CHAPTER # 01

STOICHIOMETRY

This word was derived from stoicheion means **element** and **metry** means **measurement**.

STOICHIOMETRY: Study of relative amounts of substances in a chemical reactions is called stoichiometry.

The branch of chemistry which deals with the study of quantitative relationship between reactants and products in balanced chemical equations is called stoichiometry.

STOICHIOMETRIC AMOUNT:

Amounts of reactants and products in balanced chemical equation is called stoichiometric amount.

What is stoichiometry and stoichiometric amount? [Q No 2 (xiii)]

$1\ amu = 1.667 \times 10^{-27}\ kg$

MOLE:

When atomic mass, molecular mass, formula mass or ionic mass of a substance is expressed in gram is called mole.

FORMULA:

$$\text{Mole} = \frac{\text{Mass in gram}}{\text{Molar mass}}$$

MOLE CALCULATION:

1 mole of $O = 16g$
1 mole of $O_2 = 32g$
1 mole of $NaCl = 58.5g$
1 mole of $OH^- = 17g$

NOTE: Mole is also called gram atom, gram molecule, gram formula or gram ion.

GRAM ATOM

When atomic mass of an element is expressed in gram is called gram atom or gram mole.

$$\text{Gram atom} = \frac{\text{Mass in gram}}{\text{Atomic mass}}$$

GRAM MOLECULE:

When molecular mass of a molecule or covalent compound is expressed in gram is called gram molecule.

$$\text{Gram molecule} = \frac{\text{Mass in gram}}{\text{Molecular mass}}$$

GRAM FORMULA:

When formula mass of ionic compound is expressed in gram is called gram formula.

$$\text{Gram formula} = \frac{\text{Mass in gram}}{\text{Formula mass}}$$

GRAM ION:

When ionic mass of ionic substance is expressed in gram is called gram ions.

$$\text{Gram ions} = \frac{\text{Mass in gram}}{\text{Ionic mass}}$$

AVOGADRO'S NUMBER (N_A) OR REPRESENTATIVE PARTICLES

It is the number of atoms, ions, molecules or formula units in one mole of a substance is called Avogadro's Number.

It is denoted by N_A.

$$N_A = 6.022 \times 10^{23} \text{ Particles.}$$

Examples:

1 mole of $O = 6.02 \times 10^{23}$ atoms
1 mole of $H_2O = 6.02 \times 10^{23}$ molecules
1 mole of $NaCl = 6.02 \times 10^{23}$ formula units
1 mole of $OH^- = 6.02 \times 10^{23}$ ions.

$$2H_2 + O_2 \longrightarrow 2H_2O$$

According to Avogadro's Number, $2 \times 6.02 \times 10^{23}$ molecules of H_2 react with 6.02×10^{23} molecules of O_2 to produce $2 \times 6.02 \times 10^{23}$ molecules of H_2O.

$$NaCl \xrightleftharpoons{H_2O} Na^+ + Cl^-$$

According to Avogadro's Number, 6.02×10^{23} formula units of NaCl dissolve in water produce 6.02×10^{23} ions of sodium and 6.02×10^{23} ions of chlorine.

MOLE RATIO OR CONVERSION FACTOR

It is the ratio between number of moles of reactants taking part in chemical reaction and no. of moles of products produce in a chemical reaction is called mole ratio.

e.g.

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

According to mole ratio, 1 mole of propane react with 5 mole of oxygen to produce 3 mole of CO_2 and 4 mole of steam

NUMERICAL

e.g 1-1

$$2CH_3OH + 3O_2 \longrightarrow 2CO_2 + 4H_2O$$

a) Methanol (CH_3OH) = 3.50 moles
moles of O_2 used = ?

b) moles of H_2O produce = ?

a) CH_3OH : O_2

2 : 3

1 : 3/2

3.5 : 3/2 × 3.5 => 5.25 moles

b) $CH_3OH : H_2O$

$2 : 4$

$3.5 : 4/2 \times 3.5 \Rightarrow 7$ moles.

