SAMPLE PAPER 8

CHEMISTRY PAPER 1

(THEORY)

Maximum Marks: 70

Time Allowed: Three Hours

*(Candidates are allowed **additional 15 minutes** for **only** reading the paper.*

*They must **NOT** start writing during this time.)*

This paper is divided into four sections – A, B, C and D.
*Answer **all** questions.*
***Section – A** consists of **one** question **having sub-parts** of **one** mark each.*
***Section – B** consists of **ten** questions of **two** marks each.*
***Section – C** consists of **seven** questions of **three** marks each, and*
***Section – D** consists of **three** questions of **five** marks each.*
Internal choices have been provided in one question each in Section B, Section C and Section D.
All working, including rough work, should be done on the same sheet as, and adjacent to the rest of the answer.
The intended marks for questions or parts of questions are given in brackets [ ].
Balanced equations must be given wherever possible and diagrams where they are helpful.
When solving numerical problems, all essential working must be shown.
In working out problems, use the following data:
Gas constant R = 1.987 cal deg^{-1} mol^{-1} = 8.314 JK^{-1} mol^{-1} = 0.0821 dm^3 atm $K^{-1}mol^{-1}$
1 L atm = 1 dm^3 atm = 101.3 J, 1 Faraday = 96500 coulombs, Avogadro's number = 6.023×10^{23}

SECTION A – 14 MARKS

Question 1

(A)

(i)

Ans.: **Cannot, rate**

(ii)

Ans.: **Square planar, tetrahedral**

(iii)

Ans.: **Anhydrous $ZnCl_2$, HCl**

(iv)

Ans.: **S_N1, S_N2**

(B)

(i)

Ans.: d) P, Q and S

Explanation:

Infinite dilution signifies a state where weak electrolytes approach full ionization, strong electrolytes are fully dissociated, and interionic effects become negligible. As a solution is diluted, molar conductance increases due to enhanced dissociation, but specific conductance decreases because the number of ions per unit volume diminishes.

(ii)

Ans: a) $[Co(en)_3]^{3+}$

Explanation:

$[Co(en)_3]^{3+}$ is optically active and will give rise to optical isomers. Six co-ordinate complexes containing three identical bidenate ligands, such as $[Co(en)_3]^{3+}$ or $[Co(OX)_3]^{3-}$ are optically active.

(iii)

Ans.: b) K_2MnO_4

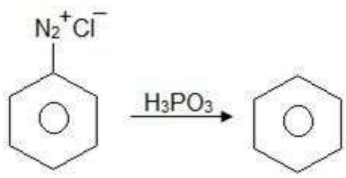
Explanation:

$$2MnO_2 + 4KOH + O_2 \rightarrow \underset{\text{(Green)}}{2K_2MnO_4} + 2H_2O$$

(iv)

Ans.: c) benzene

Explanation:



(v)

Ans.: c) 0.67

Explanation:

Total vapour pressure, $p_{total} = p_1 + p_2$

$= 100 + 50$

$= 150$ mm

$\therefore$ Mole fraction of benzene in solution,

$$x = \frac{p_1}{p_1 + p_2}$$

$$= \frac{100}{150} = \frac{2}{3} = 0.67$$

(vi)

Ans.: **a)** Both assertion and reason are true and the reason is the correct explanation of assertion.

Explanation:

Conductivity depends on the number of ions per unit volume. Conductivity decreases with the decrease in concentration for both the strong and the weak electrolytes. On dilution, the number of ions per unit volume that carry the current in the solution decreases. Thus, conductivity decreases.

On dilution, the number of ions per unit volume decreases, Thus, conductivity of electrolyte decreases on dilution.

(vii)

Ans.: **a)** Both assertion and reason are true and the reason is the correct explanation of assertion.

Explanation: Tertiary amines do not have intermolecular association due to the absence of hydrogen atom available for hydrogen bond formation.

(C)

Ans.: **(i)** A mixture of ethylene glycol and water is used in car radiators in cold countries to prevent freezing. Ethylene glycol lowers the freezing point of the coolant, ensuring that the radiator remains effective in dissipating heat even in extremely low temperatures.

(ii) The molal depression constant (K_f) remains constant even when the molality of a dilute solution is doubled, as K_f is a characteristic property dependent on the specific solute-solvent system. Changes in molality do not affect the inherent value of K_f for a given solute and solvent.

(iii)

$$\Delta T_f = \frac{1000 \times K_f \times w}{m \times W} = K_f \times \text{molality}$$

$$= 1.86 \times 0.1 = 0.186$$

Thus, f. pt. $= 0 - 0.186°C = -0.186°C$

SECTION B – 20 MARKS

Question 2

Ans.: **(i)** The correct option is Pentan-1-ol > 2-methylbutan-2-ol > 3-methylbutan-2-ol.

