SAMPLE PAPER 2

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 x 10^{23}

SECTION A – 14 MARKS

Question 1

(A)

Ans.: mol L^{-1} s^{-1}, s^{-1}

(ii)
Ans.: 6, 3

(iii)
Ans.: carbocations, nucleophilic

(iv)
Ans.: white, 2,4,6-tribrmophenol

(B)

(i)

Ans.: (c) Only Q and S

Explanation: When NaCl is added to an $AgNO_3$ solution, silver ions (Ag^+) combine with chloride ions (Cl^-) to form a white precipitate of silver chloride (AgCl). The cloudiness is due to the formation of this precipitate. The solubility product of AgCl is exceeded, which results in the precipitation of AgCl from the solution.

(ii)

Ans.: (c) 5

Explanation: $_{26}Fe = [Ar]3d^5\ 4s^2;\quad Fe^{2+} = [Ar]3d^6$

Number of unpaired electrons, n=4

$\mu = \sqrt{n(n+2)} = \sqrt{4(4+2)} = 4.89$

(iii)

Ans.: (d) f-orbital electron are poor shielders of nuclear charge.

Explanation: The size of lanthanides are smaller than expected. This is associated with the filling with the filling up of 4f orbitals which must be filled before the 5d orbitals. The electrons in f-orbitals are not effective in screening other electrons from the nuclear charge

(iv)

Ans.: (d) B < C < A

Explanation: In primary amine intermolecular association due to H-bonding is maximum while in tertiary it is minimum.

(v)

Ans.: (a) Molarity

(vi)

Ans.: (a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

Explanation: The reduction of 1 mole of Cu^{2+} ions requiring 2 faradays is consistent with the definition of the Faraday, which is the charge carried by 1 mole of electrons. The reason is valid, as 1 Faraday is indeed equal to the charge of 1 mole of electrons.

(vii)

Ans.: (d) Assertion is false but Reason is true.

Explanation: Acetylation of aniline reduces its tendency to undergo electrophilic substitution reactions due to the electron-withdrawing nature of the acetyl group, which deactivates the benzene ring. The resonance stabilization involving both the benzene ring and the acetyl group is less effective in enhancing the reactivity compared to the resonance with the original amino group.

(C)

(i)

     (d) I and IV

Ans.: (d) II represents negative deviations and III represents positive deviations.

(ii)

Ans.: (b) For positive deviations $p_A > p_A^° x_A$ and $p_B > p_B^° x_B$

(iii)

Ans.: Azeotropic mixture is defined as a binary mixture having the same composition in liquid phase and vapour phase.

SECTION B – 20 MARKS

Question 2

Ans.: (i) Increasing order of acidity: o-cresol < phenol < o-nitrophenol
O-nitrophenol is a stronger acid than phenol due to the -I and -R effects of the NO_2 group, but o-cresol is a weaker acid due to the +I effect of the CH_3 group.

(ii) The OH group in phenols is a powerful electron donor. As a result, the benzene ring's electron density is quite high, and it repels nucleophiles. To put it another way, nucleophiles are unable to approach the benzene ring, hence phenols rarely undergo nucleophilic substitution reactions.
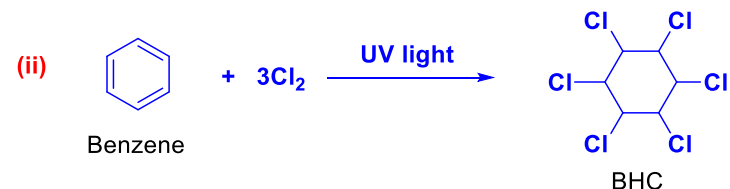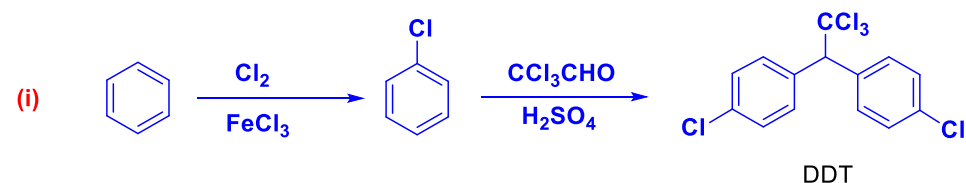
Question 3

Ans.: (i) The atomic radii of transition elements in any series are not much different and hence can replace each other easily in lattice.
(ii) Zn^{2+} does not have any unpaired electron while Cu^{2+} has an unpaired electron and can undergo d-d transition emitting colour.

