P525/2

MARKING GUIDE

CHEMISTRY PAPER 2

UNNASE

MOCK EXAMINATION

2022

CamScanner

1.(a) (i) D-block element is one in which the d sub energy level is fully filled or partially filled while transition element is one in which the d sub energy level is partially filled in one of its stable oxidation states. (02)

(ii) Zinc is not considered as a transition element because both zinc atoms and zinc ions have fully filled 3d sub energy level (orbitals). (02)

(b) (i) Complex ion is either positively charged ion or negatively charged in which the central atom or ion is bonded to atoms or molecules with lone pairs of electrons through coordinate bonds. (01)

(ii) ionic radius
charge on the ion
vacant d orbitals (orbitals) (1½)

(c) $[Cr(H_2O)_6]^{3+}(3Cl^-)$

$[Cr(H_2O)_5Cl]^{2+}(2Cl^-) \cdot H_2O$

$[Cr(H_2O)_4Cl_2]^{+}(Cl^-) \cdot 2H_2O$ (02)

$[Cr(H_2O)_3Cl_3] \cdot 3H_2O$

(d) (i) Black solid turned to green solid. (1)

(ii) $6MnO_2(s) + 12KOH(s) + 3O_2(g) \rightarrow 6K_2MnO_4(s) + 6H_2O(l)$

OR

$3MnO_2(s) + 6KOH(s) + \frac{3}{2}O_2(g) \rightarrow 3K_2MnO_4(s) + 3H_2O(l)$ (1½)

(e) (i) Green solution turned to purple and black solid formed. (1½)

(ii) $3MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$

Manganate (VI) ions disproportionates in acidic ~~[illegible]~~ medium to form manganate VII ions and manganese(IV) oxide. (2½)

(f) Sodium hydroxide solution dropwise until in excess.

Fe^{2+}, pale green precipitate insoluble in excess and turns brown on standing.

Sn^{2+}, white precipitate soluble in excess to form a colourless solution. (2½)

(ii) Potassium iodide solution.

Co^{2+} ; no observable change

Cu^{2+} ; white precipitate in a brown solution.

$2\frac{1}{2}$

20

2. (a) $C_xH_yO_2 + \left(x + \frac{y}{4} - \frac{z}{2}\right)O_2(g) \rightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$

$x = 6$

$\frac{y}{2} = 3 \Rightarrow y = 6$

$6 + \frac{6}{4} - \frac{z}{2} = 7$

$\frac{6}{4} - \frac{z}{2} = 1$ (3½)

$6 - 2z = 4$

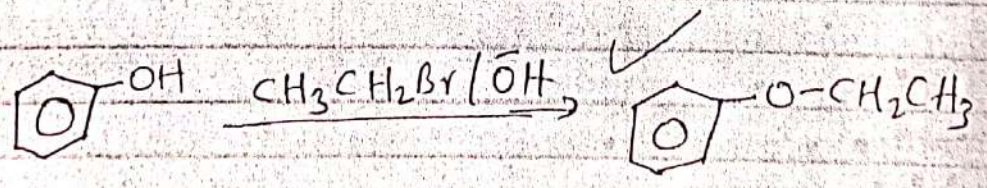
$2z = 2$

$z = 1$

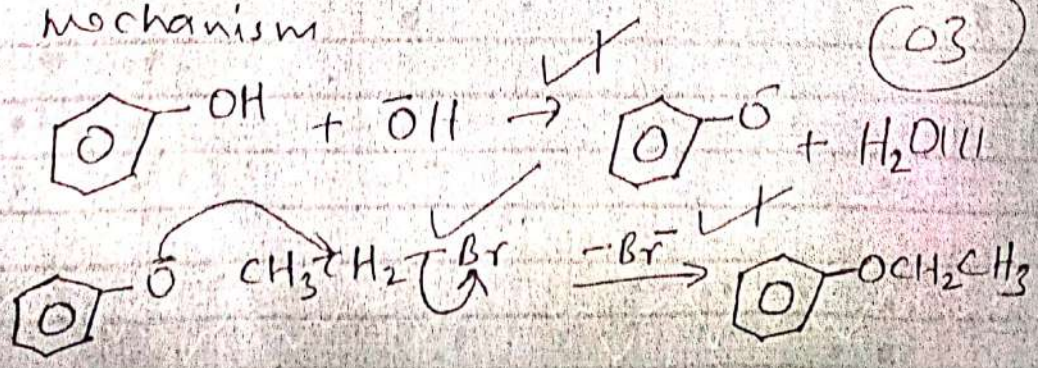
C_6H_6O

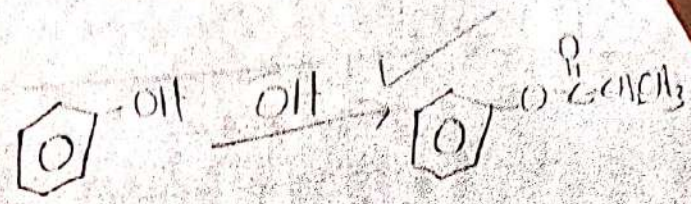
(b) C_6H_5OH, phenol. (½)

(c) (i)

