# PROPOSED MARKING SCHEME

## CHEMISTRY 01

## FORM SIX

1(a) i/ Hund's rule of Maximum multiplicity states that "Electron pairing in the degenerate orbital is – not allowed until each orbital is singly occupied

ii/ Aufbau principle states that "Electrons in an atom are arranged in the order of increasing orbital energies".

iii/ Wave particle duality of water means — electrons behave or possess both wave and particle properties

iv/. The Uncertainty principle states that "It is ~~impos~~ impossible to determine simultaneously both the exact position and momentum of a sub-atomic particle".

(b) Carbondioxide being linear structure (O=C=O) non-polar has zero resultant dipole moment (dipole moment cancel out) while sulphurdioxide ($SO_2$) being bent (V-shaped) in structure — possess lone pair as result of repulsion exerted by lone pair – bond pair electrons.

(c) $$RAM = \frac{\sum \text{Relative abundances} \times \text{Isotopic Mass}}{\sum \text{Abundance}}$$

$$RAM = \frac{\sum \text{number of atoms of Isotopes} \times \text{Isotopic Mass}}{\text{Total number of atoms in the sample}}$$

$$= \frac{(370 \times 7.016) + (30 \times 6.015)}{400} = 6.941.$$

∴ The average atomic mass of Lithium is 6.941

Alternatively

Find the % abundance of 30 atoms of $^{6}Li$ — 6.015g/mol in 400 sample of Lithium atoms

$$6.015g\ ^{6}Li = 30/400 \times 100\% = 75\%$$

% abundance of 370 atoms $^{7}Li$ — 7.016g/mol in 400 sample

$$^{7}Li\ (7.016g/mol) = \frac{370}{400} \times 100\% = 92.5\%$$

$$RAM = \frac{(\%\ \text{abundance} \times {}^{6}Li\ (6.015g/mol) + \%\ {}^{7}Li - 7.016)}{100}$$

$$\frac{1}{\lambda_1} = RH\left(\frac{1}{(2)^2} - \frac{1}{(3)^2}\right)$$

$$\frac{1}{656.1\,nm} = RH\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$\frac{1}{656.1\,nm} = 0.13889RH \quad \text{—— i ——}$$

$$\frac{1}{\lambda_2} = RH\left(\frac{1}{2^2} - \frac{1}{(4)^2}\right)$$

$$\frac{1}{\lambda_2} = RH\left(\frac{1}{4} - \frac{1}{16}\right)$$

$$\frac{1}{\lambda_2} = RH \times 0.1875$$

$$\frac{1}{\lambda_2} = 0.1875RH \quad \text{—— ii ——}$$

divide eqn i/ii

$$\frac{\frac{1}{656.1\,nm}}{1/\lambda_2} = \frac{0.13889RH}{0.1875RH}$$

$\frac{\lambda_2}{656.1\,nm} =$ ~~1.34989~~ 0.74075

$$RAM = \frac{(7.5 \times 6.015) + (92.5 \times 7.016)}{100}$$

$$= \frac{(45.1125) + (648.98)}{100}$$

$$= \frac{694.0925}{100} = 6.941$$

$\therefore$ Relative (average) atomic mass $= 6.941$

(d) from $\frac{1}{\lambda} = R_H \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$

Balmer series (Visible region

For first line the spectral line of Balmer series $n_1 = 2$

$n_2 = 3$

For the second line of Balmer series spectral line $n_1 = 2$

$n_2 = 4$

Wavelength of second line of Balmer series

$\lambda_2 = ?$

Wavelength of first line of Balmer series

$\lambda_1 = 656.1\,nm$

$$\lambda_2 = (656.1 \times 0.74075)\,\text{nm}$$

$$= 486.003\,\text{nm}$$

∴ Wavelength of the second spectral line — in the Balmer series 486.003nm.

2(a) vapour pressure of compound $P_G^o = 119\,\text{mmHg}$
let Mass of compound G = $M_G$
∴ let Mass of water be $M_{H_2O}$
vapour pressure of $H_2O$, $P^o_{H_2O} = 641\,\text{mmHg}$

Ratio by Mass of cpd $G/_{H_2O} = 1.62 : 1.0$

from $PV = nRT$.

