



SAMPLE PAPER 1

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 $R = 1.987 \text{ cal deg}^{-1} \text{ mol}^{-1} = 8.314 \text{ JK}^{-1} \text{ mol}^{-1} = 0.0821 \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1}$

$1 \text{ L atm} = 1 \text{ dm}^3 \text{ atm} = 101.3 \text{ J}$, $1 \text{ Faraday} = 96500 \text{ coulombs}$, $\text{Avogadro's number} = 6.023 \times 10^{23}$

SECTION A – 14 MARKS

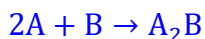
Question 1

(A)

(i)

Ans.: increase, two

EXPLANATION



$$r_1 = k[A]^2[B]$$

$$r_2 = k[2A]^2[B/2]$$

$$\text{Or } r_2 = 2k[A]^2[B]$$

$$\therefore r_2 = 2r_1$$

(ii)

Ans.: 6, 3

EXPLANATION

In the given complex $[E(en)_2(C_2O_4)]^+NO_2^-$, ethylenediamine is a bidentate ligand and $(C_2O_4^{2-})$ oxalate ion is also bidentate ligand. Therefore, coordination number of the complex is 6 *i.e.*, it is an octahedral complex.

Oxidation number of E is given by

$$x + 2 \times 0 + 1 \times (-2) = +1$$

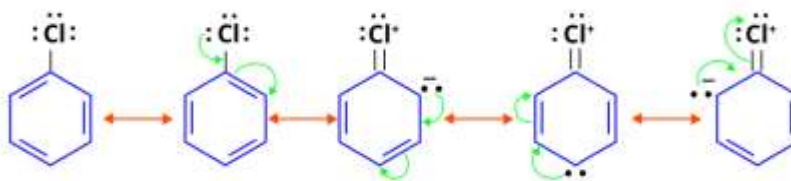
$$\therefore x = 3$$

(iii)

Ans.: ortho-para, less

EXPLANATION

The ortho-para directing nature of chlorobenzene can be explained by the resonance structures that distribute electron density, making the ortho and para positions more favorable for electrophilic substitution reactions.



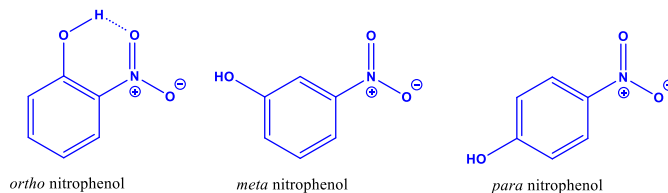
Chlorobenzene's least reactivity in nucleophilic substitution reactions is attributed to resonance effect which increases electron density on the benzene ring. Additionally, in chlorobenzene, the carbon atom to which halogen atom is attached is sp^2 hybridized and thus it being more electronegative than sp^3 hybridized carbon, it cannot be replaced by a nucleophile.

(iv)

Ans.: lowest, lowest

EXPLANATION

Among the three isomeric nitrophenols, the ortho isomer, or o-nitrophenol, displays distinct characteristics due to the arrangement of nitro (NO_2) and hydroxyl (OH) groups on the benzene ring. Ortho-nitrophenol is steam volatility and has lower boiling point, and reduced solubility in water due to the presence of intramolecular hydrogen bonding.



(B)

(i)

Ans.: (b) Only Q and R

EXPLANATION

For a first order reaction, the half-life is independent of the initial concentration of the reactants but is inversely proportional to the rate constant (k). If the half-life decreases due to the addition of a catalyst, it implies that the rate constant has increased and an increase in the rate constant k due to the addition of the catalyst corresponds to an increased rate of the reaction. Catalysts often provides an alternative alternate pathway with the lower activation energy, leading to an increased rate.