This is because increased branching results in a more compact molecular shape, reducing surface area and weakening van der waals forces, leading to a lower boiling point.

(ii) Ethanol produces a yellow precipitate of CHI_3 on reaction with NaOH and Iodine solution whereas methanol, which do not have a free methyl group doesn't.

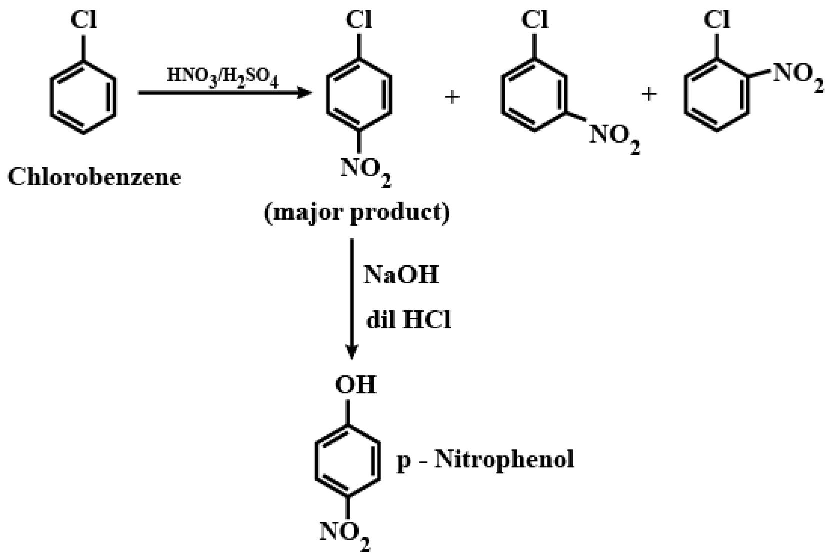
Question 3

Ans.: **(i)** Lanthanoids have similar outer electronic configurations and show a +3-oxidation state, leading to comparable chemical properties. The different lanthanoids differ mainly in the number of 4f-electrons which are buried deep in the atoms and hence, do not influence the properties. Small differences in the size of trivalent lanthanoid ions, caused by lanthanoid contraction, are also the reasons for their very similar chemical behaviors.

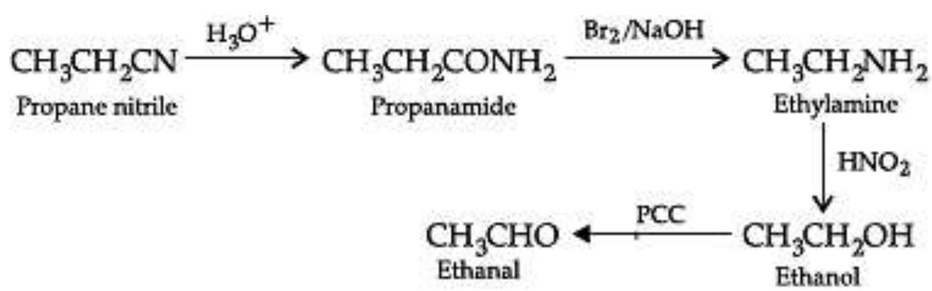
(ii) In the 3*d*-transition series as we move from Sc (21) to Mn (25) the number of unpaired electrons increases and hence paramagnetic character increases. After Mn, the pairing of electrons in the d-orbital starts and the number of unpaired electrons decreases and hence, paramagnetic character decreases.

Question 4:

Ans.: **(i)**



(ii)



Question 5:

Ans.:

(i) Due to the removal of an electron from the stable d^{10} configuration of Zn^{2+}.

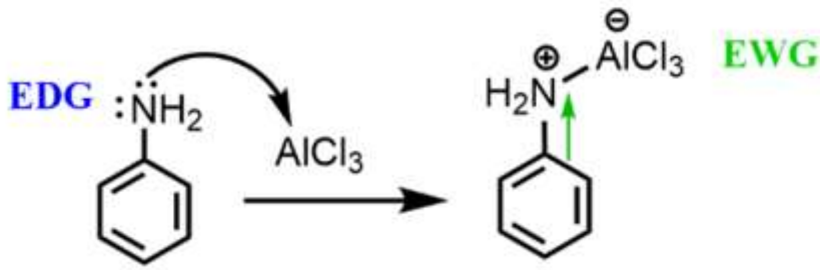
(ii) Transition metals despite having high E° oxidation, are poor reducing agents because of their high heat of vaporization, high ionisation energies and low heats of hydration.

