Chapter-1
Mole Concept

Matter

Anything that has mass and occupies space is called matter.
Eg: Phone, laptop, earphone, copy, pen, brick, gun, sunglass, etc.

State whether the following things are matter or not :-

(i) Paper → Yes
(ii) Love → No (its a feeling)
(iii) Anger → No (its a feeling)
(iv) Rain → No (its a phenomenon)
(v) Electricity → No (it is the movement of electrons)
(vi) Light (Photons) → No (its an energy)
(vii) Fire → No (the energy released from fire is not a matter but the gases released from fire are matter)
(viii) Electrons → Yes (electron has mass of 9.1×10^{-28} g or 9.1×10^{-31} kg).

Physical Classification of Matter

Solid	Liquid	Gas	Plasma	Bose Einstein Condensate
Fixed shape & fixed volume.	Fixed volume but not fixed shape.	Neither fixed shape nor fixed volume.	Exist at very high temperature	Exist at very low temperature.
Strong forces	Medium force	Very weak force	Eg: Stars	
Eg: Ice	Eg: Water	Eg: Water vapour		

Chemical Classification of Matter

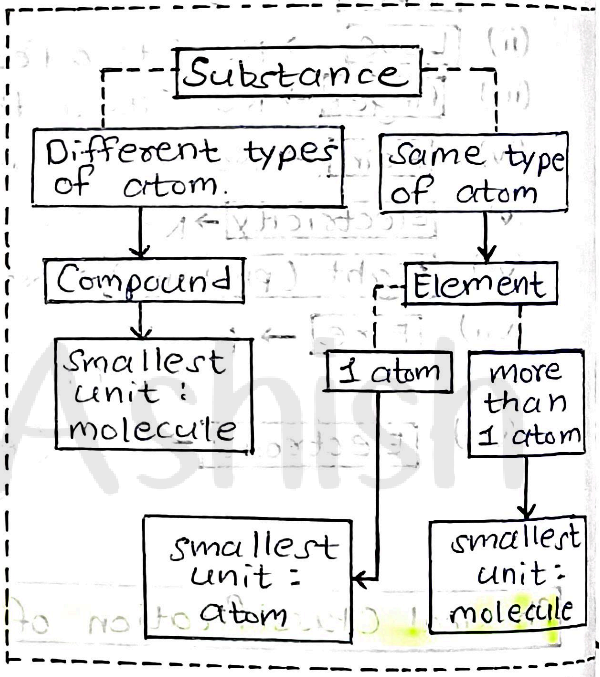
- Matter
  - Pure Substance
    - Elements
    - Compounds
  - Mixture
    - Homogeneous
    - Heterogeneous

Pure Substance: Pure substances are substances that are made up of only one kind of particle.
Eg: Fe, Al, Au, H_2, H_2O, CO_2, etc.

Elements: Elements constitute the simplest chemical substances in which all the atoms are exactly the same.
Eg: Each squre (□) of periodic table contains 1 element

Compounds: Compounds are chemical substances made up of two or more elements that are chemically bound together in a fixed ratio.

Eg: H_2O, CO_2, CH_4, $NaHCO_3$, Na_2CO_3, $CaSO_4 \cdot 2H_2O$, NH_3, $CaCl_2$, etc.



Classify the following in element/compound and smallest unit atom/molecule :-

Substance	Element/ Compound	Smallest unit Atom/Molecule
CH_4	Compound	Molecule
C_2H_5OH	Compound	Molecule
Au	Element	Atom
Fe	Element	Atom
O_2	Element	Molecule
P_4	Element	Molecule
NH_3	Compound	Molecule
O_3	Element	Molecule
Zn	Element	Atom
Pt	Element	Atom
NH_4OH	Compound	Molecule
$CaSO_4 \cdot \frac{1}{2} H_2O$	Compound	Molecule

Mixture: When two or more substance mix with each other without participating in a chemical change and without any fixed composition.
Eg: Sugar in water, salt in water, milk, blood, sand in water, etc.

Homogeneous Mixture: The mixture which possess the same properties and combination throughout their mass.

Eg: True solution, alloys, mixture of gases, etc.

Heterogeneous Mixture: The mixture which possess different properties and composition in various parts, i.e., the properties are not uniform.

Eg: $\underbrace{\text{Blood, milk}}_{\text{Colloids}}$, $\underbrace{\text{sand in water, chalk powder in water, etc.}}_{\text{Suspension}}$

Cations and Anions

Ions: Charged species (either charged atoms or charged group of atoms).

+vely charged ions ---- Ions ---- -vely charged ions

+vely charged ions → Cations → Formed due to loss of electrons

-vely charged ions → Anions → Formed due to gain of electrons

List of Cations :-

Name of ion	Symbol
1. Hydrogen ion	H^+
2. Lithium ion	Li^+
3. Sodium ion	Na^+
4. Potassium ion	K^+
5. Beryllium ion	Be^{2+}
6. Magnesium ion	Mg^{2+}
7. Calcium ion	Ca^{2+}
8. Barium ion	Ba^{2+}
9. Aluminium ion	Al^{3+}
10. Iron (II) (Ferrous)	Fe^{2+}
11. Iron (III) (Ferric)	Fe^{3+}
12. Mercury (I) (Mercurous)	Hg^+ / Hg_2^{2+}
13. Mercury (II) (Mercuric)	Hg^{2+}

Name of ion	Symbol
14. Zinc ion	Zn^{2+}
15. Lead (II) (Plumbus)	Pb^{2+}
16. Lead (IV) (Plumbic)	Pb^{4+}
17. Silver ion	Ag^+
18. Copper (I) (Cuprous)	Cu^+
19. Copper (II) (Cuperic)	Cu^{2+}
20. Ammonium ion	NH_4^+

Note: 'us' is used for lower charge and 'ic' is used for higher charge.

NH_4^+ is made up of 2 non-metals.

List of Anions :-

	Name of ion	Symbol
1.	Chloride	$\longrightarrow Cl^-$
2.	Bromide	$\longrightarrow Br^-$
3.	Oxide	$\longrightarrow O^{2-}$
4.	Iodide	$\longrightarrow I^-$
5.	Flouride	$\longrightarrow F^-$
6.	Hydride	$\longrightarrow H^-$
7.	Sulphide	$\longrightarrow S^{2-}$
8.	Sulphate	$\longrightarrow SO_4^{2-}$
9.	Sulphite	$\longrightarrow SO_3^{2-}$
10.	Nitride	$\longrightarrow N^{3-}$
11.	Nitrate	$\longrightarrow NO_3^-$
12.	Nitrite	$\longrightarrow NO_2^-$
13.	Phosphide	$\longrightarrow P^{3-}$
14.	Phosphate	$\longrightarrow PO_4^{3-}$
15.	Phosphite	$\longrightarrow PO_3^{3-}$
16.	Peroxide	$\longrightarrow O_2^{2-}$
17.	Hydroxide	$\longrightarrow OH^-$
18.	Carbonate	$\longrightarrow CO_3^{2-}$
19.	Hydrogen Carbonate	$\longrightarrow HCO_3^-$
20.	Hydrogen Sulphate	$\longrightarrow HSO_4^-$
21.	Hydrogen Sulphite	$\longrightarrow HSO_3^-$
22.	Acetate	$\longrightarrow CH_3COO^-$
23.	Formate	$\longrightarrow HCOO^-$
24.	Oxalate	$\longrightarrow C_2O_4^{2-}$
25.	Cyanide	$\longrightarrow CN^-$
26.	Permanganate	$\longrightarrow MnO_4^-$
27.	Chromate	$\longrightarrow CrO_4^{2-}$
28.	Dichromate	$\longrightarrow Cr_2O_7^{2-}$

How to write formula of salt ?

Step-1: Identify cations and anions.

Step-2: Exchange charges of both by criss cross.

Example: (i) Magnesium Chloride

$Mg^{2+} \times Cl^-$

Ans ⇒ $MgCl_2$

(ii) Calcium Oxalate

$Ca^{2+} \times C_2O_4^{2-}$

Ans ⇒ CaC_2O_4

(iii) Aluminium Sulphate

$Al^{3+} \times SO_4^{2-}$

Ans ⇒ $Al_2(SO_4)_3$

(iv) Magnesium Nitride

$Mg^{2+} \times N^{3-}$

Ans ⇒ Mg_3N_2

(v) Zinc Phosphate

$Zn^{2+} \times PO_4^{3-}$

Ans ⇒ $Zn_3(PO_4)_2$

(vi) Ammonium Nitrate

$NH_4^+ \times NO_3^-$

Ans ⇒ NH_4NO_3

Definition of Mole

The amount of any substance which contains equal number of particles (atoms, molecules, ions) as there are no. of carbon atoms in 12 grams of C-12.

12 gram C-sample = 6.022×10^{23} atoms of C

1 mole = 6.022×10^{23} particles of any substance.

Avogadro's Number (N_A) = 6.022×10^{23}

1 mole = N_A particles

1 mole pens = N_A pens = 6.022×10^{23} pens

1 mole chairs = N_A pens = 6.022×10^{23} chairs

= No. of legs = $4 N_A$ legs = $4 \times 6.022 \times 10^{23}$ legs.

1 mole Na = N_A atoms of Na = 6.022×10^{23} Na atoms

1 mole CO_2 = N_A molecules of CO_2 = 6.022×10^{23} molecules of CO_2.

2 moles of chloride ions = $2 N_A$ Cl^- ions = $2 \times 6.022 \times 10^{23}$ Cl^- ions.

Practise Questions

Q.1 Write the formula of

(a) Calcium Carbonate

$Ca^{2+} \times CO_3^{2-}$

⇒ $CaCO_3$

(b) Calcium hydroxide

$Ca^{2+} \times OH^-$

⇒ $Ca(OH)_2$

(c) Ammonium Sulphate

$NH_4^+ \times SO_4^{2-}$

⇒ $(NH_4)_2SO_4$

(d) Sodium bicarbonate

$Na^+ \times HCO_3^-$

$\Rightarrow NaHCO_3$

(e) Ferrous sulphate

$Fe^{2+} \times SO_4^{2-}$

$\Rightarrow FeSO_4$

(f) Lead (II) sulphate

$Pb^{2+} \times SO_4^{2-}$

$\Rightarrow PbSO_4$

Q.2 Write the number of particles present in

(a) 2 moles of Fe

$\Rightarrow$ 2 N_A atoms of Fe = $2 \times 6.022 \times 10^{23}$ atoms of Fe

= $\boxed{1.2044 \times 10^{24}}$ atoms of Fe

(b) 5 moles of $CaCO_3$

$\Rightarrow$ 5 N_A molecules of $CaCO_3$ = $5 \times 6.022 \times 10^{23}$ molecules of $CaCO_3$

= $\boxed{3.011 \times 10^{24}}$ molecules of $CaCO_3$

(c) 1 mole of SO_4^{2-}

$\Rightarrow$ 1 N_A ions of SO_4^{2-} = $\boxed{6.022 \times 10^{23}}$ SO_4^{2-} ions

(d) 10 moles of Mg^{2+}

$\Rightarrow$ 10 N_A Mg^{2+} ions = $10 \times 6.022 \times 10^{23}$ Mg^{2+} ions

= $\boxed{6.022 \times 10^{24}}$ Mg^{2+} ions

(e) 2.5 moles of $CuSO_4 \cdot 5H_2O$

$\Rightarrow$ 2.5 N_A molecules of $CuSO_4 \cdot 5H_2O$

= $2.5 \times \cancel{10^{23}}\ 6.022 \times 10^{23}$ molecules of $CuSO_4 \cdot 5H_2O$

= $\boxed{1.5 \times 10^{24}}$ molecules of $CuSO_4 \cdot 5H_2O$

Atomic Mass Unit (amu) / Unified Mass (u)

→ It is defined as 1/12th mass of one C-12 atom.

$$\boxed{1 \text{ amu} = \frac{\text{Mass of one C-12 atom}}{12}}$$

→ Mass of all the atoms are measured in terms of amu.

Eg: He-atom = $4 \times \frac{1}{12}$ (C-12 atom) = $\boxed{4 \text{ amu}}$

O-atom = $16 \times \frac{1}{12}$ (C-12 atom) = $\boxed{16 \text{ amu}}$

→ 1 amu in gram :-

Weight of one C-12 atom = 1.9924×10^{-23} g

$$\Rightarrow 1\,amu = \frac{\text{wt. of one C-12 atom}}{12}$$

$$= \frac{1.9924 \times 10^{-23}}{12} \approx \boxed{1.67 \times 10^{-24}\,g}$$

$\therefore$ $\boxed{1\,amu = 1.67 \times 10^{-24}\,gram}$

$\boxed{amu \rightarrow u}$

Also, $\boxed{1\,amu = 1/N_A}$

Why C-12 ?
• Most abundant.
• Most stable isotopes.

Different types of masses

Why measuring mass of an atom is very difficult?
→ Atom is very small in size.
→ Atom generally do not exist independently except noble gases.

1 Atomic Mass :-

→ It is the mass of one atom of any element.

→ It is measured in amu/u.

Element	Atomic Mass	Element	Atomic Mass	Element	Atomic Mass
H	1u	P	31u	Pb	207u
He	4u	S	32u	Ra	226u
Li	7u	Cl	35.5u	U	238u
Be	9u	Ar	40u	Hg	200u
B	10u	K	39u	Ga	70u
C	12u	Ca	40u	Ge	72u
N	14u	Cu	63.5u	Cr	52u
O	16u	Fe	56u	Mn	55u
F	19u	Zn	65u	Co	59u
Ne	21u	I	127u	Ni	58u
Na	23u	Au	197u	Ti	48u
Mg	24u	Ag	107u		
Al	27u	Ba	137u		
Si	28u				

2 Molecular Mass :-

→ It is the mass of one molecule of any compound.

→ It is the sum of masses of all atoms present in a molecule.

Eg: $\boxed{CaCO_3} = \boxed{40+12+16\times 3} = \boxed{100u}$

→ Its unit is 'amu' or 'u'.

Molecule	Molecular Mass
H_2O	→ 18u
$CaCO_3$	→ 100u
NH_3	→ 17u
N_2	→ 28u
O_2	→ 32u
Glucose ($C_6H_{12}O_6$)	→ 180u
Sugar ($C_{12}H_{22}O_{11}$)	→ 342u
$NaCl$	→ 58.5u
O_3	→ 48u
H_2O_2	→ u
H_2SO_4	→ 98u
HNO_3	→ 63u
H_2CO_3	→ 62u
$CaSO_4 \cdot 2H_2O$ (Gypsum)	→ 172u
$CaSO_4 \cdot 1/2\, H_2O$ (POP)	→ 145u
$CaSO_4 \cdot 5H_2O$	→ 249.5u

Molecule	Molecular Mass
Mg^{+2}	→ 24u
NO_3^-	→ 62u
HCl	→ 36.5u
Cl_2	→ 71u
$CaCl_2$	→ 111u
PO_4^{3-}	→ 95u
H_2S (Rotten egg like smell)	→ 34u
Ammonium ion (NH_4^+)	→ 18u
D_2O [$D = {}^2_1H$ (Duterium)]	→ 20u
NO_2	→ 46u
NO	→ 30u
HNO_2	→ 47u
SO_3	→ 80u

Charges on ions are ignored while calculating molar mass

3 Relative Atomic Mass :-

→ It is the mass of an atom, relative to mass of 1/12 th of a C-12 atom.

$$\boxed{RAM = \frac{\text{Atomic Mass}}{\frac{1}{12}\text{ mass of 1 C-12 atom (1u)}}}$$

→ RAM is unitless.

→ For RAM remove 'u'.

Element	Atomic Mass	RAM
C	12u	12
Ca	40u	40
Cl	35.5u	35.5
Mg	24u	24
Na	23u	23

4 Relative Molecular Mass :-

→ It is the mass of any species with relative to the $\frac{1}{12}$ th of a C-12 atom.

$$\boxed{RMM = \frac{\text{Molecular Mass}}{1u}}$$

→ It is unitless.