(ii)

Ans.: (d) $\Delta_t = (4/9)\Delta_0$

EXPLANATION

The crystal field splitting in tetrahedral complexes is smaller than that in octahedral complexes because there are two third ligands of octahedral complexes and none of the ligands approach the metal d -orbitals. For the same metal, ligand and metal- ligand distance, it is observed that $\Delta_t = (4/9)\Delta_0$

(iii)

Ans.: (c) Purple to colourless

EXPLANATION

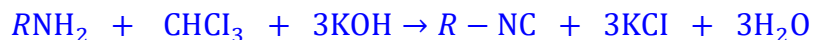
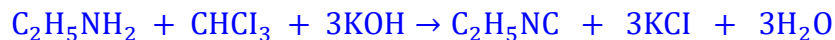
The colour change from purple to colourless, observed when hydrogen peroxide (H_2O_2) is added to a potassium permanganate (KMnO_4) solution under acidic conditions, signifies the reduction of the MnO_4^- ion to Mn^{2+} ions. This reaction, driven by the reducing properties of hydrogen peroxide, results in the loss of the characteristic purple color associated with the permanganate ion.

(iv)

Ans.: (b) $\text{C}_2\text{H}_5\text{NC}$

EXPLANATION

This is carbylamine reaction which is used to distinguish 1° amines from other amines. The reaction is given by 1° amines only.



1° amine chloroform isocyanide
(bad smelling)

(v)

Ans.: (d) 0.1 M $\text{K}_4[\text{Fe}(\text{CN})_6]$

EXPLANATION

Potassium hexacyanoferrate(II) $[(K_4[Fe(CN)_6])]$ will dissociate into a higher number of ions compared to the other options, leading to a greater boiling point elevation. The greater the concentration of solute particles in a solution, the higher the boiling point.

(vi)

Ans.: (b) Both Assertion and Reason are true but Reason is not the correct explanation for Assertion.

EXPLANATION

Molar conductivity at infinite dilution of a strong electrolyte can be determined by extrapolation as linear graph is obtained. For weak electrolyte molar conductivity at infinite dilution cannot be determined experimentally and by extrapolation because graph is not linear, maximum value of molar conductivity at infinite dilution cannot be obtained.

(vii)

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

EXPLANATION

The Gabriel synthesis is a chemical reaction that transforms primary alkyl halides into aliphatic primary amines. This is used for the preparation of aliphatic primary amines. It involves nucleophilic substitution (S_N2) of alkyl halides by the anion formed by the phthalimide. But aryl halides do not undergo nucleophilic substitution with the anion formed by the phthalimide. Hence, aromatic primary amines cannot be prepared by this process.

(C)

Ans.: (i) Opening a can of soda results in a sudden pressure decrease. According to Henry's law, which links gas solubility to pressure, this causes dissolved carbon dioxide (CO_2) to escape from the liquid, forming bubbles and releasing into the air.

(ii) The Henry's law constant rises with temperature due to increased molecular energy. This impacts gas solubility in liquids, with higher temperatures resulting in greater dissolution and lower temperatures leading to reduced solubility.

(iii) $K_H = 4.27 \times 10^5 \text{ mmHg}$ $p = 760 \text{ mmHg}$

According to Henry's law, $p = K_H \times x_{CH_4}$

$$x_{CH_4} = \frac{p}{K_H} = \frac{760}{4.27 \times 10^5} = 1.78 \times 10^{-3}$$

SECTION B – 20 MARKS

Question 2

Ans.: (i) p -Nitrophenol > Phenol > Ethanol (acidic character)

[Not required to write this explanation in Exam: The acidic character of p -nitrophenol is enhanced by the electron-withdrawing nitro group, making it more acidic than phenol. Phenol, in turn, exhibits higher acidity than ethanol due to resonance stabilization of its conjugate base. ethanol, lacking the electron-withdrawing or resonance-stabilizing features, is the least acidic among the three compounds.]

(ii) Ethers cannot form Hydrogen bonds with water because it is less polar than water and cannot break hydrogen bonds formed between H_2O molecules.