Question 4
Ans.:

(i)

(ii)

Question 5

Ans.:

(i) On moving from Ti to Cu, the atomic radii decrease due to increase in nuclear charge. Therefore, atomic volume decreases with increase in atomic mass. Hence, density increases.

(ii) Zn has completely filled d-orbitals in its atomic as well as in its common oxidation state.

Question 6

Ans.:

(i) (±) 2 -butanol is a racemic mixture which is optically inactive due to the external compensation. The rotation of one enantiomer will be cancelled due to the rotation of the other isomer, making the mixture optically inactive.

(ii) Both enantiomers will have the different optical activity.

(iii) In CH_3-X, the carbon atom is sp^2 hybridized while in halobenzene carbon atom is sp^2 hybridised. The sp^2 hybridized carbon is more electronegative due to greater s-character and hold the electron pair of C-X bond bond tightly than sp3 hybridized carbon with less s-character. Thus C-X bond length in C-X is larger than C-X bond in halobenzene.
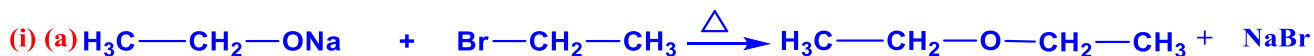
Question 7

Ans.: (i) The specific resistance of a substance is its resistance when cell is one meter long and its area of cross Section is one m^2. Its SI unit is Ωm (ohm meter)

(ii) 'B' is strong electrolyte. For strong electrolyte Λ_m increases slowly with dilution since the number of ions remains the same, only the interionic attraction decreases thus the molar conductivity increases slightly.
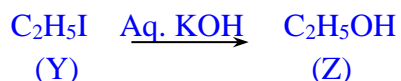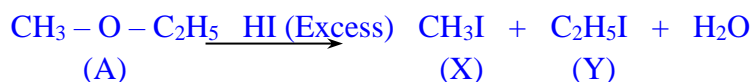
Question 8

Ans.:

(i) (a) $H_3C-CH_2-ONa \quad + \quad Br-CH_2-CH_3 \xrightarrow{\triangle} H_3C-CH_2-O-CH_2-CH_3 + \quad NaBr$

(b) $CH_3CH_2OH + 4I_2 + 6NaOH \longrightarrow CHI_3 + HCOONa + 5NaI + 5H_2O$

OR

(ii)

Ans.: If A reacts with HI, it could be ether

$CH_3 - O - C_2H_5 \xrightarrow{HI (Excess)} CH_3I + C_2H_5I + H_2O$
(A)   (X)   (Y)

$C_2H_5I \xrightarrow{Aq. KOH} C_2H_5OH$
(Y)   (Z)

Question 9

Ans.:

$W_2 = 10.50$ g, $W_1 = 200$ g

$M_2(MgBr_2) = 184$ mol^{-1}

$K_f = 1.86$ K kg mol^{-1}

$MgBr_{2(aq)} \rightarrow Mg^{2+}_{(aq)} + 2Br^-_{(aq)}, i = 3$
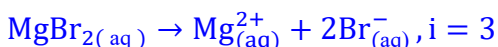
$\Delta T_f = iK_f m, \Delta T_f = \dfrac{i \times K_f \times W_2 \times 1000}{M_2 \times W_1}$

$\Delta T_f = \dfrac{3 \times 1.86 \times 10.50 \times 1000}{184 \times 200} = 1.592$ K

Question 10

Ans.: (i) Aromatic carboxylic acids do not undergo Friedel Crafts reaction because - COOH group is deactivating and the catalyst aluminium chloride (Lewis acid) gets bonded to the carboxyl group.