Self check 1-1

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

Moles of $NH_3 = 5.0$ moles

a) Mole of $N_2 = ?$

b) Mole of $H_2 = ?$

a) $NH_3 : N_2$

$2 : 1$

$1 : 1/2$

$5 \times 1 : 1/2 \times 5 \Rightarrow 2.5$ moles

b) $NH_3 : H_2$

2 moles : 3 moles

$1 : 3/2$

$1 \times 5 : 3/2 \times 5 \Rightarrow 7.5$ moles

Example 1.2:

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

Mass of $Fe_2O_3 = 425g$

Mass of Fe formed $= ?$

Molar mass of $Fe_2O_3 = 2 \times 56 + 16 \times 3 = 160g$

Mole $= \frac{425}{160} = 2.66$ moles

$Fe_2O_3 : Fe$

$1 : 2$

$2.66 : 2 \times 2.66 \Rightarrow 5.32$ moles.

Mass in gram of Fe = Mole ~~x Molar~~ · mass

$= 5.32 \times 56 \Rightarrow 297.92 g$

Self-check 1.2

$$2H_2 + O_2 \longrightarrow 2H_2O$$

Mass of hydrogen $(H_2) = 1.02 \times 10^5$ kg

Mass of oxygen $(O_2) = ?$

$$\text{Mole} = \frac{1.02 \times 10^8}{2.016} \Rightarrow 0.5059 \times 10^8 \text{ moles}$$

$H_2 : O_2$

$2 : 1$

$1 : 1/2$

$0.5059 \times 10^8 : \frac{1}{2} \times 0.5059 \times 10^8 \Rightarrow 0.253 \times 10^8$ moles

Mass in gram of $(O_2) = 0.253 \times 10^8 \times 32$

$= 8.09 \times 10^8$ g

$= 8.09 \times 10^5$ kg

Example 1.3

$$2KClO_3 \longrightarrow 2KCl + 3O_2$$

$KClO_3 = 490$ g

No: of molecules of $O_2 = ?$

Molar mass of $KClO_3 = 39 + 35.5 \times 16 \times 3 = 122$ g/mol

Moles of $KClO_3 = \frac{490}{122.5} \Rightarrow 4$ moles

$KClO_3 : O_2$

$2 : 3$

$1 : 3/2$

$4 : 3/2 \times 4 \Rightarrow 6$ moles

No: of molecules $=$ Mole $\times 6.02 \times 10^{23}$

$= 6 \times 6.02 \times 10^{23} \Rightarrow 36.12 \times 10^{23}$

$\Rightarrow 3.612 \times 10^{24}$ molecules.

Example 1.4:

$H_2SO_4 = 20g$

a) No: of H_2SO_4 molecules = ?

b) No: of H^+ & SO_4^{-2} ions

c) Mass of individual ions

a) No: of molecules $= \frac{\text{Mass in gram}}{\text{Molar mass}} \times 6.02 \times 10^{23}$

$= \frac{20}{98} \times 6.02 \times 10^{23}$

$\Rightarrow 1.228 \times 10^{23}$ molecules.

b) $H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{-2}$

1 molecules of H_2SO_4 produce $H^+ = 2$

1.228×10^{23} " " $= 2 \times 1.228 \times 10^{23}$

$= 2.456 \times 10^{23}$ H^+ ions

1 molecule of H_2SO_4 produce $SO_4^{-2} = 1$

$= 1 \times 1.228 \times 10^{23}$

$= 1.228 \times 10^{23}$ SO_4^{-2} ions.

No: of ions $= \frac{\text{Mass in gram}}{\text{ionic mass}} \times N_A$

$2.456 \times 10^{23} = \frac{\text{Mass in gram } H^+}{1.008} \times 6.02 \times 10^{23}$

Mass of $H^+ = 0.411g$

No: of SO_4^{-2} ions $= \frac{\text{Mass in gram}}{\text{ionic mass}} \times N_A$

$1.228 \times 10^{23} = \frac{\text{Mass in gram of } SO_4^{-2}}{96} \times 6.02 \times 10^{23}$

Mass in gram of $SO_4^{-2} = 19.58 g$

$22.414 dm^3 = 22.414 L$
$22414 cm^3 = 22414 mL$
$\therefore 1 dm^3 = 1 L$
$1 cm^3 = 1 mL$ | $1 dm^3 = 1000 cm^3$

Pg 09:

MOLAR VOLUME (V_m)

1 mole of any gas at S.T.P occupy volume **$22.414 dm^3$**. This volume is called **molar volume**.