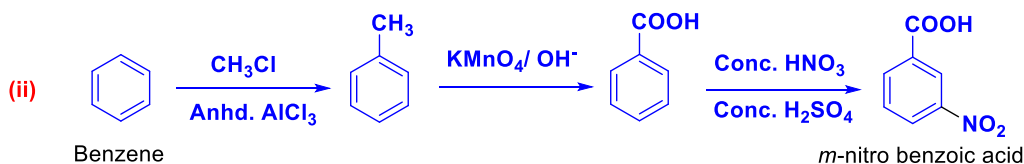
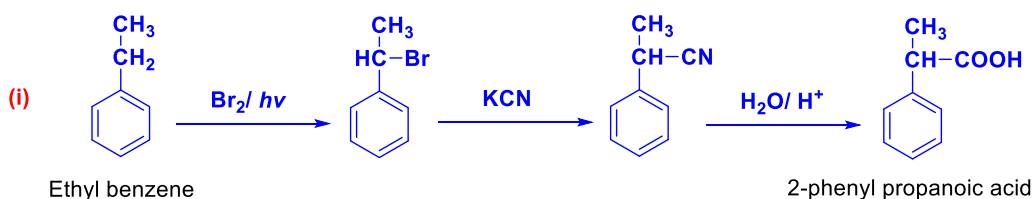
Question 3

Ans.: (i) Scandium is classified as a transition element because it possesses incompletely filled 3d orbitals ($3d^1$) in its ground state, allowing for variable oxidation states. On the other hand, zinc atom has completely filled d-orbitals ($3d^{10}$) in its ground state as well as in oxidized state, hence it is not regarded as transition element.

(ii) Ce, Pr and Nd belong to 4f series (lanthanoids) whereas Th, Pa and U belong to 5f series (actinoids). When filling of 4f and 5f starts, electrons in 5f penetrate less into the inner core. Therefore, they are more effectively shielded from the nuclear charge than 4f electrons of lanthanoids. As a result, outer electrons of 5f series experience less force of attraction by the nucleus and hence have lower ionization enthalpies.

Question 4

Ans.:

**Question 5**

Ans.:

(i) $CuCl_2$ is more stable than Cu_2Cl_2 . The stability of Cu^{2+} (aq.) rather than Cu^+ (aq.) is due to the much more negative $\Delta_{hyd} H$ of Cu^{2+} (aq) than Cu^+ (aq).

(ii) It is due to similar energy of $(n - 1)d$ and ns orbitals, electrons from both can be lost.

Question 6

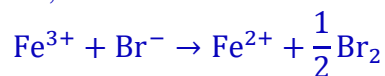
Ans.:

- (i) Both enantiomers will have the same melting point.
- (ii) Both enantiomers will have the different optical activity.

Question 7

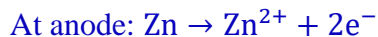
Ans.:

- (i) No, because for the reaction,



$$E^\ominus = 0.771 - 1.09 = -0.319 \text{ V is negative}$$

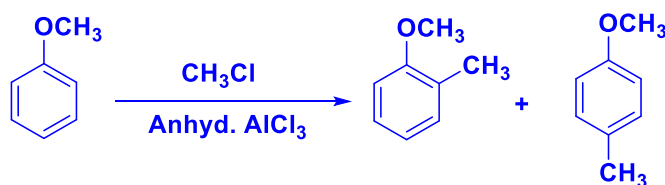
- (ii) Now the cell ' B ' has higher e.m.f and it will act as a galvanic cell.



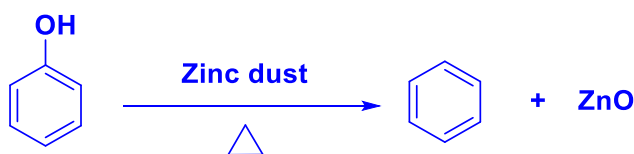
Question 8

Ans.:

- (a) Methyl group is introduced at *ortho* and *para* positions of anisole.



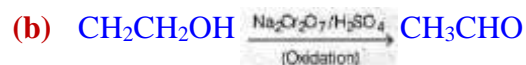
- (b) Phenol is reduced to benzene.