Assuming that no volume change in both liquid G and water = V
Temperature for distillation $T = 95.2°c$ (constant temperature).

$$P_G V = n_G RT$$

$$n_G = \frac{P_G V}{RT} \text{ ——— i —}$$

$$P_{H_2O} V = n_{H_2O} RT$$

$$n_{H_2O} = P_{H_2O} V$$

$$n_{H_2O} = \frac{P_{H_2O}V}{RT} \quad \text{—ii—}$$

Divide eqn i/ii

$$\frac{n_G}{n_{H_2O}} = \frac{P_G V}{RT} \times \frac{RT}{P_{H_2O}V}$$

$$\therefore \frac{n_G}{n_{H_2O}} = \frac{P_G}{P_{H_2O}} \quad \text{—iii—}$$

but $n_G = \frac{\text{Mass of compound G}}{\text{Molar Mass}} = \frac{M_G}{Mr_G}$

$n_{H_2O} = \frac{\text{Mass of } H_2O}{\text{Molar Mass}} = \frac{M_{H_2O}}{Mr_{H_2O}}$

$$\frac{n_G}{n_{H_2O}} = \frac{M_G}{Mr_G} \times \frac{Mr_{H_2O}}{M_{H_2O}} = \frac{M_G}{M_{H_2O}} \times \frac{Mr_{H_2O}}{Mr_G}.$$

$$\frac{P_G}{P_{H_2O}} = \frac{M_G}{M_{H_2O}} \times \frac{Mr_{H_2O}}{Mr_G}$$

But $\frac{M_G}{M_{H_2O}} = \frac{1.62}{1}$

Moles of $N_2$ reacted = 1 mol

Moles of $H_2$ were = 4 moles but requiered for complete reaction in reaction ratio were 3 moles (all nitrogen reacted).

∴ Remained moles of $H_2$ after reaction

= (4 moles − 3 moles) = 1 mole of $H_2$.

$N_2$ is the limiting while $H_2$ are in excess.

Reaction ratio of $H_2$ and $NH_3$ produced after reaction

~~$3H_2$~~ : 1 mol of $H_2$ : 2 mol of $NH_3$.

Then Total number of moles in the flask remained = moles of ($H_2$ + moles $NH_3$)

= 1 mol of $H_2$ + 2 mol of $NH_3$

= 3 moles

Pressure exerted by a gas $P_T$ = ?

number of moles of gas $n_T$ = 3 moles

Volume of flask = 2400 $cm^3$

= 2.4 $dm^3$

Universal gas constant, R = 0.0821 atm $dm^3 mol^{-1} K^{-1}$

Temperature, T = 0.15 °C

= (273 + 0.15) K

= 273.15 K

from PV = nRT

$$\frac{P_G}{P_{H_2O}} = \frac{1.62}{1} \times \frac{Mr_{H_2O}}{Mr_G}$$

Molarmass of water $Mr_{H_2O} = 18g/mol$

$$\frac{119mmHg}{641mmHg} = \frac{1.62}{1} \times \frac{18g/mol}{Mr_G}$$

$$\frac{119}{641} = \frac{(1.62 \times 18)g/mol}{Mr_G}$$

$$Mr_G = \left(\frac{641 \times 1.62 \times 18}{119}\right) g/mol$$

$$= \left(\frac{18691.56}{119}\right) = 157.07g/mol$$

∴ Molecular mass of compound $G = 157.07g/mol$

(b) Reaction

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

Reaction ratio $H_2 : N_2$

$= 3$ moles f $H_2$ : 1 mole f $N_2$

Assuming the gas $(CO_2)$ behave ideally

$PV = nRT$.

$$n_{CO_2} = \frac{PV}{RT} = \frac{(1.3 \times 0.25)}{(0.0821 \times 304)}$$

$$= \left(\frac{0.325}{24.9584}\right) \text{moles}$$

number of moles of $CO_2$ = 0.01302 moles of $CO_2$.

= 0.01302 moles X Molar mass of $CO_2$

= 0.01302 mol X 44g/mol

= 0.573g of $CO_2$.

Since ratio of $CaCO_3$ decomposed with ~~1 mol of~~ respect to $CO_2$ produced were in 1 : 1

1 mol $CaCO_3$ : 1 mol $CO_2$.

0.0132 moles of $CO_2$ ≡ 0.01302 mol $CaCO_3$.

= 0.013 moles X Molar mass of $CaCO_3$

= 0.01302 mol X 100g/mol = 1.302g of $CaCO_3$.

Then 100g ~~of~~ $CaCO_3$ ≡ 56g of CaO

1.302g ≡ ?

$$P = \frac{nRT}{V}$$

$$P_T = \frac{3\,mol \times 0.0821\,atm\,dm^3\,mol^{-1}K^{-1} \times 273.15\,K}{2.4\,dm^3}$$

$$= \left(\frac{67.276845}{2.4}\right) atm$$

$$= 28.032\,atm$$

∴ Total pressure of the final mixture is 28.032 atm.