Examples:

1 mole of $H_2 = 2.016 g = 22.414 dm^3 = 6.02 \times 10^{23}$ molecules
1 mole of $CH_4 = 16 g = 22.414 dm^3 = 6.02 \times 10^{23}$ molecules.
1 mole of $N_2 = 28 g = 22.414 dm^3 = 6.02 \times 10^{23}$ molecules

Example 1.5:

Moles of $Cl_2 = 2.5$ moles
vol. of Cl_2 at S.T.P = ?

1 mole of Cl_2 has volume at S.T.P $= 22.414 dm^3$
2.5 moles " " $= 22.414 \times 2.5$
$= 56.035 dm^3$

Self-check 1.3:

a) Moles of oxygen molecules (O_2) =
vol: of O_2 at STP $= 50 dm^3$

$22.414 dm^3$ of O_2 at STP has no. of mole = 1 mole
$1 dm^3$ " " $= \frac{1}{22.414}$
$50 \times 1 dm^3$ " " $= 2.23$ moles

b) Mole of $N_2 \overset{at\ STP}{=} 0.80$ mole
volume of N_2 at STP = ?

1 mole of N_2 at STP has volume $= 22.414\ dm^3$

0.80 moles " " " " $= \frac{22.414}{1} \times 0.80$

$\Rightarrow 17.93\ dm^3$

PERCENTAGE COMPOSITION

Relative amount of each element present in a compound is called percentage **composition**.

Determination of percentage composition:

These are 2 steps for determination of percentage composition.

1. Calculate molar mass of compound.
2. Calculate percentage of each element by using this formula.

$$\% \text{ of element} = \frac{\text{Mass of element in compound}}{\text{Molar mass of compound}} \times 100$$

Example: Calculate percentage composition of MgO?

Molar mass of $MgO = 24 + 16 = 40g$

$\% \text{ of } Mg = \frac{24}{40} \times 100 \Rightarrow 60\%$

$\% \text{ of } O = \frac{16}{40} \times 100 \Rightarrow 40\%$

Example 2: Calculate percentage composition of glucose? Q No 05: b)

Molar mass of $C_6H_{12}O_6 = 12\times6 + 1\times12 + 16\times6 \Rightarrow 180\,gmol^{-1}$

$\% \text{ of } C = \frac{72}{180} \times 100 \Rightarrow 40\%$

$\% \text{ of } H = \frac{12}{180} \times 100 \Rightarrow 6.66\%$

$\% \text{ of } O = \frac{96}{180} \times 100 \Rightarrow 53.33\%$

Example 3: Calculate percentage composition of sucrose?

Molar mass of $C_{12}H_{22}O_{11} = 12\times12 + 1\times22 + 16\times11 \Rightarrow 342\,gmol^{-1}$

$\% \text{ of } C = \frac{144}{342} \times 100 \Rightarrow 42.1\%$

$\% \text{ of } H = \frac{22}{342} \times 100 \Rightarrow 6.4\%$

$\% \text{ of } O = \frac{176}{342} \times 100 \Rightarrow 51.46\%$

LIMITING AND NON-LIMITING REACTANT

QNo 02 . iv

Limiting reactant	Non-limiting (excess) reactant
* Reactants which consume earlier during the chemical reaction is called limiting reactant.	* Reactant left unreacted after the completion of reaction is called non-limiting reactant.
* Reactant which produce least mole of product during the chemical reaction is called limiting reactant.	* Reactant which produce excess mole of product during the chemical reaction is called non-limiting reactant.
* It controls the amount of product.	* It does not control amount of product.

Example:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

Moles of H_2 = 10 moles
Moles of O_2 = 7 moles.

According to balanced chemical equation:

$H_2 : H_2O$
$2 : 2$
$1 : 2/2$
$10 : \frac{2}{2} \times 10 \Rightarrow 10$ moles.

According to balanced chemical equation:

$O_2 : H_2O$
$1 : 2$
$7 : 2 \times 7 \Rightarrow 14$ moles.

1. H_2 is a limiting reactant in this reaction.
2. O_2 is a non-limiting reactant in this reactant.

Identification of limiting reactant:

There are three steps for identification of limiting reactant.