Question 6:

Ans.:

(i) Product B is Aniline

(ii) No, the product B (Aniline) does not react with isopropyl chloride because of ring deactivation by $AlCl_3$.



Ring deactivated

Question 7:

Ans.:

The reaction is:

$A(s) + 2B^{+}(1\times10^{-3}M) \longrightarrow A^{+2}(0.4\ M) + 2B(s)$

Substituting the values in Nernst equation,

$E = E^{\circ} - (0.059/2)\log[A^{+2}/[B^{+}]^{2}]$

$= 0.80-(-2.37)-(0.059/2)\log(0.4/(10^{-3})^{2})$

$= 3.17-0.1652$

$= 3.0047\ V$

Question 8:

Ans.: (i) (a)

$$\underset{(3^{0}\text{ alcohol})}{H_3C\text{-}\underset{\displaystyle CH_3}{\underset{|}{C}}(OH)\text{-}CH_3} \xrightarrow[\text{dehydration}]{Cu/573K} \underset{(\text{alkene})}{H_3C\text{-}\underset{\displaystyle CH_3}{\underset{|}{C}}=CH_2}$$

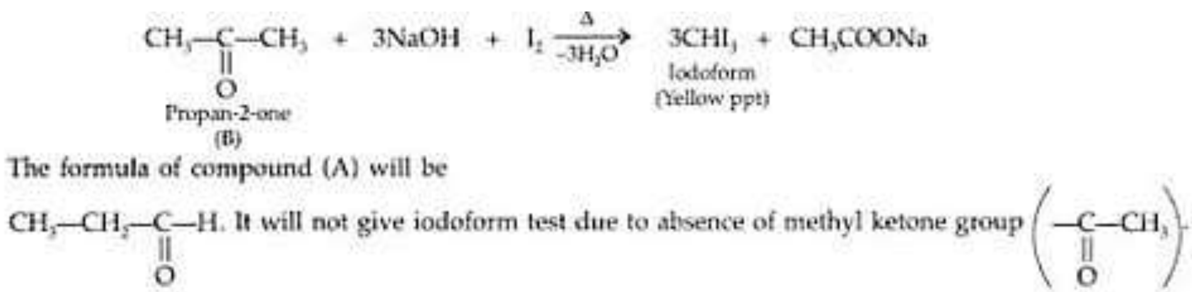
(b)

$$\overset{\beta}{C}H_3-\overset{\alpha}{C}H_2-OH \xrightarrow[623\ K]{Al_2O_3} \underset{\text{Ethene}}{CH_2=CH_2} + H_2O$$

OR

Ans.: **(ii)**

The given compound has molecular formula C_3H_6O. One of its functional isomers i.e., B shows an iodoform test which can be only shown by compounds having methyl ketone so the compound B will be Acetone or 2-propanone. Its functional isomer A will be propanal.



Question 9:

Ans.:

Molar mass of ethylene glycol $[C_2H_4(OH)_2] = 2 \times 12 + 6 \times 1 + 2 \times 16 = 62$ g mol^{-1}