OR

Ans.:

- (a) Since an organic compound (A) with molecular formula $\text{C}_2\text{H}_6\text{O}$ on oxidation with $\text{Na}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$ gives compound (B) which reduces Tollens' reagent, therefore, (A) must be ethanol and (B) must be ethanal (B).



Ethanol (A) Ethanal (B)

M.F. $\text{C}_2\text{H}_6\text{O}$

Question 9**Ans.:**

Given, $W_B = 1.5$ g, $W_A = 90$ g, $M_B = ?$, $K_b = 2.52$ kg mol⁻¹

$$\Delta T_b = (353.93 - 353.23)K = 0.70 K$$

$$\text{Now, } \Delta T_b = K_b \times m$$

$$\Rightarrow \Delta T_b = K_b \times \frac{W_B}{M_B} \times \frac{1000}{W_A}$$

$$\Rightarrow 0.70 = 2.52 \times \frac{1.5}{M_B} \times \frac{1000}{90}$$

$$\Rightarrow M_B = \frac{2.52 \times 1.5 \times 100}{0.70 \times 9} = \frac{378}{6.3} = 60 \text{ g mol}^{-1}$$

Question 10

Ans.: (i) The phenoxide ion has lower resonance stabilization due to the negative charge being distributed over one oxygen atom and carbon atoms. In contrast, the carboxylate ion achieves higher stability by spreading the negative charge over two electronegative oxygen atoms, making it more stable than the phenoxide ion.

(ii) Oxidation of aldehyde is easier than ketones as in propanal there is one oxidisable-H present attached to the carbonyl carbon whereas propanone being ketone does not have the oxidisable-H atom. Also, as the carbonyl carbon contains two alkyl groups attached to it in ketone, it becomes less reactive responsible for less reactivity of propanone compared to propanal.

Question 11**Ans.:**

(i) Transition metal ions possess unpaired electrons in their lower energy d-orbitals. When visible light interacts, these electrons undergo *d-d* transitions, absorbing specific wavelengths due to quantized energy changes. The transmitted light then displays a color complementary to the absorbed one, reflecting the selective absorption and transmission of light by the transition metal ion.

(ii) Zinc, cadmium and Mercury have completely filled d-orbitals in their atomic as well as in their common oxidation states. They do not exhibit characteristic properties of transition elements; hence they are not considered as transition elements.

SECTION C – 21 MARKS

Question 12

Suppose order with respect to NO is m and order with respect to Cl_2 is n ,

Then the rate will be:

$$\text{Rate} = k [\text{NO}]^m [\text{Cl}_2]^n$$

$$0.60 = k (0.15)^m (0.15)^n \quad \dots(1)$$

$$1.20 = k (0.15)^m (0.30)^n \quad \dots(2)$$

$$2.40 = k (0.30)^m (0.15)^n \quad \dots(3)$$

Dividing equations (3) by (1), we get

$$\frac{2.40}{0.60} = \frac{k (0.30)^m (0.30)^n}{k (0.15)^m (0.15)^n}$$

$$4 = 2^m$$

$$2^2 = 2^m$$

$$m = 2$$

Dividing equation (2) by (1), we get

$$\frac{1.20}{0.60} = \frac{k (0.30)^m (0.30)^n}{k (0.15)^m (0.15)^n}$$

$$2 = 2^n$$

$$n = 1$$

(a) Rate law expression is $\text{Rate} = k [\text{NO}]^2 [\text{Cl}_2]$

(b) $0.60 \text{ mol L}^{-1} = k (0.15 \text{ mol L}^{-1})^2 (0.15 \text{ mol L}^{-1})$

$$k = 177.77 \text{ mol}^{-2}, \text{L}^2 \text{ min}^{-1}$$

(c) $\text{Rate} = 177.77 \text{ mol}^{-1} \text{L}^2 \text{ min}^{-1} \times (0.25 \text{ mol L}^{-1})^2 \times (0.25 \text{ mol L}^{-1})$
 $= 2.778 \text{ mol L}^{-1} \text{ min}^{-1}$

