JINJA JOINT EXAMINATIONS BOARD

MOCK EXAMINATIONS

MARKING GUIDE 2023

Proposed marking guide for JJEB UACE -2023 chemistry 525/2

1(a)

(i) Chromium (III) ions (reject formula) 01

(ii) $Cr(H_2O)_6^{3+} \longrightarrow$ violet solution 01

$Cr(OH)_4^-$ $\longrightarrow$ green solution 01

b (i) $Cr(OH)_{3(s)} + OH^-_{(aq)} \longrightarrow Cr(OH)^-_{4(aq)}$ 1½

(ii) $2Cr(OH)_4^-{}_{(aq)} + 2OH^-_{(aq)} + 3H_2O \longrightarrow 2CrO_4^{2-}{}_{(aq} + 8H_2O_{(l)}$ 1½

Or $2Cr(OH)_6^{3-} + 3H_2O_{(l)} \longrightarrow CrO_4^{2-}{}_{(aq)} + 2OH^-_{(aq)} + 8H_2O_{(l)}$

Or $2CrO_2^-{}_{(aq)} + 3H_2O_{(l)} + 2OH^-_{(aq)} \longrightarrow 2CrO_4^{2-}{}_{(aq)} + 4H_2O_{(l)}$

Or $2Cr^{3+}{}_{(aq)} + 10OH^-_{(aq)} + 3H_2O_{(aq} \longrightarrow CrO_4^{2-}{}_{(aq)} + 8H_2O_{(l)}$

(iii) $CrO_4^{2-}{}_{(aq)} + Pb^{2+}{}_{(aq)} \longrightarrow PbCrO_{4(s)}$ 1½

C (i) $(NH_4)_2Cr_2O_{7\,(aq)} \longrightarrow Cr_2O_{3(s)} + N_{2(g)} + 4H_2O_{(l)}$ 1½

(ii) $2Cr_2O_{3(s)} + 3O_{2(g)} + 8NaOH_{(aq} \longrightarrow 4Na_2CrO_{4(aq)} + 4H_2O_{(l)}$ 2½

Green solid turns yellow

d (i) $2CrO_4^{2-}{}_{(aq)} + 2H^+_{(aq)} \longrightarrow Cr_2O_7{}^{2-}{}_{(aq)} + H_2O_{(L)}$ 2½

Yellow solution turns orange

(ii) $Cr_2O_7{}^{2-}{}_{(aq)} + 2\,OH^-{}_{(aq)} \longrightarrow 2CrO_4^{2-}{}_{(aq)} + H_2O_{(aq)}$ 2½

Orange solution turns yellow

(e) (i) $3Sn^{2+}{}_{(aq)} + Cr_2O_7^{2-}{}_{(aq)} + 14H^+{}_{(aq)} \longrightarrow 3Sn^{4+}{}_{(aq)} + 2Cr^{3+}{}_{(aq)} + 7H_2O_{(l)}$

(ii)

Moles of $Cr_2O^{2-}{}_7$ reacted $= \left(\frac{23.5 \times 0.01}{1000}\right)$

$= 0.000235$moles

Moles of Sn^{2+} reacted $= (0.000235 \times 3)$

$= 0.000705$ moles

$25cm^3$ of solution contain 0.000705 moles of Sn^{3+}

$250cm^3$ will contain $\left(\frac{0.000705 \times 250}{25}\right)$

$= 0.00705$ moles

1mole of Sn^{2+} weighs 119g

0.00705 will weigh 119×0.00705

$= 0.839$ g

% of Sn^{2+} $= \left(\frac{0.839 * 100}{3.8}\right) = 22.08\%$

5

2.

