing Hydrogen atoms

$C_2H_6 + O_2 \rightarrow CO_2 + 3H_2O$

b. Balancing Carbon atoms

$C_2H_6 + O_2 \rightarrow 2CO_2 + 3H_2O$

c. Balancing Oxygen atoms

$C_2H_6 + O_2 \rightarrow 2CO_2 + 3H_2O$

Total number of oxygen atoms on the right side = (2 x 2)+ (3x 1)=4+3 = 7

To get 7 oxygen atoms on the left side , multiply O_2 with 7/2

$C_2H_6 + 7/2\ O_2 \rightarrow 2CO_2 + 3H_2O$

Since 7/2 is a fraction, multiply all by 2

$2 \times C_2H_6 + 2 \times (7/2)O_2 \rightarrow 2 \times 2CO_2 + 2 \times 3H_2O$

Answer: $2\ C_2H_6 + 7O_2 \rightarrow 4\ CO_2 + 6\ H_2O$ + Heat + Light

3. Butane is one of the important components in the domestic fuel , LPG.
Write the balanced chemical equation for the combustion of butane (C_4H_{10})
Answer:

$2\ C_4H_{10} + 13\ O_2 \rightarrow 8CO_2 + 10H_2O$ + Heat + Light

♥♥♥ 5. 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.A number of products are made in this way.
Propane is one of the simplest hydrocarbons which can undergo thermal cracking.
Examine the equation for the thermal cracking of propane.

$$\underset{\text{Propane}}{CH_3\text{-}CH_2\text{-}CH_3} \rightarrow \underset{\text{Ethene}}{CH_2{=}CH_2} + \underset{\text{Methane}}{CH_4}$$

Another example is given below

$$\underset{\text{Heptane}}{CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3} \rightarrow \underset{\text{Butane}}{CH_3-CH_2-CH_2-CH_3} + \underset{\text{Propene}}{CH_3-CH=CH_2}$$

The same question can be answered in may ways . Look at a few of those

$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$	→	$CH_3-CH_2-CH_3$	+	$CH_3\text{-}CH_2-CH=CH_2$
7 Carbon atoms		3 Carbon atoms		4 Carbon atoms
$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$	→	$CH_3-CH_2-CH_2\text{-}CH_2-CH_3$	+	$CH_2=CH_2$
7 Carbon atoms		5 Carbon atoms		2 Carbon atoms
$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$	→	CH_3-CH_3	+	$CH_3\text{-}CH_2\text{-}CH_2-CH=CH_3$
7 Carbon atoms		2 Carbon atoms		5 Carbon atoms
$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$	→	CH_4	+	$CH_3-CH_2-CH=CH-CH_2-CH_3$
7 Carbon atoms		One carbon atom		6 Carbon atoms

[Here we have 7 carbon atoms. The number 7 can be split in may ways (4+3 ,5+2,6+1) . Double bond can be given in between any two carbon atoms. Total number of C, H & O should be the same on both sides.]

When hydrocarbons with larger number of carbon atoms undergo thermal cracking, the carbon chain can undergo cleavage or breaking in a number of ways. The products formed as a result of thermal cracking depend on the nature of the hydrocarbons getting cracked, temperature and pressure.
When saturated hydrocarbons are subjected to thermal cracking the products formed contain both saturated and unsaturated hydrocarbons.
Plastic wastes, which are polymers can be converted to simpler molecules by thermal cracking. This helps to control pollution to some extent.

♥♥♥ Complete the table containing chemical reaction of hydrocarbons

$CH\equiv CH + H_2$	$\rightarrow$	…………………
$CH_3Cl + Cl_2$	$\rightarrow$	………………… + HCl
…………………	$\rightarrow$	$-[CH_2-CH_2]_n-$
CH_4 + …………………	$\rightarrow$	$CO_2 + H_2O$
………………… $+ H_2$	$\rightarrow$	CH_3-CH_3

Answer:

$CH\equiv CH + H_2$	$\rightarrow$	$CH_2=CH_2$
$CH_3Cl + Cl_2$	$\rightarrow$	CH_2Cl_2 + HCl
$n\ CH_2=CH_2$	$\rightarrow$	$-[CH_2-CH_2]_n-$
$CH_4 + O_2$	$\rightarrow$	$CO_2 + H_2O$
$CH_2=CH_2 + H_2$	$\rightarrow$	CH_3-CH_3

♥♥♥ 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
$CH\equiv CH + H_2$	$-[CH_2-CH_2]_n-$	Combustion

Answer:

Reactants (A)	Products (B)	Name of the reaction (C)
$CH_3-CH_3 + Cl_2$	$CH_3-CH_2Cl + HCl$	**Substitution reaction**
$C_2H_6 + O_2$	$CO_2 + H_2O$	**Combustion reaction**
$nCH_2=CH_2$	$-[CH_2-CH_2]-$	**Polymerisation**
$CH_3-CH_2-CH_3$	$CH_2=CH_2 + CH_4$	**Thermal cracking**
$CH\equiv CH + H_2$	$CH_2=CH_2$	**Addition reaction**