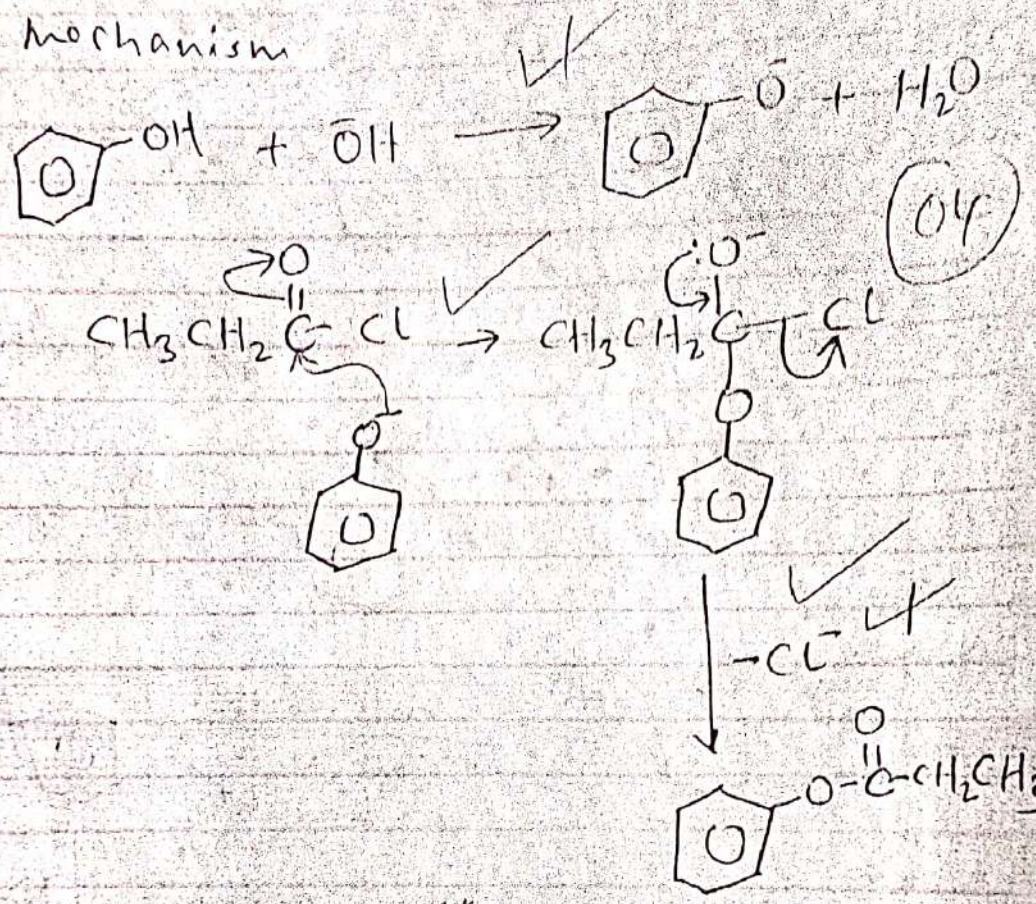


Mechanism (03)



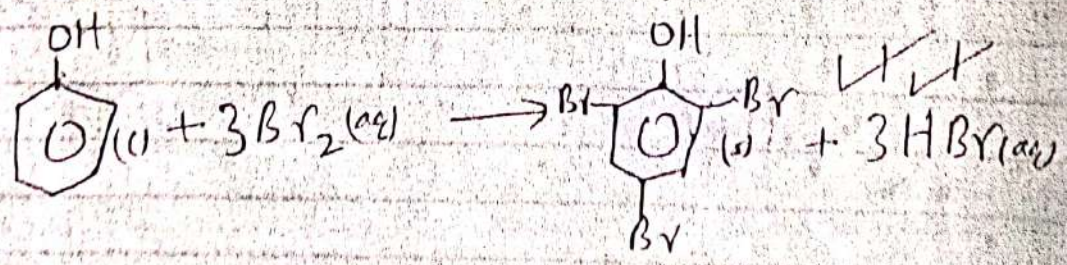
(ii) CH_3CH_2COCl + 

Mechanism



(04)

(d) Reddish brown solution turns colourless and white precipitate formed.

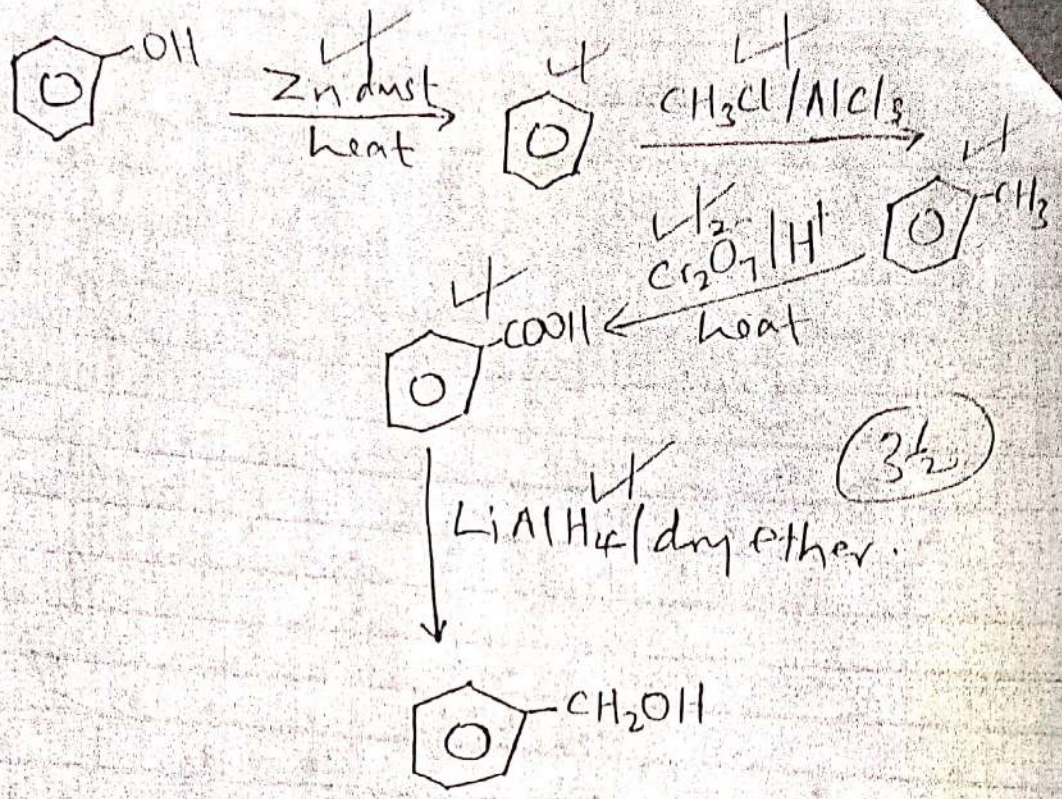


2,4,6-tribromophenol.

