SOLUTIONS OF MOLE CONCEPT

EXERCISE # 1

PART - I

A-1. (i) 2 g of H_2 = 1 mole H_2
1 mole = 22.4 L

(ii) 16 g of O_3 = $\frac{1}{3}$ mole of O_3

Volume of $\frac{1}{3}$ mole O_3 at STP = 22.4 × $\frac{1}{3}$ = 7.466 L

A-2. Number of moles of N_2O in 100 g mixture = $\frac{66}{44}$ = 1.5

Number of moles of H_2 in 100 g mixture = $\frac{34}{2}$ = 17

$M_{average} = \frac{100}{18.5} = 5.40$

B-2. 1 g atom of Fe (56 g Fe) is present in 1 mole of the compound. As 4.6 g Fe are present in 100 g of the compound, 56 g of Fe will be present in $\frac{100}{4.6}$ × 56 g = 1217 g of the compound.

B-3.

Element	**Atomic mass**	**%**	**Relative no. of atoms**	**Simple ratio**	**Simplest whole No.**
H	**1**	**25**	25	$\frac{25}{6.25}$ = 4	**4**
C	**12**	**75**	$\frac{75}{12}$ = 6.25	$\frac{6.25}{6.25}$ = 1	**1**

So empirical formula **CH_4.**

C-1. $Ag_2CO_3 \xrightarrow{\Delta} 2Ag + CO_2$
276 g Ag_2CO_3 = 216 g of Ag
∴ 2.76 g of Ag_2CO_3 = 2.16 g of Ag.

C-2. $3Fe + 4H_2O \xrightarrow{\Delta} Fe_3O_4 + 4H_2$

$\frac{\text{Mole of Fe}}{\text{Mole of } H_2O} = \frac{3}{4}$

Mole of Fe = $\frac{18}{18} \times \frac{3}{4} = \frac{3}{4}$

Weight of Fe = $\frac{3}{4}$ × 56 = 42 g.

C-3. (i) Mole of oxygen = $\frac{448}{22400}$ = 0.02
Wt. of oxygen = 0.02 × 32 = 0.64 g.
$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$
0.02 mol
2 mol $KClO_3$ ≡ 2 mol KCl ≡ 3 mol O_2

(ii) Mass of $KClO_3$ originally taken = $\frac{2}{3}\times 0.2\times 122.5 = 1.64$ g

(iii) Mass of KCl produced = $\frac{2}{3}\times 0.02\times 74.5 = 0.993$ g

D-1. $3CaCO_3 + 2H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3H_2O + 3CO_2$

	$3CaCO_3$	$2H_3PO_4$	$Ca_3(PO_4)_2$	$3H_2O$	$3CO_2$
Initial mole	$\frac{50}{100}$	$\frac{73.5}{98}=\frac{3}{4}$	0	0	0
final mole	0	$\frac{3}{4}-\frac{1}{2}\times\frac{2}{3}=\frac{5}{12}$	$\frac{1}{6}$		

D-2. (a) $Br_2 + Cl_2 \longrightarrow 2BrCl$

1 mol 1mol 2mol

0.025 0.025 0.050 mol

Theoretical yield of BrCl = 0.050 mol

actual yield is = $\frac{0.05\times 80}{100}$ = 0.04 mole

(b) Br_2 left unreacted = 0.025 – 0.02 = 0.005 mol.

E-1. 2 mol $KClO_3 \equiv$ 3 mol O_2

Also 4 mol $KClO_3 \equiv$ 3 mol $KClO_4$ or $\frac{4}{3}$ mol $KClO_3 \equiv$ 1 mol $KClO_4$

$\therefore$ $KClO_3$, $2 + \frac{4}{3} = \frac{10}{3}$ moles.

E-2. Moles of Ca in Ca = moles of Ca in CaO

or 1 × moles of Ca = 1 × moles of CaO

$\frac{1}{40} = \frac{m}{56}$ or m = 1.4 g

E-3. On heating Na_2CO_3 and $NaHCO_3$, Na_2CO_3 remains unchanged while $NaHCO_3$ changes into Na_2CO_3 , CO_2 and H_2O. The loss in weight is due to removal of CO_2 and H_2O which escape out on heating.

$\therefore$ wt. of Na_2CO_3 in the product = 2.00 – 0.248 = 1.752 g.

Let the weight of Na_2CO_3 in the mixture be X g.

$\therefore$ wt. of $NaHCO_3$ = (2.00 – X) g.

Since Na_2CO_3 in the products contains X g of unchanged reactant Na_2CO_3 and rest produced from $NaHCO_3$.

The wt. of Na_2CO_3 produced by $NaHCO_3$ only = (1.752 – X) g.

Now , we have ,

$$NaHCO_3 \longrightarrow Na_2CO_3 + (H_2O + CO_2)\uparrow$$

(2.0 – X) g (1.752 – X) g

Applying POAC for Na atoms ,

moles of Na in $NaHCO_3$ = moles of Na in Na_2CO_3

1 × moles of $NaHCO_3$ = 2 × moles of Na_2CO_3

$$\frac{2.0-X}{84} = 2\times\frac{1.752-X}{106} \qquad \begin{bmatrix} NaHCO_3 = 84 \\ Na_2CO_3 = 106 \end{bmatrix}$$

$X = \frac{82}{62} = 1.328$ g.

$\therefore$ % of Na_2CO_3 = $\frac{1.328}{2.0}\times 100 = 66.4$ %.

E-4. Let x g chalk ($CaCO_3$), (5 – x) g clay present
wt of H_2O + wt of CO_2 = 1.1

$$(5 - x) \times \frac{11}{100} + \frac{x}{100} \times 44 = 1.1$$

so x = 5/3

so % of chalk = $\frac{5/3}{5} \times 100 = 33.33\%$.

F-1. (a) $K[Co(C_2O_4)_2(NH_3)_2]$
1 + x – 4 + 0 = 0
x = + 3

(b) $K_4P_2O_7$
4 + 2x – 14 = 0
2 x = 10
x = +5

(c) CrO_2Cl_2
x – 4 – 2 = 0
x = +6

(d) $Na_2[Fe(CN)_5(NO^+)]$
2 + x – 5 + 1 = 0
x = +2

(e) Mn_3O_4
3x – 8 = 0
x = +8/3

(f) $Ca(ClO_2)_2$
2 + 2x – 8 = 0
2x = 6
x = +3

(g) $[Fe(NO^+)(H_2O)_5]SO_4$
x + 1 + 0 – 2 = 0
x = +1

(h) ZnO_2^{2-}
x – 4 = – 2
x = +2

(i) $Fe_{0.93}O$
0.93x – 2 = 0
0.93x = 2

$$x = \frac{2}{0.93} = \frac{200}{93} = 2.15$$

H-1. mole of KOH = M × V(ℓ) = 1 × 0.1 = 0.1
Hence : mass of KOH = mole × molecular mass = 0.1 × 56 = 5.6 g

H-2. Molar mass of KCl = (39 + 35.5) g = 74.5 g
W_2 = 7.45 g, Mw_2 = 74.5 g
V_{sol} = 500 mL
d_{sol} = 1.2 g mL^{-1}

$$m = \frac{W_2 \times 1000}{Mw_2 \times W_1}$$

In the above relation, W_1 is unknown, so find W_1.
$W_1 = (W_{sol} - W_2)$ g = $(V_{sol} \times d_{sol} - W_2)$ g = (500 × 1.5 – 7.45) g

$$\therefore \quad m = \frac{7.45 \times 1000}{74.5 \times 592} = 0.168 \text{ mol kg}^{-1} = 0.168 \text{ m.}$$

H-3. (i) Molarity of NaOH = 2
Density = 1 g/ml
Let volume of solution = 1000 ml
∴ mass of solute = 2 × 40 = 80
Mass of solution = 1000 × 1 = 1000 g
Mass of solvent = 1000 – 80 = 920 g

$$\text{molality} = \frac{2}{920/1000} = 2.17$$

(ii) m = 5 Density = 1.5 g/ml
Let 1 Kg solvent
∴ mole of solute = 5
mass of solute = 5 × 40 = 200 g

Total mass of solution = 200 + 1000 = 1200 g

$\therefore$ Volume of solution = $\dfrac{\text{mass of solution}}{\text{density}} = \dfrac{1200}{1.5}$ = 800 ml

M = $\dfrac{5}{800/1000}$ = 6.25

(iii) In (i) mole fraction of solute = $\dfrac{2}{2+\dfrac{920}{18}} = \dfrac{36}{956} = \dfrac{9}{239}$ = 0.0377

(iv) In (ii) mole fraction of solute = $\dfrac{5}{5+\dfrac{1000}{18}} = \dfrac{90}{1090} = \dfrac{9}{109}$ = 0.0826

(v) In (i) % (w/w) of NaOH = $\dfrac{80}{1000} \times 100$ = 8 %

(vi) In (ii) % (w/w) of NaOH = $\dfrac{200}{1200} \times 100$ = 16.67 %

(vii) In (ii) % (w/v) of NaOH = $\dfrac{200}{800} \times 100$ = 25 %

I-1. $[Cl^-] = \dfrac{2\times \text{moles of } BaCl_2 + 1\times \text{moles } NaCl + 1\times \text{moles of } HCl}{0.5} = \dfrac{2\times1+1\times1+1\times1}{0.5} = \dfrac{4}{0.5}$ = 8 M.