(c) Given Volume, $V = 0.25L$

Pressure of gas, $P = 1.30\,atm$

Temperature, $T = 31°C$

$= (31+273)$

$= 304K$

Universal gas constant $R = 0.0821$

Mass of calcium oxide $m = ?$

from moles of $CO_2$ produced $n_{CO_2} = ?$

$$CaCO_{3(s)} \xrightarrow{304K} CaO_{(s)} + CO_{2(g)}$$

$CO_2 + H_2O \longrightarrow H_2CO_3$

$H_2CO_3 \rightleftharpoons 2H^+ + CO_3^{2-}$

iii/ Application of industrial acidic fertilizer ie $(NH_4)_2SO_4$ and $NH_4Cl$

This is due to cationic salt hydrolysis that increases acidity

$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$

$NH_4^+ + H_2O \rightleftharpoons NH_4OH + H^+$

iv/ The presence of soluble cations of aluminum ion, Iron (III) ions in the soil.

$Al^{3+} + H_2O \rightleftharpoons Al(OH)_3 + H^+$

$[Al.(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Al(H_2O)_5OH]^{2+} + H_3O^+$

(v) Industrial emission of gases such as $SO_2$ and $NO_2$.

The above gases ($SO_2$ and $NO_2$) react with rain water in atmosphere forming acidic rain which fall and precipitate in the soil

$NO_2 + H_2O \rightleftharpoons HNO_3 + HNO_2$

$NO_2 + H_2O \rightleftharpoons H_2SO_4 \rightleftharpoons 2H^+ + SO_3^{2-}$

$$= \left(\frac{1.302 \times 56}{100}\right) g$$

$$= \frac{72.912}{100} g$$

$= 0.729129$ of cao

∴ Mass of calcium oxide (CaO) $= 0.729129$

3(a) i/ Atmospheric carbon dioxide, reacts with rain water to form weak carbonic acid which fall as precipitates in the soil. Carbonic acid dissociate to form hydrogen ions and carbonate ions

$CO_2$ + Rain water $(H_2O) \longrightarrow H_2CO_3$ (Carbonic acid)

$H_2CO_3 \rightleftharpoons 2H^+ + CO_3^{2-}$

ii/ Decay of organic matter in soil Decompose in the soil with help of Microbes producing water and carbon dioxide which combine with soil moisture to form carbonic acid

~~$CO_2$~~ $CH_2O$ (organic matter) $+ O_2 \xrightarrow{Microbes} CO_2 + H_2O$

HCl is present in excess while NaOH is limiting reagent

Excess moles of HCl $= 3\times10^{-3}$ moles $- 1.5\times10^{-3}$ moles
$= 1.5\times10^{-3}$ moles.

Since are in 1 NaOH : 1 HCl

Then 1 Mol of HCl $\equiv$ 1 Mol of NaOH
$1.5\times10^{-3}$ mol $\equiv$ ?

$= 1.5\times10^{-3}$ mol NaOH

$1.5\times10^{-3}$ Moles of HCl $\equiv$ Sum of Exchangeable base cations of NaOH ($\Sigma$EBC).

$1.5\times10^{-3}$ Moles of Exchangeable base cations of NaOH $= 1.5\times10^{-3}$ eq $= 1.5$ meq/10g of oven dry soil.

$1.5$ meq $\equiv 10$g
$\Sigma n_B \equiv 100$g

$$= \frac{1.5\text{ meq} \times 100\text{g}}{10\text{g}}$$

$\Sigma n_B = 15$meq
Where $\Sigma n_B$ is exchangeable base cations in 100g of the oven dry soil $=$ ~~15m~~ 15meq

from $PBS = \frac{\Sigma n_B}{C.E.C} \times 100\%$

$$= \frac{15\text{meq}}{35\text{meq}} \times 100\% = 42.86\%$$

$\therefore$ Percentage base saturation (PBS) $= 42.86\%$

vi) Root respiration

It involves oxidation of carbohydrates into carbondioxide gas that reacts with soil water to yield carbonic acid which increases acidity

vii) Nitrification of ammonium ions by ~~aer~~ aerobic bacteria to produce hydrogen ions

- It involve conversion of ammonia or ammonium ions into nitrates or nitrites and hydrogen ions that account for soil acidity

(b) To find moles of each reagent

from $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(s)} + H_2O_{(l)}$

Moles of acid

$0.1\ Mol \equiv \cancel{10}\ 1L$ $= (0.1 \times 30 \times 10^{-3})$ Moles

$? \times 30 \times 10^{-3} L$

$= 3 \times 10^{-3}$ Moles

For ~~N~~ Base.