CamScanner

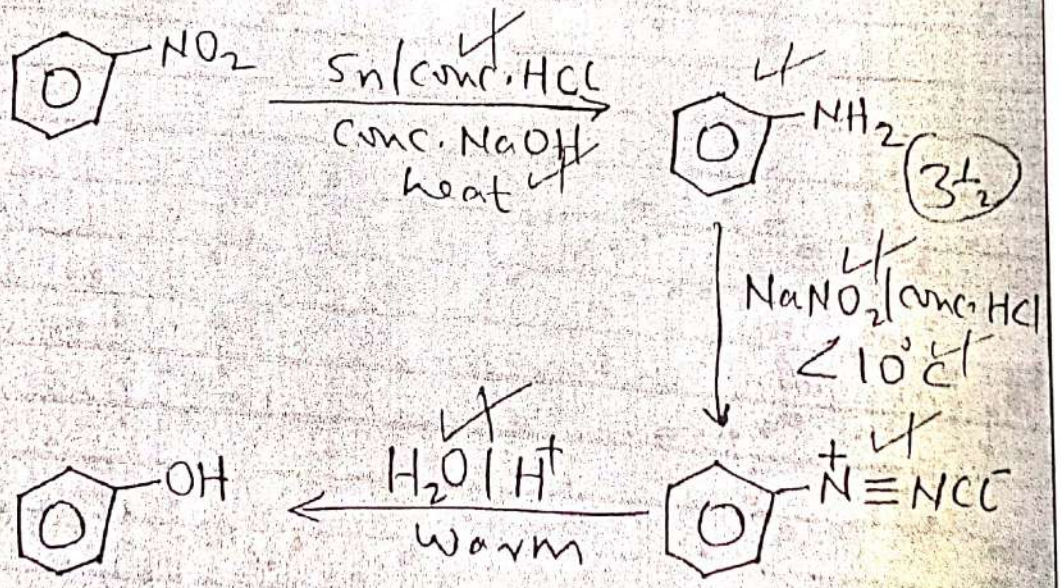
(e)

(i)


OH
Zn dust
heat
CH3Cl/AlCl3
CH3
Cr2O7/H+
heat
COOH
LiAlH4/dry ether.
CH2OH

(3½)

(ii)


NO2
Sn/conc.HCl
conc. NaOH
heat
NH2
NaNO2/conc.HCl
<10°C
N≡NCl
H2O/H+
warm
OH

(3½)

20

3. (a)(i) Base ionisation constant is the ratio of the product of the molar concentration of the ions produced by the weak base to the molar equilibrium concentration of unionised weak base at a given temperature. (01)

(ii) solubility product is the product of the molar concentration of the ions raised to appropriate powers of a sparingly soluble ionic salt electrolyte in its saturated solution at a given temperature. (01)

(iii) common ion effect is the lowering of the solubility precipitation of a sparingly soluble ionic salt electrolyte on addition of a more soluble salt compound with similar one ion common to both at a given temperature. (01)

(b) (i) $NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$

R.F.M of $NH_3 = 14 + 1 \times 3$
$= 17$

$[NH_3] = \frac{0.68}{17} = 0.04M$.

$K_b = \frac{\alpha^2 c}{1-\alpha}$ (2½)

$= \frac{\left(\frac{2.087}{100}\right)^2 \times 0.04}{1 - 0.02087}$

$= 1.77936 \times 10^{-5}$ $moldm^{-3}$

(ii) $Ag_2CrO_{4(s)} + aq \rightleftharpoons 2Ag^+_{(aq)} + CrO^{2-}_{4(aq)}$

R.F.M of $Ag_2CrO_4 = 108 \times 2 + 52 + 16 \times 4$
$= 332$

mass of Ag_2CrO_4 that dissolved
$= \frac{3.36}{100} \times 0.68$
$= 0.0228489$

$[Ag_2CrO_4] = \frac{0.0228489}{332}$
$= 6.8819 \times 10^{-5}$ mol dm^{-3}

$[Ag^+] = 2 \times 6.8819 \times 10^{-5}$
$= 1.37639 \times 10^{-4}$ mol dm^{-3}

$3\frac{1}{2}$

$K_{sp} = [Ag^+]^2 [CrO_4^{2-}]$

$= (1.37639 \times 10^{-4})^2 \times 6.8819 \times 10^{-5}$

$= 1.3037 \times 10^{-12}$ mol^3 dm^{-9}

(c) Excess of silver chromate is shaken with a given volume of distilled water until equilibrium is attained at a given temperature. stirring
The mixture is filtered to obtain a filtrate which is a saturated solution of silver chromate at that temperature.

either

The electrolytic conductivity of the filtrate is measured using a conductivity cell.

The electrolytic conductivity of pure water is determined.

