KAMSSA 2022 CHEM 2 MARKING GUIDE

QUESTION ONE

(a)

Mass of hydrogen in 0.06279 of compound **Y**

= mass of hydrogen in water in water= 2/18X 0.036

0.004g

22400 cm^3 of CO_2 weigh 44g

29.88 cm^3 of CO_2 weigh $\left(\frac{44}{22400} x\ 29.88\right) g$

$= 0.058679$ g

Mass of Carbon in 0.02099 of compound **Y**

= mass of carbon in $CO_2 = \frac{12}{44}$x 0.05869

0.016g

Either:

0.0209g of Y contain 0.016g 0f carbon

0.0627g of Y contain $\left(\frac{0.016}{0.0209}\ x\ 0.0627\right)$g of carbon

=0.048g of carbon

0.048g of carbon Mass of Oxygen in organic compound Y

= 0.0627-(0.048+0.004) = 0.0107g

Elements	C	H	O
Moles	$\frac{0.048}{12}$	$\frac{0.004}{1}$	$\frac{0.0107}{16}$
	=0.004	=0.004	$=6.6875\times10^{-4}$
Mole ratio	$\frac{0.004}{6.6875x10^{-4}}$	$\frac{0.004}{6.6875x10^{-4}}$	$\frac{6.6875x10^{-4}}{6.6875x10^{-4}}$
	=5.95	=5.98	=1
	6	6	2

Alternatively:

0.0627g of Y Contain 0.004g of hydrogen

0.0209g 0f y contain $\left(\frac{0.004}{0.0627} x0.0209\right)$g of H = 0.00133g

Mass of Oxygen in compound Y = 0.0209-(0.00133 +0.016) =0.00357g

Elements	C	H	O
Moles	$\frac{0.061}{12}$	$\frac{0.00133}{1}$	$\frac{0.00357}{16}$
	=0.00133	=0.00133	=0.000223
Mole ratio	$\frac{0.00133}{0.000223}$	$\frac{0.00133}{0.000223}$	$\frac{0.000223}{0.000223}$
	=5.95	=5.96	=1
	6	6	2

Empirical formula is C_6H_6O

(b) $\frac{W_{H2O}}{W_Y} = \frac{P^O_{H2O}}{P^O_Y} x \frac{M_{H20}}{M_Y}$

Where W_{H2O} is mass percentage of water= 72.1%

W_Y is mass percentage of Y = 100-72.1= 27.9%

P^O_{H2O} is the vapour pressure of water= 707mmHg

$P^o{}_y$ is the vapour pressure of Y = (760-707) = 53mmHg

M_{H2O} is molar mass of water = (2+16)=18
M_Y is molar mass of Y = ?

$$\frac{72.1}{27.9} = \frac{707x18}{53xM_Y}$$

M_Y= 92.9g

(C_6H_6O)n = 92.9

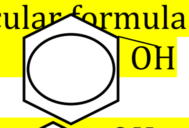
72n + 6n + 16n = 92.9

n = 0.988

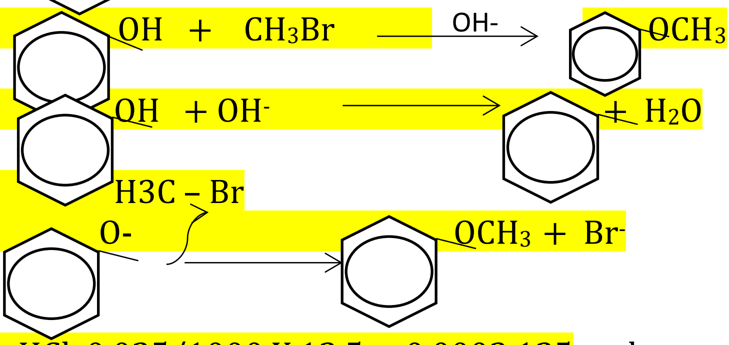
1

Molecular formula of Y is C6H6O

(ii)



(iii)



(c)

Moles HCl 0.025/1000 X 12.5 =0.0003 125 moles

HCl (aq) + NH_3 (aq) ⟶ NH_4Cl (aq)

Moles of NH3 that reacted = 1x00003125= 0.0003125

Concentration of ammonia. in the organic (CCl_4) layer at equilibrium.

=0.0003125/ 25 X1000 = 0.0125 M

Moles of HCl =0.25/1000x20= 0.005 moles

$$KD = \frac{NH3_{CCl4}}{NH3_{aq\ free}}$$

[NH3] Free that layer = $\frac{[NH3]_{CCl4}}{KD} = \frac{0.0125}{0.04}$ = 0.3125M

Then [NH_3] that complexed with Zn^{+2}

= [NH_3] in aqueous layer - [NH_3] free in aqueous layer

= 0.4 – 0.3125 = 0.0875 $moldm^{-3}$

From Zn^{+2} (aq) + $4NH_3$(aq) ⟶ $Zn(NH_3)_4{}^{+2}$(aq)

The concentration of Zn^{2+} = 1/4x0.0875 = 0.021875 moles

Zn(s) + H^+ (aq) ⟶ Zn^{+2} (aq) + H_2(g)