Moles of Base

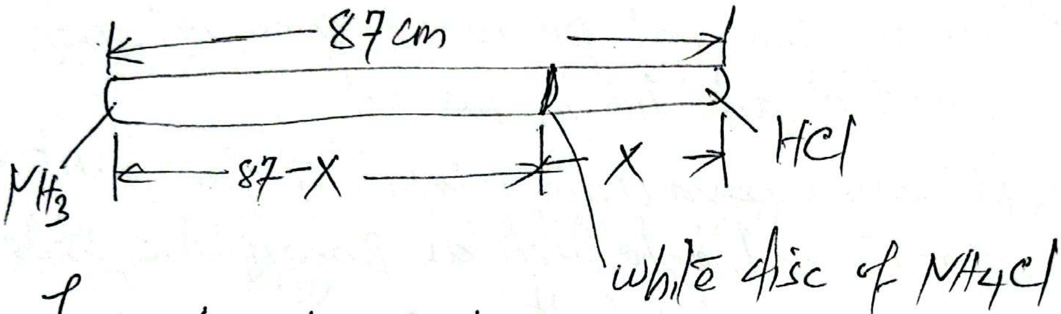
$0.1\ Mol \equiv 1L$ $= (0.1 \times 15 \times 10^{-3})$ Moles

$? \equiv 15 \times 10^{-3} L$

$= 1.5 \times 10^{-3}$ Moles

Since number of moles of HCl is greater than moles of base, and they react in 1 : 1 Then

(b) let distance for diffusion of ammonia ($d_1$) be X
distance for HCl to diffuse, $d_2$ be 87-X
Distance of ~~cotton wool~~ glass tube = 87cm
Molar mass of ammonia, $NH_3$ ($Mr_{NH_3}$) = 17g/mol
Molar mass of HCl ($Mr_{HCl}$) = 36.5g/mol



from Graham's law

$$\frac{d_1}{d_2} = \sqrt{\frac{Mr_{HCl}}{Mr_{NH_3}}}$$

$$\frac{X\,cm}{(87-X)\,cm} = \sqrt{\frac{36.5g/mol}{17.0g/mol}}$$

$$\frac{X}{87-X} = \sqrt{\frac{36.5}{17.0}} = 51.72\,cm$$

∴ Distance through which ammonia moistened plug does occur is 51.72cm.

(c) i/ Negative effects of repeated irrigation

- It cause washing away of soluble plant nutrients through leaching process making soil acidic.

ii/ Negative effects of overliming

- It causes drying out of soil
- Increases the soil PH which does not support microbial activities in the soil
- It causes ~~inva~~ unavailability for plant-growth nutrients such as Boron, zinc, phosphorous and Cobalt.

4 (a) i/ Because at low pressure and high temperature real gases molecules are far apart in such a way that no significant intermolecular force of attraction between gas particles and the volume of gas molecules, almost negligible making real gas behave as ideal gas.

ii/ In solid, the particles are closely packed and the empty space between the particles are very small therefore solids are incompressible and maintain their shape when subjected to ~~out~~ external force, hence solids are rigid.

iii/ Intermolecular forces between particles in the solid state are very strong, therefore are strongly held at fixed position and particles can not separate from one another, hence solid have definite volume.

2i) Born Haber cycle is the thermal chemical cycle which shows different routes which shows how solid-crystal lattice compounds are formed from their simple elements in their normal physical.

Application of Born Haber cycle.

- Used to determine lattice energy of ionic crystal compounds.

(b). $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$ $\Delta H = -92.2\ kJmol^{-1}$

$\Delta H_{rexn} = \sum H_{formation\ of\ products} - \sum H_{formation\ of\ reactants}$

$\Delta H_r = 2\Delta H_f(NH_3) - \Delta H_f(N_2) + 3\Delta H_f(H_2)$.

Heat of formation of free elements are equal to zero

$-92.2\ kJmol^{-1} = 2\times\Delta H_f(NH_3) + (3\times0)$

$-92.2\ kJmol^{-1} = 2\Delta H_f NH_3 + 0$

$\frac{-92.2\ kJmol^{-1}}{2} = \frac{2\Delta H_f}{2}$

$\Delta H_{f_{NH_3}} = -46.1\ kJmol^{-1}$.

$\therefore$ Enthalpy of formation of Ammonia $= -46.1\ kJmol^{-1}$.