The electrolytic conductivity of the of ions of silver chromate can be determined from the formula

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

The molar conductivity of the ions of silver chromate at infinite dilution can be obtained from tables in the data book and can be used to determine the molar conductivity of silver chromate from the formula

$$\Lambda_{Ag_2CrO_4} = 2\Lambda_{\infty} Ag^+ + \Lambda_{\infty} CrO_4^{2-}$$

The molar concentration of the solution which is the solubility of silver chromate can be determined from the formula

$$\Lambda_c = \frac{K}{c}$$

If the solubility of silver chromate is c mol dm^{-3}, then the solubility product can be determined.

$$Ag_2CrO_4(s) + aq \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq)$$

c 2c c

$$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$$

$= (2C)^2 (C)$

$= 4C^3 \text{ mol dm}^{-9}$

(OR)

A known volume of the filtrate is pipetted, excess of potassium iodide solution and dilute sulphuric acid added. The reaction produces iodine according to following equation.

$$\cancel{2CrO_4^{2-}(aq) + 16H^+(aq) + 6I^-(aq) \rightarrow 2Cr^{3+}(aq) + 3I_2(aq) + 8H_2O}$$

$$2CrO_4^{2-}(aq) + 16H^+(aq) + 6I^-(aq) \rightarrow 2Cr^{3+}(aq) + 3I_2(aq) + 8H_2O(l)$$

The iodine liberated is titrated against standard solution of sodium thiosulphate using starch indicator. (06)

The concentration of chromate ions is determined which is used to determine the concentration of silver chromate.

If x mol dm^{-3} is the molar concentration of silver chromate, the solubility can be determined as follows.

$$\underset{x}{Ag_2CrO_4(s)} + aq \rightleftharpoons \underset{2x}{2Ag^+(aq)} + \underset{x}{CrO_4^{2-}(aq)}$$

$$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$$

$$= (2x)^2(x) = 4x^3 \text{ mol dm}^{-3}$$

(d) (i) solubility of silver chromate decreases because addition of silver nitrate increases the concentration of silver ions and excess silver ions will react with chromate ions to form insoluble silver chromate hence lowering the solubility. (2½)

Alternative Concepts to KSP

(ii) Addition of ammonia solution increases the solubility of silver chromate because ammonia molecules react with silver ions to form a soluble complex called diamminesilver(I)ion. The concentration of silver ions in the solution reduces and thus more silver chromate dissolves to restore the equilibrium. (2½)

(e) When excess hydrogen chloride gas was bubbled through a mixture of salts (sea water), the solubility of sodium chloride reduces due to the presence of chloride ions from hydrogen chloride and this will lead to precipitation of sodium chloride which can be filtered off, washed with little distilled water and then dried. (02)

20

4. (a) Ideal solution is one with uniform intermolecular forces of attraction and there is no volume change and no enthalpy change on mixing the components. (01)

(b)(i) Graph.

(ii) The boiling point of pure butanol is 117°C while that pure ethanol is 78.5°C.
Butanol has a higher relative formula mass than ethanol therefore the intermolecular forces in butanol are stronger than those of ethanol and thus more energy is required to break the intermolecular forces in butanol than those in ethanol. (04)
When the amount of ethanol in the ~~increased in~~ mixture is increased, the vapour ~~is~~ will be richer in ethanol a more volatile component and the mixture boils at a lower temperature because the vapour pressure of the mixture can easily reach external atmospheric pressure.
Therefore the boiling points of the mixture decrease towards the boiling point of pure ethanol.

UGANDA NATIONAL EXAMINATIONS BOARD

(To be fastened together with other answers to paper)

Candidate's Name .....

Signature .....

Subject Name ..... Paper code .....

Random No

Personal Number

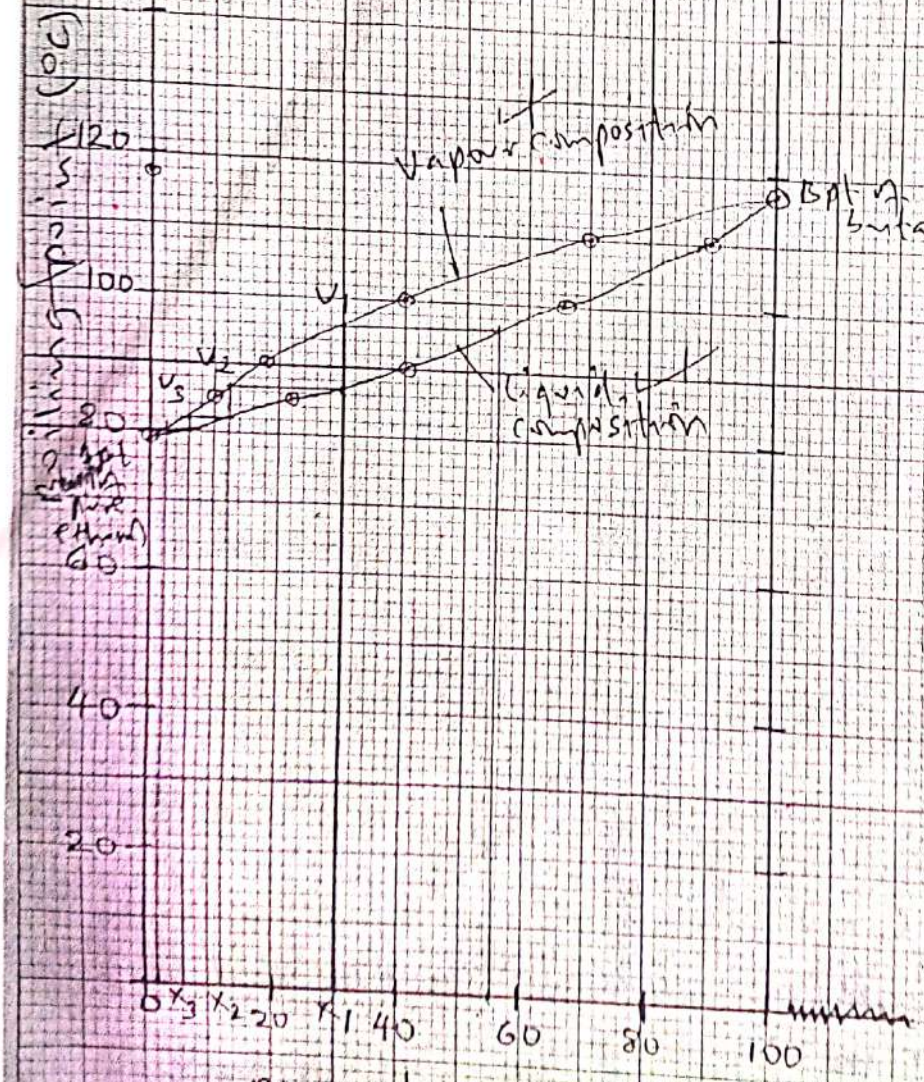
(14)