(a) (i) Volume of carbon dioxide = 16.76-5 = $11.76 dm^3$

Mass of carbon dioxide $= \left(\frac{44 x 11.76}{24}\right)$

$= 21.56\ dm3$

Mass of C in carbondioxide $= \left(\frac{12 x 21.56}{44}\right)$

$= 5.88 g$

Mass of H_2 in H_2O $= \left(\frac{2 x 4.41}{18}\right)$

$= 0.49\ g$

Elements	C	H
Masses	5.88	0.49
Moles	$\frac{5.88}{12} = 0.49$	$\frac{0.49}{1} = 0.49$
Mole ratio	$\frac{0.49}{0.49} = 1$	$\frac{0.49}{0.49} = 1$
Empirical formula	CH	

(ii) $1 cm^3$ weighs $1.161 x 10^{-3}$

$22400 cm^3$ will weigh$(1.161 x 10^{-3} x 22400)$

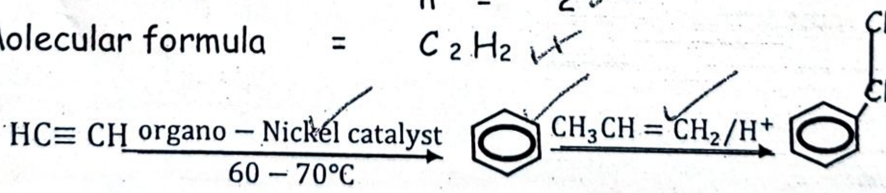
$= 26$

$(CH)_n = 26$ 2½

$n = 2$

Molecular formula $= C_2H_2$

b (i)



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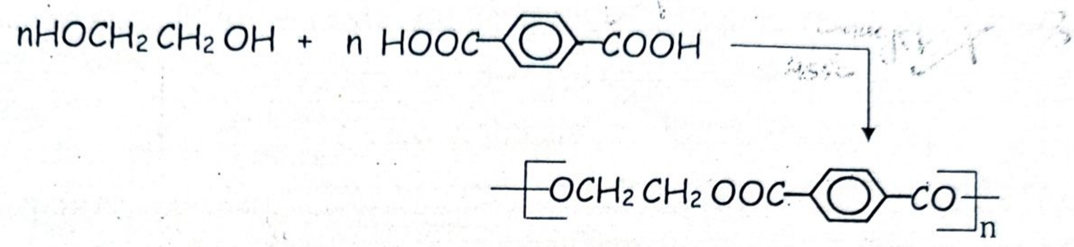
(ii)

$HC{\equiv}CH \xrightarrow[Hg_2SO_4/60°C]{conc\ H_2SO_4/H_2O} CH_3CHO \xrightarrow{dilute\ NaOH_{(aq)}} CH_3CH(OH)CH_3CHO$

$CH_3CH(OH)CH_3CHO \xrightarrow[Heat]{conc\ H_2SO_4} CH_3CH{=}CHCHO$ 2

2

(iii) $HC\equiv CH \xrightarrow[\text{lindlar's catalyst}]{H_2} H_2C{=}CH_2 \xrightarrow{MnO_4^-/OH^-} HOCH_2CH_2OH$



C (i) $HC\equiv CH + 2AgNO_3 + 2NH_3 \longrightarrow AgC\equiv CAg + 2NH_4NO_3$

OR

$HC\equiv CH + Ag(NH_3)_2^+ \longrightarrow AgC\equiv CAg + NH_3 + NH_4^+$ 2

Name: Silver acetylide or silver dicarbide

(ii) Moles of Ag_2C_2 $= \frac{2.4}{(108x2) + (24)} = 0.01$

Moles of Y reacted $= 0.01$ moles

1 mole of Y occupies 24000 at rtp

0.01 moles will occupy 2400x 0.01

$=$ 240 cm3 3

Volume of ethene $=$ 400-240

$=$ 160cm^3

% $= \frac{160x100}{400}$

$=$ 40%

T = 20

3(a) (i) Freezing point constant

This is the depression in freezing point of a solvent that occurs when one mole of a non volatile solute is dissolved in one thousand grams of a pure solvent.