* Calculate no: of moles of reactant from given amount of reactant.
* Calculate mole of product with respect to each reactant by using balanced chemical equation.
* Identify the reactant which produce least mole of product.

NOTE:

* There is no concept of limiting reactant in reversible reaction. Because in reversible reaction, reactant are not compreletly converted into product.
* If reactant are mixed with stoichiometric ratio, there is no limiting reactant in this reaction.

Example No 1.6:

Mass of $K_2Cr_2O_7$ = 200g
Mass of H_2SO_4 = 200g

A) Calculate mass of atomic oxygen produce = ?
B) Mass of reactant left unreactant = ?

$$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$

Molar mass of $K_2Cr_2O_7 = 2\times39 + 2\times52 + 7\times16 \Rightarrow 294\ g\ mol^{-1}$
Molar mass of $H_2SO_4 = 2\times1 + 1\times32 + 4\times16 = 98\ g\ mol^{-1}$

Moles of $K_2Cr_2O_7 = \frac{200}{294} = 0.68$ moles.

Moles of $H_2SO_4 = \frac{200}{98} \Rightarrow 2.04$ moles

$K_2Cr_2O_7$: [O]
1 : 3
0.68 : $3\times0.68 = 2.04$ moles.

H_2SO_4 : [O]
4 : 3
1 : 3/4
2.04 : $(3/4)\times2.04 \Rightarrow 1.53$ moles.

H_2SO_4 is a limiting reactant.

Mole of [O] = 1.53 moles.

Molar mass × Mole = Mass in gram of [O]

Mass of [O] = 1.53×16
$\Rightarrow 24.48$ g

H_2SO_4 : $K_2Cr_2O_7$
4 : 1
1 : 1/4
2.04 : $1/4\times2.04 \Rightarrow 0.51$ moles.

Pg 15:

Consumed moles of $K_2Cr_2O_7$ / H_2SO_4 = 0.51 moles.

Excess mole of $K_2Cr_2O_7$ = 0.68 − 0.51 = 0.17 moles

Mass of $K_2Cr_2O_7$ = 0.17 × 294 = 49.98 g.

Example 1.7:

$$Mg + S \longrightarrow MgS$$

Mass of Mg = 1.50 g

Mass of S = 1.50 g

Mass of MgS = ?

Moles of Mg = $\frac{1.50}{24}$ = 0.06 mol.

Moles of S = $\frac{1.50}{32}$ = 0.04 mole.

Mg : MgS

1 : 1

0.06 : 1 × 0.06 => 0.06 moles.

S : MgS

1 : 1

0.04 : 1 × 0.04 => 0.04 moles.

Since S is a limiting reactant.

So moles of MgS = 0.04 moles.

Mass of MgS = 0.046 × 56

= ~~2.24~~ g => 2.576 g

Self-check 1.4:

$$2Al + 3Br_2 \longrightarrow 2AlBr_3$$

2) Mass of Al = 15.8 g

Mass of Br_2 = 55.6 g

limiting reactant = ?

Mass of $AlBr_3$ produced = ?

Mole of Al = $\frac{15.8}{27}$ => 0.5851 moles.

Mole of Br_2 = $\frac{55.6}{160}$ => 0.3475 moles

Al : $AlBr_3$
2 : 2
1 : 2/2
0.5851 : 2/2 × 0.5851 => 0.5851 moles.

Br_2 : $AlBr_3$
3 : 2
1 : 2/3
1 × 0.3475 : 2/3 × 0.3475 => 0.2317 moles.

Since Br_2 is a limiting reactant.
So Moles of $AlBr_3$ = 0.2317 moles.

Mass of $AlBr_3$ = 267 × 0.2317
= 61.86g

1) $Zn + S \longrightarrow ZnS$

Mass of Zn = 6g
Mass of S = 4g
limiting reactant = ?
Mass of ZnS = ?

Mole of Zn = $\frac{6}{65}$ = 0.0923 moles

Mole of S = $\frac{4}{32}$ = 0.125 moles

Zn : ZnS
1 : 1
0.0923 : 1 × 0.0923 => 0.0923 moles.

Pg 17:

$S : ZnS$

$1 : 1$

$0.125 : 1 \times 0.125 \Rightarrow 0.125$ moles.