Question 13

Ans.: (i) $\text{C}_6\text{H}_5\text{NH}_2 < (\text{C}_2\text{H}_5)_2\text{NH} < \text{C}_2\text{H}_5\text{NH}_2$

Explanation: Aniline ($\text{C}_6\text{H}_5\text{NH}_2$) is the least soluble due to its nonpolar phenyl group. Diethylamine ($\text{C}_2\text{H}_5)_2\text{NH}$) is more soluble than aniline, and Ethylamine ($\text{C}_2\text{H}_5\text{NH}_2$) has the highest solubility due to its less bulky ethyl group, facilitating stronger hydrogen bonding with water.

(ii)

$\text{C}_6\text{H}_5\text{NH}_2 > \text{C}_6\text{H}_5\text{NHCH}_3 > \text{C}_2\text{H}_5\text{NH}_2$

Explanation: Low pK_b value indicates a stronger base.

This is because the pK_b values generally decrease with the presence of electron-donating alkyl groups, and aniline ($\text{C}_6\text{H}_5\text{NH}_2$) has the highest pK_b due to the electron-withdrawing effect of the phenyl group. The presence of methyl groups in $\text{C}_6\text{H}_5\text{NHCH}_3$ further decreases its pK_b value, thus making it less basic than $\text{C}_2\text{H}_5\text{NH}_2$.

Question 14**Ans.:**

(i) Starch is a polysaccharide.

(ii) **α -Helix structure:** The polypeptide chains are held together (stabilized) by intramolecular H bonding.

β -Pleated sheet structure: The two neighbouring polypeptide chains are held together by intermolecular H-bonding.

(iii) Disease caused by the deficiency of Vitamin B₁₂ is Pernicious anaemia.

Question 15

Ans.: (a) Calculation of relative lowering of vapour pressure

Vapour pressure of water (p_A^o) = 17.5 mm of Hg

lowering of vapour pressure ($p_A^o - p_A$) = 0.061

\therefore Relative lowering of vapour pressure.

$$\frac{p_A^o - p_A}{p_A^o} = \frac{0.061}{17.5} = 0.00348$$

(b) Calculation of vapour pressure of solution

P = Vapour pressure of solvent - Lowering in vapour pressure.