→ For RMM remove 'u'

Molecule	Molecular Mass	RMM
Calcium Hydroxide $[Ca(OH)_2]$	74u	74
Sodium Phosphate (Na_3PO_4)	164u	164
Magnesium Chloride $(MgCl_2)$	95u	95
Ammonium Chloride (NH_4Cl)	53.5u	53.5
Magnesium Nitride (Mg_3N_2)	100u	100
Glucose $(C_6H_{12}O_6)$	180u	180
Sulphuric Acid (H_2SO_4)	98u	98

5 Gram Atomic Mass :-

→ The mass of 1g-atom of any element in gram is called gram atomic mass (GAM).

→ It is the mass of 1 mole atoms (N_A atoms).

$\boxed{\text{g-atom, g-molecule, g-ion = Mole}}$

→ Its unit is gram.

→ For GAM replace 'u' with 'g'.

Element	Atomic Mass	RAM	GAM
K	39u	39	39g
Cl	35.5u	35.5	35.5g
Na	23u	23	23g
O	16u	16	16g
C	6u	6	6g

6 Gram Molecular Mass :-

→ The mass of 1g-molecule of any species in gram is called gram molecular mass (GMM).

→ It is the mass of 1 mole molecules (N_A molecules)

$\boxed{\text{g-atom, g-molecule, g-ion = Mole}}$

→ Its unit is gram.

→ For GMM replace 'u' with 'g'

Molecule	Molecular Mass	RMM	GMM
Glucose ($C_6H_{12}O_6$)	180u	180	180g
Sulphuric Acid (H_2SO_4)	98u	98	98g
Benzene (C_6H_6)	78u	78	78g
Sodium Nitrate ($NaNO_3$)	85u	85	85g
NO_2	46u	46	46g

Q.1 For Mg, find:

(i) Atomic Mass = $\boxed{24u}$

(ii) RAM = $\boxed{24}$

(iii) GAM = $\boxed{24g}$

(iv) Mass of 5 atoms = $5 \times 24 = \boxed{120u}$

(v) Mass of 10 atoms in gram ⇒ Mass of 10 atoms = 120u

Mass of 10 atoms (in gram):

$= 120 \times 1.67 \times 10^{-24}$

Ans ⇒ $\boxed{400.8 \times 10^{-24} g}$

(vi) Mass of 20 atoms in gram ⇒ Mass of 20 atoms = 480 u

Mass of 20 atoms (in gram):

$= 480 \times 1.67 \times 10^{-24}$

Ans ⇒ $\boxed{801.6 \times 10^{-24} g}$

Q.2 For $CaCO_3$, find:

(i) Molar mass = $40 + 12 + 3 \times 16 = \boxed{100u}$

(ii) RMM = $\boxed{100}$

(iii) GMM = $\boxed{100 g}$

(iv) Mass of 5 molecules = $5 \times 100 = \boxed{500u}$

(v) Mass of 10 molecules in gram ⇒ $10 \times 100 \times 1.67 \times 10^{-24}$

Ans ⇒ $\boxed{1670 \times 10^{-24} g}$

Q.3 Find the mass of 1g-molecules of Nitric Acid.

⇒ Nitric Acid = HNO_3

Molar Mass of HNO_3 = $1 + 14 + 16 \times 3 = 63u$

1g-molecules ⇒ $\boxed{63 g}$ Ans

Q.4 Find the mass of 20 molecules of $MgCl_2$ in gram. If your answer is $x \times 10^{-24} g$, report "x" to nearest integer.

⇒ Mass of 1 molecule of $MgCl_2$ = $24 + 71 = 95u$

Mass of 20 molecule of $MgCl_2$ = $20 \times 95 = 1900u$

Mass of 20 molecule of $MgCl_2$ in gram = $1900 \times 1.67 \times 10^{-24}$

$= 3173 \times 10^{-24}$

Ans ⇒ $\boxed{x = 3173}$

Calculation Related to Mole

→ **Mole** : Amount of substance.
- Weight
- No. of particles

→ **GAM** = Mass of 1 mole atom.
GMM = Mass of 1 mole molecule.

→ Mass of 1 mole = Molar Mass
- 1 mole atom
- 1 mole molecules
- 1 mole ion

→ **Formulas** :-

(i) No. of moles (n) when weight is given

$$n = \frac{\text{Given weight}}{\text{Molar Mass}}$$

(ii) No. of moles (n) when no. of particles is given

$$n = \frac{\text{total no. of particles}}{N_A\ (6.022 \times 10^{23})}$$

Question (Type-1)

Find no. of moles of :

1. 10g of $CaCO_3$
   $\Rightarrow \frac{10}{100} = \frac{1}{10} = \boxed{0.1\ mol}$

2. 20g of NaOH
   $\Rightarrow \frac{20}{40} = \frac{1}{2} = \boxed{0.5\ mol}$

3. 48g of Mg
   $\Rightarrow \frac{48}{24} = \boxed{2\ mol}$

4. 186g of NO_3^- ion
   $\Rightarrow \frac{186}{62} = \boxed{3\ mol}$

Question (Type-2)

Find no. of moles of :

1. 6.022×10^{23} atoms of Na
   $\Rightarrow \frac{6.022 \times 10^{23}}{6.022 \times 10^{23}} = \boxed{1\ mol}$

2. 6.022×10^{20} molecules of H_2SO_4
   $\Rightarrow \frac{6.022 \times 10^{20}}{6.022 \times 10^{23}} = \boxed{10^{-3}\ mol}$

3. 3.011×10^{21} molecules of glucose
   $\Rightarrow \frac{3.011 \times 10^{21}}{6.022 \times 10^{23}} = \frac{1}{2} \times 10^{-2} = \boxed{5 \times 10^{-3}\ mol}$

4. 6.022×10^{24} ions of SO_4^{2-}
   $\frac{6.022 \times 10^{24}}{6.022 \times 10^{23}} = \boxed{10\ mol}$

Q.1 Find the no. of particles present in 0.5 moles of O_2.

$\Rightarrow \quad n = \dfrac{\text{no. of particles}}{6.022 \times 10^{23}}$

$\Rightarrow \quad 0.5 = \dfrac{\text{no. of particles}}{6.022 \times 10^{23}}$

$\Rightarrow$ no. of particles $= 0.5 \times 6.022 \times 10^{23}$

Ans $\Rightarrow$ $\boxed{3.011 \times 10^{23}}$

Q.2 Find the mass of 10 moles of NH_3

$\Rightarrow$ Molar Mass of $NH_3 = 17g$

$n = \dfrac{\text{Given mass}}{\text{Molar mass}}$

$10 = \dfrac{\text{mass}}{17} = \boxed{170\,g}$ Ans

Q.3 Find no. of moles of -

1. 25g of $CaCO_3$

$\Rightarrow \quad \dfrac{25}{100} = \dfrac{1}{4} = \boxed{0.25 \text{ mol}}$

2. 45 g of $H_2C_2O_4$ (oxalic acid)

$\Rightarrow \quad \dfrac{45}{90} = \dfrac{1}{2} = \boxed{0.5 \text{ mol}}$

3. 36g of water

$\Rightarrow \quad \dfrac{36}{18} = \boxed{2 \text{ mol}}$

4. 23g of C_2H_5OH

$\Rightarrow \quad \dfrac{23}{46} = \dfrac{1}{2} = \boxed{0.5 \text{ mol}}$

5. 24.95g of $CuSO_4 \cdot 5H_2O$

$\Rightarrow \quad \dfrac{24.95}{249.5} = \boxed{0.1 \text{ mol}}$

Q.4 Find no. of moles of -

1. 3.011×10^{24} molecules of HNO_3

$\Rightarrow \quad \dfrac{3.011 \times 10^{24}}{6.022 \times 10^{23}} = \dfrac{1}{2} \times 10 = \boxed{5 \text{ mol}}$

2. 1.5055×10^{22} molecules of CH_4.

$\Rightarrow \dfrac{1.5055 \times 10^{22}}{6.022 \times 10^{23}} = 0.25 \times 10^{-1}$

$\Rightarrow \boxed{0.025 \text{ mol}}$

3. 12.044×10^{21} molecules of sugar.

$\Rightarrow \dfrac{12.044 \times 10^{21}}{6.022 \times 10^{23}} = 2 \times 10^{-2}$

$\Rightarrow \boxed{0.02 \text{ mol}}$

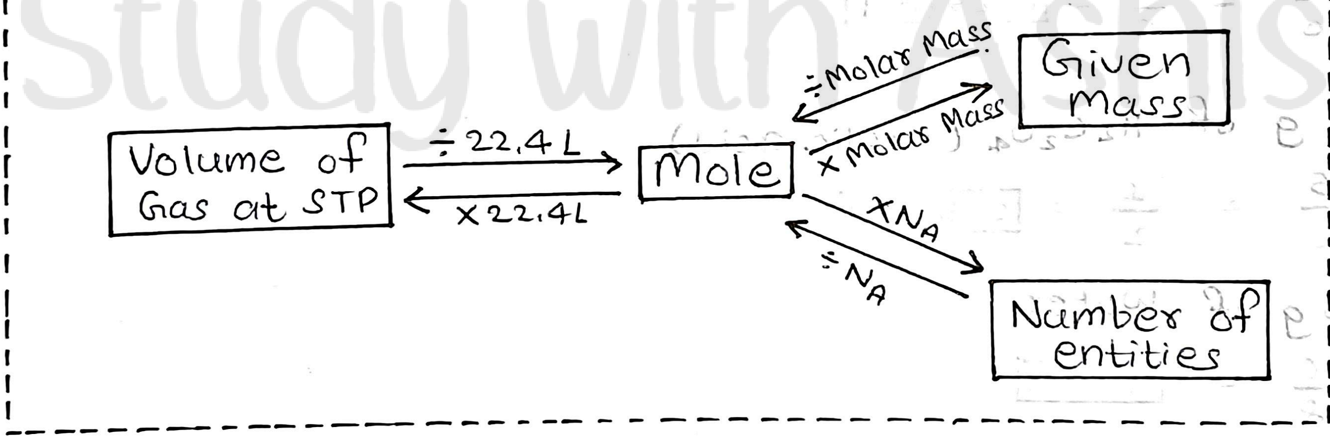
4. 30.11×10^{23} atoms of Na.

$\Rightarrow \dfrac{30.11 \times 10^{23}}{6.022 \times 10^{23}} \Rightarrow \boxed{5 \text{ mol}}$

5. $0.2\ N_A$ ions of Zn^{+2}

$\Rightarrow \dfrac{0.2 \times 6.022 \times 10^{23}}{6.022 \times 10^{23}} = \boxed{0.2 \text{ mol}}$

Mole Chart



Moles and Volume of Gas :-

→ Only applicable for gases.

$$\boxed{n = \frac{\text{Given volume}}{\text{Molar Volume}} = \frac{V}{V_m}}$$

→ **Molar Volume** : The volume occupied by one mole of any gas at given pressure and temperature is called molar volume.

→ There are 2 conditions :-

1. STP
2. NTP

→ Standard Temperature and Pressure (STP):-

Temperature	= 0°C =	273 K
Pressure	= 1 bar =	10^5 Pa
V_m = 22.7 L		

→ Normal Temperature and Pressure (NTP):-

Temperature	= 0°C = 273 K
Pressure	= 1 atm = 1.01325×10^5 Pa
V_m = 22.4 L	

$$\boxed{n_g = \frac{V}{V_m}}$$

At, T = 0°C, P = 1 atm

$$n_g = \frac{V(L)}{22.4(L)}$$

At, T = 0°C, P = 1 bar

$$n_g = \frac{V(L)}{22.7(L)}$$

Practice Questions

1. Find no. of moles of $O_2(g)$ if it occupies 11.2L at 0°C and 1 atm.

=> $n_g = \frac{11.2}{22.4} = \frac{1}{2} = \boxed{0.5 \text{ mol}}$ Ans

2. Find the weight of 2.5 moles of Glucose.

=> Molar mass of Glucose ($C_6H_{12}O_6$) = 180u

=> $n = \frac{\text{Given mass}}{\text{molar mass}}$

$2.5 = \frac{x}{180}$ => $x = 2.5 \times 180 = \boxed{450 g}$ Ans

3. 0.5 moles of a substance weighs 50g, the substance may be

(a) H_2SO_4

(b) HCl

(c) HNO_3

(d) $CaCO_3$ (Ans)

=> Molar Mass of the substance = $\frac{50}{0.5}$ = 100u

=> Molar mass of $CaCO_3$ = 100u

∴ The substace may be $CaCO_3$.

4 Find the no. of molecules present in 90g of glucose.

$\Rightarrow n = \frac{\text{Given mass}}{\text{molar mass}} = \frac{90}{180} = \boxed{0.5 \text{ mol}}$

$\Rightarrow$ no. of molecules $= 0.5 N_A$

$= 0.5 \times 6.022 \times 10^{23}$

Ans $\Rightarrow \boxed{3.011 \times 10^{23} \text{ molecules}} = N_A/2$

(a) N_A (b) $2N_A$ (c) $N_A/2$ ✓ (d) $N_A/3$

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5 Which of the following contains maximum no. of molecules?

(a) 11.2 L of O_2 at 0°C, 1 atm

(b) 24 g of Ozone

(c) 25 g of $CaCO_3$

(d) 22400 ml of CO_2 at 0°C, 1 atm.

$\Rightarrow$ No. of moles in-

(a) 11.2 L of O_2

$\Rightarrow \frac{11.2}{22.4} = \boxed{0.5 \text{ mol}}$

(b) 24 g of ozone

$\Rightarrow \frac{24}{48} = \boxed{0.5 \text{ mol}}$

(c) 25 g of $CaCO_3$

$\Rightarrow \frac{25}{100} = \boxed{0.25 \text{ mol}}$

(d) 22.4 L of CO_2

$\Rightarrow \frac{22.4}{22.4} = \boxed{1 \text{ mol}}$

$\Rightarrow$ No. of molecules in -

(a) 11.2 L of O_2

$\Rightarrow 0.5 \times 6.022 \times 10^{23}$

$= \boxed{3.011 \times 10^{23}}$

(b) 24 g of Ozone

$\Rightarrow 0.5 \times 6.022 \times 10^{23}$

$= \boxed{3.011 \times 10^{23}}$

(c) 25 g of $CaCO_3$

$\Rightarrow 0.25 \times 6.022 \times 10^{23}$

$= \boxed{1.5055 \times 10^{23}}$

(d) 22.4 L of CO_2

$\Rightarrow \boxed{6.022 \times 10^{23}}$

Ans $\Rightarrow$ 22.4 L (22400 ml) of CO_2 has maximum no. of molecules.

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6 Select the option which has maximum mass.

(a) 44.8 L of O_2 at 0°C, 1 atm

$\Rightarrow n = \frac{44.8}{22.4} = 2 \text{ mol}$

mass $= 2 \times 32 = \boxed{64 g}$

(b) 60×10^{23} molecules of $H_2(g)$ [Take $N_A = 6 \times 10^{23}$]

$\Rightarrow n = \dfrac{60 \times 10^{23}}{6 \times 10^{23}} = 10$ mol

Mass $= 10 \times 2 = \boxed{20g}$

(c) 5 moles of CO_2

$\Rightarrow$ Mass $= 5 \times 44 = \boxed{220g}$

(d) 11.35L of CH_4 at (0°C, 1 bar)

$\Rightarrow n = \dfrac{11.35}{22.7} = 0.5$ mol

Mass $= 0.5 \times 16 = \boxed{8g}$

Ans $\Rightarrow$ 5 moles of CO_2 has maximum mass (220g)

Calculation of electron, proton and neutron

Representation of an atom

$$^{A}_{Z}X$$

Z = no. of 'p' + no. of 'e⁻' in neutral atom

A = no. of 'p' + no. of 'n'

X = Any element
A = Mass no.
Z = Atomic no.