(ii) when a non volatile solute is dissolved in a solvent to form a solution, the solute uniformly distributed itself such that at the surface of the solution there are both solute and solvent molecules, this reduces the escaping tendence of solvent molecules into the vapour since the solute particles are non volatile, therefore the solution will exert lower vapour pressure than the pure solvent.

b (i) 3g of camphor dissolve 1.8g of Naphthalene

100g of camphor will dissolve $\left(\frac{1.8x100}{3}\right)$ = 60.0g

18.75°C is depression caused by 60g

40°C will be caused by Mr = $\left(\frac{60x40}{18.75}\right)$= 128

(ii)

- solution is dilute
- naphthalene is non volatile
- naphthalene does not react with camphor 2
- naphthalene doesn't dissociate or associate in camphor

C (i) Eutectic mixture. This is a liquid mixture which when cooled at a constant pressure will solidify or freeze at a constant temperature below the freezing point of the components in it to form a solid mixture of the same composition as the liquid mixture.

Or This is a solid mixture which when heated at a constant pressure will melt at a constant temperature below the melting point of the components in it to form a liquid mixture of the same composition as the solid mixture

(ii) Check graph paper

(iv) the liquid mixture cools without change in phase upto about 65.5°C(from graph), solid naphalene begins to solidfyout of the liquid mixture which increases the composition of biphenyl in the liquid mixture causing a further decrease in freezing point of naphthalene toward the eutectic point (37°C). At the eutectic point solid biphenyl also begins to solidify together with solid naphthalene, the composition and temperature remains constant until all the liquid mixture is solidified such that any further decrease in temperature cools the solid mixture with no change in phase and composition

(v)

- The melting point and composition of eutectic varies with change in pressure
- Microscopy shows a heterogeneous mixture of separate distinct crystals
- X-ray diffraction pattern of eutectic mixtures do not conform to a pure compound

3

4 (a) aluminium ion has a high charge and small ionic radius hence high charge density and polarizing power, therefore tends to polarize electron clouds of anions with large ionic radius like the chloride ion to give aluminium chloride covalent characters. However the fluoride ion in aluinium fluoride has a small ionic radius and cannot be readily polarized by the aluminium ion making aluminum fluoride ionic

4½

(b) lead(II) chloride is a sparingly soluble salt that dissolves in water according to the equation below;

$$PbCl_{(s)} + (aq) \rightleftharpoons Pb^{2+}_{(aq)} + 2Cl^{-}_{(aq)}$$

When added to dilute hydrochloric acid which completely dissociates to release hydrogen ions and chloride ions, the equilibrium concentration of chloride ion increase since it's a common ion, the lead(II) ion react with excess chloride ions to precipitate lead(II) chloride which reduces the solubility . However when added to concentrated hydrochloric acid, the chloride ions from the acid react with the lead (II) ions to form a soluble complex which reduce the equilibrium concentration of lead(II) ions, therefore more lead(II) chloride dissolves to replace the complexed lead(II) ions .

$Pb^{2+}_{(aq)} + 4Cl^{-}_{(aq)} \longrightarrow PbCl^{2-}_{4(aq)}$

(c) The pie electrons in the carbon-carbon bond are donated to one of the bromine atom of bromine to form a bromocarbonium ion and a bromide ion, however due to a higher concentration of the chloride ion since it's a solvent, more of the carbonium ions are attacked by chloride ions to give a bromochloro compound as the major product.

$$CH_3CH{=}CH_2 + Br_2 \xrightarrow{Cl^-_{(aq)}} CH_3\underset{}{\overset{Cl}{\overset{|}{C}}}HCH_2Br$$

<u>Mechanism</u>

$$CH_3CH{=}CH_2 \longrightarrow CH_3\overset{+}{C}HCH_2Br + Br^-$$ 5

$$Br{-}Br$$

$$CH_3\overset{+}{C}HCH_2Br \longrightarrow CH_3\underset{Cl}{\underset{|}{C}}HCH_2Br$$

$$Cl^-$$

(d)

Ammonia is a weak base that partially ionizes in water to form ammonium ions and hydroxide ions .

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH^{+}_{4(aq)} + OH^{-}_{(aq)}$$

The hydroxyl ions react with magnesium ions to form insoluble magnesium hydroxide observed as a white precipitate.