(ii) Due to the presence of a strong electron withdrawing (-NO$_2$) group in 4-nitrobenzoic acid, it stabilizes the carboxylate anion and hence strengthens the acid. Therefore, 4-nitrobenzoic acid is more acidic than benzoic acid and its pK$_a$ value is lower.

Question 11

Ans.:

(i) Lanthanoid contractions- The cumulative effect of the regular decrease in size or radii of Lanthanoid with increase in atomic number is called Lanthanoid contraction.
Its Causes: The shape of f orbitals is diffused. They have poor shielding effect due to which the effective nuclear charge increases with increase in atomic number. This causes a decrease in atomic radii.
Its Consequence are: Due to Lanthanoid contraction:

- Radii of the members of the third transition series are similar to those of second transition series.
- It becomes difficult to separate Lanthanides.

(ii) The colour of Lanthanoids and Actinoids is due to f-f transitions. When one or more unpaired electrons are present in the f orbital, light in the visible region is absorbed which results in f-f transition and colour.

SECTION C – 21 MARKS

Question 12

Ans.: Ans.: $\log k = \log A - \frac{E_a}{2.303RT}$ — — — — — — — — — — — — (i)

$\log k = 14.2 - \frac{10^4}{T}$ $(Given)$ — — — — — — — — — — — (ii)

Comparing equations (i) and (ii), we have

$\frac{E_a}{2.303RT} = \frac{10^4}{T}$

$E_a = 10^4 \times 2.303 \times 8.314$

$= 191471.4$ J/mol

$= 191.47$ kJ/mol

$t_{1/2} = \frac{0.693}{k}$ [For first order reaction]

$k = \frac{0.693}{200 \text{ min}}$

$= 0.0034$ min^{-1} or 3.4×10^{-3} min^{-1}

Question 13

Ans.: (i) $C_6H_5NH_2 < C_6H_5NHCH_3 < CH_3NH_2 < (C_2H_5)_2NH$

(ii) $(CH_3)_3N < C_2H_5NH_2 < C_2H_5OH$

Question 14

Ans.:

(i) Oil soluble Vitamine : Vitamin D
Natural source : Fish liver oil, butter, milk, eggs etc.

(ii) The two monosaccharides are joined together by an oxide linkage formed by the loss of a water molecule. Such a linkage between two monosaccharides through oxygen atom is called glycosidic linkage for e.g., Cl of α-glucose and C2 of β-fructose are held together by glycosidic linkages. They are present in disaccharides, oligosaccharides and polysaccharides.
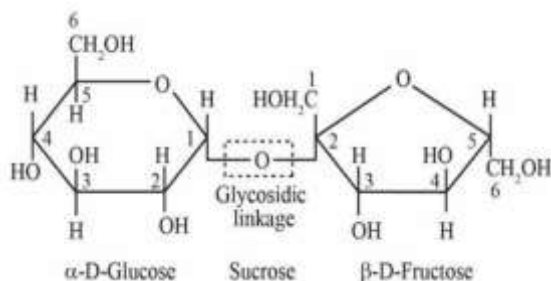
(iii) Maltose is a disaccharide as it consists of two α D-glucose units.

Question 15

Ans.:

Here, $n = 3$ because 1 molecule of $BaCl_2$ on dissociation gives three ions.