Therefore,

no. of protons (p) = Z
no. of neutrons (n) = $A - Z$
no. of electrons (e^-) = Z − Charge (with sign.)

Q.1 Find no. of e^-, p and n -

(i) $^{23}_{11}Na$

$\Rightarrow A = 23$
$Z = 11$

$\Rightarrow p = Z = \boxed{11}$
$n = A - Z = 23 - 11 = \boxed{12}$
$e^- = Z - \text{charge} = 11 - 0 = \boxed{11}$

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

$\Rightarrow A = 24$
$Z = 12$

$\Rightarrow p = \boxed{12}$
$n = \boxed{12}$
$e^- = 12 - (2) = \boxed{10}$

(iii) $^{14}_{7}N^{3-}$

$\Rightarrow A = 14$
$Z = 7$

$\Rightarrow p = \boxed{7}$
$n = \boxed{7}$
$e^- = 7 - (-3) = \boxed{10}$

(iv) O_2

$\Rightarrow O_2 = 2\left({}^{16}_{8}O\right)$

$\Rightarrow p = 2\times 8 = \boxed{16}$

$n = 2(16-8) = \boxed{16}$

$e^- = 2(8) - 0 = \boxed{16}$

(v) H_2

$\Rightarrow 2\left({}^{1}_{1}H\right)$

$\Rightarrow p = 2\times 1 = \boxed{2}$

$n = 2(1-1) = \boxed{0}$

$e^- = (2\times 1) - 0 = \boxed{2}$

(vi) O_3

$\Rightarrow 3\left({}^{16}_{8}O\right)$

$\Rightarrow p = 3\times 8 = \boxed{24}$

$n = 3(16-8) = \boxed{24}$

$e^- = 3(8-0) = \boxed{24}$

(vii) CO_2

$\Rightarrow {}^{12}_{6}C,\ 2\left({}^{16}_{8}O\right)$

$\Rightarrow p = (6) + (2\times 8) = \boxed{22}$

$n = (12-6) + 2(16-8) = \boxed{22}$

$e^- = (6-0) + 2(8-0) = \boxed{22}$

(viii) NO

$\Rightarrow {}^{14}_{7}N,\ {}^{16}_{8}O$

$\Rightarrow p = 7 + 8 = \boxed{15}$

$n = (14-7) + (16-8) = \boxed{15}$

$e^- = (7-0) + (8-0) = \boxed{15}$

(ix) $C_6H_{12}O_6$

$\Rightarrow 6\left({}^{14}_{6}C\right),\ 12\left({}^{1}_{1}H\right),\ 6\left({}^{16}_{8}O\right)$

$\Rightarrow p = (6\times 6) + (12\times 1) + (6\times 8) = 36 + 12 + 48 = \boxed{96}$

$n = 6(14-6) + 12(1-1) + 6(16-8) = 48 + 0 + 48 = \boxed{96}$

$e^- = 6(6-0) + 12(1-0) + 6(8-0) = 36 + 12 + 48 = \boxed{96}$

(x) CO_3^{2-}

$\Rightarrow {}^{12}_{6}C,\ 3\left({}^{16}_{8}O\right)$

$\Rightarrow p = 6 + (3\times 8) = \boxed{30}$

$n = (12-6) + 3(16-8) = \boxed{30}$

$e^- = 30 - (-2) = \boxed{32}$

(xi) NO_3^-

$\Rightarrow {}^{14}_{7}N,\ 3\left({}^{16}_{8}O\right)$

$\Rightarrow p = 7 + (3\times 8) = \boxed{31}$

$n = (14-7) + 3(16-8) = \boxed{31}$

$e^- = 31 - (-1) = \boxed{32}$

(xii) SO_4^{2-}

$\Rightarrow {}^{32}_{16}S,\ 4\left({}^{16}_{8}O\right)$

$\Rightarrow p = 16 + (4\times 8) = \boxed{48}$

$n = (32-16) + 4(16-8) = \boxed{48}$

$e^- = 48 - (-2) = \boxed{50}$

Q.2 For 183 g of HCO_3^- ion

(i) Find no. of e^-, p and n in 1 particle.

=> ${}^{1}_{1}H$, ${}^{12}_{6}C$, $3({}^{16}_{8}O)$

=> $p = 1 + 6 + (3 \times 8)$
$= \boxed{31}$

$n = (1-1) + (12-6) + 3(16-8)$
$= \boxed{30}$

$e^- = 31 - (-1) = \boxed{32}$

(ii) Find no. of moles e^-, p and n.

=> In 1 molecule of HCO_3^-
no. of p = 31
no. of n = 30
no. of e^- = 32

=> 1 mole of HCO_3^- constains
p = 31 moles
n = 30 moles
e^- = 32 moles

=> No. of moles of HCO_3^- = $\frac{183}{61}$ = 3 moles

Ans => 3 moles of HCO_3^- contains.
p = 3 × 31 = 93 moles
n = 3 × 30 = 90 moles
e^- = 3 × 32 = 96 moles

(iii) Find no. of e^-, p, n.
=> p = 93 N_A
n = 90 N_A
e^- = 96 N_A

To find no. of moles / no. of e^-, p & n:-

- Find no. of e^-, p, n in one particle.
- Find no. of moles of the given substance.
- For, no. of moles of proton = n_{sub} × no. of 'p' in 1 particle
  no. of moles of neutron = n_{sub} × no. of 'n' in 1 particle
  no. of moles of electron = n_{sub} × no. of 'e^-' in 1 particle
- For, no. of proton = n_{sub} × no. of 'p' in 1 particle × N_A
  no. of neutron = n_{sub} × no. of 'n' in 1 particle × N_A
  no. of electron = n_{sub} × no. of 'e' in 1 particle × N_A

Q.3 Find no. of e^-, p and n in 2 mols of CN^- ion.

⇒ In 1 molecule of CN^-

$p = 6 + 7 = 13$ $\quad [{}^{12}_{6}C, {}^{14}_{7}N]$

$n = 6 + 7 = 13$

$e^- = 13 - (-1) = 14$

⇒ no. of moles of proton = $2 \times 13 = 26$ mol

no. of moles of neutron = $2 \times 13 = 26$ mol

no. of moles of electron = $2 \times 14 = 28$ mol

⇒ no. of protons = $26 N_A$

no. of neutrons = $26 N_A$

no. of electrons = $28 N_A$

Q.4 Find no. of moles of e^-, p, n in 120 g of carbonate ion.

⇒ $n_{CO_3^{2-}} = \frac{120}{60} = \boxed{2 \text{ mol}}$

⇒ No. of e^-, p, n in 1 particle :

$p = 6 + (3 \times 8) = 30$ $\quad [{}^{12}_{6}C, 3({}^{16}_{8}O)]$

$n = (12 - 6) + 3(16 - 8) = 30$

$e^- = 30 - (-2) = 32$

⇒ No. of moles of proton = $2 \times 30 = 60$ mol

No. of moles of electron = $2 \times 32 = 64$ mol

No. of moles of neutron = $2 \times 30 = 60$ mol

Q.5 Find no. of e^-, p and n present in 220 g of CO_2.
(Mass no. of C is 14 and O is 18).

⇒ Molar Mass = $14 + 2 \times 18 = 50$ g

⇒ $n_{CO_2} = \frac{220}{50} = 4.4$ mol

⇒ In 1 particle of CO_2 –

$p = 6 + (2 \times 8) = 22$ $\quad [{}^{14}_{6}C + 2({}^{18}_{8}O)]$

$n = (14 - 6) + 2(18 - 8) = 28$

$e^- = 22$

⇒ no. of 'p' = $4.4 \times 22 N_A$

no. of 'n' = $4.4 \times 28 N_A$

no. of 'e' = $4.4 \times 22 N_A$

Q.6 Find the volume of CO_2 at $T = 0°c$, $P = 1\,atm$, given its weight 66 g.

$\Rightarrow \quad n_{CO_2} = \frac{66}{44} = \frac{3}{2} = 1.5\ mol$

$\Rightarrow \quad V_{CO_2} = n_{CO_2} \times V_m$
$= 1.5 \times 22.4$

Ans $\Rightarrow$ $\boxed{33.6\,L}$

Atomicity and Moles

Atomicity : The total no. of atoms present in one molecule / ion of any substance.

Substance	Atomicity
CO_2	3
O_3	3
SO_4^-	5
Cl_2	2
P_4	4
S_8	8

Substance	Atomicity
$C_6H_{12}O_6$	24
$C_{12}H_{22}O_{11}$	45
CO_3^{2-}	4
PO_4^{3-}	5
Mg^{2+}	1

For Particular Atom :

$\boxed{\text{No. of moles of atom } (n_{atom})} = \boxed{n_{sub} \times (\text{atomicity})_{atom}}$

$\boxed{\text{No. of atoms}} = \boxed{n_{sub} \times N_A \times (\text{atomicity})_{atom}}$

Q.1 Find no. of 'O' atoms in -

(i) 10 mol CO_2

$\Rightarrow$ Atomicity of O = 2

No. of 'O' atoms $= n_{CO_2} \times N_A \times (\text{atomicity})_O$
$= 10 \times N_A \times 2 = \boxed{20\,N_A}$ Ans

(ii) 22.7 L of SO_3 ($T = 0°c$, 1 bar)

$\Rightarrow \quad n_{SO_3} = \frac{22.7}{22.7} = 1\ mol$, Atomicity of O = 3

No. of 'O' atoms $= 1 \times N_A \times 3 = \boxed{3\,N_A}$ Ans

(iii) 2 N_A ions of SO_4^{2-}

$\Rightarrow$ $n_{SO_4^{2-}} = 2$ mol , Atomicity of 'O' = 4

No. of 'O' atoms = $2 \times 4 \times N_A = \boxed{8 N_A}$ Ans

(iv) 56 g of CaO

$\Rightarrow$ $n_{CaO} = \frac{56}{56} = 1$ mol , Atomicity of 'O' = 1

No. of 'O' atoms = $1 \times 1 \times N_A = \boxed{N_A}$ Ans

Q.2 For 18g of Glucose.

(i) Find no. of moles of C, O, H atoms.

$\Rightarrow$ $n_{Glucose} = \frac{18}{180} = 0.1$ mol

$\Rightarrow$ Atomicity of C = 6
O = 6 [Glucose = $C_6H_{12}O_6$]
H = 12

$\Rightarrow$ No. of moles of C-atom = $0.1 \times 6 = 0.6$ mol
No. of moles of O-atom = $0.1 \times 6 = 0.6$ mol
No. of moles of H-atom = $0.1 \times 12 = 1.2$ mol

(ii) Find no. of C, O, H atoms.

$\Rightarrow$ No. of C-atom = $0.6 N_A$
No. of O-atom = $0.6 N_A$
No. of H-atom = $1.2 N_A$

Q.3 Which of the following constains maximum no. of 'O' atom?

(a) 16 g of O

$\Rightarrow$ $n_O = \frac{16}{16} = 1$ mol

No. of 'O' atom = $1 \times N_A \times 1 = \boxed{1 N_A}$

(b) 16 g of O_2

$\Rightarrow$ $n_{O_2} = \frac{16}{32} = 0.5$ mol

No. of 'O' atom = $0.5 \times 2 \times N_A = \boxed{1 N_A}$

(c) 48g of O_3

=> $n_{O_3} = \frac{48}{48} = 1$ mole

No. of 'O' atom $= 1 \times 3 \times N_A = 3N_A$

(d) 5 moles of $CaCO_3$

=> No. of 'O' atom $= 5 \times 3 \times N_A = 15N_A$

Ans => 5 moles of $CaCO_3$ has maximum no. of 'O' atoms.

Q.4 Find mass of C, H and O atoms present in 2 moles of glucose.

=> Glucose = $C_6H_{12}O_6$

=> $n_{glucose} = 2$ moles

=> $n_C = 2 \times 6 = 12$ moles

$n_H = 2 \times 12 = 24$ moles

$n_O = 2 \times 6 = 12$ moles

Ans => Mass of C-atom $= 12 \times 12 = 144g$

Mass of H-atom $= 24 \times 1 = 24g$

Mass of O-atom $= 12 \times 16 = 192g$

Q.5 Find the no. of moles of magnesium phosphate that contains 8 moles of oxygen atoms.

(a) 2 moles (b) 3/2 moles (c) 2/3 moles (d) None of these

=> $\boxed{Mg^{2+} \times PO_4^{3-} = Mg_3(PO_4)_2}$

=> $n_{O\text{-atom}} = n_{Mg_3(PO_4)_2} \times (\text{Atomicity})_O$

$8 = n_{Mg_3(PO_4)_2} \times 8$

$\therefore \boxed{n_{Mg_3(PO_4)_2} = 1 \text{ mole}}$

Ans => (d) option

Q.6 Which of the following contains maximum mass of O in it and also arrange in increasing order.

(a) 5 moles of Ozone

=> $n_{O\text{-atom}} = 5 \times 3 = \boxed{15 \text{ mol}}$

(b) 220g of CO_2

=> $n_{CO_2} = \frac{220}{44} = 5$ mol

$n_{O\text{-atom}} = 5 \times 2 = \boxed{10 \text{ mol}}$

(c) 227 L of SO_3 (P = 1 bar, T = 0°C)

=> $n_{SO_3} = \frac{227}{22.7} = 10$ mol

$n_{O\text{-atom}} = 10 \times 3 = \boxed{30 \text{ mol}}$

(d) $2N_A$ molecules of $Mg(PO_4)_2$

=> $n_{O\text{-atom}} = 2 \times 8 = \boxed{16 \text{ mol}}$

Ans => As 227L of SO_3 have maximum no. of moles of 'O' atom. Therefore, it has maximum mass of 'O' in it.

=> $\boxed{B < A < D < C}$

Q.7 Find the no. of moles of $C_6H_{12}O_6$ contains:

(i) $6N_A$ atoms of H

=> $6N_A$ H-atoms = 6 moles of H-atoms.

=> $n_{H\text{-}atom} = n_{glucose} \times H_{atomicity}$

$6 = n_{glucose} \times 12$

$n_{glucose} = \frac{1}{2} = \boxed{0.5 \text{ moles}}$ Ans

(ii) equal number of H atom present in 49 grams of H_2SO_4.

=> $n_{H_2SO_4} = \frac{49}{98} = \frac{1}{2}$ moles

=> $n_{H\text{-}atom} = n_{H_2SO_4} \times (\text{atomicity})_{H \text{ in } H_2SO_4}$

$= \frac{1}{\cancel{2}} \times \cancel{2}$

$\therefore n_{H\text{-}atom} = 1$ mole

=> $n_{H\text{-}atom} = n_{C_6H_{12}O_6} \times (\text{atomicity})_{H \text{ in glucose}}$

$1 = n_{C_6H_{12}O_6} \times 12$

$\therefore n_{C_6H_{12}O_6} = \boxed{\frac{1}{12} \text{ moles}}$ Ans

Q.8 Which of the following contain maximum no. of total oxygen atom?

(i) 16 gm of 'O' atom

=> n = 1 mole

no. of 'O' atom = $1 \times N_A \times 1$ => $\boxed{N_A \text{ atoms}}$

(ii) 10 gm of $CaCO_3$

=> $n = \frac{10}{100} = 0.1$ moles

no. of 'o' atom = $0.1 \times N_A \times 3$ => $\boxed{0.3 N_A \text{ atoms}}$

(iii) 32 gm of O_2

=> n = 1 mole

no. of 'O' atom = $1 \times N_A \times 2$ => $\boxed{2N_A \text{ atoms}}$

(iv) 48 gm of O_3

=> n = 1 mole

no. of 'O' atom = $1 \times N_A \times 3$ => $\boxed{3N_A \text{ atoms}}$

Ans => 48 gm of O_3 contains maximum no. of total oxygen atom.