I-2. Volume of HNO_3 = 50 ml, density = 1.5

d = $\dfrac{M}{V}$, mass of solution = 50 × 1.5

weight of HNO_3 = $\dfrac{75\times63}{100} = \dfrac{3}{4} \times 63$

Mole of HNO_3 = $\dfrac{3}{4} \times \dfrac{63}{63} = \dfrac{3}{4}$ Mole

M = $\dfrac{\text{Mole of } HNO_3}{\text{Volume of solution}}$ = 1 = $\dfrac{3}{4\times V_{lit}}$ = 1

V = $\dfrac{3}{4}$ lt = 750 ml

Volume of water added = 750 – 50 = 700 ml

I-3. Molarity = $\dfrac{\text{Moles}}{V_{lt}}$ $\Rightarrow$ 3 = $\dfrac{1+6}{V_{lt}}$ So V = 7/3 = 2.33 Lt.

I-4. (i) Mass of NaOH = 300 × $\dfrac{30}{100}$ + 500 × $\dfrac{40}{100}$ = 90 + 200 = 290 g

mass of solution = 300 + 500 = 800

% w/w of NaOH in mixture = $\dfrac{290}{800} \times 100$ = 36.25 %

(ii) Density of final solution = 2 g/ml

Volume of solution = $\dfrac{800}{2}$ = 400 ml

% w/v of NaOH = $\dfrac{290}{400} \times 100$ = 72.5 %

(iii) In (i) molality of final solution = $\dfrac{290/40}{(800-290)\times 1/1000} = \dfrac{29/4}{510} \times 1000$ = 14.2

PART - II

A-1. Statement of avogadro's hypothesis.

A-2. Mol. wt. of gas is $= \frac{16 \times 22.4}{5.6} = 64$ g

$32 + 16x = 64$
$x = 2$

B-1. Empircal mass of $CH_2O = 12 + 2 + 16 = 30$

$n = \frac{\text{Molar mass}}{\text{Empirical mass}} = \frac{120}{30} = 4$

Hence : molecular formula = $(CH_2O)\ 4 = C_4H_8O_4$

B-2.

Elements	%	% / Atomic mass	Simple ratio	Simplest whole no.
Ca	20	20/40 = 0.5	1	1
Br	80	80/80 = 1	2	2

Hence : Empirical formula = $CaBr_2$

$n = \frac{200}{200} = 1$

Hence : Molecular formula = $CaBr_2$

B-3. 8% sulphur by mass means – 8 g sulphur is present in 100 g solid.

$\therefore$ 32 g sulphur (1 mole atom) will be present in $= \frac{100}{8} \times 32 = 400$ g

[$\because$ compound must be having at least one atom of sulphur]

$\Rightarrow$ min. mol. mass = 400 g.

B-4. % of C $= \frac{\text{mass of C}}{\text{molar mass}} \times 100$

$69.98 = \frac{21 \times 12}{M} \times 100$

M = 360.1.

C-1. $KClO_3 \longrightarrow KCl + \frac{3}{2} O_2$

$\frac{3}{2}$ mole or 33.6 litre O_2 from 1 mole $KClO_3$

11.2 litre of O_2 formed by $\frac{1}{3}$ mole $KClO_3$

C-3. $2\,Al + \frac{3}{2} O_2 \longrightarrow Al_2O_3$ $\Rightarrow$ weight of Al required $= 2 \times 27 = 54$ g

C-4. Moles of CO_2 formed = moles of $H_2SO_4 = 0.01$ $\Rightarrow$ Volume of $CO_2 = 22.4 \times 0.01 = 0.224$ L.

C-5. By applying POAC for C atoms

moles of ethylene × 2 = mole of polythene × n × 2

$\frac{100\,g}{28} \times 2 = \frac{\text{wt. of polethene}}{28 \times n} \times n \times 2$

wt. of polyethene = 100 g

C-6. $3M + N_2 \longrightarrow M_3N_2$

Let Atomic wt. of metal = a

so (3a + 28) g nitride contains metal = 3a gram

$\therefore$ 14.8 g nitride contains metal = $\frac{3a}{3a+28} \times 14.8 = 12$

so a = 40.

D-1.

	H_2SO_4 +	$Ca(OH)_2$ $\longrightarrow$	$CaSO_4$ +	$2H_2O$
Initial mole	0.5	0.2	0	0
finally mole	0.5 – 0.2	0	0.2	0.4

D-2.

	Zn +	Fe +	2S $\longrightarrow$	Zn (FeS_2)
initial mole	2	3	5	0
final mole	0	3–2 = 1	5 –4 =1	2

D-3.

	2 X +	3 Y $\longrightarrow$	X_2Y_3
weight	W gram	W gram	0
Mole	$\frac{w}{36}$	$\frac{w}{24}$	
L.R. $\rightarrow$	$\frac{w}{36} \times \frac{1}{2}$	$\frac{w}{24 \times 3}$	

No. one is L.R.

$$2X + 3Y \longrightarrow X_2Y_3$$

$$\frac{w}{36} \qquad \frac{w}{24} \qquad \frac{w}{2[36]}$$

Weight of X_2Y_3 = $\frac{w}{2 \times 36}$ [72 × 2] = 2 w

So weight of X_2Y_3 = 2 [weight of X Taken]

D-4. $C + CO_2 \longrightarrow 2CO$

Given moles $\left(\frac{6}{12}\right) = 0.5$ $\quad \left(\frac{44}{44}\right) = 1$

So C is limiting reagent

$\therefore$ CO formed = 1 moles

Now moles of Ni need to react with 1 moles of CO are $\frac{1}{4} \times 58.7 = 14.675$ g.

E-1. Moles of Na_2CO_3 = $\frac{21.2 \times 10^3}{106} = 200$

So moles of CO_2 = 200

& so moles of $CaCO_3$ reqd = 200

$\therefore$ wt of $CaCO_3$ reqd = 200 × 100 = 20 kg.

E-2.

$M + X_2 \longrightarrow MX_2$

$MX_2 + X_2 \longrightarrow M_3X_8$

$M_3X_8 + Na_2CO_3 \longrightarrow NX + CO_2 + M_3O_4$

mole of NX = $\frac{206}{103} = 2$

POAC for X Atom :
No. of X atom in M_3X_8 = No. of X Atom in NX
8 [No. of mole of M_3X_8] = 1 [No. of mole of NX]
No. of mole of M_3X_8 = $\left[\frac{2}{8}\right] = \frac{1}{4}$ mole

Now POAC for M Atom
3 [No. of mole of M_3X_8] = 1 × [No. of Mole of M]

∴ $3 \times \frac{1}{4}$ = No. of mole of M

weight of M atom = $\frac{3}{4} \times 56 = 42$ gram

E-3. **Balanced equation :**

$NaI + AgNO_3 \longrightarrow AgI + NaNO_3$ (1)
$2AgI + Fe \longrightarrow FeI_2 + 2Ag$ (2)
$2FeI_2 + 3Cl_2 \longrightarrow 2FeCl_3 + 2I_2$ (3)

From (3)

$$\frac{\text{mole of } I_2}{2} = \frac{\text{mole of } FeI_2}{2}$$

$$\frac{\text{mole of } FeI_2}{1} = \frac{\text{mole of AgI}}{2}$$

$$\frac{\text{mole of AgI}}{1} = \frac{\text{mole of } AgNO_3}{1}$$

∴ mole of I_2 = (mole of FeI_2)

$$= \left(\frac{\text{mole of AgI}}{2}\right) = \left(\frac{\text{mole of } AgNO_3}{2}\right)$$

$$\frac{254 \times 10^3}{254} = \frac{\text{mole of } AgNO_3}{2}$$

2×10^3 = mole of $AgNO_3$ = $\frac{\text{mass of } AgNO_3}{\text{molar mass of } AgNO_3}$

mass of $AgNO_3$ = $170 \times (2 \times 10^3)$ g = 340×10^3 g = 340 kg.

E-4.

	I_2	+ $2Cl_2$ $\longrightarrow$	ICl	+ ICl_3
Given mass	25.4 gram	14.2 gram	0	0
initial mole	0.1 mole	0.2 mole	0	0
final mole	0	0	0.1	0.1

E-5. $P_4 + O_2 \longrightarrow P_4O_6 + P_4O_{10}$
31 gram   32 gram

According to question weight of P is conserved so

Let Mole of P_4O_6 = a
Mole of P_4O_{10} = b
Initial weight of P = Final weight of P.
31 = [a × 4] × 31 + [b × 4] × 31
4 a + 4b = 1]   (1) × 3
Initial weight of oxygen = Final weight of oxygen
32 = [a × 6] × 16 + [a × 10] × 16
3a + 5b = 1]   (2) × 4

12 a + 20 b = 4
12 a + 12 b = 3   So   b = $\frac{1}{8}$
8 b = 1

Similarly $a = \frac{1}{8}$

So weight of $P_4O_6 = \frac{1}{8} \times 220 = 27.5$ $P_4O_{10} = \frac{284}{8} = 35.5$.