$W_2 = 12.48$ g, $W_1 = 1.0$ kg $= 1000$ g

$T_b = 373.0832$ K, K_b, for $H_2O = 0.52$ K m^{-1}

$M_2(BaCl_2) = 208.34$ g mol^{-1}

$T_b = T_b - T_b^o = 373.0832$ K $- 373$ K $= 0.0832$ K

$$M_{2 \, (observed)} = \frac{K_b \times W_2 \times 1000}{\Delta T_b \times W_1}$$

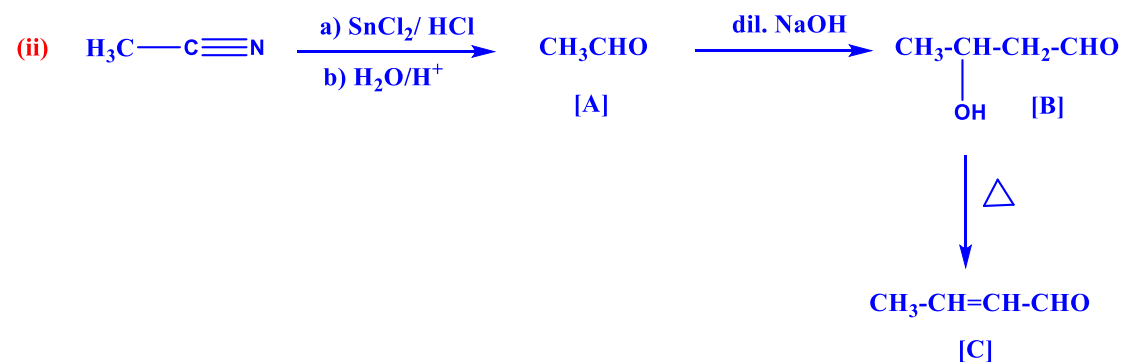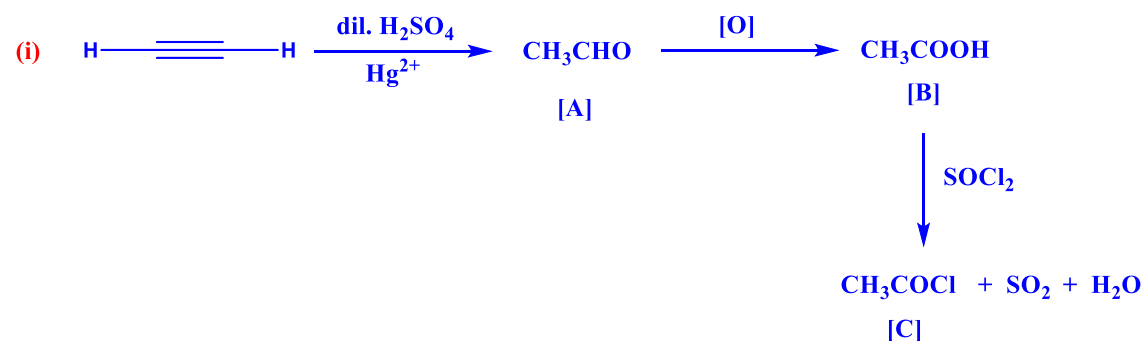$$M_{2 \, (observed)} = \frac{0.52 \times 12.48 \times 1000}{0.0832 \times 1000}$$

$$M_{2 \, (observed)} = 78 \text{gmol}^{-1}$$

$$i = \frac{M_{2 \, (calculated)}}{M_{2 \, (observed)}} = \frac{208.34 \text{gmol}^{-1}}{78 \text{gmol}^{-1}} = 2.67$$