A graph of boiling point-composition diagram for butanol-ethanol system.

Title ✓
axes ✓✓
scale ✓✓
Pts - ✓✓
Shape - ✓✓
Label ✓✓

(05)

SCALE:
Horizontal 1cm rep 10% butanol
Vertical 1cm rep 10°C



(iii) When a liquid mixture containing 45% ethanol (55% butanol), ~~it~~ is heated, it will boil at 96°C giving vapour of 70% ethanol which is a more volatile component.
When the vapour is condensed it will form a liquid mixture of the same composition as that of the vapour represented by X_1.
When the condensed liquid is boiled, it will boil at a temperature of 87°C giving vapour of 88% ethanol which still a more valatile component which condenses to a liquid of the same composition represented by X_2. (04)
Repeated ~~vaporisation~~ vaporisation and condensation produces ethanol as a pure distillate and the residue in the flask is pure butanol.

(c) (i) Raoult's law states that the partial vapour pressure of a volatile component in a liquid mixture at a given temperature is the product of the mole fraction and the vapour pressure of the pure component at that temperature. (01)

(ii) The intermolecular ~~formular~~ forces of attractions in pure components are different from those in the mixture and the vapour pressure above the mixture is either smaller or higher than that predicted by Raoult's law.

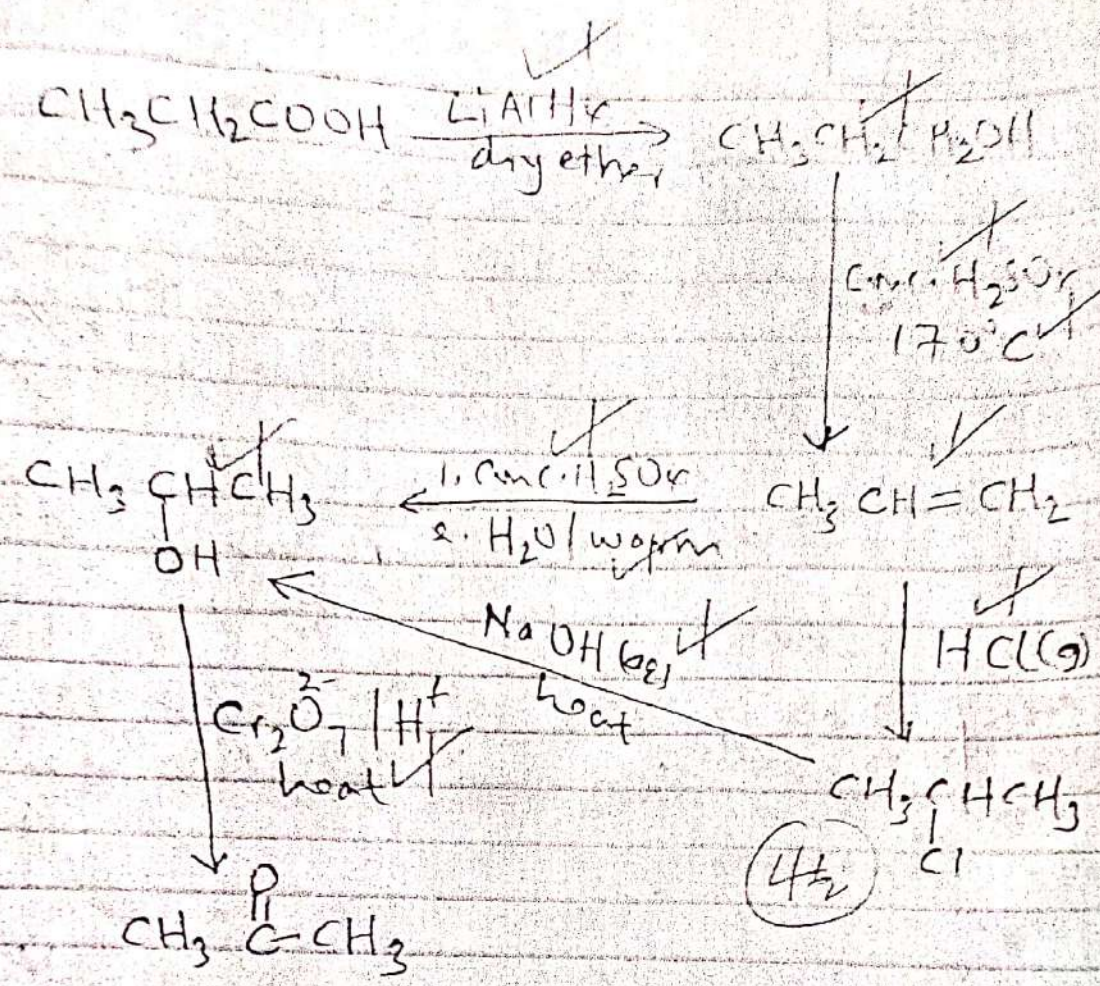
M-T- Raoult's law
The partial V.P of a volatile component in an ideal soln is proportional to its mole fraction at a given temp