Since Zn is a limiting reactant.

So moles of $ZnS = 0.0923$ moles.

Mass of $ZnS = 97 \times 0.0923 \Rightarrow 8.9531g$

Example 1.8:

$$Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2NH_4OH$$

Moles of $NH_4Cl = 1.87$ moles.

Moles of $Ca(OH)_2 = 1.35$ moles

$Ca(OH)_2 : NH_4OH$

$1 : 2$

$1.35 : 2 \times 1.35 \Rightarrow 2.7$ moles

$NH_4Cl : NH_4OH$

$2 : 2$

$1 : 2/2$

$1.87 : 2/2 \times 1.87 \Rightarrow 1.87$ moles

Since NH_4Cl is a limiting reactant.

$NH_4Cl : Ca(OH)_2$

$2 : 1$

$1 : 1/2$

$1.87 : 1/2 \times 1.87 \Rightarrow 0.935$ moles

Consumed moles of $Ca(OH)_2 = 0.935$ moles

Excess moles of $Ca(OH)_2 = 1.35 - 0.935$

$= 0.415$ moles

Mass of $Ca(OH)_2 = 74 \times 0.415$

$\Rightarrow 30.71g$

Pg 18:

Excersise; Q No 07:

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

Mass of AgCl = ?

Mass of $AgNO_3$ = 120g

Mass of NaCl = 52g

Moles of $AgNO_3 = \frac{120g}{170gmol^{-1}} \Rightarrow 0.7059$ moles.

Moles of NaCl $= \frac{52}{58.5} \Rightarrow 0.89$ moles.

$AgNO_3$: AgCl

1 : 1

0.7059 : $1 \times 0.7059 \Rightarrow 0.7059$ moles.

NaCl : AgCl

1 : 1

0.89 : $1 \times 0.89 \Rightarrow 0.89$ moles.

Since $AgNO_3$ is a limiting reactant.

So, moles of AgCl = 0.7059 moles.

Mass of AgCl $= 0.7059 \times \cancel{0.7059}\ 143.5$

$= 101.29$ g

THEORETICAL YIELD, ACTUAL YIELD AND PERCENTAGE YIELD

Theoretical yield, Numerical yield, Calculated yield or stoichiometric yield:

Amount of product calculated with the help of balanced chemical equation is called theoretical yield.

Actual, experimental or practical yield:

Amount of product actually obtained during the chemical reaction is called actual yield.

Percentage yield:

Efficiency of the reaction can be checked with the help of percentage yield.
Higher will be the percentage yield, higher ~~will~~ efficiency will be of the reaction, and vice versa.

$$\%\ \text{yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

Q No 02: xi.
Why is actual yield less than theoretical yield?

Due to following reasons, actual yield is lesser than theoretical yield.

* These may be impurities in reactant.
* There may be side reaction which produce by product.
* Reaction may be reversible.
* There may be mechanical loss during filtration, distillation, crystallization and drying of crystal.
* Practically inexperienced workers produce low yield due to many short-comings.

NOTE:

Reaction in which actual yield is almost equal to theoretical yield such reactions are called quantitative reactions.

Self-check 1.5

2) $CH_4 + 2H_2O \longrightarrow CO_2 + 4H_2$

Mass of $CH_4 = 1250g$

a) Mass of $CO_2 = ?$

Moles of $CH_4 = \frac{1250}{16} \Rightarrow 78.125$ moles.

$CH_4 : CO_2$

$1 : 1$

$78.125 : 1 \times 78.125 \Rightarrow 78.125$ moles.

Moles of $CO_2 = 78.125$ moles.

Mass of $CO_2 = 78.125 \times 44 \Rightarrow 3437.5g$

Theoretical yield of $CO_2 = 3437.5g$

b. Actual yield of $CO_2 = 3000g$

$$\% \text{ yield} = \frac{\text{Actual yield}}{\text{theoretical yield}} \times 100$$

$$= \frac{3000}{3437.5} \times 100$$

$$= 87.27\%$$

1) $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO$

a) Actual yield of $C_6H_{12}O_6 = 10g$

C_2H_5OH theoretical yield = ?