Moles Zinc ions in 500 cm^3 = 0.021875/1000 X 500 = 0.0109 moles

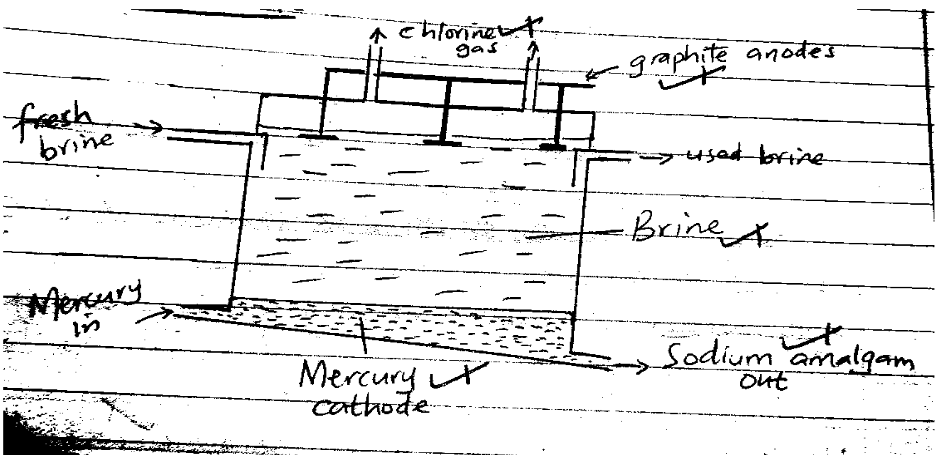
Moles of Zinc in the ore = 0.0109x 1 = 0.0109 moles

Mass of Zinc in ore = 0.0109 × 64.5= 0.703g

Percentage purity of Zinc the are = 0.703/ 3.0 X 100 = 23.43%

QUESTION TWO

Chlorine is manufactured by electrolysis of bring using graphite (carbon) anodes and mercury cathode.



The chloride ions migrate (are attracted) to the anode (positive electrode) and become discharged to liberate chlorine gas.

$2Cl^- (aq) \rightarrow Cl_2(g) + 2e$

$2Cl^- (aq) - 2e \rightarrow Cl_2(g)$

b) (i) $2Cl_2 + 2H_2O \rightarrow 4HCl(aq) + O_2(g)$

(ii) Cl_2 (g)) + 2NaOH (aq) → NaCl (aq) + NaOCl (aq) + H_2O(aq)

(iii) $Cl_2(g) + Na_2SO_3(aq) +$ H2O $\rightarrow Na_2SO_4(aq) + 2HCl(aq)$

Or $Cl_2(g) + SO_3{}^{2-}(aq) + H_2O \rightarrow SO_4{}^{2-} (aq) + 2HCl(aq)$

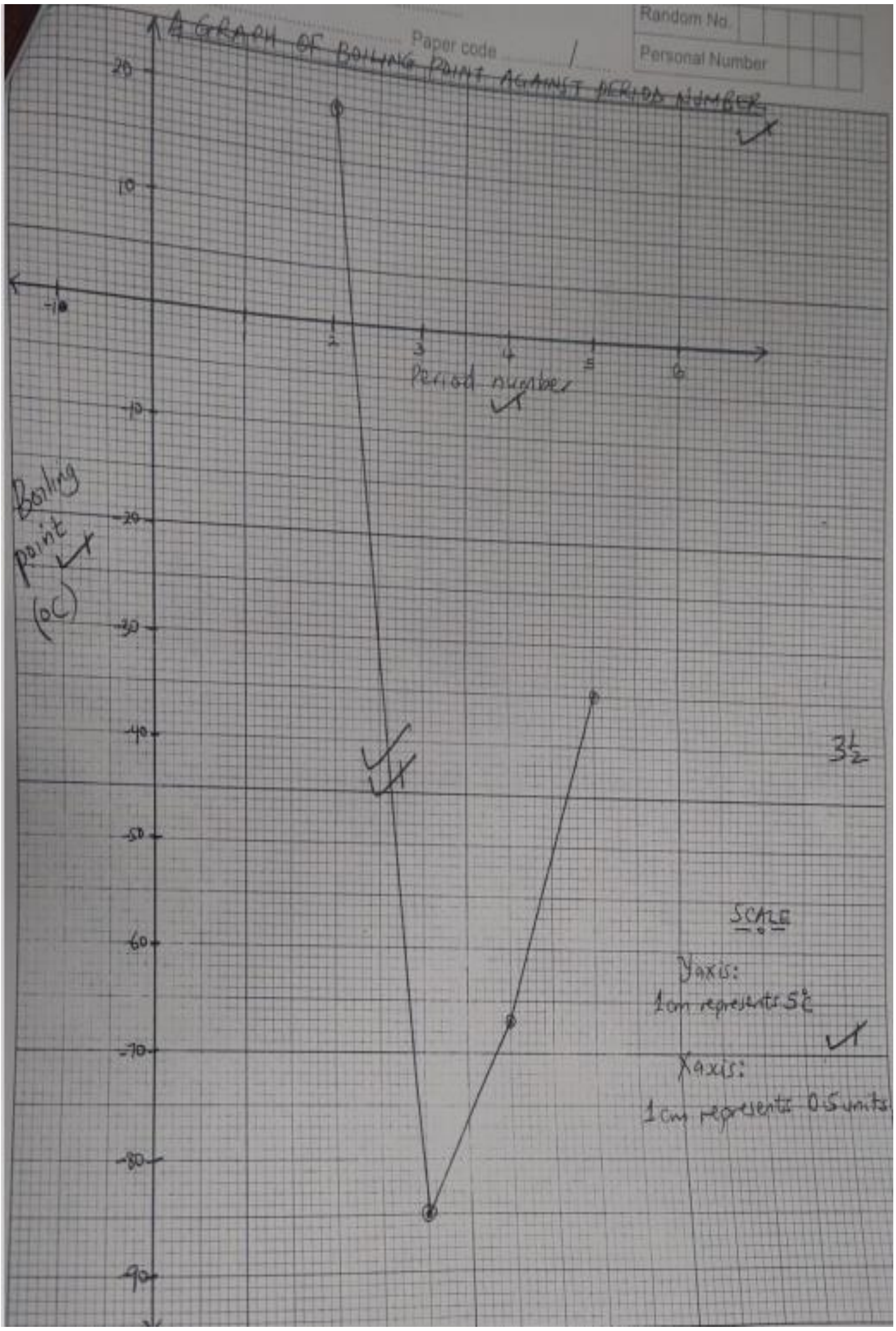
Or $Cl_2(g) + SO_3{}^{2-}(aq) + H_2O \rightarrow SO_4{}^{2-} (aq) + 2H^+(aq) + 2Cl^-(aq)$

Or $Cl_2(g) + SO_3{}^{2-}(aq) + H_2O \rightarrow H_2SO_4 (aq) + 2Cl^-(aq)$

Or $Cl_2(g) + Na_2SO_3(aq) +$ H2O $\rightarrow H_2SO_4(aq) + 2NaCl (aq)$

(c)

Graph



(i) See graph paper attached

(ii) Generally the boiling points of the hydrides of group VII elements increase down the group.