(16)

The mixtures that exhibit stronger intermolecular forces of attraction will have a lower vapour pressure and their boiling points will be higher than the pure components while those mixtures that exhibit weaker inter molecular forces of attraction will have a higher vapour pressure and their boiling points are lower than the individual components. (03)

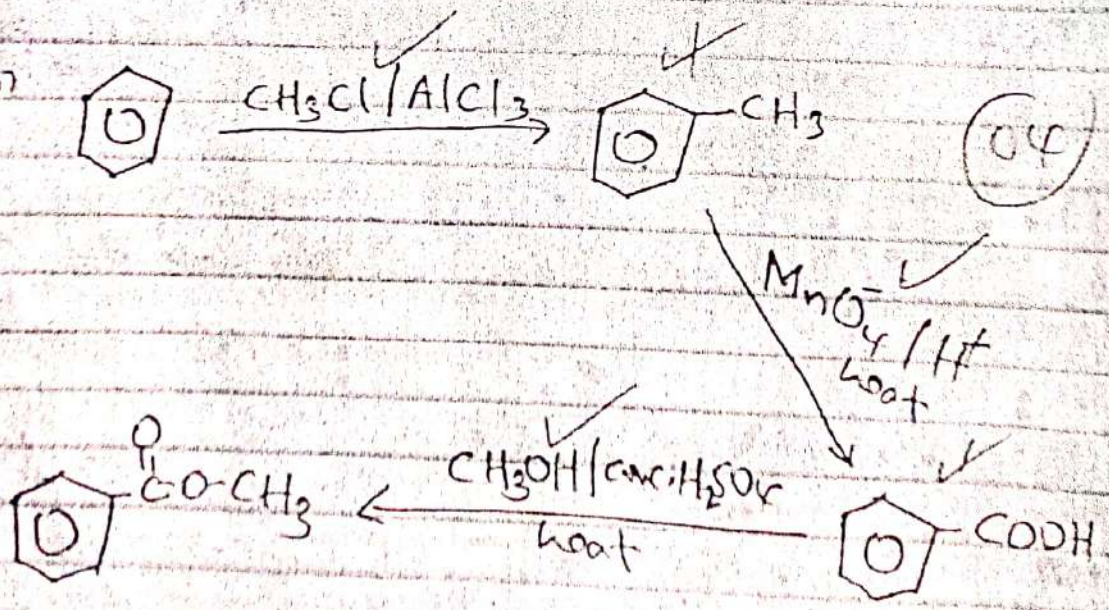
20

5. (a)


CH3CH2COOH
LiAlH4
dry ether
CH3CH2CH2OH
Conc. H2SO4
170°C
CH3CH=CH2
1. Conc. H2SO4
2. H2O / warm
CH3CH(OH)CH3
HCl(g)
CH3CH(Cl)CH3
NaOH (aq)
heat
Cr2O7 / H+
heat
CH3-C(=O)-CH3

4½

(b)