(c) Compressibility factor is the factor that expresses the extent or degree of deviation of real gases from ideality.

i/ When compressibility factor of gas is less than one it shows the gas deviates negatively from ideality, that means the gas deviates more from ideality and repulsive intermolecular forces pre-dominates.

ii/ When compressibility factor of a gas is greater than one it shows the gas deviates positively from ideality, means that the gas deviates less from ideality and attractive intermolecular forces pre-dominates.

iii/ When compressibility factor is equal to one it shows that gases behaves as an ideal gas attractive intermolecular force and repulsive ~~force~~ intermolecular forces cancel each other

5 (a) This is because in chemical reactions there are two processes which occur, the Bond breaking in reactants which requires (absorbs) heat from surrounding and Bond formation (formation of products) which releases/liberate heat to the surroundings. The two process accompanied by changes in masses of reactant and products.

$\Delta H_{C_2H_2} = (4 \times -393.5) + (2 \times -285.8) + (2598)\ kJmol^{-1}$

$= -1574\,kJmol + -571.6\,kJmol^{-1} + 2598.8\,kJmol^{-1}$

$= -2145.6\,kJmol^{-1} + 2598.8\,kJmol^{-1}$

$= (2598.8 - 2145.6)\,kJmol^{-1}$

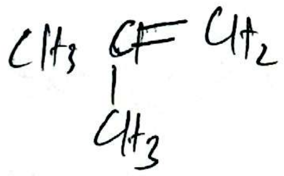
$= 453.2\,kJmol^{-1}$

∴ Standard Enthalpy of formation f acetylene is $453.2\,kJmol^{-1}$.

6 (a) i/ Possible Isomers f M are;

$CH_3CH_2CH=CH_2$ But-1-ene

$CH_3CH=CH-CH_3$ But-2-ene

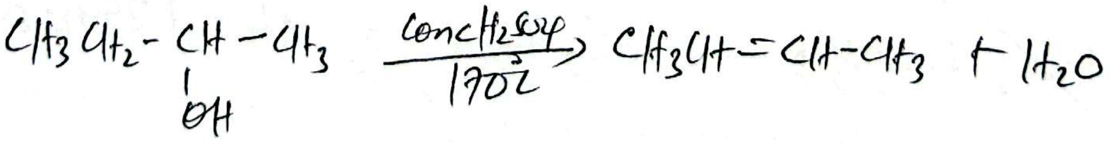


$CH_3\underset{\underset{CH_3}{|}}{C}=CH_2$ 2-Methylpropene

ii/ Compound M is $CH_3CH=CH-CH_3$ (But-2-ene)

Compound N is $CH_3COOH$ (ethanoic acid) (or acetic acid).

iii/



$CH_3CH_2-\underset{\underset{OH}{|}}{CH}-CH_3 \xrightarrow[170°C]{conc\,H_2SO_4} CH_3CH=CH-CH_3 + H_2O$

$CH_3CH=CH-CH_3 + O_3 + H_2O \longrightarrow CH_3COOH$.

(c). Formation of $C_2H_2$.

$2C + H_2 \longrightarrow C_2H_2$.

Given

i) $C + O_2 \longrightarrow CO_2 \quad \Delta H = -393.5\,kJmol^{-1}$.

ii) $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O \quad \Delta H = -285.8\,kJmol^{-1}$.

iii) $2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O. \quad \Delta H = -2598.8$

Inverse eqn iii

$$\begin{aligned} 4\times &\left\{ C + O_2 \longrightarrow CO_2 \quad \Delta H = -393.5\,kJmol^{-1} \right. \\ 2\times &\left\{ H_2 + \tfrac{1}{2}O_2 \longrightarrow H_2O \quad \Delta H = -285.8\,kJmol^{-1} \right. \\ & \quad 4CO_2 + 2H_2O \longrightarrow 2C_2H_2 + 5O_2 \quad \Delta H = +2598.8\,kJmol^{-1} \end{aligned}$$

$$\left\{ \begin{aligned} &4C + 4\cancel{O_2} \longrightarrow \cancel{4CO_2} \quad \Delta H = 4\times -393.5\,kJmol^{-1} \\ &2H_2 + \cancel{O_2} \longrightarrow \cancel{2H_2O} \quad \Delta H = 2\times -285.8\,kJmol^{-1} \\ &\cancel{4CO_2} + \cancel{2H_2O} \longrightarrow 2C_2H_2 + 5\cancel{O_2} \quad \Delta H = +2598.8\,kJmol^{-1} \end{aligned} \right.$$

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$4C + 2H_2 \longrightarrow 2C_2H_2 \quad (4\times -393.5) + (2\times -285.8) + (2598.8)\,kJmol^{-1}$

- Some metal hydroxides are used in extraction of metals from their ores. ie Sodium hydroxide used in extraction of aluminium from Bauxite ore.