The molecular mass of the hydrides generally increases down the group. This leads to an increase in the magnitude and strength of the Van der Waal's forces of attraction. Consequently more heat energy is required to break these forces of attraction leading to an increase the boiling points. However due to the small atomic radius of both fluorine and hydrogen together with the high electronegativity of fluorine atom, the hydrogen to fluorine bond is highly strongly polar. This leads to the formation of strong it hydrogen bonds between hydrogen fluoride molecules. Hence a lot of heat energy is required to break these bonds leading to an abnormally high boiling point.

(iii) The acidic strength of the hydrides of t group VII elements increases down the group. The atomic radius of the halogens increases down the group. This increases the hydrogen to halogen bond length such that it becomes weaker and can more easily be broken. Hence protons become more easily released and the acidic strength increases.

QUESTION THRE

(d)(i) Neutral Iron (iii) chloride solution

A **violet solutions** formed with both organic compounds.

(ii) Bromine water

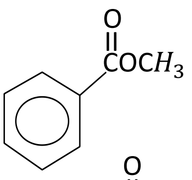
A white precipitate is observed with compound X (phenol) and observable change with 2,4,6-trinitrophenol.

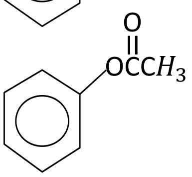
OR O Sodium carbonate solution or

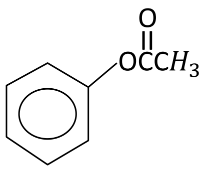
Sodium hydrogen carbonate solution.

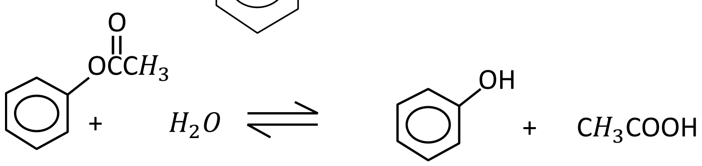
kkik

Bubbles of a colourless gas are evolved with 2,4,6-trinitrophenol and no observable change with phenol.

(a)  methylbendazoate

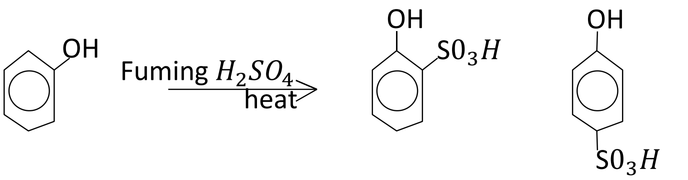
 Phenylethanoate

(b) W is  Or phenylethanoate

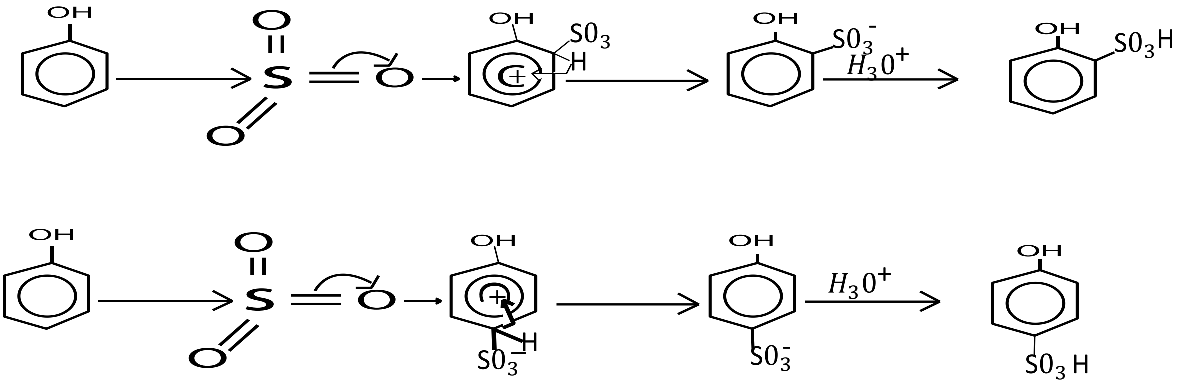


$$(CH_3COO)_2Ca \xrightarrow{\text{heat}} CH_3\overset{O}{\overset{\|}{C}}CH_3 + CaCO_3$$