CH3Cl / AlCl3
CH3
MnO4- / H+
heat
COOH
CH3OH / Conc. H2SO4
heat
C(=O)O-CH3

04

(c) $CH_3CH=CHCH_3 \xrightarrow[2.\ H_2O/Zn/CH_3COOH]{1.\ O_3/CCl_4} CH_3CHO$

4½

$CH_3CHO \xrightarrow[H_2SO_4,\ 0^\circ C]{KCN/dil} CH_3CH(OH)CN$

$CH_3CH(OH)CN \xrightarrow[\text{Reflux (heat)}]{H_2O/H^+} CH_3CH(OH)COOH$

(d) $CH_3CH=CH_2 \xrightarrow[2.\ H_2O/warm]{1.\ conc.\ H_2SO_4} CH_3CH(OH)CH_3$

04

$CH_3CH(OH)CH_3 \xrightarrow[heat]{Cr_2O_7^{2-}/H^+} CH_3C(=O)CH_3$

$CH_3C(=O)CH_3 \xrightarrow{PCl_5} CH_3C(Cl)_2CH_3$

OR $CH_3CH=CH_2 \xrightarrow{Cl_2/CCl_4} CH_3CH(Cl)CH_2Cl$

04

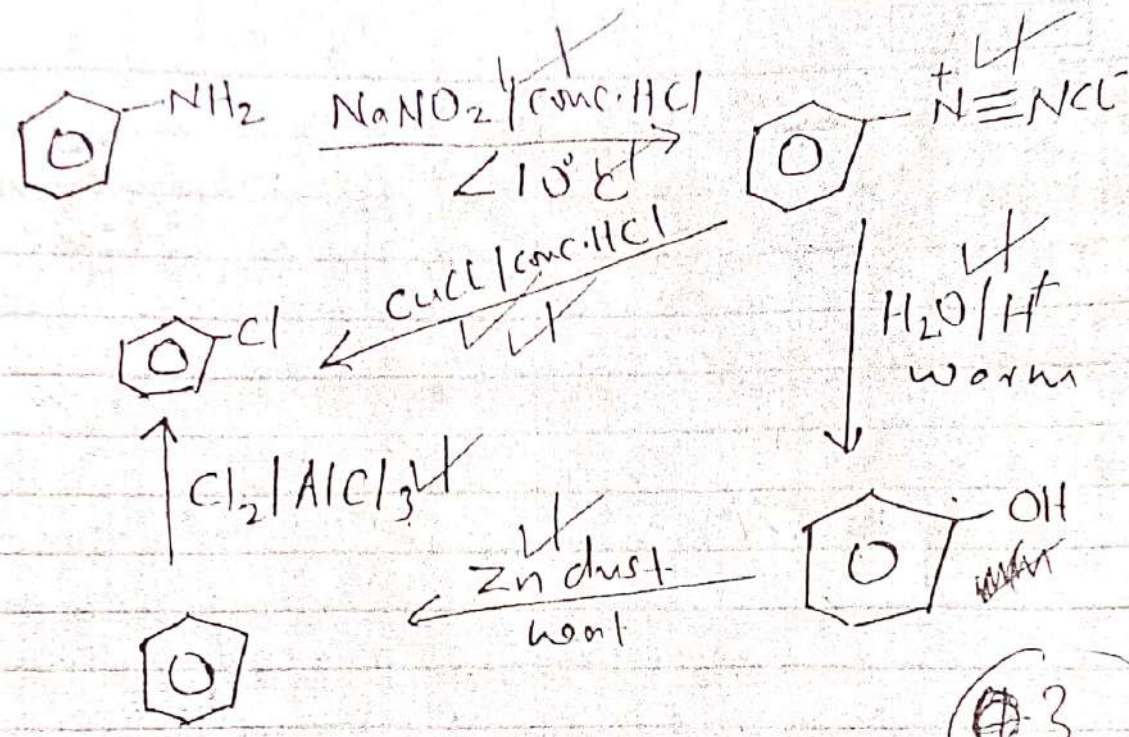
$CH_3CH(Cl)CH_2Cl \xrightarrow[heat]{KOH/alcohol} CH_3C\equiv CH$

$CH_3C\equiv CH \xrightarrow{\text{excess } HCl} CH_3C(Cl)_2CH_3$

CamScanner

(19)

(e)


NH2
NaNO2 / conc. HCl
< 10°C
N≡NCl
CuCl / conc. HCl
Cl
H2O / H+
warm
Cl2 / AlCl3
OH
Zn dust
heat

(3)

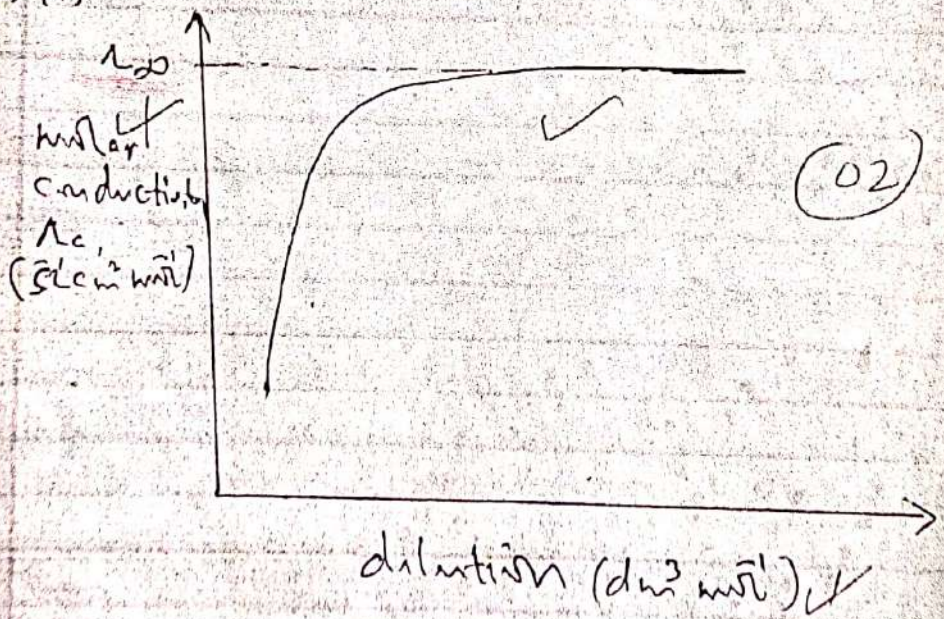
20

6. (a) (i) Electrolytic conductivity, is the conductance of a solution of an electrolyte placed between electrodes of cross sectional area of $1cm^2$ or $1m^2$ and a distance of 1cm or 1m apart. (01)

Reciprocal of resistivity.

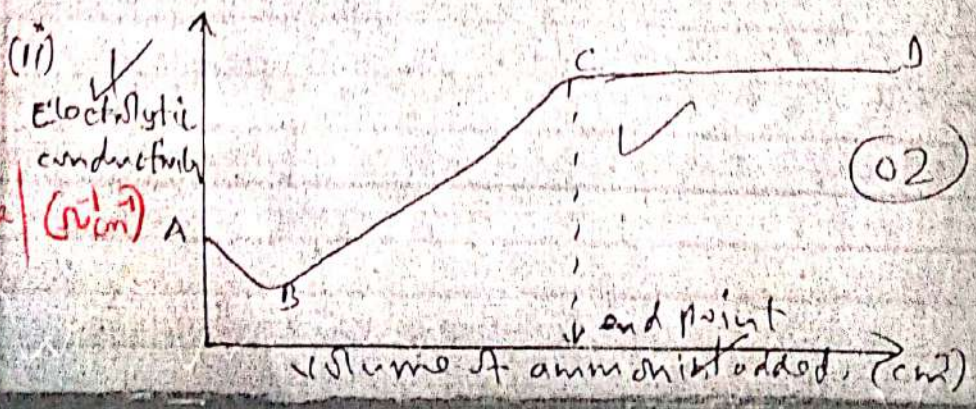
(ii) Molar conductivity is the conductance of a solution containing one mole of an electrolyte placed between electrodes of unit cross sectional area and a unit distance apart. (01)

(b) (i)



(02)

(ii)



(02)

$S cm^{-1}$

(a) For molar conductivity of Potassium chloride.
Initially the molar conductivity is low because the ions of Potassium chloride are closer to each other and this increases the ionic interference and thus reduces the ionic mobility. (04)
ionic freedom is low
As the dilution increases, the ions become far apart and thus the molar conductivity increases.
At infinity dilution, the ions move independently of each other and the molar conductivity remains constant.