However in the presence of ammonium chloride which is a strong electrolyte that completely dissociates to form ammonium ions and chloride ions, the high concentration of ammonium ions suppresses the ionization of ammonia such that the ionic product of magnesium hydroxide in solution fails to exceed the solubility product for precipitation to occur. 5

5(a) Free radical substitution

These are reactions of alkanes in which a free radical replaced one or more hydrogen atoms from one carbon atom to form product e.g halogenations of alkanes in presence of u.v rays

$$CH_4 + Cl_2 \xrightarrow[rays]{U.V} CH_3Cl + HCl$$

Mechanism:

$$Cl-Cl \longrightarrow \dot{Cl} + \dot{Cl}$$

$$H_3C-H + \dot{Cl} \longrightarrow \dot{C}H_3 + HCl$$

$$\dot{C}H_3 + Cl-Cl \longrightarrow CH_3Cl + \dot{Cl}$$

$$\dot{Cl} + \dot{Cl} \longrightarrow Cl_2$$

4

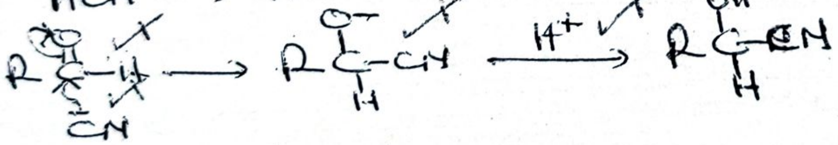
(b) Nucleophilic addition

These are reactions of carbonyl compounds in which a nucleophilic reagent adds itself across the carbon to oxygen double bond of the carbonyl compound without elimination or substitution of any atom example is addition of hydrogen cyanide or sodium sulphite solution

$$RCHO + HCN \longrightarrow RCH(OH)CN$$

Mechanism

$$HCN \longrightarrow H^+ + \bar{C}N$$



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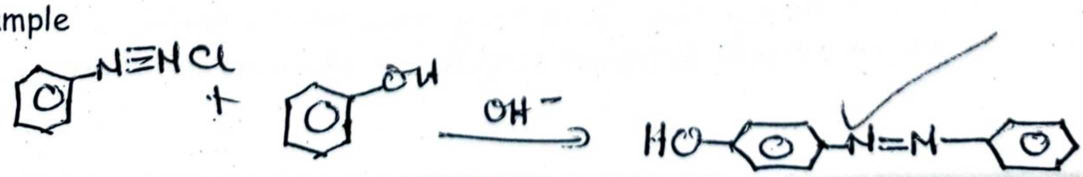
(c) Coupling reactions

These are reactions of benzene diazonium salts with aromatic compounds containing electron donating groups like hydroxyl group , amino group or alkyl group .

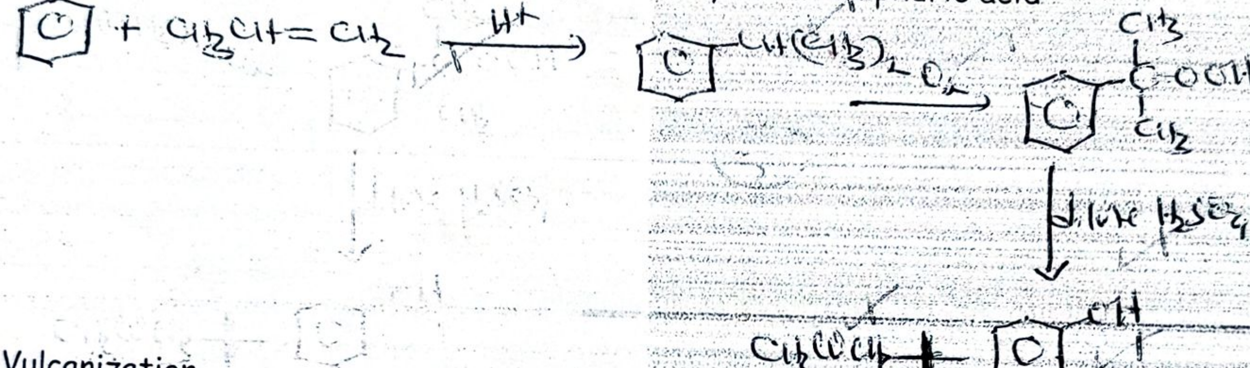
The reaction occurs at para position but if occupied then the reaction occurs at the para position but if occupied then the reaction occurs at the ortho position 3