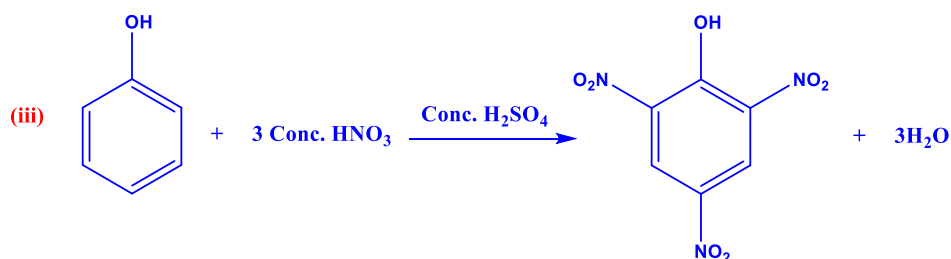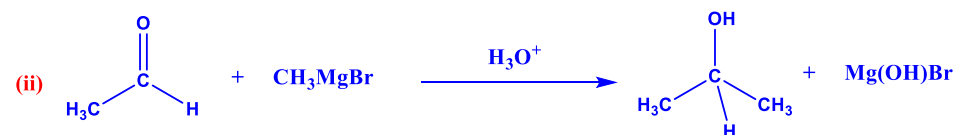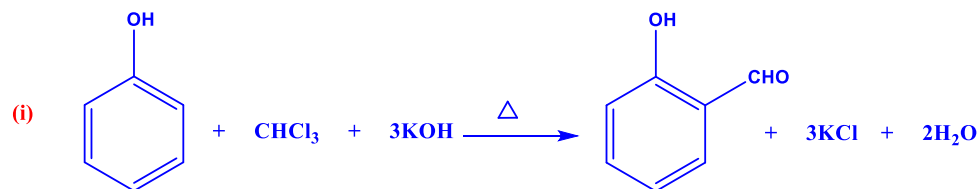$$\alpha = \frac{i - 1}{n - 1} = \frac{2.67 - 1}{3 - 1} = \frac{1.67}{2} = 0.835 = 83.5\%$$

Question 16

Ans.:

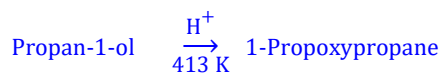(i) $H-\!\!\!\equiv\!\!\!-H \xrightarrow[\text{Hg}^{2+}]{\text{dil. H}_2\text{SO}_4} \underset{[A]}{CH_3CHO} \xrightarrow{[O]} \underset{[B]}{CH_3COOH}$

CH_3COOH [B] $\xrightarrow{SOCl_2}$

$\underset{[C]}{CH_3COCl} + SO_2 + H_2O$

(ii) $H_3C-C\equiv N \xrightarrow[\text{b) H}_2\text{O/H}^+]{\text{a) SnCl}_2/\text{HCl}} \underset{[A]}{CH_3CHO} \xrightarrow{\text{dil. NaOH}} \underset{\overset{|}{OH} \quad [B]}{CH_3\text{-CH-CH}_2\text{-CHO}}$

$\xrightarrow{\triangle} \underset{[C]}{CH_3\text{-CH=CH-CHO}}$

Question 17

Ans.:

(i)

$$\text{(Phenol)} + CHCl_3 + 3KOH \xrightarrow{\Delta} \text{(Salicylaldehyde)} + 3KCl + 2H_2O$$

(ii)

$$\text{(Acetaldehyde)} + CH_3MgBr \xrightarrow{H_3O^+} \text{(Propan-2-ol)} + Mg(OH)Br$$

(iii)

$$\text{(Phenol)} + 3 \text{ Conc. } HNO_3 \xrightarrow{\text{Conc. } H_2SO_4} \text{(Picric acid)} + 3H_2O$$

OR

(ii)

Ans.: $2CH_3CH_2CH_2 - OH$ $CH_3CH_2CH_2 - O - CH_2CH_2CH_3$

$$\text{Propan-1-ol} \xrightarrow[\text{413 K}]{H^+} \text{1-Propoxypropane}$$

The mechanism of this reaction involves the following three steps:

Step 1: Protonation

$$CH_3CH_2CH_2 - \underset{\cdot\cdot}{\overset{\cdot\cdot}{O}} - H \xrightarrow{H^+} CH_3CH_2CH_2 - \underset{\cdot\cdot}{\overset{\cdot\cdot}{O}}{}^+ - H$$