E-6. $LiAlH_4$ + t-butyl alcohol $\xrightarrow{Ether}$ $LiAlHC_{12}H_{27}O_3$ (M.W. = 254)
0.05 mole 12.7 gram

$= \frac{12.7}{254} = 0.05$ mole

Li atom remain conserved so
No. of mole of $LiAlH_4$ = No. of mole of $LiAlHC_{12}H_{27}O_3$
So No. of mole of $LiAlHC_{12}H_{27}O_3$ = 0.05

$\%\ \text{yield} = \frac{0.05}{0.05} \times 100 = 100\%$

E-7. $NaH_2PO_4 + Mg^{2+} + NH_4^+ \longrightarrow Mg(NH_4)PO_4.\ 6H_2O \xrightarrow{heated} Mg_2P_2O_7$
Since P atoms are conserved , applying POAC for P atoms,
moles of P in NaH_2PO_4 = moles of P in $Mg_2P_2O_7$
1 × moles of NaH_2PO_4 = 2 × moles of $Mg_2P_2O_7$
(∵ 1 mole of NaH_2PO_4 contains 1 mole of P and 1 mole of $Mg_2P_2O_7$ contains 2 moles of P)

$$\frac{\text{wt. of } NaH_2PO_4}{\text{mol. wt. of } NaH_2PO_4} = 2 \times \frac{\text{wt. of } Mg_2P_2O_7}{\text{mol. wt. of } Mg_2P_2O_7}$$

$$\frac{\text{wt. of } NaH_2PO_4}{120} = 2 \times \frac{1.054}{222}.$$

Wt. of NaH_2PO_4 = 1.14 g.

E-8. $CaCl_2$ + NaCl = 10 g
Let weight of $CaCl_2$ = x g
$CaCl \to CaCO_3 \to CaO$
1 mol 1 mol 1 mol
$\frac{x}{111}$ mol $\frac{x}{111}$ mol $\frac{x}{111}$ mol

Mole of CaO = $\frac{1.62}{56}$

$\therefore \frac{x}{111} = \frac{1.62}{56}$

x = 3.21 g

% of $CaCl_2 = \frac{3.21}{10} \times 100 = 32.1$ %

E-9. $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$
for 1 mole NaOH $\frac{1}{2}$ mole H_2SO_4 required
70 g H_2SO_4 in 100 g solution
$\frac{98}{2}$ g H_2SO_4 in = $\frac{100}{70} \times 49 = 70$ g solution.

F-1. $2(+1) + 2\ x = 0$ $\therefore$ $x = -1$

F-2. $2(+2) + 2x + 7(-2) = 0$ $\therefore$ $x = +5$

F-3. SO_3^{2-} ⇒ $1(x) + 3(-2) = -2 \therefore x = +4$

$S_2O_4^{2-}$ ⇒ $2(x) + 4(-2) = -2 \therefore x = +3$

$S_2O_6^{2-}$ ⇒ $2(x) + 6(-2) = -2 \therefore x = +5$

F-4. NaN_3 $1(+1) + 3(x) = 0 \therefore x = -1/3$

N_2H_2 $2(x) + 2(+1) = 0 \therefore x = -1$

NO $1(x) + 1(-2) = 0 \therefore x = +2$

N_2O_5 $2(x) + 5(-2) = 0 \therefore x = +5$

F-5. Fe_3O_4 can be written as $FeO.Fe_2O_3$.

In FeO , Fe has oxidation state + 2 , in Fe_2O_3 has oxidation state + 3.

resultant oxidation number = $\frac{1\times 2 + 2\times 3}{3} = \frac{8}{3}$.

F-6. $N_2H_4 \xrightarrow{-10e^-} 2N^{x+}$

(– 2)

$\therefore$ $2x - 2(-2) = 10.$ $\therefore$ $2x = 6$ $\therefore$ $x = +3.$

G-1. Valency factor ratio is inversely related to molar ratio.

$(V.f.)HI : (V.f.)HNO_3 = 1 : 3 = 2 : 6 \therefore$ Molar ratio = 6 : 2

G-2. $MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$

V.f. = 5 V.f. = 2

$\therefore$ Balanced equation : $2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

G-3. $xP_4 + yHNO_3 \longrightarrow 4H_3PO_4 + NO_2 + H_2O$ $\therefore (V.f.)P_4 : (V.f.)\ HNO_3 = 20 : 1$

Oxidation states: 0, +5, +5, 4

$HNO_3 \to NO_2$: 1

$P_4 \to H_3PO_4$: $4 \times 5 = 20$

$\therefore$ x = 1; y = 20

G-4. $X^- + XO_3^- + H^+ \longrightarrow X_2 + H_2O$

V.f. = 1 V.f. = 5

$\therefore$ Molar ratio = 5 : 1

G-5. Equating number of O-atoms on both sides :

$3b = a + b + 2a + c/2$

$\therefore 4b = 6a + c$

Also, from charge balance : $c = a + b$ $\therefore a : b : c = 3 : 7 : 10$

H-1. Molarity = $\frac{6.02\times 10^{22}}{6.02\times 10^{23}} \times \frac{1}{1/2} = 0.2$

H-2. Mole = M × V

$100 \times 10^{-3} = 0.8 \times V$

V = 0.125

H-3. Molarity of Cl^- = 3 (molarity of $FeCl_3$) = $3\left(\frac{M}{30}\right) = \frac{M}{10}$.

H-4. Let, $n_{H_2O} = n_{NaCl} = n$

$m = \frac{\text{Mole of solute}}{\text{wt. of solvent (kg)}} = \frac{n}{n \times 18} \times 1000$

$= \frac{1}{18} \times 1000 = 55.55$ m.

H-5. Mole fraction of A i.e. $X_A = \frac{n_A}{\text{Total moles}}$

So $X_{H_2O} = \frac{n_{H_2O}}{\text{Total moles}}$

Now $\frac{X_A}{X_{H_2O}} = \frac{n_A}{n_{H_2O}}$

and molality $= \frac{n_A \times 1000}{n_{H_2O} \times 18} = \frac{X_A \times 1000}{X_{H_2O} \times 18} = \frac{0.2 \times 1000}{0.8 \times 18}$ = **13.9 Ans.**

H-6. Molarity $= \frac{98 \times 10 \times 1.84}{\text{Gmm}} = 18.4$ M $\{\because M = \frac{(\% \ w/w) \times (d) \times 10}{\text{Mol. mass of solute}}\}$ (d in g/ml.)

H-7. Weight of KOH = 2.8 gram
Volume of solution = 100 ml

$M = \frac{2.8 \times 1000}{56 \times 100} = \frac{28}{56} = 0.5$ M

I-1. $M_1V_1 + M_2V_2 = M_R [V_1 + V_2]$
$1 \times 500 + 1 \times 500 = M_R [500 + 500]$
$M_R = 1$

I-2. $M_{final} = \frac{M_1V_1 + M_2V_2}{V_1 + V_2 + V_{water}}$; $0.25 = \frac{0.6 \times 250 + 0.2 \times 750}{250 + 750 + V_{water}}$; So $V_{water} = 200$ ml.

I-3. Moles of Cl^- in 100 ml of solution $= \frac{2}{58.5} + \frac{4}{111} \times 2 + \frac{6}{53.5} = 0.2184$

Molarity of $Cl^- = \frac{0.2184}{100} \times 1000 = 2.184$.

I-4. Conc. of cation $= \frac{400 + 300 + 200}{400}$

conc. of anion $= \frac{200 + 300 + 400}{400}$

$\therefore$ ratio of the conc. = 1

I-5. Let volume is V ml

$H_2SO_4 + 2\,NaOH \longrightarrow Na_2SO_4 + 2H_2O$
mmole 0.2 V 40 x 0.1

m. moles of H_2SO_4 remains $= 0.2\,V - \frac{40 \times 0.1}{2}$

$\frac{0.2V - \frac{40 \times 0.1}{2}}{V + 40} = \frac{6}{55}$

V = 70 ml

PART - III

1. (A) C : H : O = $\frac{51.17}{12}$: $\frac{13.04}{1}$: $\frac{34.78}{16}$ = 4 : 12 : 2 or 2 : 6 : 1

Empirical formula = C_2H_6O & molar mass = 46 g/mol

Mol formula = C_2H_6O

C_2H_6O + $3O_2$ $\longrightarrow$ $2CO_2$ + $3H_2O$

1 mole — 44.8 L at STP

0.25 mole — (11.2 L at STP)

(B) C: H = $\frac{10.5}{12}$: $\frac{1}{1}$ = $\frac{7}{8}$: 1 = 7 : 8 Empirical formula = C_7H_8

Mol wt. = 2 × VD = 2 × 46 = 92

Mol formula = Empirical formula = C_7H_8

$C_7H_8 + 9O_2 \longrightarrow 7CO_2 + 4H_2O$

$n_{CO_2} > n_{H_2O}$

(C) C : H = 42.857 : 57.143

= 3 : x (given)

On solving, x = 4 ∴ molecular formula = C_3H_4

1 mole of C_3 H_4 contains $4N_A$ hydrogen atoms.