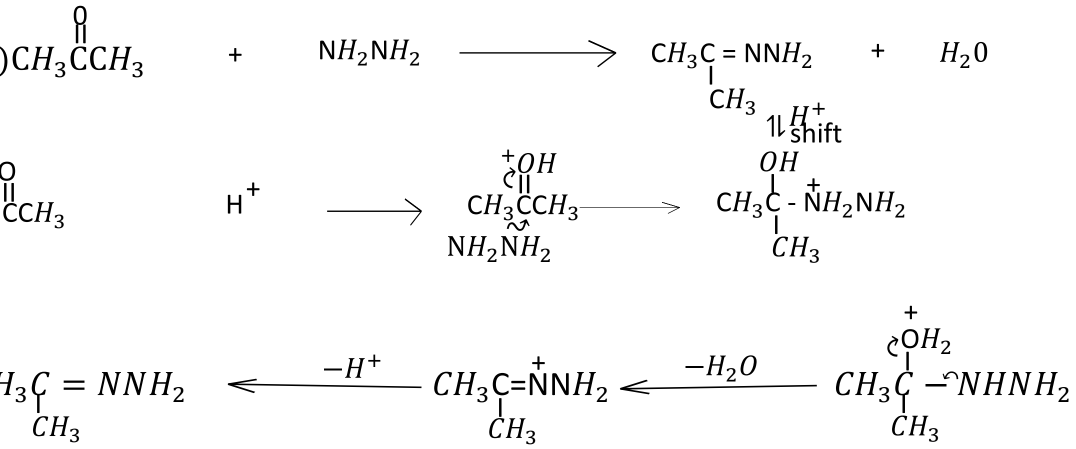
(c)

(i) 

$$2H_2SO_{4(l)} \rightleftharpoons H_3O^+_{(aq)} + SO_{3(g)} + HSO^-_{4(aq)}$$



(ii)



(d) (i)Neutrai Iroon (ii) Chloride solution

A violet solution is formed with both organic compounds

(ii) Bromine water

A white precipitate is observed with compound x (phenol) and no observable change with 2,4,6 – trinitrophenol.

OR Sodium carbonate solution or sodium hydrogen carbonate solution.

Bubbles of a colourless gas are evolved with 2,4,6 -trinitrophenol and no observable change with phenol.

QUESTION 4

(a) Let the mole fraction of ethanol be X_1 and that of methanol be X_2

P ethanol = X$P^o_{ethanol}$ P ethanol = $X_2\ P^o_{methanol}$

but $X_1 + X_2 = 1$ $X_2 = 1 - X_1$

hence P methanol = (1$-X_1$) P° methanol

p ethanol =x,400 p methanol$(1 - x_1)$ 1400

then from P total =P ethanol + P methanol

$760 = (400x_1) + (1 - x_1)1400$

$760 = 400x_1 + 1400 - 1400x_1$

$x_1 = 0.64\ or\ 64\%$

$x_2 = 1 - 0.64 = 0.36\ or\ 36\%$

(b) 1 mole fraction of toluene =1-0.6=0.4

P toluene =$X_{toluene}\ P°_{toluene} = 0.6 \times 2920 = 1168Nm^{-2}$

$P_{benzene=}X_{benzene}P°_{benzene} = 0.6\ \times 1000 = 600Nm^{-2}$

P total=P toluene +P benzene = 1168 +600 =1768Nm^{-2}

Composition of toluene in vapour =$\left(\frac{1168}{1768} = 0.66\ or\ 66\%\right)$

or 0.6606 or 66,06

composition of benzene in vapor $=\left(\frac{600}{1768} = 0.34\ or\ 34\%\right)$

or 0.3393 or 33.93

<u>alternatively,</u> 1-0.66=0.34 or 34%

or 1-0.6606 =0.3393 or 33.93%

ii) P toluene $=0.66 \times 2920 = 1927.2 Nm^{-2}$

P benzene $=0.34\times1000 = 340 Nm^{-2}$

P total $=1927.2 + 340 = 2267.2 Nm^{-2}$

Composition of toluene on vapour $=\frac{1927.2}{2267.2} = 0.85\ or\ 85\%$

Composition of benzene in vapor $=\frac{340}{2267.2} = 0.15\ or\ 15\%$

or 1-0.85 =0.15 or 15

alternatively

using X toluene $=0.6606 \times$ X benzene $=0.3393$

P toluene $=0.6606 \times 2920 = 1928.952 Nm^{-2}$

P benzene $=0.3393 \times 1000 = 339.3 Nm^{-2}$

P total $=1928.952 + 339.3 = 2268.252 Nm^{-2}$

Composition of toluene in vapour $=\frac{1928.952}{2268.252} = 0.8502$

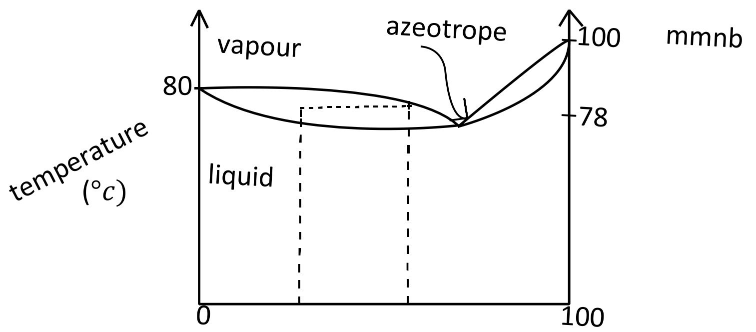
or 85.04%

composition of benzene in vapour $=\frac{339.3}{2268.252} = 0.1496$

or 14.96%

(d) this is a liquid mixture that boils at a constant temperature to produce a vapor with the same composition as the boiling liquid mixture

(ii)



When mixture is heated, it boils to produce a vapour richer in water. On condensing, a distillate is formed with the same composition

Successive distillation produces the azeotropic mixture as the distillate and pure alcohol Y as the residue

(d)(i) This is a liquid mixture which on cooling solidifies | freezes the components at the same time without change in its composition at a constant temperature.

OR This is a sold mixture which on heating melts the components at the same time at constant temperature to form a liquid without change in composition.