Propan-1-ol
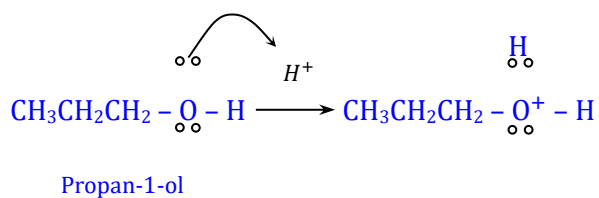
Step 2: Nucleophilic attack
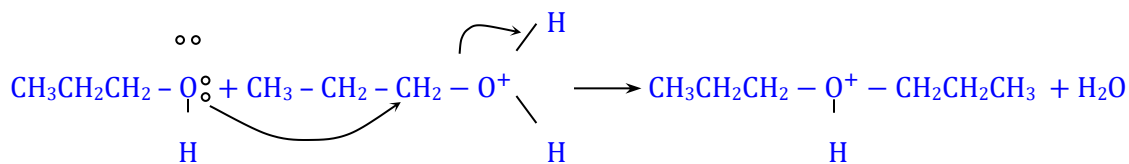
$$CH_3CH_2CH_2 - \overset{\cdot\cdot}{\underset{|}{O}}{}^{\cdot\cdot} + CH_3 - CH_2 - CH_2 - O^+ \longrightarrow CH_3CH_2CH_2 - \overset{+}{\underset{|}{O}} - CH_2CH_2CH_3 + H_2O$$

Step 3: Deprotonation

$$CH_3CH_2CH_2 - \overset{+}{\underset{|}{O}} - CH_2CH_2CH_3 \longrightarrow CH_3CH_2CH_2 - O - CH_2CH_2CH_3 + H^+$$

1-Propoxypropane
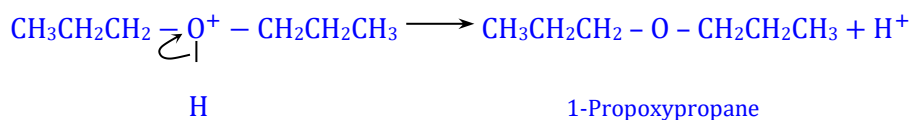
Question 18

Ans.: (i)

$$P_A = 2P_0 - P_t$$
$$= (2 \times 0.4) - 0.7 = 0.1$$
$$k = \frac{2.303}{5} \log P_0/P_A$$
$$k = \frac{2.303}{100} \log 0.4/0.1$$
$$k = \frac{2.303}{100} \times 0.6021$$
$$= 1.39 \times 10^{-2} \text{ s}^{-1}$$

(ii) For Ist order reaction

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

If $[A]_0 = a$, $[A] = a - \frac{a \times 20}{100} = 0.80a$

$t = 10$ min

$$k = \frac{2.303}{10} \log \frac{a}{0.80\ a} = \frac{2.303}{10} \times 0.0969$$
$$= 0.0223$$

If $[A]_0 = a$, $[A] = a - \frac{a \times 75}{100} = 0.25\ a$
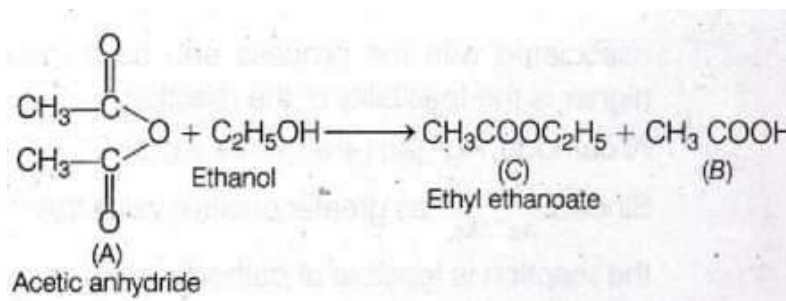
$$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]}$$
$$= \frac{2.303}{0.0223} \log \frac{a}{0.25\ a}$$
$$= \frac{2.303}{0.0223} \times 0.6021$$

$= 62.18$ min

SECTION D – 15 MARKS

Question 19

Ans.: (i) (a) Aldol condensation is given by aldehydes having α–hydrogen atom. Acetaldehyde has α–H but HCHO does not have α–hydrogen atom. Hence, does not give aldol condensation.