Q.9 Which of the following contain maximum no. of total oxygen atom ?

(i) 11.35 ml of $SO_2(g)$ at STP

$\Rightarrow n_{SO_2} = \frac{11.35}{22.7 \times 10^3} = 5 \times 10^{-3}$ moles

no. of 'O' atom $= 5 \times 10^{-3} \times N_A \times 2 = 10 \times 10^{-3} N_A$

$\Rightarrow 10^{-2} N_A$ atoms

(ii) 6.022×10^{23} molecules of HNO_3

$\Rightarrow n_{HNO_3} = 1$ mole

no. of 'O' atom $= 1 \times N_A \times 3 \Rightarrow 3 N_A$ atoms

(iii) 48 mg of O_2

$\Rightarrow n_{O_2} = \frac{48}{48 \times 10^3} = 10^{-3}$ moles

no. of 'O' atom $= 10^{-3} \times N_A \times 2 \Rightarrow 2 \times 10^{-3} N_A$ atoms

(iv) $\frac{1}{100}$ mole of $CuSO_4 \cdot 5H_2O$

$\Rightarrow$ no. of 'O' atom $= \frac{1}{100} \times N_A \times 9 \Rightarrow \frac{9}{100} N_A$ atoms

Ans $\Rightarrow$ 6.022×10^{23} molecules of HNO_3 has maximum no. of total $\boxed{\text{oxygen atom.}}$

Q.10 Find no. of moles and total no. of atoms present in

(i) 18 gm of H_2O

$\Rightarrow n_{H_2O} = 1$ mole

no. of moles of atom $= 1 \times 3 \Rightarrow \boxed{3 \text{ moles}}$

no. of atoms (total) $= 1 \times 3 \times N_A \Rightarrow \boxed{3 N_A}$

(ii) 18 ml of water vapour

$\Rightarrow n_{H_2O(g)} = \frac{V}{V_m} = \frac{18}{22.4 \times 10^3} = 0.8 \times 10^{-3}$ moles

no. of moles of atom $= 3 \times 0.8 \times 10^{-3} \Rightarrow \boxed{2.4 \times 10^{-3} \text{ moles}}$

no. of total atoms $\Rightarrow \boxed{2.4 \times 10^{-3} N_A}$

(iii) 18 ml of water (d = 1g/ml)

$\Rightarrow d = m/v \Rightarrow 1 = m/18 \Rightarrow \boxed{m = 18g \text{ (water)}}$

$\Rightarrow n = 18/18 = \boxed{1 \text{ mole}}$

$\Rightarrow$ no. of moles of atom $= 1 \times 3 \Rightarrow \boxed{3 \text{ moles}}$

no. of total atoms $= \boxed{3 N_A}$

Note: Liquid ke case me volume known hone par (given mass / molar mass) wale formula use nahi karna. Pahle density ki help se mass pata karna hai fir molar mass se divide karna hai.

Average Atomic Mass (AAM)

→ Calculated for those elements which are present in their isotopic form in nature.

→ **Isotopes:** Atoms with same atomic no. (Z) but different mass no. (A).

Eg: $H \rightarrow {}^{1}_{1}H,\ {}^{2}_{1}H,\ {}^{3}_{1}H$

$Cl \rightarrow {}^{37}_{17}Cl,\ {}^{35}_{17}Cl$

$$AAM = \frac{(Mass)_{Isotope1} \times Abd + (Mass)_{Isotope2} \times Abd + \ldots\ldots}{Total\ Abd\ (100)}$$

(Abd = Abundance)

Q.1 Cl is known to exist in 2 isotopic for ${}^{37}_{17}Cl$ and ${}^{35}_{17}Cl$ and their abundance is 75% and 25% respectively. Find avg. atomic mass of Cl.

=> $AAM = \frac{37 \times 75 + 35 \times 25}{100} = \boxed{36.5}$ Ans

Q.2 B has AAM of 10.8. Find the % abundance of ${}^{10}_{5}B$, if it is known to exist in ${}^{10}_{5}B$ and ${}^{11}_{5}B$.

=> Let the abundance of ${}^{10}_{5}B$ be x %.
Then the abundance of ${}^{11}_{5}B = (100 - x)$ %

=> $10.8 = \frac{10x + 11(100 - x)}{100} = \frac{10x + 1100 - 11x}{100}$

=> $1080 = 10x + 1100 - 11x$

=> $-20 = -x$

$\therefore x = 20$

Ans => Abundance of ${}^{10}_{5}B = 20\%$
Abundance of ${}^{11}_{5}B = 80\%$

Q.3 Ag^{107} and Ag^{109}, AAM = 108.5
Find the abundance of lighter isotope.

=> Let the abundance of Ag^{107} be x %
Then the abundance of Ag^{109} = $(100-x)$ %

$$\Rightarrow 108.5 = \frac{107x + 109(100-x)}{100}$$

$$10850 = 107x + 10900 - 109x$$

$$-50 = -2x$$

$$\therefore x = 25$$

Ans => $\boxed{\text{Abundance of lighter isotope } (Ag^{107}) = 25\%}$

Average Molecular Mass (AMM)

→ It is used for mixture of gases.

→ It is the mass of 1 mole of a gaseous mixture.

→ Also known as molar mass of mixture.

$$\boxed{AMM = \frac{\text{Total Mass}}{\text{Total Moles}}}$$

Eg: A container have 100 moles of air $(N_2 + O_2)$ in which n_{N_2} = 80 moles and n_{O_2} = 20 moles, then avg. molecular mass :-

n_{N_2} = 80 moles
$W_{N_2} = n_{N_2} \times 28$
$\Rightarrow (80 \times 28)$ g

n_{O_2} = 20 moles
$W_{O_2} = n_{O_2} \times 32$
$\Rightarrow (20 \times 32)$ g

$$AMM = \frac{\text{Total Mass}}{\text{Total moles}} = \frac{80 \times 28 + 20 \times 32}{100} = \frac{2880}{100} \Rightarrow \boxed{28.8}$$

Q.1 N_2 = 560 g
O_2 = 320 g
Find AAM

$$\Rightarrow n_{N_2} = \frac{560}{28} = 20$$

$$n_{O_2} = \frac{320}{32} = 10$$

$$\Rightarrow AMM = \frac{560 + 320}{30} = \frac{880}{30} \Rightarrow \boxed{29.33} \text{ Ans}$$

Q.2 Two gases A and B with their molar masses 20 and 30 respectively are mixed in the ratio a:b and their average molecular mass was found 24. If these gases are mixed in the ratio b:a then find average molecular mass.

=> Mass of A = 20
Mass of B = 30

$n_A = a$

$n_B = b$

=> $W_A = n_A \times 20$
$= 20a$

$W_B = 30 \times n_B$
$= 30b$

=> $AAM = \frac{\text{Total Mass}}{\text{Total Moles}}$

$24 = \frac{20a + 30b}{a+b}$

$24a + 24b = 20a + 30b$

$4a = 6b$

$2a = 3b$

$\therefore a = \frac{3}{2} b$

=> Condition-2

$AAM = \frac{20b + 30a}{a+b}$

Substituting $a = 3/2\, b$:

$AAM = \frac{20b + 30 \times \frac{3}{2} b}{\frac{3}{2} b + b}$

$= \frac{(20+45)\cancel{b}}{\frac{5}{2}\cancel{b}}$

$= \frac{65}{5} \times 2$

Ans => $\boxed{26}$

Average Molecular Mass (AMM)

Study with Ashish

Ideal Gas Equation

Parameters of Gas :-

1. Pressure (P)
2. Temperature (T)
3. Volume (V)
4. Amount of Gas (n) (no. of moles of gas)

Note : Temperature = Always in kelvin (K)

Equation => $\boxed{PV = nRT}$

Here,

R = Universal Gas Constant

$R = 0.314\ J\,mol^{-1}\,K^{-1}$

$R = 0.0821\ (L\text{-}atm)\,mol^{-1}K^{-1}$

$R = 2\ Cal\,mol^{-1}\,K^{-1}$

Q.1 Find no. of moles of O_2 if it has a pressure of 0.821 atm and occupies a volume of 20L at 27°C.

=> P = 0.821 atm
V = 20L
T = 27°C = 300 K

=> PV = nRT

$n = \frac{PV}{RT} = \frac{\cancel{0.821}^{10} \times 2\cancel{0}}{\cancel{0.0821} \times 30\cancel{0}}$

Ans => $\boxed{\frac{2}{3}\ \text{moles}}$

Q.2 Find the no. of particles present in N_2 gas.
Given : $P = 1$ atm, $V = 8.21$ L, $T = 27°C$.

$\Rightarrow n_{N_2} = \frac{PV}{RT} = \frac{1 \times \cancel{8.21}^{100}}{\cancel{0.0821} \times 3\cancel{00}} \Rightarrow \frac{1}{3}$ moles

$\Rightarrow$ no. of particles $= n_{N_2} \times N_A$

Ans $\Rightarrow$ $\boxed{\frac{1}{3} N_A}$

Q.3 Find the weight of CH_4 that is present in a sample of CH_4 with $P = 2$ atm, $T = 27°C$, $V = 20$ L.

$\Rightarrow R = 0.0821$ L-atm $mo^{-1} k^{-1} \approx \frac{1}{12}$ (for solving purpose)

$\Rightarrow PV = nRT$

$n = \frac{PV}{RT} = \frac{2 \times 20}{300 \times \frac{1}{12}} = \frac{8}{5} \Rightarrow 1.6$ moles

$\Rightarrow Wt_{CH_4} = n_{CH_4} \times$ molar mass

$= 1.6 \times 16$

Ans $\Rightarrow$ $\boxed{25.6\ g}$

Q.4 Comment whether dry air or moist air is heavier.

Dry Air (100 mol)

N_2	$= 80$ mol
O_2	$= 20$ mol

$\Rightarrow n_{N_2} = 80$ moles

$n_{O_2} = 20$ moles

$\Rightarrow wt_{N_2} = (80 \times 28)$ g

$wt_{O_2} = (20 \times 32)$ g

$\Rightarrow AMM = \frac{W_{N_2} + W_{O_2}}{100}$

$= \frac{80 \times 28 + 20 \times 32}{100}$

$\Rightarrow \boxed{28.8\ g}$

Moist Air (100 mol)

N_2	$= 75$ mol
O_2	$= 15$ mol
H_2O	$= 10$ mol

$\Rightarrow n_{N_2} = 75$ moles

$n_{O_2} = 15$ moles

$n_{H_2O} = 10$ moles

$\Rightarrow wt_{N_2} = (75 \times 28)$ g

$wt_{O_2} = (15 \times 32)$ g

$wt_{H_2O} = (10 \times 18)$ g

$\Rightarrow AMM = \frac{75 \times 28 + 15 \times 32 + 10 \times 18}{100}$

$\Rightarrow \boxed{27.6\ g}$

Ans $\Rightarrow$ Dry air is heavier.

Q.5 Find temperature in Kelvin scale.

$$\boxed{\frac{C}{5} = \frac{F-32}{9}} \qquad \boxed{K = °C + 273}$$

1. 273°C
$\Rightarrow$ $273 + 273 = \boxed{546K}$

2. −40°C
$\Rightarrow$ $-40 + 273 \Rightarrow \boxed{233 K}$

3. −40 F
$\Rightarrow$ $\frac{C}{5} = \frac{(-40-32)}{9} \Rightarrow C = \frac{-72 \times 5}{9} \Rightarrow -40°C$
$\Rightarrow -40°C \Rightarrow \boxed{233 K}$

4. 32° F
$\Rightarrow$ $\frac{C}{5} = \frac{(32-32)}{9} \Rightarrow C = 0$
$\Rightarrow 0 + 273 \Rightarrow \boxed{273 K}$

Density

→ It is the mass per unit volume.

→ Density is of two types -
1. Absolute density 2. Relative density

Absolute Density :-

→ It is the mass per unit volume.

→ Units : $\boxed{kg/L}$ or $\boxed{kg/m^3}$ or $\boxed{g/mL}$ or $\boxed{g/cm^3}$

→ SI Unit : $\boxed{kg/m^3}$

(a) For Solids and Liquids :-

$$d \text{ or } \rho = \frac{mass}{Volume}$$

If Pressure and Temperature is constant. Then $d \propto$ Molar Mass.

(b) For Gases :-

$$d = \frac{mass}{volume} = \frac{PM}{RT}$$

Proof

$PV = nRT$

n = no. of moles of gas = given mass(m) / molar mass (M)

$PV = \frac{m}{M} \times RT$

$PM = \frac{m}{V} \times RT$

$\frac{PM}{RT} = \frac{m}{V} \Rightarrow \boxed{d = \frac{PM}{RT}}$

P = Pressure

M = Molar Mass of Gas

R = Universal Gas Constant

T = Temperature (K)

Relative Density :-

→ It is unit less.

(a) For Solids and Liquids :-

$$\boxed{R.d. = \frac{d_{solid/liquid}}{d_{H_2O}\ (at\ 4°C)}}$$

→ Since, d_{H_2O} (at 4°C) = 1 g/cm³

Therefore, Rd of solid or liquid is its density without unit.

(b) For Gases :-

→ For gases relative density = vapour density

→ Vapour density is the ratio of density of any gas to the density of $H_2(g)$ at same temperature and pressure.

$$\boxed{V.d. = \frac{\text{Molar Mass}}{2}}$$

Proof

$$(V.d)_{gas} = \frac{d_{gas}}{d_{H_2}} = \frac{\frac{\cancel{P}M_{gas}}{\cancel{RT}}}{\frac{\cancel{P}M_{H_2}}{\cancel{RT}}}$$

⇒ Since, temperature and pressure is constant and molar mass of H_2 = 2

$$\Rightarrow \boxed{V.d = \frac{\text{Molar Mass}}{2}}$$

Q.1 Find vapour density of

(i) CO_2

⇒ $Vd = \frac{M}{2} = \frac{44}{2} \Rightarrow \boxed{22}$

(ii) SO_3

⇒ $Vd = \frac{80}{2} \Rightarrow \boxed{40}$

(iii) N_2

⇒ $Vd = \frac{28}{2} \Rightarrow \boxed{14}$

(iv) O_2

⇒ $Vd = \frac{32}{2} \Rightarrow \boxed{16}$

(v) He

⇒ $Vd = \frac{4}{2} \Rightarrow \boxed{2}$

Q.2 For a gas C_2H_y. The Vd is 15. Find y.

⇒ Vd = 15

$$15 = \frac{2 \times 12 + y \times 1}{2}$$

⇒ 30 = 24 + y

∴ $\boxed{y = 6}$ Ans

Q.3 Find Vd of

(i) NO_2
=> $Vd = \frac{14+32}{2}$
Ans => $\boxed{23}$

(ii) NO
=> $Vd = \frac{14+16}{2}$
Ans => $\boxed{15}$

(iii) SO_2
=> $Vd = \frac{32+32}{2}$
Ans => $\boxed{32}$

(iv) O_3
=> $Vd = \frac{48}{2}$
Ans => $\boxed{24}$

(v) H_2S
=> $Vd = \frac{2+32}{2}$
Ans => $\boxed{17}$

(vi) NH_3
=> $Vd = \frac{14+3}{2} = \frac{17}{2}$
Ans => $\boxed{8.5}$

(vii) Cl_2
=> $Vd = \frac{\cancel{2} \times 35.5}{\cancel{2}}$
Ans => $\boxed{35.5}$

(viii) Ar
=> $Vd = \frac{40}{2}$
Ans => $\boxed{20}$

Stoichiometry

→ Application of mole concept to chemical reaction.
→ It can be only applied to a balanced chemical reaction.

Eg: $\boxed{N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)}$

=> 1 molecule of N_2 reacts with 3 molecules of H_2 to form 2 molecules of NH_3.