Example



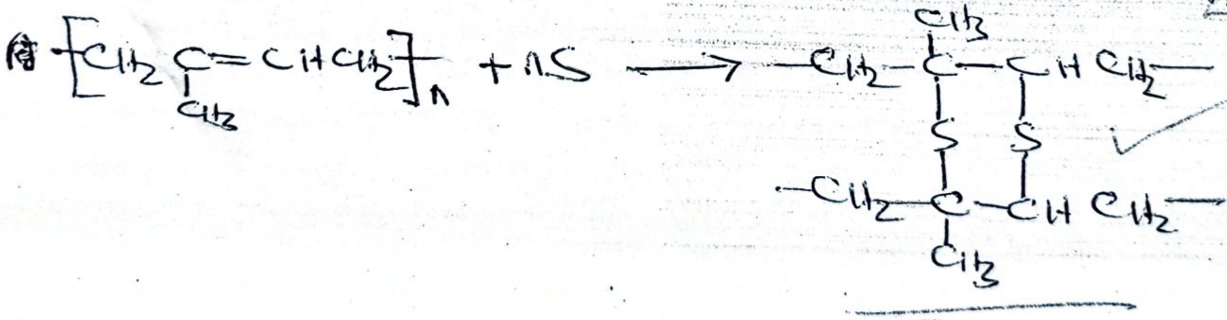
Cumene

This is the process used in the manufacture of phenol and propanone on a large scale that involves the formation of cumene benzene from benzene as the first intermediate that is oxygenated to cumene hydro peroxide which is hydrolysed to phenol and propanone by dilute sulphuric acid



Vulcanization

This is the reaction in which natural rubber is strongly headted in specific amount of sulphur , to form sulphur cross linkages between polymer chains of rubber so as to improve on its tensil strength , elasticity and strength , durability



T = 20

6(a) (i) The boiling points generally increase from hydrogen fluoride to hydrogen iodide. However hydrogen fluoride has an abnormally high boiling point.

From hydrogen fluoride to hydrogen iodide the hydrides adoprt a simple molecular structure in which molecules are held by weak van-der-waals forces of attraction whose magnitude and strength increase with increase in molecular mass, therefore more heat energy is required to break the forces of attraction for boiling to occur from hydrogen chloride to hydrogen fluoride.

The fluorine atom in hydrogen fluoride has a very small atomic radius and highest electronegativity making the hydrogen -fluoride bond highly polar, therefore hydrogen fluoride molecule interact through strong intermolecular hydrogen bonds which require a higher amount of heat to be broken for boiling to occur.

(ii) The acidic strength increases from hydrogen fluoride to hydrogen iodide. This is because the atomic radius of the halogen atoms increases from fluorine to iodine, the hydrogen-halogen bond length increases from hydrogen fluoride to hydrogen iodide while the bond strength decreases in the same order and readily releases hydrogen ions in solution. 4

Hydrogen fluoride is the weakest acid because of the smallest atomic radius and highest electronegativity of the fluorine atom, the hydrogen fluorine bond is the shortest and strongest making the acid dissociate partially in solution.

(b) Hydrogen fluoride is commonly prepared by action of cold concentrated sulphuric acid on calcium fluoride

$CaF_{2(s)} + H_2SO_{4(l)} \longrightarrow CaSO_{4(s)} + 2HF_{(g)}$ 5

Hydrogen bromide is prepared by hydrolysis of phosphorus-tribromide obtained by reacting phosphorus with bromine

$PBr_{3(l)} + 3H_2O_{(l)} \longrightarrow H_3PO_{3(aq)} + 3HBr_{(g)}$

(c) (i) pale yellow precipitate

(ii) $Ag^+_{(aq)} + Br^-_{(aq)} \longrightarrow AgBr_{(s)}$ Acept molecular equation.