Number of moles of ethylene glycol 222.6 g / 62 g mol^{-1} = 3.59 mol

Therefore, molality of the solution =3.59 mol / 0.200 kg = 17.95 m

Total mass of the solution = (222.6 + 200) g = 422.6 g

Given,

Density of the solution = 1.072 g mL^{-1}

Therefore, Volume of the solution = 422.6 g / 1.072 g mL^{-1}

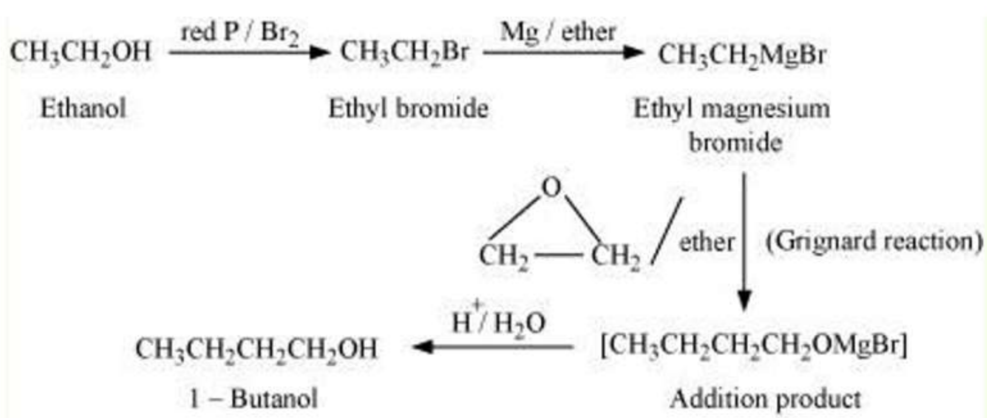
= 394.22 mL

= 0.3942×10^{-3} L

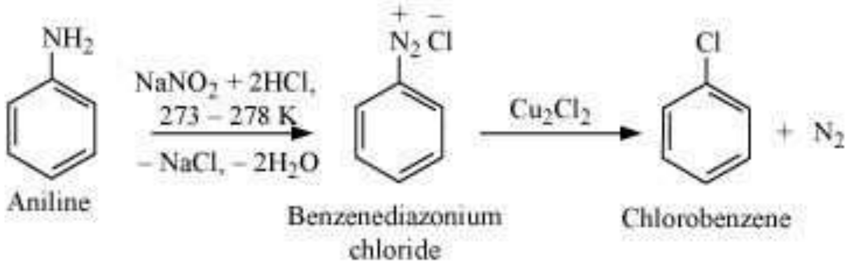
Molarity of the solution = 3.59 mol / 0.39422×10^{-3} L= 9.11 M

Question 10:

Ans.: **(a)**



(b)



Question 11:

Ans.:

(i) Zinc has lowest enthalpy of atomisation due to weak metallic bond which is due to absence of unpaired electrons.

(ii) Iron has higher enthalpy of atomization than that of copper due to higher number of unpaired electrons in iron.

SECTION C – 21 MARKS

Question 12:

Ans.:

(i) Rate $= k[NO]^x[O_2]^y$

$7.2 \times 10^{-2} = k[0.3]^x[0.2]^y$ Eqn (1)

$6.0 \times 10^{-3} = k[0.1]^x[0.1]^y$ Eqn (2)

$2.88 \times 10^{-1} = k[0.3]^x[0.4]^y$ Eqn (3)

$2.40 \times 10^{-2} = k[0.4]^x[0.1]^y$ Eqn (4)

Dividing eqn 4 by eqn 2

$$\frac{2.40\times10^{-2}}{6.0\times10^{-3}} = \frac{k[0.4]^x[0.1]^y}{k[0.1]^x[0.1]^y}$$

$$x = 1$$

Dividing eqn 3 by eqn 1

$$\frac{2.88\times10^{-1}}{7.2\times10^{-2}} = \frac{k[0.3]^x[0.4]^y}{k[0.3]^x[0.2]^y}$$

$$y = 2$$

order w.r.t. NO = 1, order w.r.t. O_2 is 2

(ii) Rate law

Rate $= k[NO]^1[O_2]^2$,

overall order of the reaction is 3.

(iii) Rate constant $k = \dfrac{\text{rate}}{[NO]^1[O_2]^2}$

$$= \frac{7.2\times10^{-2}}{0.3\times(0.2)^2}$$

Question 13:

Ans.:

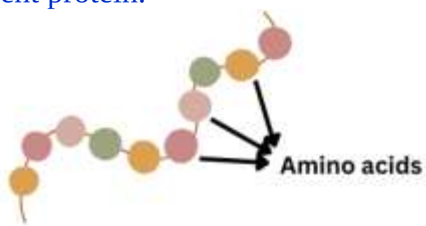
(i) $NH_3 < (CH_3)_3N < CH_3NH_2 < (CH_3)_2NH$

(ii) $NH_3 < C_2H_5NH_2 < (C_2H_5)_3N < (C_2H_5)_2NH$

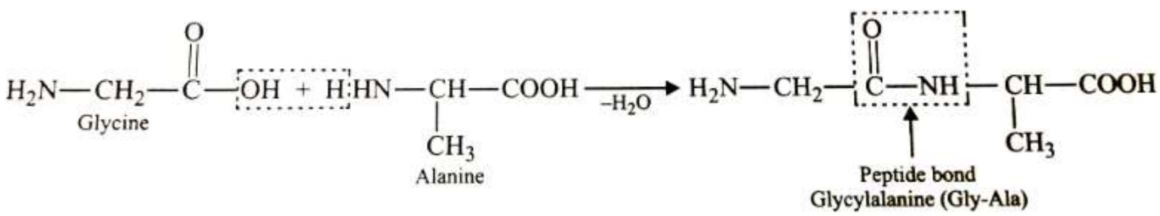
Question 14:

Ans.:

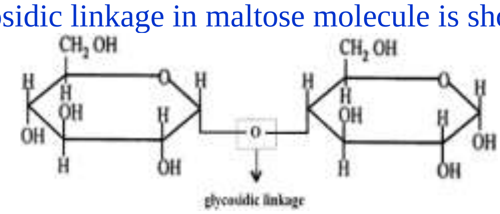
(a) Primary structure: The primary structure of protein refers to the specific sequence in which various amino acids are present in it, i.e., the sequence of linkages between amino acids in a polypeptide chain. The sequence in which amino acids are arranged is different in each protein. A change in the sequence creates a different protein.