=> 10 molecules of N_2 reacts with 30 molecules of H_2 to form 20 molecules of NH_3.

=> N_A molecules of N_2 reacts with $3N_A$ molecules of H_2 to form $2N_A$ molecules of NH_3.

=> 1 mole of N_2 reacts with 3 moles of H_2 to form 2 moles of NH_3.

=> 28 g of N_2 reacts with 6 g of H_2 to form 34 g of NH_3.

=> 1 l of N_2 reacts with 3 l of H_2 to form 2 l of NH_3. (Only for gas) (P and T are constant).

Q.1 $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

- 1 molecule of CH_4 reacts with 2 molecules of O_2 to form 1 molecule of CO_2 and 2 molecules of H_2O.
- 10 molecules of CH_4 reacts with 20 molecules of O_2 to form 10 molecules of CO_2 and 20 molecules of H_2O.
- N_A molecules of CH_4 reacts with $2N_A$ molecules of O_2 to form N_A molecules of CO_2 and $2N_A$ molecules of H_2O.
- 1 mole of CH_4 reacts with 2 moles of O_2 to form 1 mole of CO_2 and 2 moles of H_2O.
- 16 g of CH_4 reacts with 64 g of O_2 to form 44 g of CO_2 and 36 g of H_2O.
- 1 L of CH_4 reacts with 2 L of O_2 to form 1 L of CO_2 and 2 L of H_2O.

Q.2 $PCl_5 \rightarrow PCl_3 + Cl_2$

- 1 molecule of PCl_5 breaks to form 1 molecule of PCl_3 and 1 molecule of Cl_2.
- 10 molecules of PCl_5 breaks to form 10 molecules of PCl_3 and 10 molecules of Cl_2.
- N_A molecules of PCl_5 breaks to form N_A molecules of PCl_3 and N_A molecules of Cl_2.
- 1 mole of PCl_5 breaks to form 1 mole of PCl_3 and 1 mole of Cl_2.
- 208.5 g of PCl_5 breaks to form 137.5 g of PCl_3 and 71 g of Cl_2.
- 1 L of PCl_5 breaks to form 1 L of PCl_3 and 1 L of Cl_2.

Q.3 Find no. of moles of O_2 required to completely react with 2 moles of C to form CO_2.

$\Rightarrow$ Balanced Reaction = $\boxed{1C + 1O_2 \rightarrow 1CO_2}$

$$\Rightarrow \frac{n_C}{1} = \frac{n_{O_2}}{1} = \frac{n_{CO_2}}{1}$$

$$\Rightarrow n_C = 2$$

$$\therefore \boxed{n_{O_2} = 2} \text{ Ans}$$

$\boxed{aA + bB \longrightarrow cC + dD}$ → Balanced eqn

a, b, c, d are stoichiometric coefficents of A, B, C, D.

A, B → Reactants   C, D → Products

Reactants reduce because they react.
Product increase because it's forming.

Stoichiometry

$$\boxed{\frac{(n_A)_{reacted}}{a} = \frac{(n_B)_{reacted}}{b} = \frac{(n_c)_{formed}}{c} = \frac{(n_d)_{formed}}{d}}$$

Q.4 Write the stoichiometric relation of

(i) $\boxed{N_2 + H_2 \longrightarrow NH_3}$

$\Rightarrow N_2 + 3H_2 \longrightarrow 2NH_3$ (Balanced eqn)

$$\Rightarrow \frac{(n_{N_2})_{react}}{1} = \frac{(n_{H_2})_{react}}{3} = \frac{(n_{NH_3})_{formed}}{2}$$

(ii) $\boxed{C + O_2 \rightarrow 2CO}$

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

$$\Rightarrow \frac{(n_c)_{react}}{2} = \frac{(n_{O_2})_{react}}{1} = \frac{(n_{CO})_{formed}}{2}$$

(iii) $\boxed{Pb(NO_3)_2 + KI \longrightarrow PbI_2 + KNO_3}$

$\Rightarrow Pb(NO_3)_2 + 2KI \longrightarrow PbI_2 + 2KNO_3$

$$\Rightarrow \frac{[n_{Pb(NO_3)_2}]_{react}}{1} = \frac{[n_{KI}]_{react}}{2} = \frac{[n_{PbI_2}]_{formed}}{1} = \frac{(n_{KNO_3})_{formed}}{2}$$

(iv) $\boxed{CH_4 + O_2 \rightarrow CO_2 + H_2O}$

$\Rightarrow CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

$\Rightarrow \frac{(n_{CH_4})\text{reacted}}{1} = \frac{(n_{O_2})\text{reacted}}{2} = \frac{(n_{CO_2})\text{formed}}{1} = \frac{(n_{H_2O})\text{formed}}{2}$

(v) $\boxed{Pb(NO_3)_2 \xrightarrow{\Delta} PbO + NO_2 + O_2}$

$\Rightarrow 2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + 4NO_2 + O_2$

$\Rightarrow \frac{[n_{Pb(NO_3)_2}]\text{reacted}}{2} = \frac{(n_{PbO})\text{formed}}{2} = \frac{(n_{NO_2})\text{formed}}{4} = \frac{(n_{O_2})\text{formed}}{1}$

(vi) $\boxed{H_2O \xrightarrow[\text{acidic}]{\text{electricity}} H_2 + O_2}$

$\Rightarrow 2H_2O \xrightarrow[\text{acidic}]{\text{electricity}} 2H_2 + O_2$

$\Rightarrow \frac{(n_{H_2O})\text{reacted}}{2} = \frac{(n_{H_2})\text{formed}}{2} = \frac{(n_{O_2})\text{formed}}{1}$

(vii) $\boxed{Mg + O_2 \rightarrow MgO}$

$\Rightarrow Mg + \frac{1}{2}O_2 \rightarrow MgO$

$\Rightarrow \frac{(n_{Mg})\text{reacted}}{1} = \frac{(n_{O_2})\text{reacted}}{1/2} = \frac{(n_{MgO})\text{formed}}{1}$

Q. 5 Find the moles of CO_2 formed and O_2 required for complete combustion of 2 moles of CH_4.

$\Rightarrow \cancel{CO_2} + \cancel{O_2} \longrightarrow \cancel{CH_4}$

$\Rightarrow \boxed{CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O}$

$\Rightarrow \frac{(n_{CH_4})\text{req.}}{1} = \frac{(n_{O_2})\text{req.}}{2} = \frac{(n_{CO_2})\text{formed}}{1} = \frac{(n_{H_2O})\text{formed}}{2}$

$\Rightarrow n_{O_2} = 2 \times n_{CH_4} = 2 \times 2 = 4 \text{ moles}$

$n_{CO_2} = 1 \times n_{CH_4} = 1 \times 2 = 2 \text{ moles}$

Ans $\Rightarrow$ $\boxed{\begin{array}{l} n_{CO_2} = 2 \text{ moles} \\ n_{O_2} = 4 \text{ moles} \end{array}}$

Q.6 Find the no. of moles of NH_3 formed by complete reaction of 15×10^{23} molecules of N_2 with required H_2. [Take $N_A = 6 \times 10^{23}$]

$\Rightarrow$ $\boxed{N_2 + 3H_2 \longrightarrow 2NH_3}$

$\Rightarrow$ $n_{N_2} = \dfrac{\cancel{15}^{5} \times \cancel{10^{23}}}{\cancel{6}_{2} \times \cancel{10^{23}}} = \boxed{\dfrac{5}{2}}$ moles

$\Rightarrow$ $\dfrac{n_{N_2}}{1} = \dfrac{n_{H_2}}{3} = \dfrac{n_{NH_3}}{2}$

$\Rightarrow$ $\dfrac{5/2}{1} = \dfrac{n_{H_2}}{3} = \dfrac{n_{NH_3}}{2}$

$\Rightarrow$ $\dfrac{5}{2} = \dfrac{n_{H_2}}{3} = \dfrac{n_{NH_3}}{2}$

$\Rightarrow$ $\dfrac{n_{NH_3}}{2} = \dfrac{5}{2}$

$\Rightarrow$ $\boxed{n_{NH_3} = 5 \text{ moles}}$ $\longleftarrow$ Ans

$\Rightarrow$ $\dfrac{n_{H_2}}{3} = \dfrac{5}{2} = \boxed{\dfrac{15}{2} \text{ moles}}$

Q.7 Find the amount (in gram) of CO_2 formed by complete decomposition of $CaCO_3$ ($w = 200g$).

$\Rightarrow$ $\boxed{CaCO_3 \xrightarrow{\Delta} CaO + CO_2}$

$\Rightarrow$ $n_{CaCO_3} = \dfrac{200}{100} = \boxed{2 \text{ moles}}$

$\Rightarrow$ $\dfrac{n_{CaCO_3}}{1} = \dfrac{n_{CaO}}{1} = \dfrac{n_{CO_2}}{1}$

$\Rightarrow$ $\boxed{2 = n_{CO_2}}$ [$\because n_{CaCO_3} = 2$]

$\Rightarrow$ $n_{CO_2} = \dfrac{\text{given mass}}{\text{molar mass}}$ $\Rightarrow$ $2 = \dfrac{\text{mass}}{44}$

$\therefore$ amount of CO_2 = 44×2

Ans $\Rightarrow$ $\boxed{88g}$

Limiting Reagent

→ The reactant which is completely consumed during a chemical reaction is called limiting reagent.

→ The reactant which gets completely consumed first is called limiting reagent.

→ The amount of product formed and the amount of reactants (other than limiting reagent) reacted depends only upon limiting reagent.

Reactant
- Limiting Reagent
- Excess Reagent

Ex: There is a pen with 4 refill

Body	+ 4 Refill ⟶	Pen	
50	200	50	(Both are L.R.)
40	200	40	(Refill is L.R.)
50	120	40	(Body is L.R.)

Steps to Find Limiting Reagent :-

Step-1 Write balanced chemical reaction.

Step-2 Find no. of moles of all reactants.

Step-3 Divide no. of moles of each reactant by their stoichiometric coefficient to obtain a ratio (r).

Step-4 Reactant with minimum value of 'r' is limiting reagent.

Question Practise of Limiting Reagent

1. Find Limiting Reagent for $\boxed{A + 2B \rightarrow 3C}$ If $n_A = 5$ moles, $n_B = 6$ moles.

⇒ $n_A = 5$

$n_B = 6$

⇒ $r_A = \frac{5}{1} = 5$

$r_B = \frac{6}{3} = 2$

⇒ Since, B has lowest value of 'r'

⇒ Therefore, B is the limiting reagent.

2 ~~A + 2B → 3C~~. Find L.R. if 8g H_2 react with 8g O_2.

⇒ $\boxed{2H_2 + O_2 \rightarrow 2H_2O}$

⇒ $n_{H_2} = \frac{8}{2} = \boxed{4 \text{ moles}}$

$n_{O_2} = \frac{8}{32} = \boxed{\frac{1}{4} \text{ moles}}$

⇒ $r_{H_2} = \frac{4}{2} = \boxed{2}$

$r_{O_2} = \frac{\frac{1}{4}}{1} = \frac{1}{4} = \boxed{0.25}$

⇒ Since, O_2 has lowest value of r,

⇒ Therefore O_2 is the limiting reagent.

---

3 Find the L.R. if 48g of each carbon, hydrogen and oxygen reacts to form glucose.

⇒ $\boxed{6C + 3O_2 + 6H_2 \rightarrow C_6H_{12}O_6}$

⇒ $n_{H_2} = \frac{48}{2} = \boxed{24 \text{ moles}}$

$n_{O_2} = \frac{48}{32} = \boxed{\frac{3}{2} \text{ moles}}$

$n_C = \frac{48}{12} = \boxed{4 \text{ moles}}$

⇒ $r_{H_2} = \frac{24}{6} = \boxed{4}$

$r_{O_2} = \frac{\frac{3}{2}}{3} = \boxed{\frac{1}{2}}$

$r_C = \frac{4}{6} = \boxed{\frac{2}{3}}$

Ans ⇒ O_2 is the limiting reagent as it has lowest value of r.

---

4 $\boxed{A + 2B \rightarrow 3C + 2D}$ If initially 8 moles of A was reacted with 12 moles of B, then find

(i) Limiting reagent

⇒ $n_A = 8$, $n_B = 12$

⇒ $r_A = \frac{8}{1} = \boxed{8}$

$r_B = \frac{12}{2} = \boxed{6}$

Ans ⇒ B is the limiting reagent as it has lowest value of r

(ii) Find moles of C and D formed.

$\Rightarrow \frac{n_A}{1} = \frac{n_B}{2} = \frac{n_C}{3} = \frac{n_D}{2}$

$\Rightarrow \frac{n_B}{2} = \frac{n_C}{3} = \frac{n_D}{2}$

$\Rightarrow 6 = \frac{n_C}{3} \quad \therefore \boxed{n_C = 18 \text{ moles}}$

$\Rightarrow 6 = \frac{n_D}{2} \quad \therefore \boxed{n_D = 12 \text{ moles}}$

(iii) Moles of excess reagent left unreacted.

$\Rightarrow$

$\frac{(n_A)\text{reacted}}{1} = \frac{(n_B)\text{reacted}}{2}$

$\Rightarrow (n_A)\text{reacted} = 6 \text{ moles}$

$\Rightarrow (n_A)\text{ unreacted} = (n_A)\text{total} - (n_A)\text{reacted}$

$= 8 - 6$

Ans $\Rightarrow$ $\boxed{2 \text{ moles}}$

$\boxed{5}$ $\boxed{A + 3B + 2C \rightarrow 2D + 4E}$ If $n_A = 4$, $n_B = 6$, $n_C = 8$. Find

(i) Limiting reagent

$\Rightarrow r_A = 4/1 = 4$

$r_B = 6/3 = 2$

$r_C = 8/2 = 4$

Ans $\Rightarrow$ B is the limiting reagent as it has the lowest value of r.

(ii) n_D and n_E formed

$\Rightarrow \frac{n_B}{3} = \frac{n_D}{2} = \frac{n_E}{4}$

$\Rightarrow 2 = \frac{n_D}{2} \quad \therefore n_D = 4 \text{ moles}$

$\Rightarrow 2 = \frac{n_E}{4} \quad \therefore n_E = 8 \text{ moles}$

(iii) $\frac{(n_A)\text{ reacted}}{1} = \frac{(n_B)\text{reacted}}{3} \quad \therefore (n_A)\text{reacted} = \boxed{2 \text{ moles}}$

$(n_A)\text{ left} = 4 - 2 = \boxed{2 \text{ moles}}$

$\Rightarrow \frac{(n_C)\text{reacted}}{2} = \frac{(n_B)\text{ reacted}}{3} \Rightarrow n_C = 2 \times \frac{6}{3} = \boxed{4 \text{ moles}}$

$(n_C)\text{left} = 8 - 4 = \boxed{4 \text{ moles}}$

6 If 1 kg of H_2 reacts with 1 kg of N_2 to form NH_3. Find

(i) Limiting Reagent

=> $N_2 + 3H_2 \rightarrow 2NH_3$

=> $n_{N_2} = \frac{1000}{28} = \frac{250}{7}$ moles

$n_{H_2} = \frac{1000}{2} = 500$ moles

=> $r_{N_2} = \frac{\frac{250}{7}}{1} = \frac{250}{7}$

$r_{H_2} = \frac{500}{3}$

Ans => $\boxed{N_2 \text{ is the limiting reagent because it has minimum value of } r.}$

(ii) Amount of NH_3 formed (in grams)

=> $\frac{n_{N_2}}{1} = \frac{n_{NH_3}}{2}$

$\frac{250}{7} = \frac{n_{NH_3}}{2}$

$\therefore n_{NH_3} = \frac{500}{7}$ moles

=> $wt_{NH_3} = \frac{500}{\cancel{7}} \times \cancel{28}^{4}$

Ans => $\boxed{2000\ g}$

(iii) Amount of excess reagent left unreacted (in grams).