(d) (i) observation : white precipitate that dissolves to form a colourless solution 3

Equations

$Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \longrightarrow PbCl_{2(s)}$

$PbCl_{2(s)} + 2Cl^-_{(aq)} \longrightarrow PbCl^{2-}_{4(aq)}$

Observation: blue solution turns yellow

Equations

$Cu(H_2O)^{2+}_{6(aq)} + 4Cl^-_{(aq)} \longrightarrow CuCl^{2-}_{4(aq)} + 6H_2O_{(l)}$ 2

T = 20

7 (a) (i) This is the conductance of a solution of one mole of an electrolyte placed between two parallel electrodes with unit cross section area and separated by unit distance at a given temperature

(ii) Solubility product is the product of the molar concentration of ions of sparingly soluble electrolyte present in a saturated solution each raised to appropriate powers as expressed in a balanced solubility equation at a given temperature.

(b) (i) The conductivity of water to be used to prepare a saturated solution of calcium phospahte is measured using conductivity meter and recorded as K_{water}

Excess calcium phosphate is added to a given volume of water in a container, the mixture is stirred /shaken for some time and left to settle at a constant temperature .The electrolytic conductivity of the saturated solution then measured and recorded as $K_{solution}$.

The molar conductivity of calcium phosphate at infinite dilution (Λ_o) is obtained using Kohlrausch's law from the ionic molar conductivities of calcium ions and phosphate ions obtained from tables of ionic molar conductivities ;

Treatment of results :

6

$$\Lambda_o Ca_3(PO_4)_2 = 3\Lambda_o Ca^{2+} + 2\Lambda_o PO_4^{3-}$$

The electrolytic conductivity of calcium phosphate is obtained as ;

$$K\, Ca_3(PO_4)_2 = K_{solution} - K_{water}$$

But $\Lambda = \frac{K}{C}$ where C is the solubility in moldm^{-3}

Assumptions :

The molar conductivity of calcium phosphate at infinite dilution is equal to molar conductivity at any concentration since calcium phosphate is sparingly soluble

Let X be the solubility of $Ca_3(PO_4)_2$

Equation :

$$Ca_3(PO_4)_{2(S)} \rightleftharpoons 3Ca^{2+}{}_{(aq)} + 2PO_4^{3-}{}_{(aq)}$$

$[Ca^{2+}] = 3x$

$[PO_4^{3-}] = 2X$

$K_{SP} = [Ca^{2+}]^3[PO_4^{3-}]^2$

$= (3X)^3(2X)^2$

$= 9x4X^6$

$K_{SP} = 36X^6 \text{ mol}^6\text{dm}^{-18}$

b(ii) $K_{solution} = 3.12 \times 10^{-4}\ \Omega^{-1}\ cm^{-1}$

$\Lambda_o\ Ca_3(PO_4)_2 = 3\Lambda_o(Ca^{2+}) + 2\Lambda_o(PO_4^{3-})$

$=(3X119) + (2X24)$

$= (357 + 48)$

$= 405 cm^2mol^{-1}\ \Omega^{-1}$

$K_{solute} = K_{solution} - K_{water}$

$K_{Ca3(PO4)2} = 3.12X10^{-4} - 1.16X10^{-4}$

$= 1.96X10^{-4}\ \Omega^{-1}\ cm^{-1}$

$\Lambda_O = \dfrac{K\ solute\ x1000}{C}$

$405 = \dfrac{1.96X10^{-4}\ x1000}{C}$

(4)