(ii) The <u>freezing (melting) point of cadmium</u> <u>reduces down to the eutectic point</u>. <u>At the eutectic point the freezing point remains constant.</u>

On further addition of bismuth, the freezing point of bismuth increases to that of pure it bismuth

(iii) In original mixture of the two liquids:

Mass of Cadmium = 25/100×200 = 50g
Mass of Bismuth = 75/100x200 = 150g or 200-50=150g
After cooling from 300 °c to 168°C
Mass of Cadmium remained constant liquid mixture = 50g in the
Let mass of bismuth remaining in liquid =W
then mass of bismuth /total mass X 100 = 100-38

$\frac{W}{50+W} = \frac{62}{100}$

W= 81.58g
OR mass of cadmium/total X 100 = 38

$$\frac{50}{50+W} X\ 100 = 38$$

W= 81.58g
Mass of bismuth that crystallized = 150 – 81.58 = 68.429

QUESTION FIVE

(a)(i) The metallic character increases down group elements.
This is because, there is increase in atomic radius and inert pair effect down the group. Therefore, the outermost p-orbital (valence) electrons move further away from the nucleus and their nuclear attraction decreases,
The tendency of the elements to lose the outermost p-orbital electrons to form positively charged ions increases.
(ii) The stability of the +2oxidation state increases down
This is because, the inert pair effect increases down the group. This leads to an increase in the ability of the outermost p orbital electrons to be used (participate) in bonding. Hence increasing the stability of the +2oxidation state down the group
(b)(i)
Carbon does not react with bromine
Under all conditions
Heated silicon, Germanium and tin react with bromine to form their tetrabromides $M (s) + 2Br_2 (l) \rightarrow MBr_4(l)$ where M is Si, Ge or Sn
However, heated lead reacts with bromine to form Lead (ii) bromide
$Pb(s) + Br_2(l) \rightarrow Pb\ Br_2(s)$

ii) Carbon and germanium react with hot concentrated sulphuric acid to form their dioxides, Sulphur dioxide gas and water

$$C_{(s)} + 2H_2SO_{4(l)} \rightarrow CO_{2(g)} + 2SO_2 + 2H_2O_{(l)}$$
$$Ge_{(s)} + 2H_2SO_{4(l)} \rightarrow GeO_{2(S)} + SO_{2(g)} + 2H_2O_{(l)}$$

Tin reacts with hot concentrated sulphuric acid to form tin (4) sulphate sulphur dioxide gas and water

$$S_{n(s)} + 4H_2SO_{4(l)} \rightarrow Sn(SO_4)_{2(aq)} + 2SO_{2(g)} + 4H_2O_{(l)}$$

Lead reacts with hot concentrated sulphuric acid to form lead (2) sulphate Sulphur dioxide, and water.

$$Pb_{(s)} + 2H_2SO_{4(l)} \rightarrow PbSO_{4(S)} + SO_{2(g)} + 2H_2O_{(l)}$$

(c) A red-brown (brown) precipitate is observed

$$C10^-_{(aq)} + Pb^{2+}_{(aq)} + H_2O \rightarrow PbO_{2(s)} + 2H^+_{(aq)} + Cl^-_{(aq)}$$

i)

ii) Effervescence of a greenish-yellow gas and a white solid is formed which dissolves in the worm solution and resolidfies on cooling
The residue lead (4) oxide is a powerful oxidizing agent as the lead (4) ion is unstable with respect to lead (2) ion the intermediate lead (4) chloride is reduced on

warming to lead (2) chloride as a white solid while the chloride ions are oxidised to chlorine.

$$PbO_{2(s)} + 4HCl_{(aq)} \rightarrow PbCl_{2(s)} + Cl_{2(g)} + 2H_2O_{(l)}$$

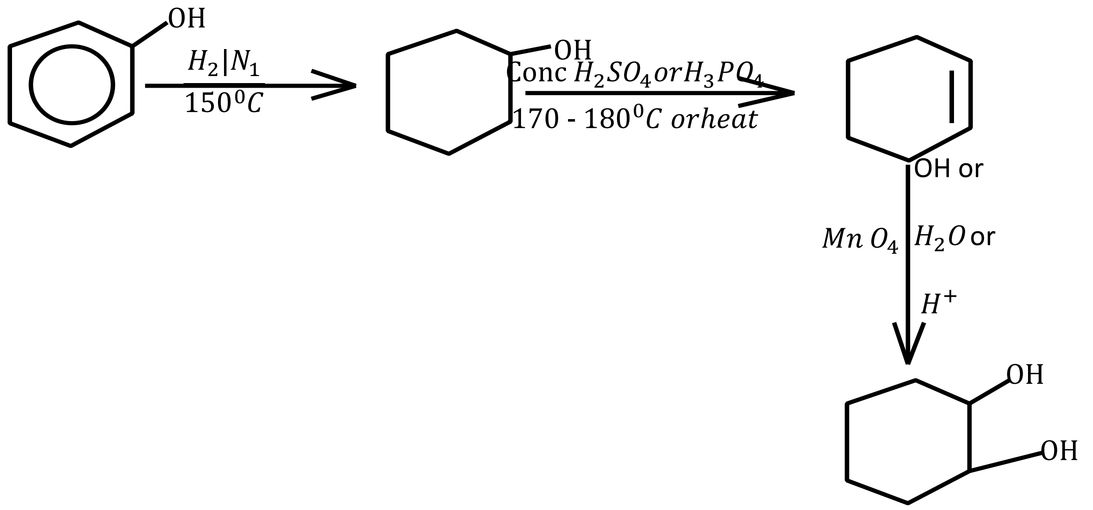
A brown solution is formed which forms a purple colour in carbonated chloride