$$= 17.5 - 0.061 = 17.439 \text{ mm of Hg}$$

(c) Calculation of mole fraction of sugar and water

$$\frac{p_A^o - p_A}{p_A^o} = x_B$$

$$\text{Here } \frac{p_A^o - p_A}{p_A^o} = 0.00348$$

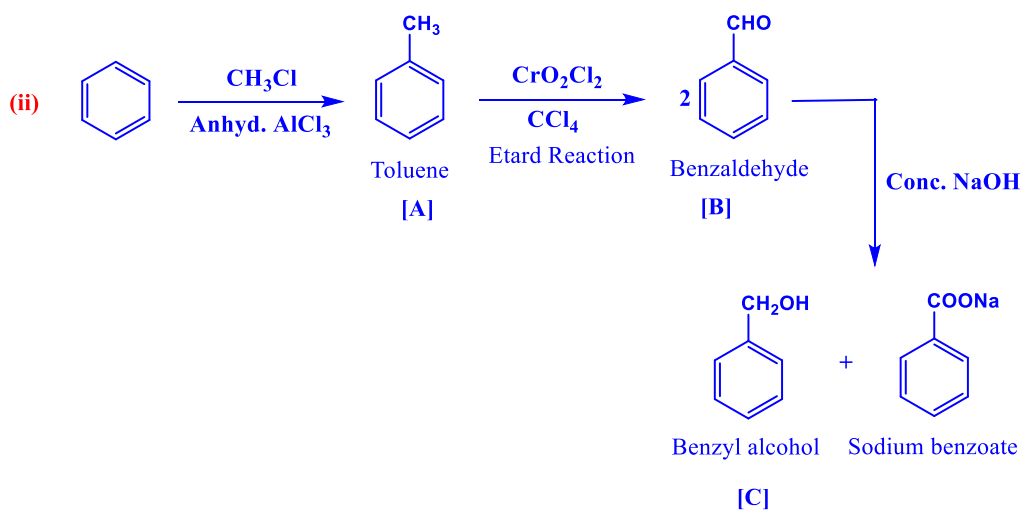
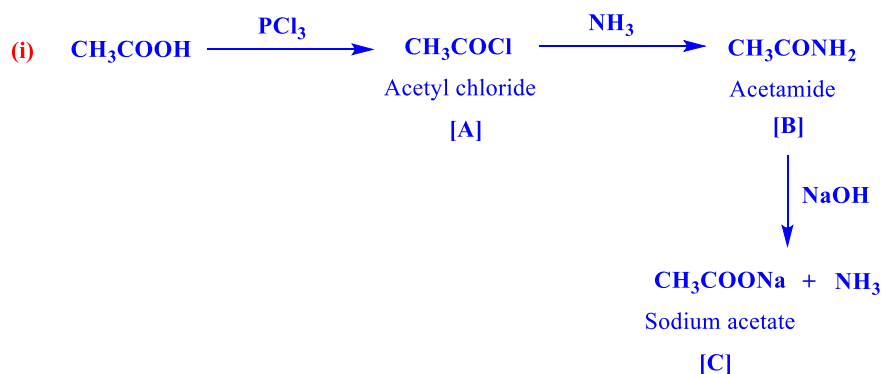
\therefore Mole fraction of sugar, $x_B = 0.00348$

Mole fraction of water

$$x_A = 1 - x_B = 1 - 0.00348 = 0.9965$$

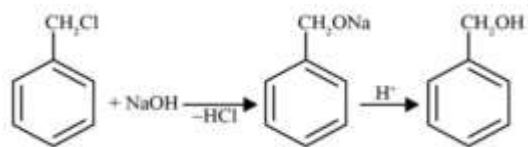
Question 16

Ans.:

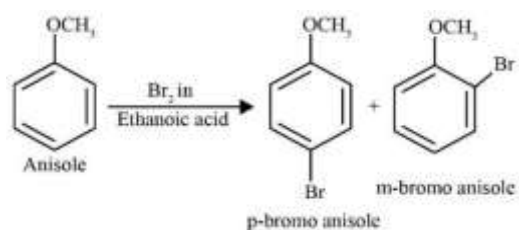


Question 17

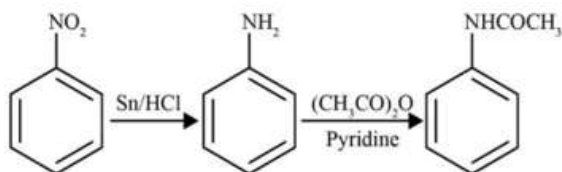
(a)



(b)



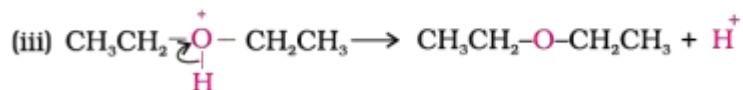
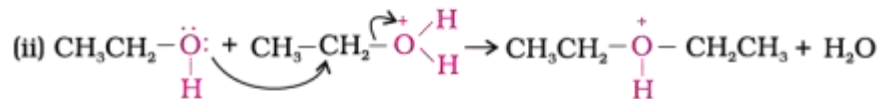
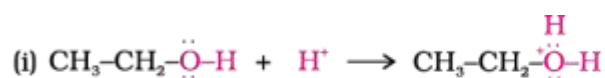
(c)



OR

(ii)

Ans.:



Question 18

Ans.:

(i) $k_1 = 4.5 \times 10^3 \text{ s}^{-1}$, $T_1 = 10 + 273 \text{ K} = 283 \text{ K}$; $K_2 = 1.5 \times 10^4 \text{ s}^{-1}$, $T_2 = ?$, $E_a = 60 \text{ kJ mol}^{-1}$