Mass of $C_6H_{12}O_6 = 10g$

Moles of $C_6H_{12}O_6 = \frac{10}{180} \Rightarrow$ ~~0.0675 moles~~ 0.0555 moles

$C_6H_{12}O_6 : C_2H_5OH$

$1 : 2$

$0.0675 : 2 \times \cancel{0.0675}$ 0.0555 $\Rightarrow \cancel{0.135}$ 0.111 moles.

Moles of $C_2H_5OH = \cancel{0.135}$ 0.111 moles

Mass of $C_2H_5OH = \cancel{0.135}$ 0.111 $\times 46 \Rightarrow 5.11g$

b) Mass of $C_6H_{12}O_6 = 10g$

actual yield of $C_2H_5OH = 0.664g$

% yield of C_2H_5OH = ?

theoretical yield of $C_2H_5OH = 5.11g$

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\% \text{ yield} = \frac{0.664}{5.11} \times 100$$

$\%$ yield of $C_2H_5OH = 12.99\%$

Exercise Q No 04- b

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

Mass of $H_2 = 42g$

actual yield of $NH_3 = 120.2g$

$\%$ yield of $NH_3 = ?$

Moles of $H_2 = \frac{42}{2} \Rightarrow 21$ moles

$H_2 : NH_3$

$3 : 2$

$1 : 2/3$

$21 : 2/3 \times 21 \Rightarrow 14$ moles

Moles of $NH_3 = 14$ moles

Mass of $NH_3 = 238\ g$

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\% \text{ yield of } NH_3 = \frac{120.2}{238} \times 100$$

$$= 50.5\%$$

Example 1.9:

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

Mass of $CuSO_4 = 1.274\ g$

actual yield of $Cu = 0.392g$

$\%$ yield of $Cu = ?$

Moles of $CuSO_4 = \frac{1.274}{159.5} = 7.987 \times 10^{-3}$ moles

Pg 23:

$CuSO_4 : Cu$

$1 : 1$

$7.987 \times 10^{-3} : 1 \times 7.987 \times 10^{-3} \Rightarrow 7.987 \times 10^{-3}$

Moles of Cu = 7.987×10^{-3} moles

Mass of Cu = $7.987 \times 10^{-3} \times 63.5$

= 0.507 g

Theoretical yield of Cu = 0.507g

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\% \text{ yield} = \frac{0.392}{0.507} \times 100$$

% yield = 77.32%

Example 1.10

$$CH_4 + 4Cl_2 \longrightarrow CCl_4 + 4HCl$$

Moles of CH_4 = 2 moles

Mass of CCl_4 = 177g

$CH_4 : CCl_4$

$1 : 1$

$2 : 1 \times 2 \Rightarrow 2$ moles

Moles of CCl_4 = 2 moles.

Mass of CCl_4 = Moles × Molar mass

= 2 × 154

= 308g

Theoretical yield of CCl_4 = 308g

Actual yield of CCl_4 = 177g

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$\% \text{ yield} = \frac{177}{308} \times 100$$

$$\% \text{ yield of } CCl_4 = 57.46\%$$

CHAPTER # 01
EXERCISE

Q No 02: Short Q/As

1-

NaCl is ionic compound. It can't exist as individual and independant molecule. Therefore, mass of NaCl is called formula mass not molecular mass.

ii. Concept of limiting reactant is not applicable in reversible reaction. Because in reversible reaction, reactant are not completly converted into product. However, limiting reactant is a reactant which is completly consumbed in a chemical reaction.

iii.

Mass of $H_2O = 9g$

No: of covalent bonds = ?

$$\text{No: of molecules} = \frac{9}{18} \times 6.02 \times 10^{23}$$

$$= 3.01 \times 10^{23} \text{ molecules.}$$

1 molecule of H_2O has bonds = 2

3.01×10^{23} " " = $2 \times 3.01 \times 10^{23}$

$= 6.02 \times 10^{23}$ No: of covalent bonds.

v.

Mass of ice = 12g
No: of molecules = ?
No: of molecules $= \frac{12}{18} \times 6.02 \times 10^{23}$
$= 4.01 \times 10^{23}$ molecules

vi.