(b) Peptide linkage: In peptide linkage amide formed between -COOH groups of one molecule of an amino acid and $-NH_2$ group of another molecule of the amino acid by the elimination of a water molecules.



(c) Glycosidic linkage: The ethereal or oxide linkage through which two monosaccharide units are joined together by the loss of a water molecule to form a molecule of disaccharide is called the glycosidic linkage. The glycosidic linkage in maltose molecule is shown below:



Question 15:

Ans.: **(i)**

Mass of K_2SO_4 = 0.025 gm

Molar mass of K_2SO_4 = 174 g / mol

Volume = 2L

Temperature = 25°C (298 K)

$$\pi V = nRT$$

$$\pi = \frac{n}{V}RT$$

$$= \frac{\text{mass}}{\text{molar mass}} \times \frac{1}{V}RT$$

$$= \frac{3 \times 0.025}{174 \times 2} \times 0.0821 \times 298$$

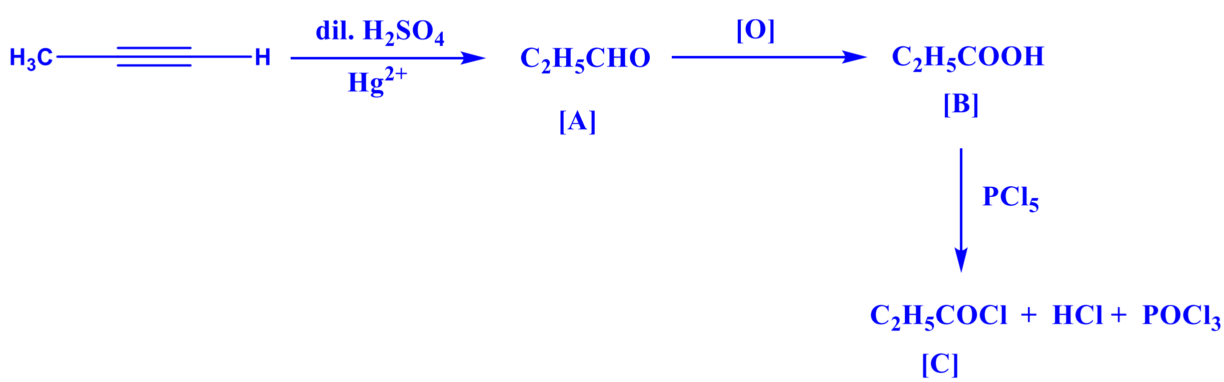
$$= 5.2728 \times 10^{-3} \text{ atm}$$

(ii) This is because van't Hoff factor for NaCl is 2 and for glucose, it is 1.

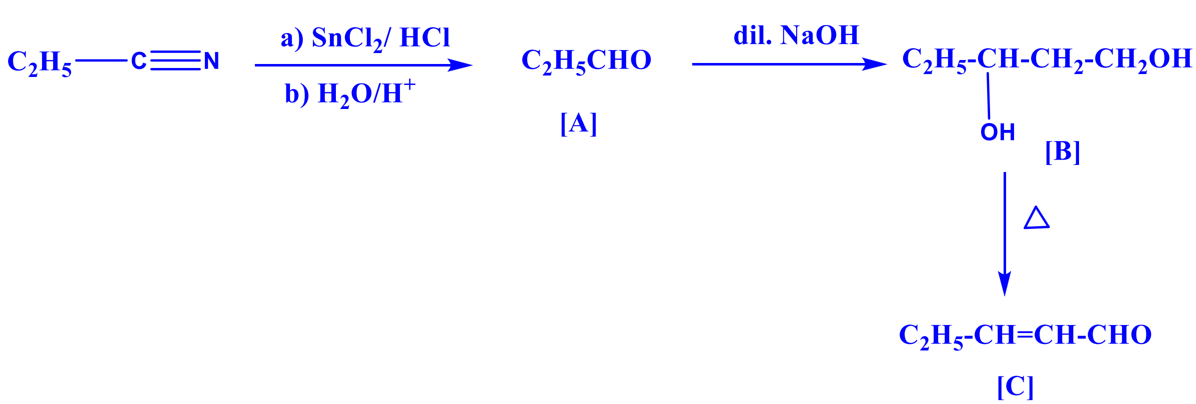
Question 16

Ans.:

(i)



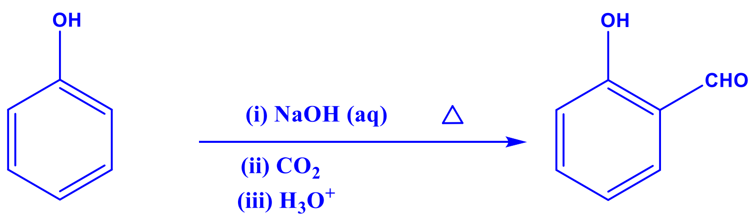
(ii)



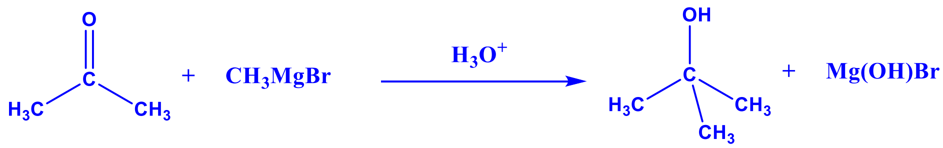
Question 17

Ans.: (i)

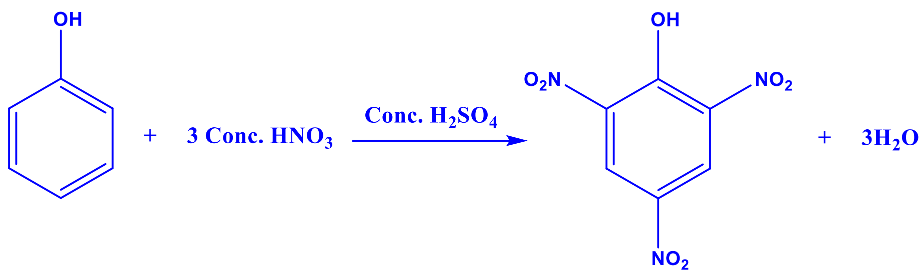
(a)



(b)



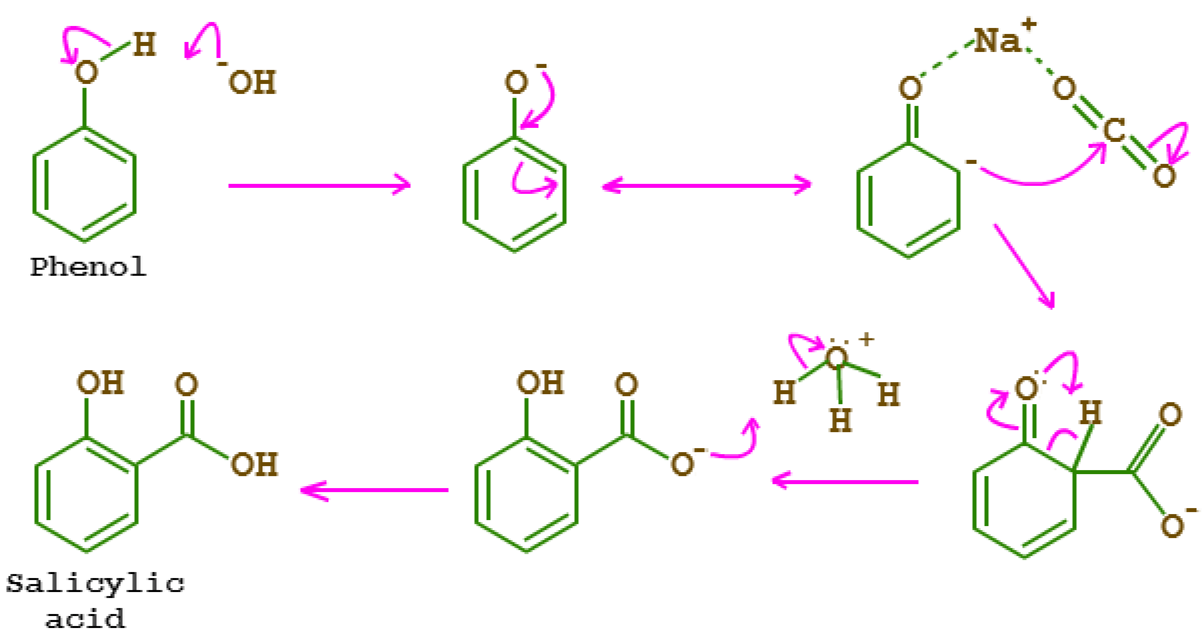
(c)



OR

(ii)

Ans.:



18.