Empirical formula is same as molecular formula

$C_3H_4 + 4O_2 \longrightarrow 3CO_2 + 2H_2O$

$n_{CO_2} > n_{H_2O}$

(D) Mass of C in organic compound = mass of C in CO_2 = $\frac{0.44}{44} \times 12 = 0.12$ g

Mass of H in organic compound = Mass of H in H_2O = $\frac{0.18}{18} \times 2 = 0.02$ g

∴ Mass of O in organic compound = 0.3 – (0.12 + 0.02) = 0.16 g

∴ C : H : O = $\frac{0.12}{12}$: $\frac{0.02}{1}$: $\frac{0.16}{16}$ = 0.01 : 0.02 : 0.01 = 1 : 2 : 1

∴ Empirical formula = CH_2O, but it contains 2 O atom per molecule

∴ Molecular formula = $C_2H_4O_2$

1 mole of $C_2H_4O_2$ contains 4 N_A hydrogen atoms.

$C_2H_4O_2 + 2O_2 \longrightarrow 2CO_2 + 2H_2O$

1 mole — 44.8 L

0.25 mole — 11.2 L

2. (A)

	Zn(s) + 2HCl (aq) ⟶		ZnCl₂(s) +	H₂ (g)
	$Zn(s)$	$2HCl\ (aq)$	$ZnCl_2(s)$	$H_2\ (g)$
Initial mole	2	2	0	0
final mole	(2-1=1)	0	1	1

Excess reagent left = $\frac{2-1}{2} \times 100 = 50\%$

Volume of H_2 = 22.4 lit.

Solid product obtained = 1 mole

Limiting reagent is HCl.

(B)

	$AgNO_3(aq)$ +	HCl ⟶	$AgCl(s)$ +	$HNO_3(g)$
Initial mole	$\frac{170}{170}=1$	$\frac{18.25}{36.5}=\frac{1}{2}$	0	0
	$1-\frac{1}{2}=\frac{1}{2}$	0	$\frac{1}{2}$	$\frac{1}{2}$

Excess reagent = $\frac{1-\frac{1}{2}}{1}$ × 100 = 50%

Volume of gas = 11.2 lit.

Solid product = $\frac{1}{2}$ mole

Limiting reagent is HCl.

(C)	$CaCO_3(s)$	$\longrightarrow$	CaO(s)	+	$CO_2(g)$
Initial mole	$\frac{100}{100}=1$		0		0
	0		1		1

Excess reagent not present

Volume of gas = 22.4 lit. at STP

Solid product is 1 mole

(D)	$2KClO_3(s)$	$\longrightarrow$	2KCl	+	$3O_2(g)$
Initial mole	2/3		0		0
	0		2/3		2

No excess reagent left

Volume of gas = 44.8 lit.

Solid product is $\frac{2}{3}$ mole.

3. (A) Molarity of cation = $\frac{M_1V_1+M_2V_2}{V_1+V_2} = \frac{0.2\times100+0.1\times400}{500} = \frac{0.6}{5}$ = 0.12

Molarity of Cl^{-} = $\frac{3(0.2)100+0.1\times400}{500} = \frac{0.6+0.4}{5}$ = 0.2

(B) Molarity of cation = $\frac{50\times0.4+0}{100}$ = 0.2

Molarity of Cl^{-} = $\frac{0.4\times50+0}{100}$ = 0.2

(C) Molarity of cation = $\frac{2(0.2)30+0}{100}$ = 0.12

Molarity of SO_4^{2-} = $\frac{30\times0.2}{100}$ = 0.06

(D) 24.5 g H_2SO_4 in 100 ml solution

Molarity = $\frac{\frac{25.4}{98}}{0.1}$ = 2.5

∴ Concentration of cation = 2 × 2.5 M

Concentration of SO_4^{2-} = 2.5 M.

EXERCISE # 2

PART - I

1. In $Ca_3(PO_4)_2$

$\frac{\text{mole of Ca atom}}{\text{mole of O atom}} = \frac{3}{8}$

mole of 'O' atom = $\frac{8}{3}$ (mole of Ca atom)

Mole of Ca atom = 3

2.

	C	H	O
mass	24	8	32
moles	$\frac{24}{12}$	$\frac{8}{1}$	$\frac{32}{16}$
ratio	2	8	2
Simple integer ratio	1	4	1

Hence empirical formula is CH_4O

3. Use reaction $C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$.

In 24 hr. moles of sucrose consumed = $\frac{34}{342} \times 24$.

$\therefore$ In 24 hr. moles of O_2 required = $\frac{34}{342} \times 24 \times 12$. (according to stoichiometry).

mass of O_2 required = $\frac{34}{342} \times 24 \times 12 \times 32 = 916.2$ g.

4. (A) Explanation : $2\text{ Ag} + \text{S} \rightarrow Ag_2S$

2 × 108 g of Ag reacts with 32 g of sulphur

10 g of Ag reacts with $\frac{32}{216} \times 10 = \frac{320}{216} > 1$ g

It means 'S' is limiting reagent

32 g of S reacts to form 216 + 32 = 248 g of Ag_2S

1 g of S reacts to form = $\frac{248}{32} = 7.75$ g

Alternately

n_{eq} of Ag = $\frac{10}{108} = 0.0925$ n_{eq} of S = $\frac{1}{16} = 0.0625$ (n_{eq} = number of equivalents)

Since n_{eq} of S is less than n_{eq} of Ag

$\Rightarrow$ 0.0625 eq of Ag will react with 0.0625 eq of S to form 0.0625 eq of Ag_2S

Hence , amount of Ag_2S = n_{eq} × Eq. wt. of Ag_2S = 0.0626 × 124 = 7.75 g

5.

	$2SO_2$ +	$O_2 \longrightarrow$	$2SO_3$
Initial mole	10	15	0
Final mole	(10 – 2x)	(15 – x)	2x

$\because$ Given 2x = 8

$\therefore$ x = 4

$\therefore$ Mole of SO_2 left = 10 – 2 × 4 = 2

Mole of O_2 left = 15 – 4 = 11

6. Let wt. of Fe = 100 g so wt. of O_2 = 10 g

$$2Fe + \frac{3}{2}O_2 \longrightarrow Fe_2O_3$$

by the stoichiometry of the reaction $\frac{10}{32}$ mole of O_2 will combine with $\frac{10}{24}$ mole of Fe

wt. of Fe = $\frac{10}{24} \times 56 = 23.3$ g or 23.3%.

7. $CaC_2 + H_2O \longrightarrow Ca(OH)_2 + C_2H_2 \longrightarrow C_2H_4$ ... (1)

$nC_2H_4 \longrightarrow -(CH_2-CH_2)-_n$ ... (2)

From equation (1)

mole of CaC_2 = mole of C_2H_4

$\frac{64 \times 10^3}{64}$ = mole of C_2H_4

From equation (2)

$$\frac{\text{mole of } C_2H_4}{n} = \frac{\text{mole of polymer}}{1}$$

$$\frac{10^3}{n} = \frac{\text{wt. of polymer}}{n(28)}$$

wt of polymer = 28×10^3 g = 28 Kg

8. Let of mol of Fe undergoing formation of FeO = x
Let mol of Fe undergoing formation of Fe_2O_3 = 1 – x

then, $Fe + \frac{1}{2}O_2 \longrightarrow FeO$

x x/2 x

$2Fe + \frac{3}{2}O_2 \longrightarrow Fe_2O_3$

$1 - x$ $\frac{3}{4}(1 - x)$ $\frac{1-x}{2}$

As given, $\frac{x}{24} + \frac{3}{4}(1 - x) = 0.65$ = Total moles of oxygen

x = 0.4 = moles of FeO

$\frac{1-x}{2}$ = 0.3 = moles of of Fe_2O_3

$\Rightarrow \frac{\text{Mole of FeO}}{\text{Mole of } Fe_2O_3} = \frac{4}{3}$

9. $C + \frac{1}{2}O_2 \longrightarrow CO$ .... (1)

Initial mole $\frac{x}{12}$ $\frac{y}{32}$ 0

final mole 0 $\frac{y}{32} - \left(\frac{x}{12}\right)\frac{1}{2}$

$CO + \frac{1}{2}O_2 \longrightarrow CO_2$ .... (2)

For no solid residue C should be zero in eq. (1)

For that $\frac{y}{32} - \frac{x}{12} \times \frac{1}{2} > 0$

$\frac{y}{32} > \frac{x}{24}$

$\frac{y}{x} > \frac{32}{24}$

$\frac{y}{x} > 1.33$

10. $(C + S) \longrightarrow CO_2 + SO_2$

$$n_{SO_2} = \frac{n_{CO_2}}{2}$$

Let wt. of C = x
So, wt. of S = 12 – x

$$\frac{12 - x}{32} = \frac{1}{2}\left(\frac{x}{12}\right)$$

x = 5.14 g.

11. $\underset{(+2)\ (-2)}{ZnS} + \underset{(+5)}{HNO_3} \longrightarrow \underset{(+2)}{Zn(NO_3)_2} + \underset{(+6)}{H_2SO_4} + \underset{(+4)}{NO_2}$

13. On balacing Na atoms on both sides of reaction, we get :
y = 6x.
∴ x : y = 1 : 6 (only A option matches).

14. Balance reaction is
$2KMnO_4 + 5H_2O_2 + 3H_2SO_4 \longrightarrow 2MnSO_4 + 5O_2 + 8H_2O + K_2SO_4$
∴ Sum of stoichiometric coefficients = 2 + 5 + 3 + 2 + 5 + 8 + 1 = 26

15. $Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$
$(H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^-) \times 3$

$Cr_2O_7^{2-} + 8H^+ + 3H_2O_2 \longrightarrow 2Cr^{3+} + 7H_2O + 3O_2$
The reaction practically occurs with this stoichiometry.