- Some metal hydroxides used in the manufature of paints. Forexample Calcium hydroxide is used in manufacture of undercoat paints which are applied as first coat on plaster walls.

- Some metal hydroxides are used in soap manufacturing ie palmitic acid)

- metal hydroxides play a significant role in production of building materials ie NaOH used in manufacturing artificial textile fibres, dyes.

(b) i) Sodium carbonate is soluble carbonate which is prepared from reaction between sodium hydroxide solution and carbon dioxide

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

ii/ Zinc carbonate is an insoluble carbonate which is prepared by precipitation reaction from ~~the~~ which soluble salt of zinc like $ZnCl_2$ reacts with any soluble carbonate such as sodium carbonate

$$ZnCl_2 + Na_2CO_3 \longrightarrow ZnCO_3\downarrow + 2NaCl$$

(b) i/

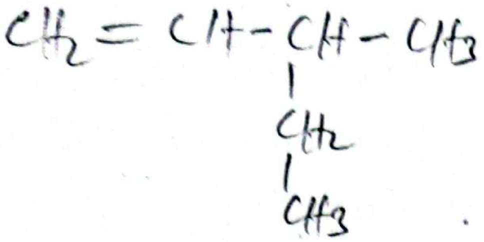
$$\begin{tikzcd}
CH_2=CH_2 \arrow[r] \arrow[d, "H_2O/H_2SO_4"] & CH_3CH_2\text{-}O\text{-}CH_2CH_3 \\
CH_3CH_2OH \arrow[ru, "\text{Conc } H_2SO_4", "140°C"'] &
\end{tikzcd}$$

ii/

$$\begin{tikzcd}
CH_3CH_2CH_3 \arrow[r] \arrow[d, "Cl_2/UV"] & CH_3\overset{Br}{C}H\text{-}CH_3 \\
CH_3CH_2CH_2Cl \arrow[r, "Alc.KOH"] & CH_3CH=CH_2 \arrow[u, "HBr"']
\end{tikzcd}$$

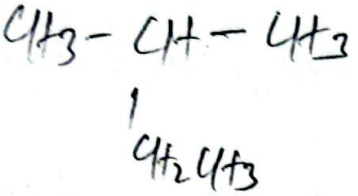
7(a) Uses of metal hydwxides

- Some metals ~~used~~ hydwxides such as $Ca(OH)_2$, NaOH, KOH etc are used in agriculture as liming materials to neutralize the soil acidity
- Some metal hydwxides are used in hospitals to give relief to patients ie ~~magnesium~~ Milk of magnesia used to neutralize stomach acid.
- Some metal hydwxide such as $Ca(OH)_2$ used in softening water by removing temporary hardness of water caused by calcium carbonate.
- Some metal hydwxide used in qualitative analysis ie $Ca(OH)_2$ used in both biology and chemistry to test presence of carbondioxide, NaOH used to test metal cation such as zinc, lead, aluminium ions etc

iv/ 

$$CH_2=CH-\underset{\underset{CH_3}{|}}{\underset{CH_2}{|}}{CH}-CH_3$$

3-Methylpent-1-ene

v/ 

$$CH_3-\underset{CH_2CH_3}{\underset{|}{CH}}-CH_3$$

2-Methylbutane.

(b) $$\underset{\underset{10cm^3}{\downarrow}}{C_xH_y} + \underset{\underset{(V_{O_2 used \atop for combustion} + V_{O_2 excess}}{\downarrow}}{\left(x+\frac{y}{4}\right)O_2} \longrightarrow \underset{\underset{40cm^3}{\downarrow}}{xCO_2} + \frac{y}{2}H_2O$$

$\delta V$ = Volume contraction = $25cm^3$

Volume of carbon dioxide produced $V_{CO_2} = 40cm^3$.