Ans.: (i)

Radioactive decay follows first order kinetics,

Decay constant (k) = $\frac{0.693}{t_{1/2}} = \frac{0.693}{5730} yr^{-1}$

According to question, living tree has 80% ^{14}C hence,

$$k = \frac{2.303}{t} \log \frac{[A]_0}{[A]}$$

$$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]}$$

$$t = \frac{2.303 \times 5730}{0.693} \log \frac{100}{80}$$

$$t = \frac{2.303 \times 5730 \times 0.0969}{0.693}$$

t = 1845 years

Hence the age of sample is = 1845 years

(ii)

$E_a = ? \, k_2 = 2k_1, T_1 = 298K, T_2 = 308K$

$$\log \frac{k_2}{k_1} = \frac{E_a}{2.303R} \left(\frac{T_2 - T_1}{T_1 T_2} \right)$$

$$\log \frac{k_2}{k_1} = \frac{E_a}{2.303 \times 8.314} \left(\frac{10}{298 \times 308} \right)$$

$$0.3010 = \frac{E_a}{2.303 \times 8.314} \times \frac{10}{298 \times 308}$$

$$E_a = \frac{0.3010 \times 2.303 \times 8.314 \times 298 \times 308}{10}$$

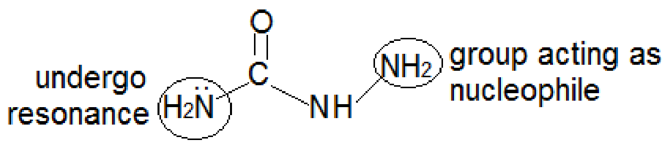
$$= 52897.7 mol^{-1}.$$

$$E_a = 52.8977 kJ mol^{-1}.$$

SECTION D – 15 MARKS

Question 19:

Ans.: (i) (a) This is due to the fact that the unshared pair of electrons on N-atom adjacent to the C=O group becomes involved in resonance interaction with these groups and hence, are less available for bond formation.

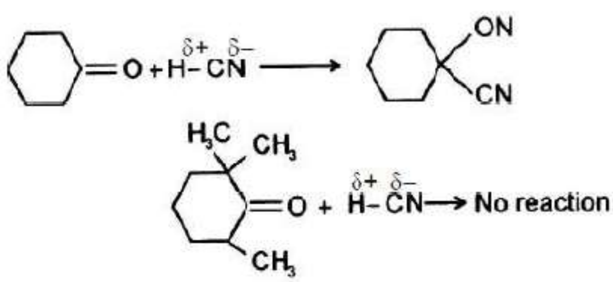


(b)

$$RCO\boxed{OH + H}OR^1 \underset{}{\overset{H^+}{\rightleftharpoons}} RCOOR^1 + H_2O$$

Both esterification and hydrolysis of ester are catalyzed by acid, the reaction is reversible and an equilibrium is established, so ester or water is removed to favor the forward reaction, as per Le Chatelier's principle.

(c)



(a) The three methyl groups are electron releasing and they increase the electron density over carbonyl carbon atom thus reducing its electrophilicity.

(b)Three methyl groups cause steric hinderance to nucleophilic attack on the carbonyl carbon of >C=group.

Ans.: (ii) (a)

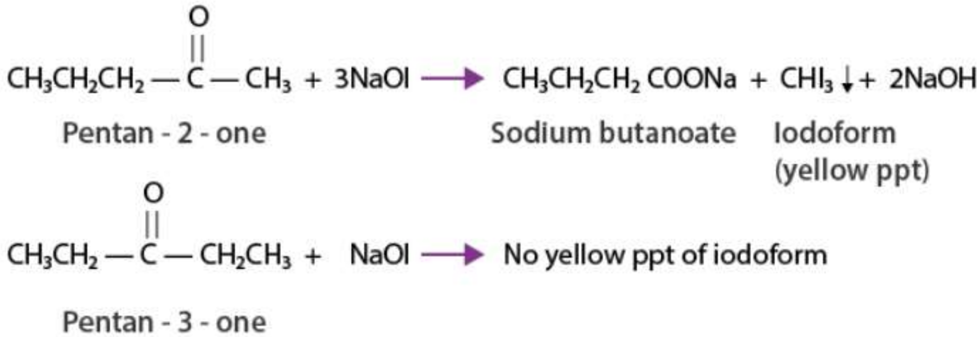
Ethanal and propanal can be distinguished by Iodoform test.