16. Molar fraction & molality is independent of temperature.

17. $M = \dfrac{\%\text{ by weight} \times 10 \times d}{Mw_2} = \dfrac{36.5 \times 10 \times 1.2}{36.5} = 12\text{ M}$

$m = \dfrac{36.5 \times 1000}{36.5 \times (100 - 36.5)} = \dfrac{1000}{63.5} = 15.7\text{ m}$

18. 1000 mL solution contain 2 mole of ethanol or 1000 × 1.025 g solution contain 2 mole of ethanol
wt. of solvent = 1000 × 1.025 – 2 × 46

$m = \dfrac{2}{1000 \times 1.025 - 2 \times 46} \times 1000$

$m = \dfrac{2}{933} \times 1000 = 2.143$

19. Mole fraction of H_2O = 1 – 0.25 = 0.75

$\dfrac{x_{C_2H_5OH}}{X_{C_2H_5OH} + X_{H_2O}} = \dfrac{n_{C_2H_5OH}}{n_{C_2H_5OH} + n_{H_2O}}$ or wt. % = $\dfrac{0.25 \times 46}{0.25 \times 46 + 0.75 \times 18} \times 100 = 46\%$.

20. Mass of H_2SO_4 formed by 4g SO_3 = 4.9 g

Mass % of H_2SO_4 = $\dfrac{100 \times 1.96 \times 0.8 + 4.9}{100 \times 1.96 + 4} = 80.8\ \%$

21. Mass of ethyl alcohol = 1.5 × 0.792 g
Mass of water = 15 × 1
Total mass of solution = 15 + 0.792 × 15 = 26.88

Volume of solution = $\dfrac{\text{mass}}{\text{density}} = \dfrac{26.88}{0.924} = 29.09$

% decrease in volume = $\left(\dfrac{30 - 29.09}{30}\right) \times 100 \approx 3\%$.

PART - II

1. Mole of SO_4^{2-} 4 × 1.25 = 5 g ion.

2. C : O : S = 3 : 2 : 4

Hydrogen is = 7.7%

$\therefore$ 100 – 7.7 = 92.3 % contains C,O & S

$$\% C = \left(\frac{3}{3+2+4}\right) \times 92.3 \quad ; \quad \% O = \frac{2}{9} \times 92.3 \; ; \quad \% S = \frac{4}{9} \times 92.3$$

Elements	%	% / Atomic mass	Simple ratio	Simplest whole no.
H	7.7	7.7	6	6
C	30.76	30.76/12 = 2.56	2	2
O	20.51	20.15/16 = 1.28	1	1
S	41.02	41.02/32 = 1.28	1	1

$\therefore$ empirical formula C_2H_6OS

minimum molar mass = 24 + 6 + 16 + 32 = 78

3. Balanced chemical equation is

$$4nXeF_6 + \left(CH_2–CH_2 \right)_n \longrightarrow \left(CF_2–CF_2 \right)_n + 4nHF + 4nXeF_4$$

$$n_{teflon} = \frac{100}{100\ n} = \frac{1}{n}$$

$\therefore$ n_{XeF_6} required $= \frac{1}{n} \times 4n = 4$ moles

4. (Atomic weight of Al and Cr = 27 and 52, M.wt. of Cr_2O_3 = 152)

Moles of Al = $\frac{49.8\ g}{27\ g\ Al}$ = 18.4 mol

$= \frac{18.4}{2}$ = 9.2 mol of Cr_2O_3

Moles of Cr_2O_3 = $\frac{200\ g}{152\ g\ Cr_2O_3}$ = 1.31 mol

Since 2 mol Al is required for 1 mol of Cr_2O_3.

So, Al is the limiting reagent and Cr_2O_3 is in excess. Moles of Cr_2O_3 is excess

= (1.31 – .92) = 0.4 mol

Weight of excess Cr_2O_3 = 0.4 × 152 = 60 g Cr_2O_3

5. From one mole of initial mixture, some FeO must have reacted with oxygen and got converted into Fe_2O_3.

$$4FeO + O_2 \longrightarrow 2Fe_2O_3$$

Initial moles $\quad \frac{3}{5} \qquad \frac{2}{5}$

Final moles $\quad \frac{3}{5} - x \qquad \frac{2}{5} + \frac{x}{2}$

But, final moles ratio is 2 : 3.

$$\therefore \quad \frac{\left(\frac{3}{5} - x\right)}{\left(\frac{2}{5} + \frac{x}{2}\right)} = \frac{2}{3}$$

$$\therefore \quad x = \frac{1}{4}$$

$\therefore$ Moles of FeO reacted = x = $\frac{1}{4}$

$\therefore$ Moles of O_2 required = $\frac{1}{4}$ (x) = $\frac{1}{16}$ = 0.0625

$\therefore$ Mass of O_2 required = 0.0625 × 32 = 2 g

6. $F_2 + 2NaOH \longrightarrow \frac{1}{2}O_2 + 2NaF + H_2O$

Mole 50×10^3 $2[50 \times 10^3]$

$2NaF + CaO + H_2O \longrightarrow CaF_2 + 2\,NaOH$

$2\times[50 \times 10^3]$ 50×10^3 Mole

Weight of lime (CaO) = $50 \times 10^3 \times 56$

= 2800 kg.

Feed amount of lime = 10,000

% Utilisation = $\frac{2800}{10,000} \times 100 = 28\%$

7. $n_{Cl_2} = \frac{112}{22.4} = 5$

$n_{KOH} = 1 \times 10 = 10$

$Cl_2 + 2KOH \xrightarrow{60\%} KCl + KClO + H_2O$

5 10 $5 \times 0.6 = 3$ $5 \times 0.6 = 3$

$3KClO \xrightarrow{50\%} 2KCl + KClO_3$

3 $\frac{2}{3} \times 3 \times 0.5 = 1$ $\frac{1}{3} \times 3 \times 0.5 = 0.5$

$4KClO_3 \xrightarrow{80\%} 3KClO_4 + KCl$

0.5 $0.8 \times \frac{0.5}{4} = 0.1$

$(n_{KCl})_{total} = 3 + 1 + 0.1 = 4.1$ moles $\approx$ 4 moles.

8. $C + O_2 \longrightarrow CO_2 + CO$

POAC on 'C' atom, 1 (mole of C) = 1 (mole of CO_2) + 1 (mole of CO)

$\frac{240}{12}$ = mole of CO_2 + $\frac{280}{28}$

Mole of CO_2 = 20 – 10 = 10

Mole % of CO_2 = $\frac{10}{20} \times 100 = 50\%$.

9. $A + \frac{1}{2}B_2 \longrightarrow AB$, 100 Kcal

x x/2 x

$A + 2B_2 \longrightarrow AB_4$, 200 Kcal

(1–x) 2(1–x) (1–x)

100 x + 200 (1–x) = 140

200 – 100 x = 140

$x = \frac{60}{100} = 0.6$

n_{B_2} used = $\frac{x}{2} + 2(1-x) = \frac{1}{2} \times 0.6 + 2\,(1-0.6) = 0.3 + 2 \times 0.4 = 1.1$ mol

Ans = 1.1 × 10 = 11

10. Let x be the mass of $CaCO_3$ hence mass of $MgCO_3$ = 92 – x

$$\underset{\frac{x}{100}}{CaCO_3} + \underset{\frac{92-x}{84}}{MgCO_3}$$
$$\downarrow \qquad\qquad \downarrow$$
$$\underset{\frac{x}{100}}{CaO + CO_2} \qquad \underset{\frac{92-x}{84}}{MgO + CO_2}$$

mass of residue = 48 g

$\Rightarrow$ $\frac{x}{100} \times 56 + \frac{92-x}{84} \times 40 = 48$

$\Rightarrow$ $\frac{x}{100} + \frac{92-x}{84} = \frac{6}{7}$ $\Rightarrow$ x = 50

$\therefore$ mass of $MgCO_3$ = 92 – 50 = 42 g.

11. C : +4 ; Mn : +6 The sum of the oxidation states of all the underlined elements is 4 + 6 = 10.

12. $\underset{(+6)}{H_2SO_5}$ and $\underset{(+2)}{Na_2S_2O_3}$

13. $2Cl_2 + S_2O_3^{2-} + 10\,OH^- \longrightarrow 2SO_4^{2-} + 4Cl^- + 5H_2O$
$S_2O_3^{2-}$ is L.R. so 2 moles of OH^- will remain.

14. Balance the equation by any method
$4Zn + 10HNO_3 \longrightarrow 4Zn(NO_3)_2 + 3H_2O + NH_4NO_3$
$\therefore$ a + b + c = 4 + 3 + 1 = 8

15. Let wg water in added to 16 g CH_3OH
molality = $\frac{16 \times 1000}{W \times 32} = \frac{500}{W}$

$\frac{500}{W} = \frac{x_A \times 1000}{(1-x_A)m_B} = \frac{0.25 \times 1000}{0.75 \times 18}$ W = 27 g.