$C = \dfrac{1.96X10^{-4}\ x1000}{405}$

$C = 0.000484 moldm^{-3}$

$K_{SP} = [Ca^{2+}]^3[PO^{3-}{}_4]^2$

$[Ca^{2+}] = 3x0.000484 = 0.001452 moldm^{-3}$

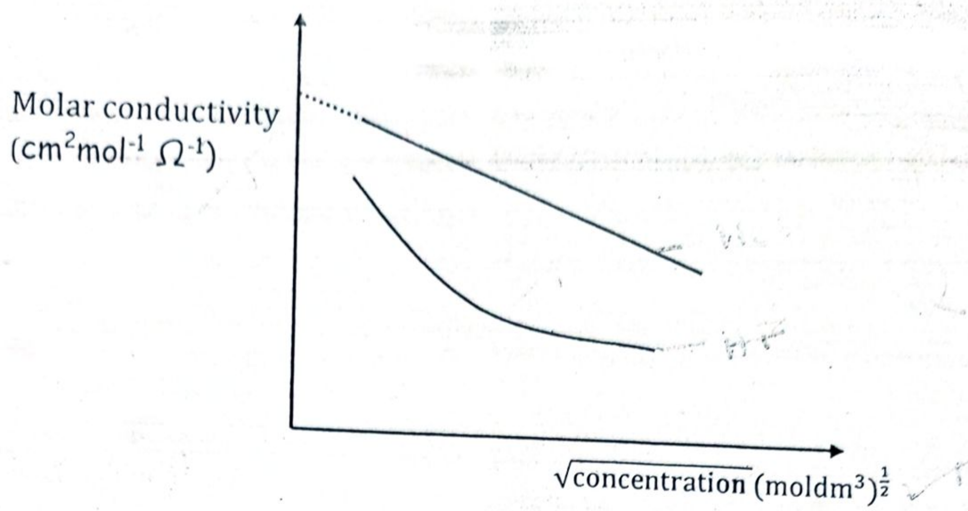
$[PO_4^{3-}] = 2X0.000484 = 0.000968\ moldm^{-3}$

$K_{SP} = (0.001452)^3(0.000968)^2$

$=$

mol^6 dm^{-18}

(c)



(d) For both hydrochloric acid and hydrofluoric acid molar conductivity decreases with increases in concentration
For hydrochloric acid acid is a strong electrolyte which undergoes complete ionization and dissociation in water , at low concentration , the inter ionic distance large with low ionic interference and high ionic mobility hence high molar conductivity, it's the concentration increase , the inter ionic distance decreases, ionic interference increases and ionic mobility decreases in conductivity
For hydrofluoric acid which is a weak electrolyte that partially ionizes in water , the conductivity is high at low concentration because the degree ionization is high at low concentration , however as the concentration increases , the degree of ionization decreases and the number of ions per unit volume decrease in conductivity .

T=20

8 (a)

(i) Thermosets .These are highly cross linked polymers that do not soften but decompose when heated and cannot be remoulded into different shapes .

(ii) Additional polymers .These are compounds of high molecular mass formed when very many unsaturated monomers combine repeatedly in a uniform pattern without loss of any small molecule b (i) the carbon chain must have carbon to carbon double bond

(ii) $H_2C=CHCN$ propenenitrile

(iii) $H_2\overset{Br}{\underset{|}{C}}H-CH_2Br \xrightarrow[\text{Heat}]{KOH/EtOH} HC\equiv CH \xrightarrow[HgSO_4,\ 60^\circ C]{Conc\ H_2SO_4/H_2O} CH_3CHO$

$CH_3CHO \xrightarrow{HCN} CH_3\overset{OH}{\overset{|}{C}}HCN \xrightarrow[\text{heat}]{Conc\ H_2SO_4} H_2C=CHCN$

$n\,H_2C=CHCN \xrightarrow{\text{organic peroxide}} \left[CH_2\overset{CN}{\overset{|}{C}}H\right]_n$ (04)

- all reagents and conditions must be correct

(iii)

- Blankets
- Woolen carpets
- Sweaters

accept any two (02)

C (i) This is the minimum pressure that must be applied to a solution to prevent /stop the net movement of solvent molecules from a region of high concentration to aregion low concentration across a semi permeable membrane at a given temperature .

(ii) $\pi V = \frac{MxRT}{Mr}$

740mmHg $= \frac{740}{760}$ =0.974atm

T = 298k

$0.974x1 = \frac{20x0.082x298}{Mr}$ 3

$Mr = \frac{20x0.082x298}{0.974x1}$

= 501.77

(ii) RFM of monomer $H_2C=CHCN$

(3X12) +(3X1) +(14X1)

53

$n = \frac{\text{molecular weight of a polymer}}{\text{molecular weight of monomer}}$ 2

$= \frac{501.77}{53} = 9.58 \approx 10$

(iv) Polymers have a high molecular mass, therefore in dilute solution, there will be very few particles of the solute that will cause negligible depression in freezing point that cannot accurately determined, Paper code .... Personal Number