$$Cl_{2(aq)} + KI_{(aq)} \rightarrow I_{2(aq)} + 2KCl_{(aq)}$$

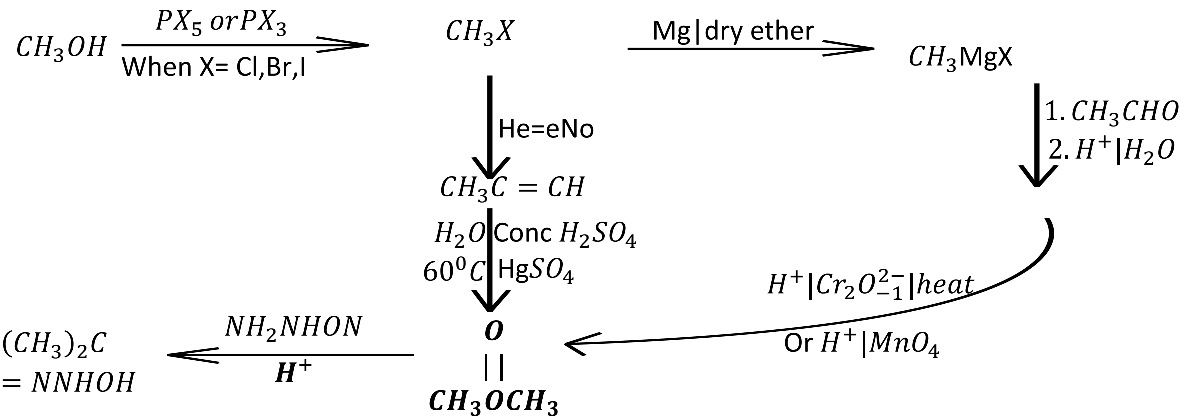
$$Cl_{2(aq)} + 2I^-_{(aq)} \rightarrow I_{2(aq)} + 2CL^-_{(aq)}$$

QUESTION SIX

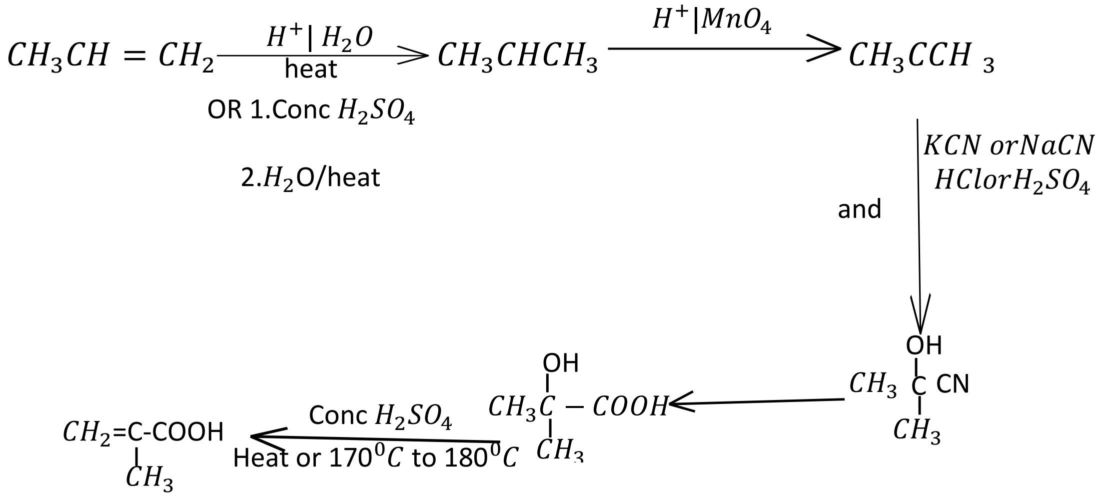
(a)



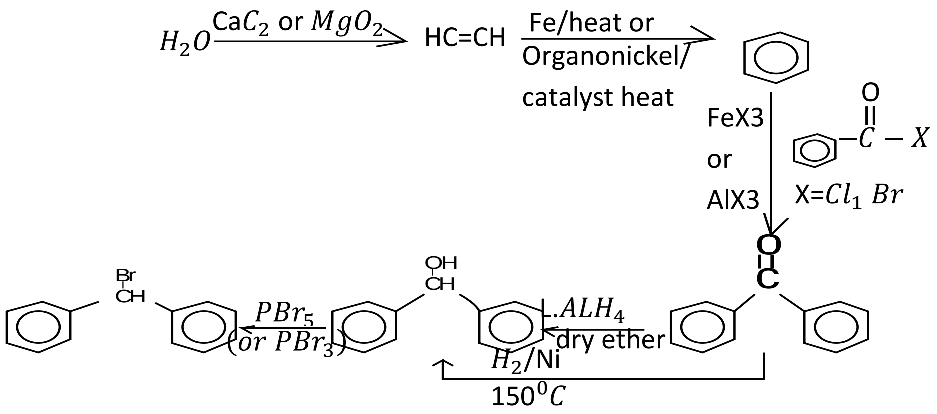
(b)