Volume of $O_2$ used for combustion $V_{O_2 used} = ?$

from Volume of $C_xH_y$, $V_{C_xH_y} = 10cm^3$.

$$\delta V = \left(V_{O_2 used \atop for comb} + V_{C_xH_y}\right) - V_{CO_2}$$

$$25 = \left(10 + V_{O_2 used}\right) = 40cm^3.$$

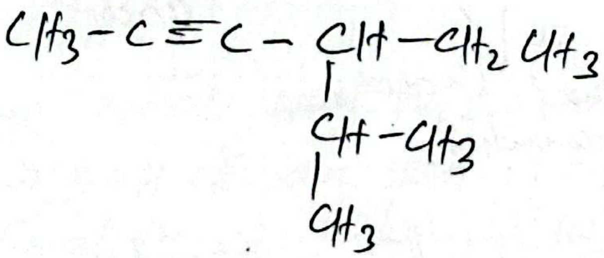
(c) i/ The gas tested in laboratory using calcium hydroxide solution (lime water). When carbon dioxide gas is passed through lime water solution the white precipitates of calcium carbonate which appear as milky are formed in the solution.

$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3$ white ppt $+ H_2O$

ii/ $NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$.

## SECTION B.

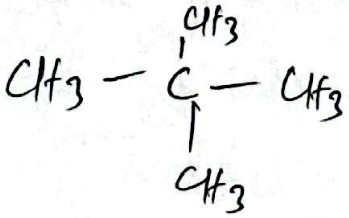
8 ⓐ i/



$CH_3-C\equiv C-\underset{\underset{\underset{CH_3}{|}}{CH-CH_3}}{\overset{}{\underset{|}{CH}}}-CH_2CH_3$

4-ethyl-5-methylhex-2-yne

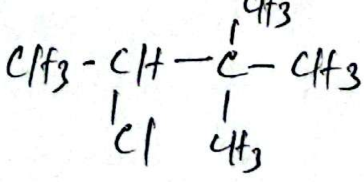
ii/



$CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_3$

2,2-dimethylpropane.

iii/



$CH_3-\underset{\underset{Cl}{|}}{CH}-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-CH_3$

3-chloro-2,2-dimethylbutane.

$$\left(x + \frac{y}{4}\right) = 5.5$$

but $x = 4$

$$4 + \frac{y}{4} = 5.5$$

$$\frac{y}{4} = 5.5 - 4$$

$$4 \times \frac{y}{4} = 1.5 \times 4$$

$$y = 6 \text{ ——— ii ——}$$

$C_4H_6$

∴ The value of $x = 4$, $y = 6$
compound is $C_4H_6$.

(c) $CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$

$$\underset{0.64g}{\downarrow} \qquad \underset{200mL}{\downarrow}$$

Temperature $T = 27^\circ C$

$= 27 + 273$

$= 300K$

Volume $= 200 \times 10^{-3}$ L

Universal gas constant $R = 0.0821$

Number of moles, $n = ?$

$25 = 10 + V_{O_2\,used} - 40$

$V_{O_2\,used} = (25+40)\,cm^3 - 10\,cm^3$.

$V_{O_2\,used} = (65-10)\,cm^3$

$= 55\,cm^3$

Volume of Oxygen used for combustion

$= 55\,cm^3$

Then ~~$xV_{CO_2} = 40$~~ from

Avogadro's law $n \propto V$

from

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

1 mol of $C_xH_y$ ≡ ~~Ho~~ x mol of $CO_2$.

10 mol of $C_xH_y$ ≡ ?

$\frac{10x}{10} = \frac{40}{10}$

$x = 4$ —— i ——

$\frac{10}{10}(x+\frac{y}{4}) = \frac{55}{10}$

$x + \frac{y}{4} = 5.5$

9

| (a) Cryoscopic constant | Ebullioscopic constant |
|---|---|
| This is a depression of freezing point of solution due to dissolution of non-volatile solute | This is the boiling point of solution increased when one mole of solute is added in 1000g of solvent. |

(b) ∴ let mass m of both solvent be x and y.

$\left(\frac{\Delta P}{P^o_X}\right)$ be relative lowering vapour pressure of X

~~Since~~ mass of x and y = m (the same).

$\left(\frac{\Delta P}{P^o_y}\right)$ be relative Lowering vapour pressure of y.

find ratio of molecular weight of two solvents $(Mr_X : Mr_y)$.

from $\frac{\Delta P}{P^o_X} = \frac{M_X}{Mr_X} \times \frac{Mr_y}{M_y} = n_y / n_X$.

$$\frac{\Delta P}{P^o_{y}} = 2\left(\frac{\Delta P}{P^o_X}\right) \text{ —— i ——}$$

Pressure $P = 1\,atm$
Assume the gas behave ideally
Mass of $CaC_2$ impure $= 0.64g$.
$PV = nRT$

$n = \frac{PV}{RT} =$ ~~$1\,atm \times 0.0821$~~

$$= \frac{1\,atm \times 200 \times 10^{-3}\,L}{0.0821 \times 300K}$$

$= 8.12 \times 10^{-3}$ moles

$CaC_2$ and $C_2H_2$ reacts in $1:1$.