(b) Acetic acid has methyl (electron releasing) group which causes + I effect and decreases its acidic strength of acetic acid.

(c) The α-hydrogen atoms in aldehydes and ketones are acidic due to the presence of the carbonyl group (C=O). The acidity arises because the hydrogen atom attached to the α-carbon can be easily removed as a proton (H^+), resulting in a resonance-stabilized enolate ion with a negative charge delocalized over the carbonyl oxygen.
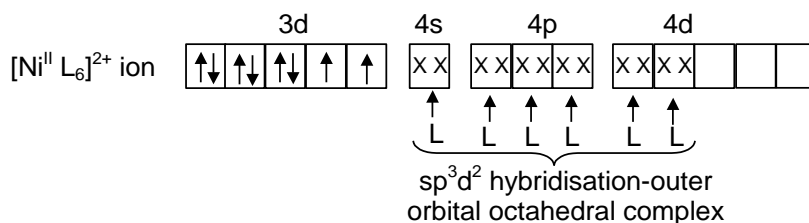
(ii)

Ans.:

$$CH_3COOC_2H_5 \quad + H_2O \quad \xrightarrow{H^+} \quad CH_3COOH \quad + \ CH_3CH_2OH$$

$$\qquad\qquad (C) \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (D)$$
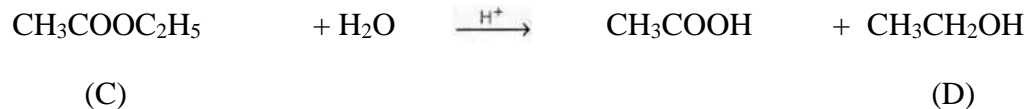
A = $(CH_3CO)_2O$

B = CH_3COOH

C = $CH_3COOC_2H_5$
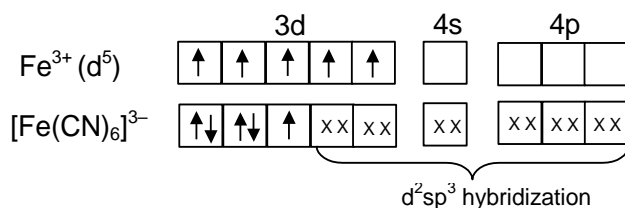
D = CH_3CH_2OH

Question 20

Ans.: (a) The electric configuration of Ni^{2+} ion ($3d^8$) indicates that two inner d-orbitals (3d-orbitals) cannot be made available to allow d^2sp^3 hybridization. However, by using two 4d-orbitals, sp^3d^2 hybridization may be possible.
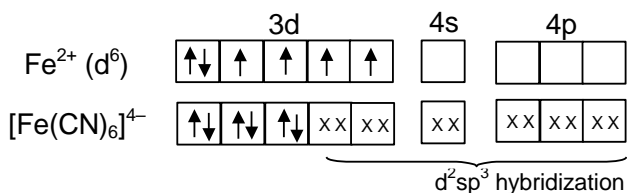

(b) $[Fe(CN)_6]^{3-}$ involves d^2sp^3 hybridization.
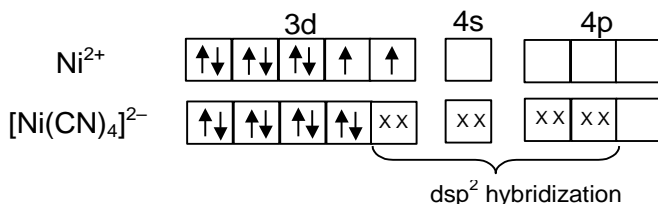

One d−orbital is singly occupied; hence it is weakly paramagnetic in nature.

$[Fe(CN)_6]^{4-}$ involves also d^2sp^3 hybridization but it has Fe^{2+} ion as central ion.