16. Molarity = $\frac{10 \times 1.8 \times 98}{98}$ = 18 M

17. Use M = $\frac{\%\text{ by weight} \times 10 \times d}{Mw_2}$

$M_1V_1 = M_2V_2$

$\frac{90 \times 10 \times 0.8}{46} \times V = \frac{10 \times 10 \times 0.9}{46} \times 80$

V = 10 mL

18. Molarity of HCl = $\frac{\text{Total moles of HCl}}{\text{Total volume}} = \frac{5 \times 2}{2+3}$ = 2 M

19. $MCl_x + x\,AgNO_3 \longrightarrow xAgCl + M(NO_3)_x$

$\frac{\text{Mole of } MCl_x}{1} = \frac{\text{Mole of } AgNO_3}{x}$

0.1 = $\frac{1}{x}$ (0.5 × 0.8)

x = $\frac{0.4}{0.1}$ = 4

PART - III

1. Mole of NH_3 = 1.7 = 0.1 Mole H atom = 0.3

Total atoms = $0.4 \times 6.02 \times 10^{23} = 2.408 \times 10^{23}$

$\% H = \frac{3 \times 1}{17} \times 100 = 17.65\%$

2. (A) and (B) Explanation : M. Wt. = 0.001293 × 22400 = 28.96

M.Wt. = d × volume of 1 mole of gas at STP

$V. D. = \frac{28.96}{2} = 14.48$

So (A) and (B) are correct answer.

3. $0.5 \times n = \frac{216}{108}$ = mol of Ag

n = 4

M.wt = 58 + [165]n g/mol = 718 g/mol

4.

	C	+	$O_2 \longrightarrow CO_2$
mass	27		88
moles	$\frac{27}{12}$		$\frac{88}{32}$

C is limiting reagent

Moles of CO_2 produced = moles of C = $\frac{27}{12}$ = 2.25

$\therefore$ Volume of CO_2 at STP = 2.25×22.4 = 50.4 L

Ratio of C and O in CO_2 = 12 : 32 = 3 : 8

Moles of unreacted O_2 = 2.75 – 2.25 = 0.5

$\therefore$ Volume of unreacted O_2 at STP = 0.5×22.4 = 11.2 L

5. (Mw of Na_2CO_3 = 106, Mw of HCl = 36.5, Mw of NaCl = 58.5)

Moles of $Na_2CO_3 = \frac{106}{106}$ = 1.0 mol

Moles of HCl = $\frac{109.5}{36.5}$ = 3.0 mol

(A) Since for 1 mol of Na_2CO_3, 2 mol of HCl is required.

So, HCl is in excess (3 – 2) = 1.0 mol

Therefore, Na_2CO_3 is the limiting quantity.

(B) Weight of NaCl formed = (1.0 mol Na_2CO_3) $\left(\frac{2 \text{ mol NaCl}}{\text{mol } Na_2CO_3}\right)\left(\frac{58.5\text{g NaCl}}{\text{mol NaCl}}\right)$

= 1 × 58.5 = 117.0 g NaCl

(C) 1 mol of Na_2CO_3 = 1 mol of CO_2 = 22.4 L at NTP

6. (i) $K_4Fe(CN)_6 + 3H_2SO_4 \longrightarrow 2K_2SO_4 + FeSO_4 + 6HCN$

	$K_4Fe(CN)_6$	$3H_2SO_4$	$2K_2SO_4$	$FeSO_4$	$6HCN$
	1 mole	5 mole			
Limiting reagent	1/1	5/3			
	(1–1)	(5–3 × 1)	2 × 1	1 × 1	6 × 1
	0 mole	2 mole	2 mole	1 mole	6 mole

Limiting reagent in step (i) is $K_4[Fe(CN)_6]$

(ii) $6HCN + 12H_2O \longrightarrow 6HCOOH + 6NH_3$

$6HCN$	$12H_2O$	$6HCOOH$	$6NH_3$
6 mole	(excess)	0	0
0		6 mole	6 mole

(iii) (a) $6NH_3 + 3H_2SO_4 \longrightarrow 3(NH_4)_2SO_4$

	6 mole	2 mole	0
Limiting reagent	6/6	2/3	
	$(6-\frac{2}{3}\times 6)$	$(2-\frac{2}{3}\times 3)$	$(3\times\frac{2}{3})$
	2 mole	0 mole	2 mole

(b) $6HCOOH \xrightarrow{H_2SO_4} 6CO + 6H_2O$

6 mole	0 mole	0 mole	
0 mole	6 mole	6 mole	

Limiting reagent in step (i) is $K_4[Fe(CN)_6]$
$(NH_4)_2SO_4$ = 2 mol
CO gas = 6 mol

7. $3A + 2B \longrightarrow A_3B_2$

	3A	2B	A_3B_2
initial mole	3	3	0
final mole	0	3–2	1

$A_3B_2 + 2C \longrightarrow A_3B_2C_2$

	A_3B_2	2C	$A_3B_2C_2$
initial mole	1	1	0
final mole	$1-\frac{1}{2}$	0	$\frac{1}{2}$

8. $CaCl_2 \rightarrow CaCO_3 \rightarrow CaO$ $\quad \frac{1.12}{56}$ = 0.02 mole CaO

$\therefore$ Moles of $CaCl_2$ = 0.02 Mole
Mass of $CaCl_2$ = 0.02 × 111 = 2.22 g

$\therefore$ % of $CaCl_2 = \frac{2.22}{4.44} \times 100 = 50$ %

9. (A) Weight of $CaCO_3$ = (0.22 g CO_2)

$$\left(\frac{1\text{ mol }CO_2}{44\text{ g }CO_2}\right)\left(\frac{100\text{ g }CaCO_3}{\text{mol }CaCO_3}\right)\left(\frac{1\text{ mol }CaCO_3}{\text{mol }CO_2}\right) = \frac{0.22\times 100}{44} = 0.5\text{ g }CaCO_3$$

(B) Moles of $CaCO_3$ = moles of Ca = $\left(\frac{0.22}{44}\right)$ = 0.005 mol

Weight of Ca = 0.005 × 40 = 0.2 g Ca

(D) % of Ca = $\frac{0.2}{1.0} \times 100$ = 20% Ca

Hence (C) is wrong.

10. Mw of $CaCO_3$ = 100, Mw of Na_2CO_3 = 106
Mw of HNO_3 = 63 g mol^{-1}

$Na_2CO_3 + CaCO_3 \longrightarrow CaCO_3 + 2NaCl$

(a) moles of $CaCO_3 = \frac{10}{100}$ = 0.1 mol

moles of Na_2CO_3 = moles of $CaCO_3 \equiv$ 2 × moles of NaCl
Weight of Na_2CO_3 = 0.1 × 106 = 10.6 g

% purity $Na_2CO_3 = \frac{10.6}{21.2}$ = 100 = 50%

(b) wrong
(c) correct
(d) moles of NaCl = 2 × 0.1 = 0.2 mol

11.

	Silica	H_2O	Impurities
% in original clay ⇒	40	19	100 – (40 + 19) = 41
% after partial drying ⇒	a	10	100 – (a + 10) = 90 – a

On heating, only water evaporates from clay, whereas silica and impurities are left as it is. Therefore, % ratio of silica and impurities remains unchanged, i.e.

$\frac{40}{a} = \frac{41}{90-a}$, ∴ a = 44.4%

% of mipurities after partial drying = (90 – a) = (90 – 44.4) = 45.6%

12. (A) Oxidation state of K is +1 in both reactant and product.
In (B), oxidation state of Cr(+6) does not change.
In (C), oxidation states of Ca and C and O do not change.
In (D), the H_2O_2 which disproportionates is both oxidising and a reducing agent.

13. S undergoes increase in oxidation number from +2 to +2.5, while I undergoes decrease in oxidation number from 0 to –1.

14. In (C) option, Cl goes from +5 to +7 and –1, while in (D) option, Cl goes from 0 to +1 and –1.

15. Cr oxidises from +3 to +6 while I reduces from +5 to –1. One I atom gain 6 electron.

16. $4H_2O + \overset{+1\times 3\ -3}{Cu_3P} \longrightarrow 3Cu^{2+} + H_3PO_4 + 11e^- + 5H^+] \times 6$

$6e^- + 14H^+ + Cr_2O_7^{2-} \longrightarrow 2Cr^{3+} + 7H_2O] \times 11$

$6Cu_3P + 124H^+ + 11Cr_2O_7^{2-} \longrightarrow 18Cu^{2+} + 6H_3PO_4 + 22Cr^{3+} + 53H_2O$

18. [Mw of KI, $(NH_4)_2SO_4$, $CuSO_4$, $CuSO_4.5H_2O$ and Al^{3+}, respectively, are, 166, 132, 160, 250 and 27 g mol^{-1}]

(A) $M = \frac{166 \times 1000}{166 \times 1000} = 1.0$ M

(B) $M = \frac{33 \times 1000}{132 \times 200} = 1.25$ M

(C) $M = \frac{25 \times 1000}{250 \times 100} = 1.0$ M

(D) $M = \frac{27 \times 10^{-3} \times 1000}{27 \times 1} = 1.0$ M

20. (A) Molarity of second solution is = $\frac{10 \times d \times x}{M} = 1$ M (B) Volume = 100 + 100 = 200 ml

(D) Mass of H_2SO_4 = $\frac{200 \times 1}{1000} \times 98 = 19.6$ g.