=> $\frac{(n_{H_2})\text{reacted}}{3} = (n_{N_2})\text{reacted}$

=> $(n_{H_2})\text{reacted} = 3 \times \frac{250}{7}$

=> $(W_{H_2})_r = (n_{H_2})_r \times 2$

$= \frac{750}{7} \times 2$

=> $\frac{1500}{7}$ g $[wt_{H_2}(\text{reacted})]$

=> $(wt_{H_2})\text{left} = 1000 - \frac{1500}{7}$

Ans => $\boxed{\frac{5500}{7}\ g}$

---

7 The mass of ammonia in grams produced when 2.8 kg of dinitrogen quantitively reacts with 1 kg of dihydrogen is ... ?

=> $\boxed{N_2 + 3H_2 \rightarrow 2NH_3}$

=> $n_{N_2} = \frac{2800}{28} = \boxed{100 \text{ moles}}$

$n_{H_2} = \frac{1000}{2} = \boxed{500 \text{ moles}}$

=> $r_{N_2} = 100/1 = \boxed{100}$

$r_{H_2} = \boxed{500/3}$

=> $\boxed{N_2 \text{ is limiting reagent as it has lowest value of } r.}$

$\Rightarrow \dfrac{n_{N_2}}{1} = \dfrac{n_{NH_3}}{2}$

$\Rightarrow 100 \times 2 = n_{NH_3}$

$\therefore \boxed{n_{NH_3} = 200 \text{ moles}}$

$\Rightarrow wt_{NH_3} = 200 \times 17$

Ans $\Rightarrow \boxed{3400g}$

Percentage Purity

→ It is calculated for those reactants in which impurities are present.

$$\% \text{ Purity} = \frac{\text{Wt of Pure Substance}}{\text{Total wt of Pure Substance}} \times 100$$

Note: In any chemical reaction only pure substance take part.

Q.1 An 80% pure sample of $CaCO_3$ was decomposed to obtain ..... g of CaO ? [$W_{CaCO_3} = 100g$]

$\Rightarrow CaCO_3 \text{ (Total)} = 100g$

$CaCO_3 \text{ (80\% pure)} = 80g$

$CaCO_3 \text{ (20\% impure)} = 20g$

$\Rightarrow n_{CaCO_3} = \dfrac{80}{100} = 0.8 \text{ moles}$

$\Rightarrow \boxed{CaCO_3 \xrightarrow{\Delta} CaO + CO_2}$

$\Rightarrow \dfrac{n_{CaCO_3}}{1} = \dfrac{n_{CaO}}{1}$

$\therefore \boxed{n_{CaO} = 0.8 \text{ moles}}$

$\Rightarrow wt_{CaO} = 0.8 \times 56$

Ans $\Rightarrow \boxed{44.8g}$

Q.2 200g of 20% pure $CaCO_3$ was decomposed. Find the volume of CO_2 formed at 0°c and 1atm.

⇒ $CaCO_3$ (total) = 200g
$CaCO_3$ (pure) = 40g (20% of 200g)
$CaCO_3$ (impure) = 160g

⇒ $n_{CaCO_3} = \frac{40}{100} = 0.4$ moles

⇒ $\boxed{CaCO_3 \xrightarrow{\Delta} CaO + CO_2}$

⇒ $\frac{n_{CaCO_3}}{1} = \frac{n_{CO_2}}{1}$

∴ $\boxed{n_{CO_2} = 0.4 \text{ moles}}$

⇒ $V_{CO_2} = n_{CO_2} \times V_m$
$= 0.4 \times 22.4L$

Ans ⇒ $\boxed{8.96L}$

Q.3 40g (50% pure) NaOH was made to react with 61.25g (80%) pure H_2SO_4. Find no. of moles of Na_2SO_4 formed.

⇒ NaOH (50% pure) = 20g
H_2SO_4 (80% pure) = $\frac{80}{100} \times 61.25 = 49g$

⇒ $\boxed{2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O}$

⇒ $n_{NaOH} = \frac{20}{40} = 0.5$ moles

$n_{H_2SO_4} = \frac{49}{98} = 0.5$ moles

⇒ $\frac{n_{NaOH}}{2} = \frac{n_{Na_2SO_4}}{1}$

∴ $n_{Na_2SO_4} = \frac{0.5}{2} = \frac{1}{4}$ moles

⇒ $wt_{Na_2SO_4} = \frac{1}{4} \times 142 = \boxed{35.5g}$ Ans

Percentage Yield

→ No reaction in reality is 100% efficient.

→ The % yield tells us about the efficiency of any reaction.

$$\% \text{ Yield} = \frac{\text{Experimental Amount}}{\text{Theoretical Amount}}$$

Q.1 $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$. If 100g of $CaCO_3$ gives 49.4g of CaO. Find % yield.

=> $\boxed{CaCO_3 \xrightarrow{\Delta} CaO + CO_2}$

$n_{CaCO_3} = \frac{100}{100} = 1$ mole

=> $\frac{n_{CaCO_3}}{1} = \frac{n_{CaO}}{1}$

$\therefore \boxed{n_{CaO} = 1 \text{ mole}}$

=> $Wt_{CaO} = 1 \times 56 = 56g$

$\therefore$ Experimental Amount = 49.4g CaO

Theoretical Amount = 56g CaO

=> $\% \text{ Yield} = \frac{49.4}{56} \times 100$

Ans => $\boxed{88.21\%}$

Q.2 $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$. If 100g of $CaCO_3$ gives 28g of CaO. Find % yield.

=> $\boxed{CaCO_3 \xrightarrow{\Delta} CaO + CO_2}$

$n_{CaCO_3} = \frac{100}{100} = 1$ mole

=> $\frac{n_{CaCO_3}}{1} = \frac{n_{CaO}}{1}$

$\therefore \boxed{n_{CaO} = 1 \text{ mole}}$

=> $Wt_{CaO} = 1 \times 56 = 56g$

$\therefore$ Experimental Amount = 28g CaO

Theoretical Amount = 56g CaO

=> $\% \text{ Yield} = \frac{28}{56} \times 100$

Ans => $\boxed{50\%}$

Note: If question is about minimum molecular mass. Then consider 1 atom of the given element.

Q.1 A compound contains 4 % sulphur in it. Find the minimum molecular mass of the compound.

=> 4 % sulphur = 1 atom

$4\% = 32$

$1\% = \frac{32}{4}$

$100\% = \frac{32}{4} \times 100$

Ans => $\boxed{800u}$

Q.2 A compound contains 3.55 % wt of Cl atom. Find the minimum molecular mass of that compound.

=> 3.55 % Cl = 1 atom

$3.55\% = 35.5$

$1\% = \frac{35.5}{3.55}$

$100\% = \frac{35.5}{3.55} \times 100$

Ans => $\boxed{1000\,u}$

Sequential Reaction

→ When in series of reaction, the product of one reaction act as reactant for other, we call such reaction as sequential reaction.

Eg: Formation of Sulphuric Acid (Contacts Process)

① $S + O_2 \longrightarrow SO_2$

② $SO_2 \; \frac{1}{2}O_2 \xrightarrow{V_2O_5} SO_3$

③ $SO_3 + H_2O \longrightarrow H_2SO_4$

All reactions must be balanced.

Put moles of reaction 1 into reaction 2

Q.1 Consider the following sequential reaction and find no. of moles of H_2SO_4 formed when 320g of S reacts with excess of O_2 and H_2O

$$\boxed{\begin{array}{l} S + O_2 \rightarrow SO_2 \\ SO_2 + \frac{1}{2}O_2 \rightarrow SO_3 \\ SO_3 + H_2O \rightarrow H_2SO_4 \end{array}}$$

$\Rightarrow$ $n_S = \frac{320}{32} = \boxed{10 \text{ moles}}$

$\Rightarrow$ Now, $\frac{n_S}{1} = \frac{n_{SO_2}}{1}$

$\therefore$ $n_{SO_2} = \boxed{10 \text{ moles}}$

$\Rightarrow$ $\frac{n_{SO_2}}{1} = \frac{n_{SO_3}}{1}$

$\therefore$ $n_{SO_3} = \boxed{10 \text{ moles}}$

$\Rightarrow$ $\frac{n_{SO_3}}{1} = \frac{n_{H_2SO_4}}{1}$

$\therefore$ Ans $\Rightarrow$ $\boxed{n_{H_2SO_4} = 10 \text{ moles}}$

Parallel Reaction

→ When one or more reactants reacts simultaneously in two different reactions (products are different), such reactions are called parallel reactions.

$$\boxed{\begin{array}{l} A + B \longrightarrow C + D \\ A + B \longrightarrow E \end{array}}$$

Ques. If 6 moles of $KClO_3$ decomposes under 2 different reactions as:

$$\boxed{\begin{array}{l} KClO_3 \longrightarrow KCl + \frac{3}{2}O_2 \\ 4\,KClO_3 \longrightarrow KCl + 3\,KClO_4 \end{array}}$$

Find the moles of $KClO_4$ formed if $n_{O_2} = 3$.

Ans $\Rightarrow$ $\boxed{n_{KClO_4} = 3 \text{ moles}}$

$\Rightarrow$ $\frac{n_{KClO_3}}{1} = \frac{n_{O_2}}{3/2}$

$\Rightarrow$ $n_{KClO_3} = \frac{3}{3} \times 2$

$\therefore$ $n_{KClO_3} = \boxed{2 \text{ moles}}$

$\Rightarrow$ Now, $n_{4KClO_3} = 6 - 4 = \boxed{4 \text{ moles}}$

$\Rightarrow$ $\frac{n_{4KClO_3}}{4} = \frac{n_{KClO_4}}{3} = \frac{4}{4} = \frac{n_{KClO_4}}{3}$

Percentage Composition

Percent of an element in a compound is called percentage composition of that element in the given compound.

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

Ques Find the percentage of underlined element in following compounds:

(i) $\underline{C}H_4$

$\Rightarrow \frac{12}{16} \times 100$

$= \boxed{75\%}$

(ii) $CaC\underline{O}_3$

$\Rightarrow \frac{48}{100} \times 100$

$= \boxed{48\%}$

(iii) $\underline{S}O_2$

$\Rightarrow \frac{32}{64} \times 100$

$= \boxed{50\%}$

Ques Insulin contains 3.4% sulphur ; the minimum molecular weight of insulin is

$\Rightarrow$ 3.4% = 1 S atom = 32

$1\% = \frac{32}{3.4}$

$100\% = \frac{32}{3.4} \times 100$

Ans $\Rightarrow$ 941.176

Empirical Formula and Molecular Formula

Molecular Formula (M.F.) : It is the representation of molecule which represent all the atom present in 1 molecule.

Eg: Glucose = $C_6H_{12}O_6$ (M.F.)

Empirical Formula (E.F.): It represents the simple ratio of different atoms present in any molecule.

Eg: Glucose = $C_1H_2O_1$ (E.F.)

Note: 2 or more compound can have same E.F.

$$\boxed{MF = (EF) \times m}$$

$$\boxed{m = \frac{\text{M.F mass}}{\text{E.F mass}}}$$

Eg: $MF (C_4H_8) = 48 + 8 = 56$

$EF (C_4H_2) = 12 + 2 = 14$

$$m = \frac{MF\ mass}{EF\ mass} = \frac{56}{14}$$

$\therefore \boxed{m = 4}$

Steps to calculate E.F and M.F :-

Step-1: Divide percentage of element by its atomic mass.

Step-2: Divide each value by smallest number among them.

Step-3: Convert into simple ratio form. This will give EF.

Step-4: Divide EF mass by given MF mass to get 'm'.

Step-5: Multiply 'm' into EF to get MF.

Example A compound has 62% carbon. 10.4% hydrogen and 27.5% oxygen. If molar mass of compound is 58, find no. of H-atom's per molecule of the compound.

Solution Let us assume that total weight is 100g.

Then, $wt_C = 62g$

$wt_H = 10.4g$

$wt_O = 27.5g$

Element	Weight	No. of mole	Simple ratio
C	62g	62/12 = 5.1	5.1/1.7 = 3
H	10.4g	10.4/1 = 10.4	10.4/1.7 = 6
O	27.5g	27.5/16 = 1.7	1.7/1.7 = 1

Now, $\boxed{EF = C_3H_6O_1}$

EF mass = 58

$$m = \frac{MF\ mass}{EF\ mass} = \frac{58}{58}$$

$\therefore \boxed{m = 1}$

$MF = (EF) \times m$

~~58 X 1~~

$MF = (C_3H_6O_1) \times m$

$\therefore \boxed{MF = C_3H_6O_1}$

Ans => $\boxed{\text{6 - H atoms per molecule}}$

Q.1 A compound contain 38.8% C, 16.0% H and 45.2% N. The formula of the compound will be ?

⇒

Element	Amount	n	Simple ratio
C	38.8	$\frac{38.8}{12} = 3.2$	$\frac{3.2}{3.2} = 1$
H	16.0	$\frac{16}{1} = 16$	$\frac{16}{3.2} = 5$
N	45.2	$\frac{45.2}{14} = 3.2$	$\frac{3.2}{3.5} = 1$

⇒ Formula will be = $\boxed{CH_5N}$ Ans

Q.2 A compound of x and y has equal mass of them. If their atomic weight are 30 and 20 respectively. Then find molecular formula of the compound.

⇒

Element	Amount	n	Simple ratio
X	x	$\frac{x}{30}$	$\frac{x/30}{x/30} = 1$
Y	x	$\frac{x}{20}$	$\frac{x/20}{x/30} = \frac{3}{2}$

⇒ Molecular Formula = $X_1 Y_{3/2}$

Ans ⇒ $\boxed{X_2Y_3}$

Q.3 2.2g of a compound of phosphorus and sulphur has 1.24g of phosphorus in it. Find E.F.

⇒ ~~$wt_{compound}$ = 2.2g~~

⇒ wt of compound = 2.2g

$P + S = 2.2g$

$1.24 + S = 2.2g$

$S = 2.2 - 1.24 = 0.96g$

∴ wt of phosphorus = 1.24g

wt of sulphur = 0.96g

E	Amt.	n	S.R.
P	1.24	1.24/31	4
S	0.96	0.96/32	3

Ans ⇒ $\boxed{E.F. = P_4S_3}$

Q.4 What is the no. of hydrogen atom per molecule of a hydrocarbon A having 85.8% carbon. [Molar mass of A = $84\ g\ mol^{-1}$] JEE Mains 2023

⇒

Element	Amount	n	Simple ratio
C	85.8	$\frac{85.8}{12} = 7.1$	$\frac{7.1}{7.1} = 1$
H	14.2	$\frac{14.2}{1} = 14.2$	$\frac{14.2}{7.1} = 2$

⇒ E.F. = CH_2

EF mass = 14

⇒ $m = \frac{MF\ mass}{EF\ mass} = \frac{84}{14} = 6$

⇒ $MF = (EF)_m = (CH_2)_6 = C_6H_{12}$

Ans ⇒ There are 12 H-atoms per compound.

Combustion of Organic Compound

1)- Compound containing only C & H (Hydrocarbons)

$$C_xH_y + \left(x+\frac{y}{2}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$$

2)- Compound containing C, O & H

$$C_xH_yO_z + \left(x+\frac{y}{2}-\frac{z}{2}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2}H_2O$$

Problems Related to Mixture

→ When two different compounds react with a similar reagent or a similar way.

→ Sabhi compounds ka reaction alag-alag likhenge.

→ **Few Common Salts :-**

1. **Heating of Carbonates** [CO_3^{2-}]

→ On heating carbonates, it gives metal oxide and CO_2 (in general).