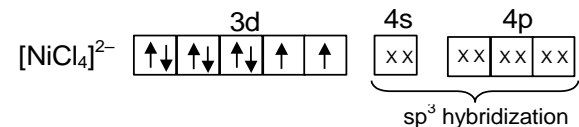All orbitals are doubly occupied; hence it is diamagnetic in nature.

(c) In $[Ni(CN)_4]^{2-}$ ion, Ni^{2+} undergoes dsp^2 hybridization, hence it is square planar in shape.

In $[Ni(CN)_4]^{2-}$, all orbitals are doubly occupied, hence it is diamagnetic ; while in $[NiCl_4]^{2-}$, two orbitals are singly occupied, hence it is paramagnetic in nature.

Strong field ligands like CN^-, CO, en, NO_2^- have very strong electron donating tendency, hence electrons of central metal ion pair up against Hund's rule and low spin complexes are formed.
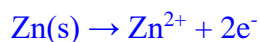
Question 21

Ans.: (i) (a) Molar conductivity of a solution at a given concentration is entire conductance of the volume 'V' of a solution containing one mole of electrolyte kept between two electrodes with area of cross section 'A' and distance of unit length. It is represented by λ_m.

In case of strong electrolytes there is a small increase in conductance with dilution because a strong electrolyte is completely dissociated in solution and the number of ions remains constant. Moreover, there will be greater inter-ionic attractions at higher concentrations which retards the motion of ions and conductance decreases.

In case of weak electrolytes there is increase in conductance with decrease in concentration due to the increase in the number of ions in the solution.
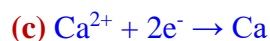
(b) Leclanche cells (dry cell) is used in transistors.

Reaction at anode,

$Zn(s) \rightarrow Zn^{2+} + 2e^-$

Reaction at cathode,

$2MnO_2 + 2NH_4^+ + 2e^- \rightarrow Mn_2O_3 + 2NH_3 + H_2O$

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

Thus, 1 mole of Ca, i.e., 40 g of Ca requires electricity = 2F

$\therefore$ 20 g of Ca will require electricity = 1F

<div align="center">**Or**</div>

Ans.: (ii) (a) Conductivity of an electrolyte solution decreases on dilution because number of ions per unit volume decreases.

(b) Conductivity $(\kappa) = 4 \times 10^{-5}$ S cm^{-1}

Concentration (C) = 0.001 M

Limiting Molar conductivity $\lambda°_m = 390$ S cm^2 mol^{-1}

Molar conductivity $\Lambda^C_m = \dfrac{\kappa \times 100}{C}$

$$\Lambda^C_m = \frac{4 \times 10^{-5} \times 1000}{0.001} = 40 \text{ S cm}^2 \text{ mol}^{-1}$$

Degree of dissociation $(\alpha) = \dfrac{\Lambda^C_m}{\Lambda°_m} = \dfrac{40}{390} = 0.102$

$$\therefore K = \frac{C\alpha^2}{1-\alpha} = \frac{0.001 \times (0.102)^2}{1 - 0.102} = \frac{1.04 \times 10^{-5}}{0.898}$$

$= 1.158 \times 10^{-5}$

(c) The reaction takes place in cell as

$Cu + 2Ag^+ \rightarrow Cu^{+2} + 2Ag$

<div style="margin-left:3em">(0.001 M) (0.10)</div>

$Cu \,/Cu^{+2}(0.10) \,\| \, Ag^+(0.001 \text{ M})/ \, Ag$

$$E_{cell} = E°_{cell} - \frac{0.059}{2}\log\frac{[Cu^{+2}]}{[Ag^+]^2}$$

$$E_{cell} = 0.46 - \frac{0.059}{2}\log\frac{0.1}{(0.001)^2}$$

$$= 0.46 - \frac{0.059}{2}\log 10^5$$

$$= 0.46 - \frac{0.059}{2} \times 5\log 10$$

$= 0.46 - (0.059/2) \times 5$

$= 0.46 - 0.1475 = 0.3125$

<div align="center">************************* The End *************************</div>