21. Vml 0.1 M NaCl
Vml 0.1 M $FeCl_2$

$[Na^+] = \frac{V \times 0.1}{V + V} = 0.05$ M

$[Fe^{2+}] = \frac{V \times 0.1}{V + V} = 0.05$ M

$[Cl^-] = \frac{V \times 0.1 + V \times 0.1 \times 2}{V + V} = 0.15$ M

PART - IV

4. 11.2 g of N_2 ⇒ $\frac{11.2}{28} = 0.4$ mole

∴ air = 0.5 mole ⇒ 0.5 × 22.4 = 11.2 Ltr air

5. 1 mole of air ⇒ 0.8 mole of N_2 = 0.8 × 28 g N_2

⇒ 0.2 mole of O_2 = 0.2 ×32 g O_2

∴ % w/w O_2 = $\frac{w_{O_2} \times 100}{w_{O_2} + w_{N_2}} = \frac{0.2 \times 32 \times 100}{0.2 \times 32 + 0.8 \times 28}$ = 22.2%

6. Density of air at NTP

1 mole of air = 0.8 mole N_2 + 0.2 mole O_2

= 0.8 × 28 + 0.2 × 32 = 28.8 g = 22.4 Ltr volume.

$D = \frac{m}{V} = \frac{22.8}{22.4}$ = 1.2857 g/L

10. % of (w/w) = $\frac{\text{Total mass of solute}}{\text{Total mass of solution}} = \frac{60 \times 0.4 + 100 \times 0.15}{60 + 100}$ × 100 = 24.4%.

11. Mass of solute = 60 × 0.4 + 100 × 0.15 = 24 + 15 = 39 g

Mass of solvent = 160 – 39 = 121 g

Molality = $\frac{\left(\frac{39}{58.5}\right)}{121 \times 10^{-3}}$ = 5.509 = 5.5 m.

12. Mass of solute = 39 g

Volume of solution = $\frac{160}{1.6}$ = 100 ml

∴ Molarity = $\frac{\left(\frac{39}{58.5}\right)}{100 \times 10^{-3}}$ = 6.67 M

15. (i) Mass of pure CsOH = $\frac{37.5 \times 80}{100}$ = 30 g

$$CsOH + HI \longrightarrow CsI + H_2O$$

CsOH	HI	CsI	H_2O
$\frac{30}{150}$	$\frac{8 \times 500}{1000}$	–	–
0.2 mole	0.4 mole		
0	0.2 mole	0.2 mole	

Base in L.R., $[H^+]$ = 0.2 M $[Cs^+]$ = 0.2 M $[I^-]$ = 0.4 M

(ii) RbOH pure = $\frac{51.25 \times 80}{100}$ = 41 g

$$RbOH + HNO_3 \longrightarrow RbNO_3 + H_2O$$

RbOH	HNO_3	$RbNO_3$	H_2O
$\frac{41}{102.5}$	$\frac{0.2 \times 500}{1000}$	–	–
0.4 mole	0.1 mole		
0.3 mole	0	0.1 mole	

Acid in L.R., $[OH^-]$ = 0.3M $[Rb^+]$ = 0.4M $[NO_3^-]$ = 0.1M

(iii) $Sr(OH)_2 + H_2SO_4 \longrightarrow SrSO_4 + 2H_2O$ [Pure $Sr(OH)_2$ = 61 × 0.8 = 48.8 gm]

$Sr(OH)_2$	H_2SO_4	$SrSO_4$	$2H_2O$
$\frac{48.8}{121.62}$	$\frac{0.8 \times 500}{1000}$	–	–
0.4 mole	0.4 mole		
–	–	0.4 mole	

$[Sr^{2+}] = [SO_4^{2-}]$ = 0.4 M

(iv) $Ba(OH)_2$ + $2HBr \longrightarrow BaBr_2 + 2H_2O$ [Pure $Ba(OH)_2$ = 342 × 0.8 = 273.6 gm]

$\frac{273.6}{171}$ $\quad$ $\frac{6.4 \times 500}{1000}$ $\quad$ – $\quad$ –

1.6 mole $\quad$ 3.2 mole

– $\quad$ – $\quad$ 1.6 mole

$[Ba^{2+}]$ = 1.6 M $\quad$ $[Br^{-}]$ = 3.2 M

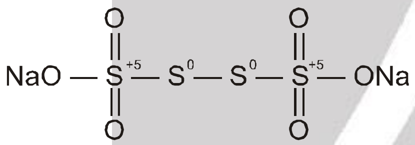
EXERCISE # 3

PART - I

1. MnO_4^- ; x + 4(–2) = – 1 $\quad$ or $\quad$ x = + 7 ;
CrO_2Cl_2 ; x + 2(–2) + 2(–1) = 0 $\quad$ or $\quad$ x = +6.

2. **(i)** 4.0 M, 500 ml NaCl
no. of m moles of NaCl = 500 × 4 = 2000 m moles = 2 moles = 2 moles of Cl^- ions
as $\quad 2Cl^- \longrightarrow Cl_2 + 2e^-$
so $\quad$ 1 mole of Cl_2 is generated.
(ii) no. of moles of Na^+ = 2 moles
so max. wt of Na amalgam (assuming equimolar Na & Hg)
= 46 + 400 = 446 g.
(iii) Two moles of e^- are required = 2 × 96500 C = 193000 C.

3. Average titre value = $\frac{25.2 + 25.25 + 25.0}{3} = \frac{75.45}{3}$ = 25.15 = 25.2 mL
number of significant figures will be 3.

4. 

So, the difference in oxidation state of sulphur is 5 – 0 = 5

5. The balance chemical equation is
$3Br_2 + 3Na_2CO_3 \longrightarrow 5NaBr + NaBrO_3 + 3CO_2$

6. Mole = $\frac{120}{60}$ = 2
mass of solution = 1120 g
V = $\frac{1120}{1.15 \times 1000} = \frac{112}{115}$ L
M = $\frac{2 \times 115}{112}$ = 2.05 mol/litre

7. 29.2% (w/w) HCl has density = 1.25 g/ml
Now, mole of HCl required in 0.4 M HCl = 0.4 × 0.2 mole = 0.08 mole
if v mol of orginal HCl solution is taken
then $\quad$ volume of solution = 1.25 v
mass of HCl = (1.25 v × 0.292)
mole of HCl = $\frac{1.25v \times 0.292}{36.5}$ = 0.08
so, v = $\frac{36.5 \times 0.08}{0.29 \times 1.25}$ mol = 8 mL

8. $6I^- + ClO_3^- \;+\; 6H_2SO_4 \;\rightarrow Cl^- + 6HSO_4^- + 3I_2 + 3H_2O$

Hence, I^- is oxidised to I_2

Coefficient of HSO_4^- = 6

and H_2O is one of the product.

Hence (A), (B), (D)

9. Given 3.2 M solution

$\therefore$ moles of solute = 3.2 mol

Consider 1 L Solution.

$\therefore$ volume of solvent = 1 L

$P_{solvent}$ = 0.4 g.mL^{-1} $\quad\therefore$ $m_{solvent}$ = P × V = 400 g

$\therefore$ molality = $\frac{3.2 \text{ mol}}{0.4 \text{ kg}}$ = 8 molal

10. Molality (m) = $\frac{X_{solute} \times 1000}{X_{solvent} \times M_{solvent}} = \frac{0.1 \times 1000}{0.9 \times M_{solvent}}$

Molarity (M) = $\frac{0.1 \times 2 \times 1000}{0.1 M_{solute} + 0.9 M_{solvent}}$

As Molality = Molarity

So $\frac{0.1 \times 1000}{0.9 \times M_{solvent}} = \frac{0.1 \times 2 \times 1000}{0.1 M_{solute} + 0.9 M_{solvent}}$

So 0.1 M_{solute} + 0.9 $M_{solvent}$ = 1.8 $M_{solvent}$

So $\frac{M_{solute}}{M_{solvent}} = 9$

So Ans is = 9

11. Correct order : $\underset{(+5)}{H_3PO_4} > \underset{(+4)}{H_4P_2O_6} > \underset{(+3)}{H_3PO_3} > \underset{(+1)}{H_3PO_2}$

12. Mole fraction of urea in aqueous solution = 0.05

Let number of moles of solution is = 1 mole

	Mole	**Mass**	**Volume**
Solute	0.05	3 g	
Solvent	0.95	17.1g	
Solution	1	20.1g	20.1/1.2 cm^3

Molarity = $\frac{n_{solute}}{V_{solution\ (in mL)}} \times 1000 = \frac{0.05 \times 1.2}{20.1} \times 1000 = \frac{60}{20.1}$ = 2.985

Answer after rounding off = 2.98

Answer after truncation = 2.98

PART - II

8. $BaCl_2.xH_2O \longrightarrow BaCl_2 + xH_2O$.

m_{H_2O} = 61 – 52 = 9g

$\Rightarrow$ $n_{H_2O} = \frac{9}{18} = \frac{1}{2}$

m_{BaCl_2} = 52 $\Rightarrow$ $n_{BaCl_2} = \frac{52}{208} = \frac{1}{4}$

$\Rightarrow$ simplest formula = $\frac{1}{4} : \frac{1}{2}$ = 1 : 2 $\Rightarrow$ $BaCl_2.2H_2O$

9. $n_A = 0.1$, $n_B = 1$, $n_C = 0.036$

Limiting reagent = C

$\Rightarrow n_{AB2C3}$ formed = $\frac{0.036}{3} = 0.012$

$\Rightarrow$ MM $_{(ABC23)}$ $\frac{4.8}{0.012} = 400$

$\Rightarrow 60 + 2x + 80 \times 3 = 400$

$x = 50$

10. Fluorine is the most electronegative element in periodic table hence it shows –1 oxidation state in all its compounds.