1 mole of $CaC_2 \equiv 1$ mole of $C_2H_2$.
$? \equiv 8.12 \times 10^{-3}$ mole

$= 8.12 \times 10^{-3}$ moles of $CaC_2$.

Mass of $CaC_2$ ~~Impure~~ pure $= n \times$ Molar mass of $CaC_2$.
$= 8.12 \times 10^{-3}$ moles $\times 64\,g/mol$
$= 0.52g$ of $CaC_2$.

% purity of $CaC_2 = \frac{\text{pure mass of } CaC_2}{\text{Impure mass of } CaC_2} \times 100\%$

$= \frac{0.52g}{0.64g} \times 100\% = 81.25\%$

∴ % purity of calcium carbide is $81.25\%$.

$2 M_{rx} = M_{ry}$

$$\frac{M_{rx}}{M_{ry}} = \frac{1}{2}$$

$\therefore M_{rx} : M_{ry} = 1 : 2$

(c): ~~$M_s$ =~~ Mass f solute $M_s = 0.96g$

freezing point $\Delta T_f = 0 - {}^-0.5065°C$

$\Delta T_f = 0.5065°C$

Freezing point constant $K_f = 1.86°C\,kg/mol$

Mass f water = ?

Volume f water $V = 150\,cm^3$

Density $\rho = 1g/cm^3$

Mass of solvent $= 150cm^3 \times 1g/cm^3$

$= 150g = 150 \times 10^{-3} kg$

from $\Delta T_f = m K_f$

For solution X

$$\frac{\delta P}{P_X^\circ} = \frac{n_A}{n_X} = \cancel{M_{rX}}\frac{M}{M_{rA}} \times \frac{M_{rX}}{M}$$

$$\frac{\delta P}{P_X^\circ} = \frac{M_{rX}}{M_{rA}} \quad \text{— i —}$$

$$\frac{\delta P}{P_y^\circ} = 2\left(\frac{\delta P}{P_X^\circ}\right) = \frac{M}{M_{rA}} \times \frac{M_{ry}}{M}$$

$$\left(\frac{\delta P}{P_y^\circ}\right) = 2\left(\frac{\delta P}{P_X^\circ}\right) = \frac{M_{ry}}{M_{rA}} \quad \text{— ii —}$$

divide eqn i/ii

$$\left(\frac{\delta P}{P_X^\circ} \times \frac{P_X^\circ}{2\,\delta P}\right) = \frac{M_{rX}}{M_{rA}} \times \frac{M_{rA}}{M_{ry}}$$

$$\left(\frac{1}{2}\right) = \frac{M_{rX}}{M_{ry}}$$

$$\Delta T_f = \frac{M_s \times 1000}{M_v \times M_{rs}} \times K_f$$

$$= \frac{M_s \times 1\,kg \times K_f}{M_v \times M_{rs}}$$

$$\frac{0.5065}{T} = \frac{0.96 \times 1 \times 1.86}{1 \times 10^{-3}\, 150 \times M_{rs}}$$

$$M_{rs} = \frac{0.96 \times 1.86}{150 \times 10^{-3}\, kg \times 0.5065}$$

$$= 23.5$$

Molar mass of fruit = 23.5 g/mol

$$\left(\frac{\Delta P}{Px^0}\right)_1 = \frac{Mr_x \times a}{m \times Mr}$$ (½ mark)

$$Mr_x \div Mr_y = 1:2$$ (½ mark)

9(c)

(c)Data given

Mass of a non-volatile solute $(m_a) = 0.50g$

Vapour pressure of pure benzene $(p^0{}_b) = 0.850\ bar$

Mass of benzene $(m_b) = 39.00g$

The vapour pressure of the solution $(P_s) = 0.845\ bar$

Asked to find the relative molecular mass of the solid substance $(Mr_a)$ =?

**Solution**

From the Roult's law of relative lowering of vapour pressure

$$\frac{p^0{}_b - Ps}{p^0{}_b} = \frac{Mr_b \times m_a}{m_b \times Mr_a}$$ (2 marks)

$$Mr_a = \frac{Mr_b \times m_a \times p^0{}_b}{(p^0{}_b - Ps)m_b} = \frac{78 \times 0.5 \times 0.850}{(0.850 - 0.8450)39} = 252.1056 g/mol = 170$$ (3 marks)

Therefore, the relative molecular mass of the non-electrolyte solid substance is ~~252.1056~~ 170