According to Avogadro's No:
1 mole of $H_2 = 6.02 \times 10^{23}$ molecules.
1 mole of $Fe = 6.02 \times 10^{23}$ atoms

1 molecule of H_2 has atoms = 2
6.02×10^{23} " " $= 2 \times 6.02 \times 10^{23}$
$= 1.204 \times 10^{24}$ atoms.

H_2 has more no: of atoms.

vii.

1 mole of $CO_2 = 44g = 6.02 \times 10^{23}$ molecules
1 mole of $N_2 = 28g$ = " "
1 mole of $H_2 = 2.016g$ = " "

1 mole of different compound have different masses but have same no: of molecules. This is because individual molecule of different compound have different masses.

viii.

$Na = 23g$; $U = 238g$

No: of atoms $= ?$; No: of atoms

No: of atoms $= \frac{23}{23} \times 6.02 \times 10^{23}$; No: of atoms $= \frac{238}{238} \times 6.02 \times 10^{23}$

$= 6.02 \times 10^{23}$ atoms ; $= 6.02 \times 10^{23}$ atoms

ix. $2KClO_3 \longrightarrow 2KCl + 3O_2$

$KClO_3 = 5g$

weight of oxygen gas produce $= ?$

Molar mass of $KClO_3 = 39 + 35.5 + 16 \times 3 \Rightarrow 122.5 gmol^{-1}$

Moles of $KClO_3 = \frac{5}{122.5} \Rightarrow 0.0408$ moles.

$KClO_3$	:	O_2
2	:	3
1	:	$3/2$
0.0408	:	$3/2 \times 0.0408 \Rightarrow 0.0612$ moles

Moles of $O_2 = 0.0612$ moles

Mass of O_2 produce $= 0.0612 \times 32$

$= 1.9584 g$

x.

1 mole of $CO_2 = 44g = 22.414 dm^3$

1 mole of $O_2 = 32g = 22.414 dm^3$

1 mole of $H_2 = 2.016g = 22.414 dm^3$

Volume occupied by 1 mole of a gas at **S.T.P** is **$22.414 dm^3$**. This volume is called **molar volume**.

Mass of 1 mole of a gas is called **molar mass.**

- Molar mass of a gas is equal to molar volume.

xii.

1 mole of any gas at S.T.P. occupied a volume of $22.414 dm^3$. This volume is called molar volume. It contains 6.02×10^{23} representative particles.

e.g.

1 mole of $CO_2 = 44g = 22.414 dm^3 = 6.02 \times 10^{23}$ particles.
1 mole of $O_2 = 32g = 22.414 dm^3 = 6.02 \times 10^{23}$ particles.
1 mole of $H_2 = 2.016g = 22.414 dm^3 = 6.02 \times 10^{23}$ particles.

QNo 03-b>

density of $CHBr_3 = 2.89 g cm^{-3}$
No: of molecules of $CHBr_3 = 4.89 \times 10^{24}$ molecules
vol: of $CHBr_3$ = ?

Solution:

Molar mass of $CHBr_3 = 12+1+80 \times 3 = 253 g mol^{-1}$

$$\text{No: of molecules} = \frac{\text{Mass in gram}}{\text{Molar mass}} \times 6.02 \times 10^{23}$$

$$\text{Mass in gram} = \frac{\text{No: of molecules} \times \text{Molar mass}}{6.02 \times 10^{23}}$$

$$= \frac{4.8 \times 10^{24} \times 253}{6.02 \times 10^{23}}$$

$$= 2017.27\, g$$

$d = m/V$

$V = m/d$

$V = 2017.27/2.89 \Rightarrow 698.02\, cm^3$

Q No 06 . b)

$$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$$

Volume of $Al = 2.50\,cm^3$

Density of $Al = 2.70\,g\,cm^{-3}$

weight of H_2 = ?

Solution:

mass of $Al = d \times v$

$= 2.70 \times 2.50$

$= 6.75g$

Mole of $Al = \dfrac{6.75}{27}$

$\Rightarrow 0.25$ moles.

$Al : H_2$

$2 : 3$

$1 : 3/2$

$0.25 : 3/2 \times 0.25 \Rightarrow 0.375$ moles

Moles of $H_2 = 0.375$ moles

Mass of $H_2 = 0.375 \times 2.016$

Mass in gram of $H_2 = 0.756g$