Eg:
$MgCO_3 \longrightarrow MgO + CO_2$
$CaCO_3 \longrightarrow CaO + CO_2$
$ZnCO_3 \longrightarrow ZnO + CO_2$
$LiCO_3 \longrightarrow Li_2O + CO_2$
$Na_2CO_3 \longrightarrow$ No rxn.

Note:

	Group-1	Group-2
Only decomposes →	Li_2CO_3	$BeCO_3$
Thermally stable (They do not decompose)	Na_2CO_3	$MgCO_3$
	K_2CO_3	$SrCO_3$
	Rb_2CO_3	$BaCO_3$
	Cs_2CO_3	

2. **Heating of Bicarbonates** [HCO_3^- ions]

→ All HCO_3^- on simple heating forms its carbonate, CO_2 and H_2O.

Eg:
$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$
$2KHCO_3 \xrightarrow{\Delta} K_2CO_3 + H_2O + CO_2$
$Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3 + H_2O + CO_2$
$MgCO_3 \xrightarrow{\text{strong heat}} MgO + CO_2$
$Ca(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 + H_2O + CO_2$
$CaCO_3 \xrightarrow{\text{strong heat}} CaO + CO_2$

→ Jo carbonates heat karne par break ho jate hain, unke HCO_3^- me present carbonate bhi break ho jate hain.

Q.1 4g of mixture containing $CaCO_3$ and sand (SiO_2) on treatment with HCl (excess) produces 0.88g of CO_2. Find % of $CaCO_3$ in the mixture.

$\Rightarrow$ $CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

$SiO_2 + HCl \longrightarrow$ No rxn.

$\Rightarrow$ Let $CaCO_3$ be x g

$\therefore$ $SiO_2 = (4-x)g$.

$\Rightarrow$ $n_{CaCO_3} = \frac{x}{100}$

Also, $n_{CO_2} = \frac{x}{100}$

$\Rightarrow$ $Wt_{CO_2} = \frac{x}{100} \times 44 = \frac{44x}{100}$

$\Rightarrow$ Acc. to question $\Rightarrow$ $\frac{44}{100}x = 0.88$

$\Rightarrow$ $\boxed{x = 2}$

$\therefore$ Wt. of $CaCO_3 = 2g$

$\Rightarrow$ Now, % of $CaCO_3 = \frac{2}{4} \times 100 = \boxed{50\%}$ Ans

---

Q.2 2g sample of $Na_2CO_3 + NaHCO_3$ loses 0.248g when heated to 300°C. Find the % of Na_2CO_3 in the mixture.

$\Rightarrow$ $Na_2CO_3 \xrightarrow{\Delta}$ No rxn.

$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2(g) + H_2O(g)$

$\Rightarrow$ Let wt. of $NaHCO_3$ be xg

Then wt. of Na_2CO_3 be $(x-2)g$

$\Rightarrow$ $n_{NaHCO_3} = \frac{x}{84}$

Also, n_{H_2O} and $n_{CO_2} = \frac{x}{84 \times 2} = \frac{x}{168}$

$\Rightarrow$ $wt_{CO_2} = \frac{x}{168} \times 44 = \frac{44}{168}x$

$wt_{H_2O} = \frac{18x}{168}$

=> Total loss in weight = $W_{CO_2} + W_{H_2O}$

$$0.24 = \frac{44x}{168} + \frac{18x}{168}$$

$$\therefore \boxed{x = 0.672g}$$

=> $wt_{Na_2CO_3} = 2 - 0.672 = 1.328\,g$

=> % of $Na_2CO_3 = \frac{1.328}{2} \times 100$

Ans => $\boxed{69.1\ \%}$

Laws of Chemical Combination

1 The Law of Conservation of Mass :-

→ It states that matter can neither be created nor be destroyed in a chemical reaction, i.e., in a chemical change, total mass remains constant.

Mass of reactant	=	Mass of product	+	mass of reactant left unreacted

→ This law in not applied in a nuclear rxn. Because in a nuclear rx^n, protons & neutrons rearrange themselves which leads to formation and destruction of element and this causes mass defect.

Q.1 $\underset{(20g)}{H_2} + \underset{(80g)}{O_2} \rightarrow H_2O$. Illustrate this rx^n follows law of conservation of mass.

=> $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$

Wt = 20g   80g   90g

$n = \frac{20}{2} = 10$ mol $\frac{80}{32} = 2.5$ mol   5 mol

=> $\frac{n_{H_2O}}{1} = \frac{n_{O_2}}{\frac{1}{2}} = 5$ mol

=> (n_{H_2})reacted = 5 mol

=> (wt_{H_2})reacted = 10g

=> (wt_{H_2})unreacted = 20 − 10 = 10g

=> | Mass of reactant | = | Mass of product | + | Mass of unreacted |
|---|---|---|---|---|
| 20 + 80 | = | 90 | + | 10 |

$$\boxed{100 = 100}$$

=> Hence, proved.

Q.2 When 4.2g $NaHCO_3$ is added to a solution of CH_3COOH weighing 10.0g, it is obsrerved that 2.2g CO_2 is released into atmosphere. The residue is found to weigh 12.0g. Show that these observations are in agreement with law of COM.

→
$$NaHCO_3 + CH_3COOH \longrightarrow CO_2 + \text{Residue}$$
$$4.2g + 10g = 2.2g + 12g$$
$$14.2g = 14.2g$$
$$LHS = RHS$$

Hence, proved

2 Law of Constant or Definite Proportion :-

→ A given compound always contains exactly the same proportion of elements by weight irrespective of their source or method of preparation.

Eg: Water (H_2O)

Mass of H : Mass of O

2 : 16

$\boxed{1 : 8}$ ← $\boxed{\text{Always fixed}}$

Note:
- Same compound obtained from different sources.
- Prove karne ke liye same element ka %age same karna hoga.

Ques 1.80g of a certain metal burnt in oxygen gave 3.0g of its oxide. 1.50g of same metal heated in steam gave 2.50g of its oxide. Show that these results illustrate the law of constant proportion.

⇒ Case - I : Metal = 1.8g
Metal oxide = 3g

Case - II : Metal = 1.5g
Metal oxide = 2.5g

⇒ %age of metal in case-I :-
$$\frac{1.8}{3} \times 100 = 60\%$$

%age of metal in case-II :-
$$\frac{1.5}{2.5} \times 100 = 60\%$$

⇒ In both cases, %age of metal is same (60%). Therefore, this follows law of constant proportion.

Note: This law is not applicable for isotopes.

3. Law of Multiple Proportion :-

→ When one element combines ~~to form~~ with the other element to form two or more different compound, the mass of one element, which combines with a constant mass of other, bear a simple ratio to one another.

Note:
- 2 elements forming 2 or more compound.
- 1 element ka mass same karne par dusre element ke masses ka ratio simple whole no. aana chahiye.

Eg: H and O → H_2O, H_2O_2

N and O → N_2O, NO, N_2O_3, N_2O_4, N_2O_5

Eg: H_2O , H_2O_2

H_2O: 2, 16 ; H_2O_2: 2, 32

$(W_o)_I : (W_o)_{II}$

16 : 32

1 : 2

Eg: CO , CO_2

CO: 12, 16 ; CO_2: 12, 32

$(W_o)_I : (W_o)_{II}$

16 : 32

1 : 2

Eg: N_2O , $2(NO)$, N_2O_3 , N_2O_4 , N_2O_5

28 16 , 28 32 , 28 48 , 28 64 , 28 80

$(W_o)_I : (W_o)_{II} : (W_o)_{III} : (W_o)_{IV} : (W_o)_{V}$

16 : 32 : 48 : 64 : 80

1 : 2 : 3 : 4 : 5

Q.1 Phosphorous and chlorine form two compounds. The first contains 22.54% by mass of phosphorous and the second 14.88% of phosphorous. Show that these data are consistent with law of multiple proportion.

=>

Compound	P	Cl
1	22.54%	77.46%
2	14.88%	85.12%

Compound-1 :-

22.54% P → 77.46% Cl

1% P → $\frac{77.46}{22.54}$% Cl

Compound - 2 :-

14.88 % P → 85.12 % Cl

1 % P → $\frac{85.12}{14.88}$ % Cl

$$\Rightarrow \frac{Cl_1}{Cl_2} = \frac{77.46 \times 14.88}{22.54 \times 85.12} = 0.6 = \frac{6}{10} = \frac{3}{5} \text{ [Simple ratio]}$$

4 Law of Volume (Gay-Lussac's Law of Volume) :-

→ If in any rx^n all the components are in gaseous state, then reactants combines in fixed volume to form fixed volume of product.

Note: Stoichiometry with volume.

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

20 L → 10 L   30 L

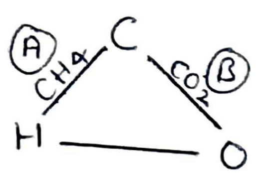
$$\underset{(g)}{aA} + \underset{(g)}{bB} \longrightarrow \underset{(g)}{cC} + \underset{(g)}{dD}$$

$$\frac{V_A}{a} = \frac{V_B}{b} = \frac{V_C}{c} = \frac{V_D}{d}$$

5 Law of Reciprocal Proportion :-

→ The ratio of weight of elements let suppose A and B combining with a third element (C) to form different compounds having same weight of C will always have simple whole no. ratio.

Eg: 3 elements



Ⓐ C : H
12 : 4

Ⓑ C : O
12 : 32

$$\boxed{\begin{matrix} H : O \\ 4 : 32 \\ 1 : 8 \end{matrix}}$$

6 Avogadro's Hypothesis :-

→ Equal volume of all gases have equal no. of molecules (not atoms) at same temperature and pressure condition.

→ If temperature and pressure is fix -
Then, no. of moles ∝ volume of any gas

$$\boxed{n \propto V}$$

Eg: At 1 atm and 0°C, find volume of

(i) 1 mol CH_4 = 22.4 L
(ii) 1 mol CO_2 = 22.4 L
(iii) 1 mol SO_2 = 22.4 L
(iv) 1 mol MIC (Methyl isocyanide) = 22.4 L

Q.1 In the rxn, $N_2 + 3H_2 \rightarrow 2NH_3$, the ratio of volume of nitrogen, hydrogen and ammonia is 1:3:2. These figures illustrate which law?

⇒ Gay Lusaac

Q.2 $Al_2(SO_4)_3 \cdot xH_2O$ contain 8% Al by mass then calculate the value of x.

⇒ Type: To find no. of water of crystallisation
Given: % of Al in compound is 8%.

⇒ $\frac{W_{Al}}{W_{compound}} \times 100 = 8$

$$\frac{2 \times 27}{2 \times 27 + 96 \times 3 + 18x} \times 100 = 8$$

$$54 \times 100 = 8(54 + 288 + 18x)$$
$$5400 = 432 + 2304 + 144x$$
$$5400 = 2736 + 144x$$

Ans ⇒ $\boxed{x = 18.5}$

Principle of Atom Conservation (POAC)

→ According to it, atom of elements are conserved during a chemical reaction.

No. of atom on product side = No. of atom on reactant side

→ **When to use** : If we do not know how to balance the reaction or we don't know the reaction at all.

→ POAC can only be applied to those element which is neither added nor being removed during ~~course~~ course of reaction.

Q.1 All carbon atom present in 962 g of $KH_3(C_2O_4)_2 \cdot 2H_2O$ is converted ~~by~~ to CO_2 by sequence of reaction. How many grams of CO_2 will be obtained?

=> [POAC on C]

=> Molar mass of $KH_3(C_2O_4)_2 \cdot 2H_2O = 39 + 3(24+64) \times 2 + 36$
$= 42 + 176 + 36$
$\Rightarrow \boxed{254}$

=> $n_{KH_3(C_2O_4)_2 \cdot 2H_2O} = \frac{962}{254} = \boxed{3.78 \text{ mol}}$

=> $(n_C)_{\text{in compound}} = \text{Atomicity} \times 3.78$
$= 4 \times 3.78 = \boxed{15.12 \text{ mol}}$

=> $(n_{C\text{-atom}})_{\text{Reactant}} = (n_{C\text{-atom}})_{\text{Product}}$

$$\boxed{15.12 = (n_{C\text{-atom}})_{\text{Product}}}$$

=> In CO_2:

$n_{C\text{-atom}} = n_{CO_2} \times (\text{atomicity})_C$

$n_{C\text{-atom}} = n_{CO_2} \times 1$

$n_{CO_2} = 15.12 \text{ mol}$

=> Wt. of $CO_2 = n_{CO_2} \times$ molar mass of CO_2
$= 15.12 \times 44$

Ans => $\boxed{665.28 \text{ g}}$

Concentration Terms

- Used for solutions.
- Solution = Solute + Solvent.
- A solution is a homogeneous mixture.
- How to identify solute and solvent?

(a) If state (phase) of solute and solvent are same:
Then, more amount = Solvent
less amount = Solute

(b) If phase is different:
Then, In general liquid is taken as solvent apart from amalgam (alloy of Hg).

Eg: (i) $H_2O(l)$ + $HCl(g)$
20g 5g
⇒ $\boxed{\text{Solvent}}$ $\boxed{\text{Solute}}$

(ii) $Cu(s) + Sn(s) \rightarrow$ Bronze
88g 12g
⇒ $\boxed{\text{Solvent}}$ $\boxed{\text{Solute}}$

- **Solubility**: The maximum amount of solute that can be dissolved in a given amount of solvent at a given temperature.
  - Solvent ka amount fix hona chahiye. (Generally 100g / 100ml)
  - Temperature should be fixed.

- **Meaning of Concentration Terms**:-
They expresses the solubility of solute in a given solvent.

- **Types of Concentration Terms**:-
1. Mass by mass percent
2. Mass by volume percent
3. Volume by volume percent
4. Parts per million (ppm)
5. Parts per billion (ppb)
6. Molarity (M)
7. Molality (m)
8. Mole fraction

1 Mass by Mass Percent

$$W/W\% = \frac{\text{wt of solute}}{\text{wt of solution}} \times 100$$

→ Unitless

→ Temperature independent

Note
weight and no. of moles are independent of temperature.

Eg: 250 g glucose was added to x g of water to form 20% W/W solution. Find the value of x.

⇒ $20 = \frac{250}{250+x} \times 100$

$20(250+x) = 25000$

$5000 + 20x = 25000$

$20x = 20000$

Ans ⇒ $\boxed{x = 1000\,g}$

2 Mass by Volume Percent

$$M/V\% = \frac{\text{Mass of solute}}{\text{Volume of soln}} \times 100$$

→ Unit = g/ml

→ Depend upon temperature

3 Volume by Volume Percent

$$V/V\% = \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$$

→ Unitless

→ Temperature dependent

4 Parts Per Million (PPM)

5 Parts Per Billion (PPB)

→ ppm and ppb are used only for those sollutions in which amount of solute is very less.

Eg: air pollutants

$$ppm = \frac{W_{solute}}{W_{soln}} \times 10^6$$

$$ppb = \frac{W_{solute}}{W_{solution}} \times 10^9$$

→ Solute is present in very small quantity. So, $\boxed{W_{soln} = W_{solvent}}$

Ques If 1 milimole of Ca is dissolved in 1 kg water. Find ppm and ppb.

$\Rightarrow$ Wt of Ca $= n_{Ca} \times (MM)_{Ca}$

$= 10^{-3} \times 40 = \boxed{4\times10^{-2} g}$

Wt of water $= 1000 g$

$\Rightarrow$ ppm $= \dfrac{4\times10^{-2}}{1000} \times 10^6 = \boxed{40 \text{ ppm}}$

$\Rightarrow$ ppb $= \dfrac{4\times10^{-2}}{1000} \times 10^9 = \boxed{4\times10^4 \text{ ppb}}$

6 Molarity (M)

→ It is defined as the no. of moles of solute present in per litre solution.

$$M = \frac{n_{solute}}{V_{soln} (L)}$$

→ Unit = mol/L or molL^{-1} or molar (M)

→ Depend upon temperature.