$CH_3CHO + 3NaOI \rightarrow HCOONa + CH_3I\downarrow + 2NaOH$

(Yellow ppt.)

$CH_3CH_2CHO + I_2/NaOH \rightarrow$ No yellow ppt.

(b)



Question 20:

Ans.: **(i)** The color of coordination compounds is influenced by the crystal-field splitting energy (Δ), which depends on the ligand. In $[Fe(CN)_6]^{4-}$, a strong-field ligand, the high CFSE results in a larger energy gap for intra d-d transitions, leading to a distinct color compared to $[Fe(H_2O)_6]^{2+}$, where the weaker-field ligand (water) results in a lower CFSE and a different transmitted color.

(ii) $FeSO_4$ solution mixed with $(NH_4)_2SO_4$ solution in 1:1 molar ratio forms a double salt, $FeSO_4$ $(NH_4)_2SO_4$-$6H_2O$ (Mohr's salt) which ionizes in the solution to give Fe^{2+} ions. Hence it gives the tests of Fe^{2+} ions. $CuSO_4$ solution mixed with aqueous ammonia in 1:4 molar ratio forms a complex salt, with the formula $[Cu(NH_3)_4]SO_4$. The complex ion $[Cu(NH_3)_4]^{2+}$ does not ionize to give Cu^{2+} ions. Hence, it does not give the tests of Cu^{2+} ion.

(iii) Aqueous solution of copper sulphate contains Cu^{2+} ions in form of complex entity, $[Cu(H_2O)_4]^{2+}$ and H_2O ligand is a weak ligand. When excess of KCN is added, a new coordination entity, $[Cu(CN)_4]^{2-}$ is formed due to following reaction:

$$CuSO_4(aq) + 4KCN \rightarrow K_2[Cu(Cn)_4] + K_2SO_4(aq)$$

$$\underset{}{[Cu(H_2O)_4]_2} + \underset{\text{(from aq. KCN)}}{4CN} \rightarrow \underset{\text{(highly stable coordination entity)}}{[CuCN_4]^{2-}} + 4H_2O$$

Cyanide ligand CN^- is a strong field ligand and stability constant of $[Cu(CN)_4]^{2-}$ is quite large and thus practically no Cu^{2+} ions are left in solution. Hence, no precipitate of copper sulphide is obtained when $H_2S(g)$ is passed through solution.

Question 21:

Ans.:

(i) The product formed at the cathode for the above reaction is sodium hydroxide (NaOH) and hydrogen (H_2).

(a) The products of electrolysis depend on the different oxidising and reducing species present in the electrolytic cell and their standard electrode potentials.

(b) Nature of the electrode used.
(ii) The nature of the electrodes are inert. The electrodes do not participate in the chemical reaction but acts only as source or sink for electrons.

(iii) The electrode reactions if the electrolyte is molten NaCl are:
Cathode reaction: $Na^+ + e^- \rightarrow Na$
Anode reaction: $Cl^- \rightarrow \frac{1}{2}Cl_2 + e^-$

(OR)

Ans.: (ii) (a)

Given ,

$$\Lambda_m^o(KCl) = 152\ Scm^2\ mol^{-1}$$

$$\Lambda_m^o(NaCl) = 128\ Scm^2\ mol^{-1}$$

$$\Lambda_m^o(KNO_3) = 111\ Scm^2\ mol^{-1}$$

$$\Lambda_m^o(NaNO_3) = ?$$

Now,

$$NaCl + KNO_3 \rightarrow NaNO_3 + KCl$$

According to kohlrausch's law, $\Lambda_m^o(NaNO_3)$ is given as,

$$\Lambda_m^o(NaNO_3) = \Lambda_m^o(NaCl) + \Lambda_m^o(KNO_3) - \Lambda_m^o(KCl)$$

$$= 128 + 111 - 152$$

$$\Lambda_m^o(NaNO_3) = 87\ Scm^2\ mol^{-1}$$

(b)

$$2Cr(s) + 3Fe^{2+}(aq) \rightleftharpoons 2Cr^{3+} + 3Fe(s)$$

$$E = E^\circ - \frac{0.059}{6}\log\frac{(0.01)^2}{(0.01)^3}$$

$$E^\circ = 0.261\ V$$

$$E = 0.261 - \frac{0.059}{6}\log 10^{-2} = 0.261 - \frac{0.059}{6}\times(-2) = 0.261 + 0.0197 = 0.2807\ V$$

(c) $Ca^{2+} + 2e^- \rightarrow Ca$

To produce 40 g Ca, electricity needed = 2F
∴ To produce 20 g Ca, electricity needed = 40/ 2 × 20 = 1F

****************************** The End ******************************