For conductimetric titration of ethanoic acid, the conductivity initially is low because ethanoic acid is a weak electrolyte which partially ionises to form fewer hydrogen ions and ethanoate ions.
The initial drop in conductivity is due to removal of ~~a few~~ highly conducting hydrogen ions and the conductivity then increases along BC due to the ions of the salt (ammonium ethanoate) which is being formed in the course of the titration. (04)
Point C is the end point and the conductivity is due to the ions of the salt only. After the end point, the conductivity almost remains constant due to the suppression of the ionisation of excess ammonia by the ammonium ions from the salt.

(d) Number of moles of NaOH $= \frac{25 \times 0.01}{1000}$

$= 3.5 \times 10^{-4}$ moles

Number of moles of HCl $= \frac{45 \times 0.02}{1000}$

$= 9.0 \times 10^{-4}$ moles

$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

mole ratio NaOH : HCl = 1:1

No. of moles of HCl that reacted $= 3.5 \times 10^{-4}$

No. of moles of excess HCl $= 9.0 \times 10^{-4} - 3.5 \times 10^{-4}$

$= 5.5 \times 10^{-4}$

No. of moles of NaCl formed $= 3.5 \times 10^{-4}$ moles

$[HCl] = \frac{5.5 \times 10^{-4}}{80} \times 1000$

$= 6.875 \times 10^{-3}$ mol dm^{-3}

$[NaCl] = \frac{3.5 \times 10^{-4}}{80} \times 1000$

$= 4.375 \times 10^{-3}$ mol dm^{-3}

$\Lambda_\infty HCl = \Lambda_\infty H^+ + \Lambda_\infty Cl^-$

$= 349.8 + 76.4$

$= 426.2\ \Omega^{-1} cm^2 mol^{-1}$

$\Lambda_\infty NaCl = \Lambda_\infty Na^+ + \Lambda_\infty Cl^-$

$= 50.1 + 76.4$

$= 126.5\ \Omega^{-1} cm^2 mol^{-1}$

(24)

$K_{HCl} = \Lambda_\infty \times C \times 10^{-3}$

$= 426.2 \times 6.875 \times 10^{-3} \times 10^{-3}$

$= 2.930125 \times 10^{-3}\ \Omega^{-1} cm^{-1}$

$K_{NaCl} = \Lambda_\infty \times C \times 10^{-3}$

$= 126.5 \times 4.375 \times 10^{-3} \times 10^{-3}$ (04)

$= 5.534375 \times 10^{-4}\ \Omega^{-1} cm^{-1}$

$K_{solution} = K_{HCl} + K_{NaCl}$

$= 2.930125 \times 10^{-3} + 5.534375 \times 10^{-4}$

$= 3.4835625 \times 10^{-3}\ \Omega^{-1} cm^{-1}$.

(ii) The molar conductivity of Lithium ion is ~~greater~~ less than that of sodium ion because Lithium ion has a smaller ionic radius than sodium ion and thus Lithium ion has higher charge density than sodium ion. The Lithium ion strongly attracts water molecules and thus becomes heavily hydrated and thus its mobility reduces. (02)

20

8. (a)(i) Sodium, magnesium and aluminium form giant metallic structures with strong metallic bonds. Sodium contributes one electron per atom towards metallic bond formation while magnesium contributes two electrons per atom toward metallic bond formation. The metallic bonds in magnesium are much stronger than those in sodium and thus more energy is required to break the metallic bonds in magnesium than in sodium. Aluminium also contributes two electrons per atom just like magnesium but the melting point of aluminium is slightly higher due to the difference in atomic radius. Aluminium has a smaller atomic radius than magnesium and the outermost electrons are strongly attracted to the nucleus making the metallic bonds in aluminium to be slightly stronger than those of magnesium. (04)

(ii) Silicon has a giant covalent structure with a three dimensional net work of strong covalent bonds which require a lot of heat to break. Chlorine is a diatomic molecule with very weak van der waals forces. (2½)

(iii) Phosphorus, sulphur and chlorine form simple molecular structures with weak van der waals forces. However, sulphur has slightly higher melting point than phosphorus because sulphur exists as S_8 molecules while phosphorus exists as P_4 molecules. (2½)
Sulphur has a much higher relative molecular mass than phosphorus and thus the van der waals forces in sulphur are stronger than those in phosphorus.

(b). Aluminium reacts with hot concentrated sodium hydroxide solution to form sodium aluminate and hydrogen gas.

$$2Al_{(s)} + 2\bar{O}H_{(aq)} + 6H_2O_{(l)} \rightarrow 2Al(OH)_4^-{}_{(aq)} + 3H_{2(g)}$$

(08)

Silicon reacts with hot concentrated sodium hydroxide solution to form sodium silicate and hydrogen gas.

$$Si_{(s)} + 2\bar{O}H_{(aq)} + H_2O_{(l)} \rightarrow SiO_3^{2-}{}_{(aq)} + 2H_{2(g)}$$

Chlorine reacts with cold dilute sodium hydroxide solution to form sodium hypochlorite (sodium chlorate(I)), sodium chloride and water.

$$Cl_{2(g)} + 2\bar{O}H_{(aq)} \rightarrow O\bar{C}L_{(aq)} + C\bar{L}_{(aq)} + H_2O_{(l)}$$

Chlorine reacts with hot concentrated sodium hydroxide solution to form