→ Commonly used units :-

decimolar $= 10^{-1}$ M
centimolar $= 10^{-2}$ M
milimolar $= 10^{-3}$ M

$$n_{solute} = M \times V_{soln}(L)$$

Where, M = molarity
V = volume of solution
n = moles of solute

Q.1 Find the molarity of aq. sol^n of glucose containing 18 g of glucose in 1 L sol^n.

$\Rightarrow$ $n_{glucose} = \dfrac{18}{180} = 0.1$ mol

$M = \dfrac{0.1}{1} = \boxed{0.1 M}$ Ans

Q.2 - If 92g of Na^+ is added to 250 ml of $soln$. Find M.

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⇒ $n_{Na^+} = 92/23 = 4$ mol

$V_{soln} = 250\,ml = 0.25\,l$

$M = \frac{4}{0.25} = \boxed{16M}$ Ans

7 Molality (m)

→ It is defined as no. of moles of solute present in per kg of solvent.

$$m = \frac{n_{solute}}{w_{solvent}(kg)}$$

→ Unit = mol/kg or mol kg^{-1} or molal (m)

→ Temperature independent.

→ Commonly used unit :-

decimolal	=	10^{-1} m
centimolal	=	10^{-2} m
milimolal	=	10^{-3} m

Eg: Find weight of NaOH required to prepare decimolal aqueous $soln$ having 2 kg of H_2O

⇒ $m = n_{NaOH}/2$

$10^{-1} = n_{NaOH}/2$

$n_{NaOH} = 0.2$ moles

$wt_{NaOH} = 0.2 \times 40 = \boxed{8g}$ Ans

8 Mole Fraction

→ It is defined as the no. of moles of any component divided by total no. of moles of all the components.

$A = n_A$ + $B = n_B$ → Solution : Total mole $= n_A + n_B$

→ Unitless

→ Temperature independent

X_A = mole fraction of A $= \frac{n_A}{n_A + n_B}$

X_B = mole fraction of B $= \frac{n_B}{n_A + n_B}$

(i) $\boxed{0 \le x_i \le 1}$

$x_i = 0 \Rightarrow$ 'i' is absent

$x_i = 1 \Rightarrow$ only 'i' is present

Eg: $N_2 = 56g$, $O_2 = 16g$

$\Rightarrow n_{N_2} = \frac{56}{28} = 2\ mol$

$n_{O_2} = \frac{16}{32} = 0.5\ mol$

$x_{O_2} = \frac{0.5}{0.5+1} = \boxed{0.2}$ Ans $\rightarrow \boxed{0 \le 0.2 \le 1}$

(ii) Sum of mole fraction of all the components in 1 solution is always = 1

$$\boxed{\sum_{i=1}^{n} x_i = 1}$$

Eg: $n_{N_2} = 2\ mol$

$n_{O_2} = 0.5\ mol$

$x_{N_2} = \frac{2}{2.5}$

$x_{O_2} = \frac{0.5}{2.5}$

$$\boxed{x_{N_2} + x_{O_2} = \frac{2}{2.5} + \frac{0.5}{2.5} = 1}$$

For 2 component system A and B

$x_A + x_B = 1$

$x_A = 1 - x_B$

$x_B = 1 - x_A$

(iii) $$\boxed{\frac{x_A}{x_B} = \frac{n_A}{n_B}}$$

Eg: Find the mole fraction of NaOH in its aq. soln of 200g containing 20g NaOH.

$\Rightarrow n_{NaOH} = \frac{20}{40} = 0.5\ mol$

$w_{H_2O} = 200 - 20$

$= 180g$

$n_{H_2O} = \frac{180}{18} = 10\ mol$

$\Rightarrow x_{NaOH} = \frac{0.5}{10.5} = \boxed{\frac{1}{21}}$ Ans

Important Points

Relation between Molarity and Molality

$$\boxed{m = \frac{1000\,M}{1000\,d - M \times (MM)_{solute}}}$$

m = Molality
M = Molarity
d = density
$(MM)_{solute}$ = Molar mass of solute

Eg: Find the molality of 2 molar aq. $soln^{n}$ of NaOH having $d = 1.5\,g/ml$ JEE Advance

$\Rightarrow$ $M = 2\,M$
$d = 1.5\,g/ml$
$(mm)_{NaOH} = 40$

$$\Rightarrow \quad m = \frac{1000 \times 2}{1500 - 2 \times 40} = \frac{2000}{1500 - 80} = \frac{200\cancel{0}}{142\cancel{0}} = \frac{100}{71}$$

Ans $\Rightarrow$ $\boxed{1.4\,m}$

→ Molarity of pure liquid :

$$\boxed{M_{pure\,liq.} = \frac{1000 \times density}{(MM)_{solvent}}}$$

Proof : $\boxed{H_2O \text{ (water)}}$

→ $M_{H_2O} = \dfrac{n_{H_2O}}{V_{H_2O(l)}}$

→ density $= d\,g/ml$

→ Let us assume we have 1 L of H_2O

→ For liq.
$d = \dfrac{m}{v}$

$m = d \times v$

→ $m_{H_2O} = 1000 \times d$

→ $n_{H_2O} = \dfrac{d \times 1000}{(MM)_{H_2O}}$

$\because V_{H_2O} = 1L$

$$\boxed{\therefore M = \frac{1000\,d}{(MM)_{pure\,liq.}}}$$

$\Rightarrow$ Hence, proved

Eg: Molarity of heavy water (D_2O) [$d = 1\,g/ml$]

$\Rightarrow$ $(MM)_{D_2O} = 20$

$$M_{D_2O} = \frac{1000 \times 1}{20} = \boxed{50}$$

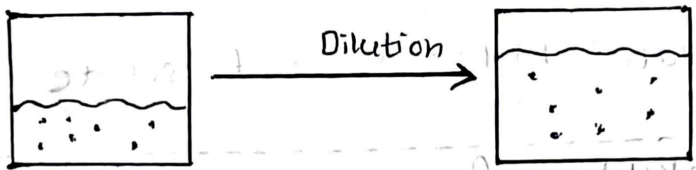
Problems related to Concentration Terms

1 Dilution

→ In dilution more solvent is added to a given solution.

→ The amount of solute remains same.

Concentrated | Diluted



$M = M_1$
$V = V_1$

$M = M_2$
$V = V_2$

Here,
$n_{solute} = M_1 V_1$

Here,
$n_{solute} = M_2 V_2$

Since, solute remains constant.

Therefore, $\boxed{n_{solute} \text{ in concentrated sol}^n = n_{solute} \text{ in diluted sol}^n}$

Hence, $\boxed{M_1 V_1 = M_2 V_2}$ — Law of dilution

Where,
M_1 = Molarity of initial solution
M_2 = Molarity of final solution
V_1 = Volume of initial solution
V_2 = Volume of final solution

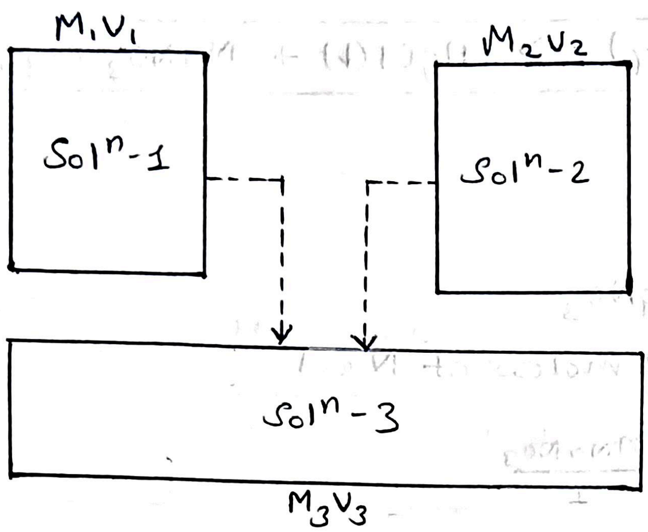
Ques A solution of NaOH(aq.) has $M = 2M$ and $V = 5L$. If 5L of H_2O is added, find molarity of diluted solution.

⇒ $M_1 = 2M$
$V_1 = 5L$
$M_2 = ?$
$V_2 = 5 + 5 = 10L$

⇒ $M_1 V_1 = M_2 V_2$
$2 \times 5 = M_2 \times 10$
$\frac{10}{10} = M_2$

Ans ⇒ $\boxed{M_2 = 1M}$

2 Mixing of solution with same solute and solvent



$\boxed{V_3 = V_1 + V_2}$

$\left[(n_{solute})_3 = (n_{solute})_1 + (n_{solute})_2\right]$

$\boxed{M_3V_3 = M_1V_1 + M_2V_2}$

$\boxed{M_3 = \dfrac{M_1V_1 + M_2V_2}{V_1 + V_2}}$

Ques $\boxed{NaCl(aq)} + \boxed{NaCl\ (aq)} \longrightarrow \boxed{NaCl\ (aq.)}$

$M_1 = 2M$ $M_2 = 3M$ $M_3 = 2.5M$

$V_1 = 3L$ $V_2 = ?$ $V_3 = ?$

Find V_2.

$\Rightarrow V_3 = V_1 + V_2 = (3 + V_2)\,L$

$\Rightarrow M_3V_3 = M_1V_1 + M_2V_2$

$2.5(3 + V_2) = 2 \times 3 + 3V_2$

$7.5 + 2.5V_2 = 6 + 3V_2$

$7.5 - 6 = 3V_2 - 2.5V_2$

$1.5 = 0.5V_2$

$\therefore \boxed{V_2 = 3L}$ Ans

3 Reaction involving solution

→ We have to apply stoichiometry.

→ But here, $\boxed{n_{solute} = M \times V}$

→ **Precipitation reaction :-**

- ppt settle down in solution.
- ppt's are never a part of solution.

→ **Few examples of ppt:** (i) $PbCl_2$, $PbBr_2$, PbI_2
(ii) $AgCl$, $AgBr$, AgI
(iii) $BaSO_4$
(iv) $CaCO_3$

Ques Find the concentration of each ion when 2M, 1L $AgNO_3$ is mixed with 2M, 2L NaCl.

=> $\boxed{AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(\downarrow) + NaNO_3(aq)}$

=> $n_{AgNO_3} = 2 \times 1 = 2\,mol$

$n_{NaCl} = 2 \times 2 = 4\,mol$

=> Limiting reagent = $AgNO_3$

=> Excess reagent = 2 moles of NaCl

=> $\frac{n_{AgNO_3}}{1} = \frac{n_{AgCl}}{1} = \frac{n_{NaNO_3}}{1}$

=> $n_{AgCl} = n_{NaNO_3} = 2\,mol$ [Ignore ppt]

=> $\boxed{NaCl}$ → Na^+ (2mol), Cl^- (2mol); $\boxed{NaNO_3}$ → Na^+ (2mol), NO_3^- (2mol)

=> $[Na^+]$ = concentration of Na^+

$= \frac{n_{Na^+}}{V(L)} = \boxed{\frac{4}{3}M}$ Ans

=> $[NO_3^-]$ = concentration of NO_3^-

$= \frac{n_{NO_3^-}}{V(L)} = \boxed{\frac{2}{3}M}$ Ans

Percentage Labelling of Oleum

→ $\boxed{\text{Oleum}} = \boxed{\text{Fuming } H_2SO_4}$

Conc. $H_2SO_4 + SO_3(g) \longrightarrow H_2S_2O_7$

$SO_3(g)$ → $\boxed{\text{Free Oleum}}$

→ Concentrated H_2SO_4 is supplied in the form of oleum to ensure safety.

Eg: 100g Olem = 60g H_2SO_4 + 40g SO_3

$SO_3(g) + H_2O \longrightarrow H_2SO_4$

$\boxed{0.5mol}$ $\boxed{0.5mol}$ $\boxed{0.5mol}$ [∵ By stoichiometry]

$\Rightarrow$ weight of extra H_2SO_4

$= n_{H_2SO_4} \times (MM)_{H_2SO_4}$

$= 0.5 \times 98 = 49g$

$\Rightarrow$ Total H_2SO_4 = $\boxed{109g}$

Q.1 **Fill the blank spaces.**

S.No.	Oleum	SO_3	H_2SO_4	H_2O req. (in g)	Total H_2SO_4	% Labelling
1	100g	20g	80g	4.5g	104.5g	104.5%
2	100g	60g	40g	13.5 g	113.5 g	113.5%
3	100g	80g	20g	18g	118g	118%
4	100g	100g	0g	22.5g	122.5g	122%
5	50g	20g	80g	4.5g	54.5g	109%

SO_3	$+ H_2O$	$\longrightarrow H_2SO_4$
1) $n = \frac{20}{80} = \frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
$w = 20g$	$\frac{1}{4} \times 18 = 4.5g$	$\frac{1}{4} \times 98 = 24.5g$
2) $n = \frac{60}{80} = \frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
$w = 60g$	$\frac{3}{4} \times 18 = 13.5g$	$\frac{3}{4} \times 98 = 73.5g$
3) $n = \frac{80}{80} = 1$	1	1
$w = 80g$	18g	98g
4) $n = \frac{100}{80} = \frac{5}{4}$	$\frac{5}{4}$	$\frac{5}{4}$
$w = 100g$	$\frac{5}{4} \times 18 = 22.5g$	$\frac{5}{4} \times 98 = 122.5g$
5) $n = \frac{20}{80} = \frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$
$w = 20g$	$\frac{18}{4} = 4.5g$	$\frac{98}{4} = 24.5g$

How is oleum labelled?

$\boxed{\text{Labelling of Oleum} = (100 + x)\%}$

Note: x = The amount of extra H_2SO_4 obtained from 100g of oleum.

x = Weight of H_2O added in 100g of oleum to convert all SO_3 into H_2SO_4.

→ Maximum % labelling of Oleum can be $\boxed{122.5\%}$

$\boxed{\text{Oleum} \rightarrow \text{max.} \rightarrow SO_3 = 100g}$

In a sol^n of 100g H_2SO_4, max. SO_3 can be 100g.

	SO_3 +	H_2O →	H_2SO_4
w =	100g	22.5g	$\boxed{122.5g}$
n =	$\frac{5}{4}$	$\frac{5}{4}$	$\frac{5}{4}$

→ % of free Oleum = $\boxed{\dfrac{W_{SO_3}}{W_{oleum}} \times 100}$

$= \boxed{\dfrac{x \times 80}{18 \times W_{oleum}} \times 100}$

If oleum is labelled $(100+x)\%$.

$xg = H_2O$

$n_{H_2O} = \frac{x}{18}$ mol

$n_{SO_3} = \frac{x}{18}$ mol

$w_{SO_3} = \frac{x}{18} \times 80$

Volume Strength of H_2O_2

$\boxed{H_2O_2 = \text{Hydrogen peroxide}}$

→ **Definition:** The volume of O_2 liberated by 1L of H_2O_2 solution at NTP.

→ **Reaction:** $H_2O_2(aq.) \longrightarrow H_2O(l) + \frac{1}{2}O_2(g)$

$\boxed{V.S_{H_2O_2} = 11.2M}$ M = Molarity of sol^n

$\boxed{V.S_{H_2O_2} = 5.6N}$ N = Normality (in redox chapter)

Ques Find the weight of H_2O_2 present in 1 L of solution having VS = 5.6.

$\Rightarrow$ $VS = 11.2 \times M$

$5.6 = 11.2 \times M$

$M = \frac{5.6}{11.2} = 0.5\,M$

$\Rightarrow$ $M = \frac{n_{H_2O_2}}{V_{sol}(L)}$ $\Rightarrow$ $0.5 = \frac{n_{H_2O_2}}{1}$

$\Rightarrow$ $n_{H_2O_2} = 0.5\,mol$

$W_{H_2O_2} = 0.5 \times 34$

$= \boxed{17g}$ Ans