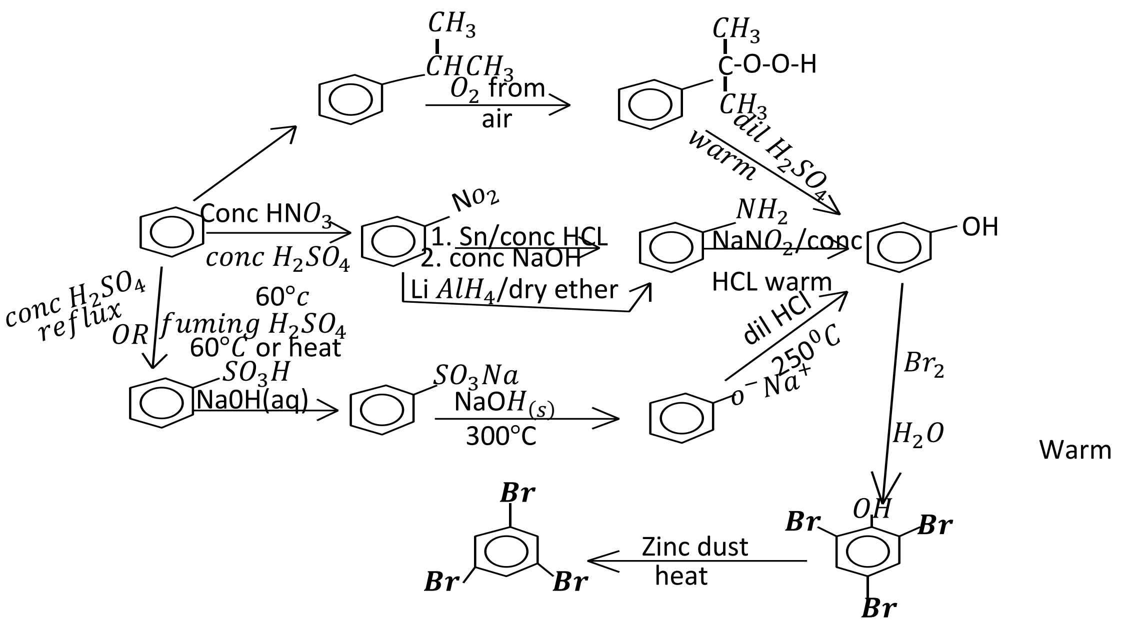
(C)



(d)



(e)



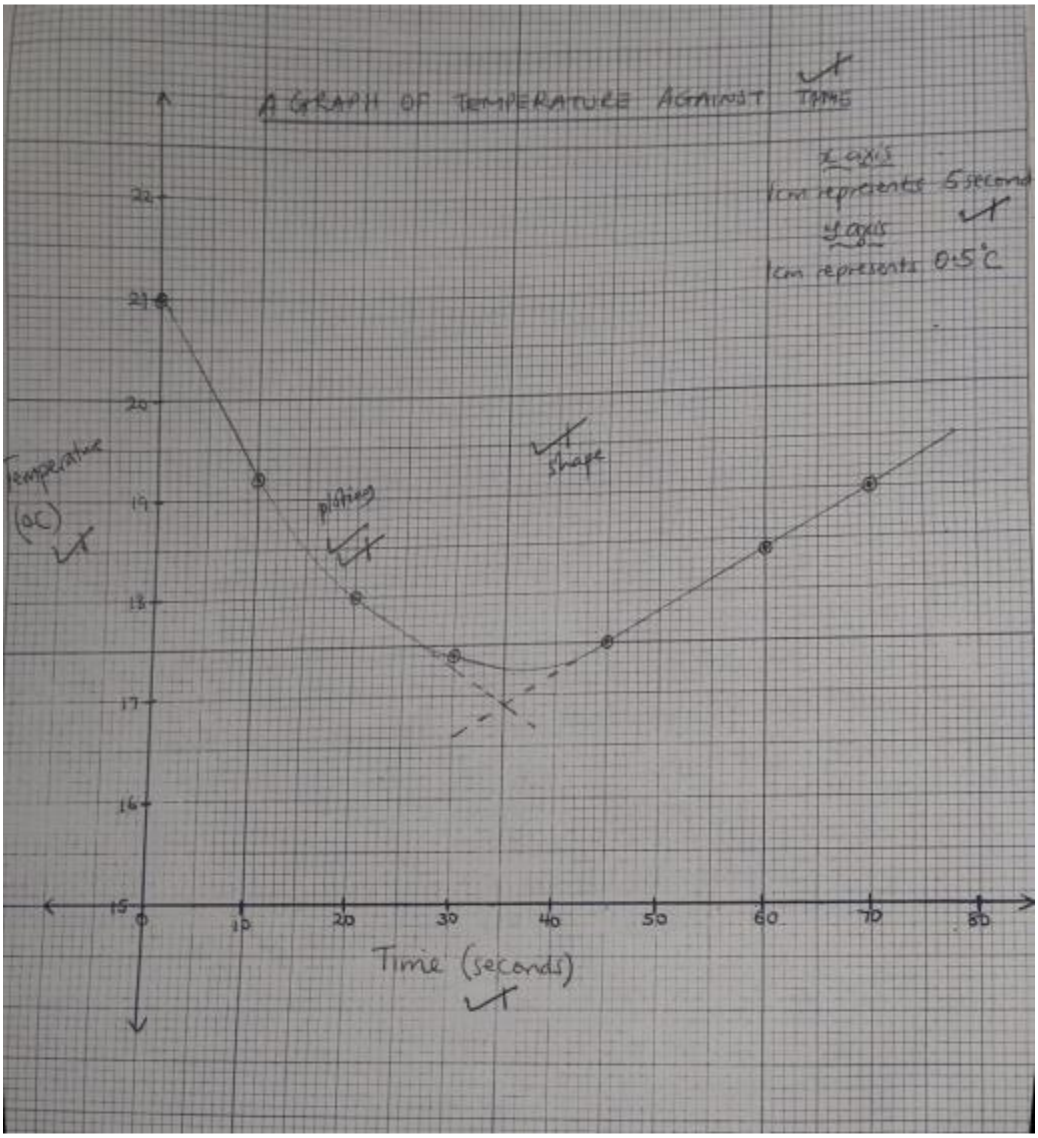
QUESTION SEVEN

10) (a) (i) Enthalpy of solution is the enthalpy change that occurs when one mile of substances is dissolved in a known amount of a solvent (in stated number of moles. of a solvent)

(ii)- Lattice energy The higher the lattice energy, the less easily it is ontweighed by the hydration energy and hence the lower the enthalpy of solution. (The reverse is true)

-Hydration energy. The higher the hydration energy the more easily it outweighs the lattice energy, hence higher the enthalpy of solution. (The reverse is true)

Graph



(iii) Minimum temperature 16.9 °c

Temperature change (fall) = Initial temp - Final temp =21-16.9 = 4.1°C

Mass of water = density X volume = 1x100 = 100g

Mass of solution = 5.35 + 100 = 105.35g

Heat energy absorbed On dissolving = mass lost by the solution

= mass of solution X specific heat capacity of solution X temperature fall.