11. $C_nH_{2n+2} + \left(\frac{3n+1}{2}\right) O_2 \longrightarrow nCO_2 + (n+1)\ H_2O$

5 L 25 L

Since volumes are measured at constant T & P

So, Volume $\propto$ mole

$\therefore$ $n_{alkane} = \left(\frac{3n+1}{2}\right) \times n_{O_2}$

$5 = \frac{3n+1}{2} \times 25$

$\therefore$ n = 3

$\therefore$ Alkane is propane (C_3H_8).

12. 8 g sulphur present in = 100 g of organic compound.

$\therefore$ 32 g sulphur present in = $\frac{100}{8} \times 32 = 400$ g of organic compound.

Hence, minimum molecular weight of compound = 400 g/mol

13. $H_3AsO_4 \xrightarrow{H_2S/HCl} As_2S_5$

Assuming 100% conversion of As, apply POAC rule for 'As' atom

$1 \times n_{H_3AsO_4} = 2 \times n_{As_2O_5}$

$\frac{35.5}{142} = 2 \times n_{As_2O_5}$ $\therefore$ $n_{As_2O_5} = 0.125$ mol

14. $n_{FeCl_3} = n_{Fe(OH)_3}$

$n_{FeCl_3} = \frac{2.14}{107} = 0.2$; $M = \frac{0.2}{100} \times 1000 = 0.2$ M

15. In $[Fe(CN)_6]^{3-}$ and $[Cu(CN)_4]^{2-}$ Fe & Cu are in their highest stable oxidation state.

16. $2NaClO_3 \xrightarrow{\Delta} 2NaCl + 3O_2$

0.16 g

$\frac{n_{NaCl}}{2} = \frac{n_{O_2}}{3}$

$n_{NaCl} = \frac{0.16}{32} \times \frac{2}{3} = \frac{1}{200} \times \frac{2}{3} = \frac{1}{300}$

$NaCl \longrightarrow AgCl$

POAC of Cl

$1 \times n_{NaCl} = 1 \times n_{AgCl}$

$\frac{1}{300} = n_{AgCl}$

Weight of AgCl = $\frac{1}{300} \times [108 + 35.5] = \frac{1}{300} \times 143.5 = 0.48$ g

17. C_xH_yCl

% Cl = 3.55

Weight of Cl = $1 \times \frac{3.55}{100}$

$n_{Cl^-} = \frac{1 \times 3.55}{100 \times 35.5}$

No of Cl^- ion = $\frac{1 \times 3.55}{100 \times 35.5} \times 6.023 \times 10^{23} = 6.023 \times 10^{20}$

18. m = $\frac{92}{23} = 4$

19. $2C_{57}H_{110}O_6(s) + 163O_2(g) \longrightarrow 114CO_2(g) + 110H_2O\ (\ell)$

445 g = $\frac{1}{2}$ mole

$\frac{110}{2} \times \frac{1}{2}$ mole = $\frac{110 \times 18}{4}$ g = 495 g.

20. Moles of sucrose required = 2 × 0.1 = 0.2

wt. = 0.2 × 342 g = 68.4 g

21. $C_xH_yN_z$ (1 mole) $\xrightarrow[\text{by Dumas method}]{\text{Combustion}}$ $6CO_2$ + $1N_2$ + $4H_2O$

on applying POAC

we get the formula $C_6H_8N_2$

22. $2NaHCO_3 + H_2C_2O_4 \rightarrow Na_2C_2O_4 + 2CO_2 + 2H_2O$

Let mass of $NaHCO_3$ be x mg

n = $\frac{0.25}{25000} = 10^{-5}$

w = 84×10^{-5} g

$\% = \frac{84 \times 10^{-5}}{10^{-2}} \times 100 = 8.4\%$

23.

	$H_2C_2O_4$	+	2NaOH	$\longrightarrow$	$Na_2C_2O_4$	+	$2H_2O$
m. mol	50×0.5		M×25				

At end point $\frac{n_{H_2C_2O_4}}{1} = \frac{n_{NaOH}}{2}$

$n_{NaOH} = 2 \times n_{H_2C_2O_4}$

M×25 = 2 × 50 × 0.5 = 2M

[NaOH] = 2M

Now n_{NaOH} is 50 ml = M × V = $2 \times \frac{50}{1000}$ = 0.1 mol

mass of NaOH is 50 ml = 4 g

24. $n_1 = \frac{8}{40} = 0.2$

$n_2 = \frac{18}{18} = 1$

mole fraction of NaOH = $\frac{0.2}{1.2} = 0.167$

molality = $\frac{8}{40} \times \frac{1000}{18} = 11.11$

25. CH_4
n_C = 1 mole
n_H = 4 mole

mole percentage of C = $\frac{n_C}{n_C + n_H}$ × 100 = $\frac{1}{1+4}$ × 100 = 20%

26. In the mixture of 56 g of N_2 + 10 g of H_2, dihydrogen (H_2) acts as a limiting reagent.

27. 20 gm KI is present in 100 gm solution
Weight of solvent = 100 – 20 = 80 gm

moles of solute = $\frac{20}{166}$

molality (m) = $\frac{20}{166 \times 80} \times 1000 \approx 1.51$

28. $C_xH_y + \left(x + \frac{y}{4}\right)O_2 \longrightarrow xCO_2 + \frac{y}{2} H_2O$

10 ml 55 ml 40 ml

$\because \frac{10}{1} = \frac{40}{x}$ $\therefore$ x = 4

$\because \frac{10}{1} = \frac{55}{\left(x + \frac{y}{4}\right)} \Rightarrow$ $\frac{10}{1} = \frac{55}{\left(4 + \frac{y}{4}\right)}$ $\Rightarrow$ y = 6

Hydrocarbon is C_4H_6

29. (1) Per gram Fe, O_2 required = $\frac{3}{224}$ mole

(2) Per gram Mg, O_2 required = $\frac{1}{48}$ mole

(3) Per gram C_3H_8, O_2 required = $\frac{5}{44}$ mole

(4) 5 mole O_2 required for 1 mole P_4 (124 gm)

per gram P_4 , O_2 required = $\frac{5}{124}$ mole

30. (1) $2Cu^+ \longrightarrow Cu^{+2} + Cu^{\circ}$ is a disproportionation reaction

31. Mass of 1 mol of AB_2 : $M_A + 2M_B = 25 \times 10^{-3}$ kg
Mass of 1 mol of A_2B_2 : $2M_A + 2M_B = 30 \times 10^{-3}$ kg
$\therefore$ $M_A = 5 \times 10^{-3}$ kg/mol
$M_B = 10 \times 10^{-3}$ kg/mol

32. $X_{solvent} = 0.8$; $X_{solute} = 0.2$

m = $\frac{X_{solute}}{X_{solvent}} \times \frac{1000}{18} = \frac{0.2}{0.8} \times \frac{1000}{18} = \frac{250}{18}$ = 13.88 mol/kg

33. Mass of CO_2 = 88g

$\therefore$ Mass of C = $\frac{12}{44} \times 88 = 24g$

Mass of H_2O = 9 g

$\therefore$ Mass of H = $\frac{2}{18} \times 9 = 1g$

35. 2 × mole of Urea ≡ mole of NH_3 ....(1)

mole of NH_3 = mole of HCl ....(2)

$\therefore$ mole of HCl = 0.02 mole

37. $10 = \frac{\text{Mass of Fe (in g)}}{100 \times 1000} \times 10^6$

or , mass Fe = 1 g

$FeSO_4.7H_2O$ (M = 277.85)

55.85 g in 1 mole

1 g — $\frac{1}{55.85}$ mole $\frac{1}{55.55} \times 277.55$ g = 4.97 g

38. mol of $NaClO_3$ = mol of O_2

mol of $O_2 = \frac{PV}{RT} = \frac{1 \times 492}{0.082 \times 300} = 20$ mol

mass of $NaClO_3$= 20 × 106.5 = 2130 g

39. As in H_3PO_4 Phosphorous is present it's maximum oxidation number state hence it cannot act as reducing agent.

40. 63% w/w $\longrightarrow$ HNO_3 solution

$M = \frac{63 \times 1.4}{63 \times 100} \times 1000$ mole/L = 14 mole/L

41. ppm = $\frac{10.3 \times 10^{-3}}{1030} \times 10^6 = 10$