=105.35 X 4.2 X 4.2 = 1814.127J

5.35g of NH_4Cl absorb 1814.127 Joules

53.5g of NH_4CI absorb $\left(\frac{1814.127}{5.35} x\ 53.5\right)$ Joules

= 18141.27 $Jmol^{-1}$

Molar enthalpy of solution of ammonium chloride = +18.141 kJ mol^{-1}

(iii) When the temperature is increased, ✓ the solubility of ammonium chloride increases. This is because the enthalpy of solution of ammonium chloride is <u>positive (endothermic) hence favoured by high temperatures.</u>

(c) (i) Cryoscopic constant is the freezing point depression that occurs when one mole of a substance is dissolved in 1000g of a solvent.

((ii) RFM of NH4Cl = 14+ 4 + 35·5 = 53.5

Freezing point depression = 0 -· 0·465 =0.465°C

Either: Let mass of water be = W

Wg of water dissolve 10.7g of salt

1000g of water dissolve $\left(\frac{10.7}{W} x\ 10000\right) g$ g of salt

(10.7/W x1000)g of salt depresses freezing point by 0.465 °C

53.5g of salt depress freezing point by $\left(\frac{0.465\ x\ W\ x\ 53.5}{10.7\ x\ 1000}\right)\ ^0c$

$\text{Kf} = \frac{0.465\ xWx\ 53.5}{10.7\ x\ 1000}$

W = 800g of water

Or

1000g of water dissolve 53.5g of salt

Wg of water dissolve $(\frac{53.5}{1000} X\ W)$ g of salt

$(\frac{53.5}{1000} X\ W)$g of salt depress freezing point by 1.86^{o}c

10.7g of salt depress freezing point by $\left(\frac{1.86\ x\ 1000x10.7}{53.5\ x\ W}\right)\ ^0C$

Hence $0.465 = (1\frac{1.86\ x\ 1000\ x\ 10.7}{53.5\ x\ W}$

W = 800g of water

QUESTION EIGHT

(a) Lead(IV) oxide reacts with <u>**excess** cold concentrated hydrochloric acid</u> to form the soluble hexachloroplumbate (iv) complex ion that appears as a yellow solution $PbO_2(s) + 4\ HCl\ (aq) + 2Cl^- \rightarrow\ PbCl_6^{-2}\ (aq)\ H_2O(l)$

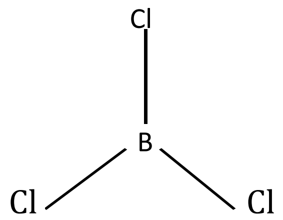
or $PbO(s) + 4H^+\ (aq) + 6Cl(g) \rightarrow PbCl_6^{-2}\ (aq)\ H_2O(l)$

or $PbO_2(s) + 6HCl(aq) \rightarrow H_2PbCl_6(aq) + 2H_2O(l)$

The hexachloroplumbate (iv) ion reacts with ammonium chloride to form the <u>insoluble ammonium hexachloroplumbate</u> (iv) as a yellow solid

$2NH_4^+(aq) + PbCl^{2-}_6\ \ (aq) \rightarrow (NH_4)_2PbCl_6(s)$

(b) Boron trichloride has <u>three bond pairs and no lone pair</u> on boron which <u>symmetrically arrange</u> around the boron atom to form a <u>trigonal planar</u> shape.



Phosphorous trichloride <u>has three bond Pairs and one lone Pair </u>on the phosphorous atom. Thus <u>the lone pair strongly repels the bond pairs</u> to form <u>a trigonal pyramidal shape</u>

(c) Alkenes are <u>unsaturated compounds with a carbon to carbon double bond</u> containing <u>localised pi bond electrons</u>. These electrons are <u>accessible to</u> <u>electron deficient chemical species that combine</u> with the alkene to form Single saturated product.

However carbonyl compounds are <u>unsaturated with carbon to oxygen localised bond electrons</u>. Due to the <u>high electronegativity of oxygen</u>, <u>the carbon atom of the carbonyl group becomes election deficient </u>and attains a partial positive charge. Hence the carbon atom <u>combines with electron rich chemical species to form</u> a single saturated product.

(c) <u>Two ethanoic acid molecules associate</u> in benzene through <u>hydrogen bonding</u> to form a dimer, unlike molecules of glucose. Thus the number of solute particles of 0.02M ethanoic acid in benzene is a half (half way), the number of solute particles of 0.02M glucose. This causes ethanoic and to <u>create a smaller depression</u> in the freezing point of benzene than glucose Hence the freezing point of a solution of 0.02 M ethanoic in benzene is higher.

(e) During the course of the reaction, butan-1-o1 forms a primary carbocation * which undergoes it rearrangement by hydride shift to form a more stable secondary carbonium ion.

$$H_2SO_4 \rightleftharpoons H^+ + \bar{O}SO_3H$$

$$CH_3CH_2CH_2OH \longrightarrow H^+ \longrightarrow CH_3CH_2CH_2CH_2\overset{+}{O}H_2$$

$$CH_3CH_2CH_2\overset{H}{\underset{H}{C}}{}^{+}\overset{+}{O}H_2 \rightleftharpoons CH_3CH_2\overset{+}{C}H_2 + H_2O$$

$$CH_3\ CH_2\overset{+}{C}H_2CH_2 \xrightleftharpoons{\text{rearrangemen}} CH_3CH_2CHCH_3$$

$$CH_3CH_2\overset{+}{C}HCH_3 \xrightarrow{-H^+} CH_3CH = CHCH_3 + H^+$$