Applying Arrhenius equation,

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

$$\log \frac{1.5 \times 10^4}{4.5 \times 10^3} = \frac{60000 \text{ J mol}^{-1}}{2.303 \times 8.314 \text{ JK}^{-1}} \left(\frac{T_2 - 283}{283 T_2} \right)$$

$$\text{or } \log 3.333 = 3133.63 \left(\frac{T_2 - 283}{283 T_2} \right)$$

$$\text{or } \frac{0.5228}{3133.63} = \frac{T_2 - 283}{283 T_2}$$

$$\text{or } 0.0472 T_2 = T_2 - 283$$

$$\text{or } 0.9528 T_2 = 283$$

$$\text{or } T_2 = \frac{283}{0.9528} = 297 \text{ K}$$

$$= 297 - 273^\circ\text{C} = 24^\circ\text{C}$$

(ii)

$$\begin{aligned} \text{(a) Rate} &= -\frac{d[\text{C}_{12}\text{H}_{22}\text{O}_{11}]}{dt} = \frac{-d[\text{H}_2\text{O}]}{dt} \\ &= \frac{d[\text{C}_6\text{H}_{12}\text{O}_6]}{dt} = \frac{d[\text{C}_6\text{H}_{12}\text{O}_6]}{dt} \end{aligned}$$

(b) Rate law equation:

$$\text{Rate} = k[\text{C}_{12}\text{H}_{22}\text{O}_{11}]$$

(c) Molecularity = 2

(d) Order = 1

SECTION D – 15 MARKS

Question 19

(i)

Ans.:

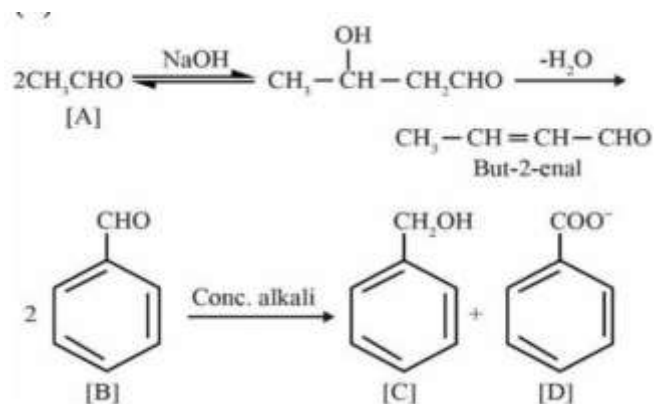
(a) CH_3COOH contains α -hydrogen and hence give HVZ reaction but HCOOH does not contain α -hydrogen and hence does not give HVZ reaction.

(b) It is because aldehydes get further oxidised to acids. So, oxidation of alcohols to aldehydes needs to be controlled.

(c) Ethanal is soluble in water due to H-bonding between the polar carbonyl group and water molecules.

(ii)

Ans.:



Question 20

Ans.: (i) $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ – there are 3 possible compounds with this formula.

$\text{Cr}(\text{H}_2\text{O})_6\text{Cl}_3$ – (Violet) produces 3 moles of AgCl upon reaction with AgNO_3 and H_2O molecules are retained.

(b) Using Nernst Equation,

$$\begin{aligned}
 E_{\text{cell}} &= E_{\text{cell}}^{\circ} - \frac{0.059}{n} \log \frac{[\text{Products}]}{[\text{Reactants}]} \\
 E_{\text{cell}}^{\circ} &= E_{\text{cell}} + \frac{0.059}{n} \log \frac{[\text{Products}]}{[\text{Reactants}]} \\
 &= 0.261 + \frac{0.059}{6} \log \frac{[\text{Cr}^{3+}]^2}{[\text{Fe}^{2+}]^3} \\
 &= 0.261 + \frac{0.059}{6} \log \frac{(10^{-2})^2}{(10^{-2})^3} \\
 &= 0.261 + \frac{0.059}{6} \log 10^2 \\
 &= 0.261 + \frac{0.059 \times 2}{6} \\
 &= 0.261 + 0.01966 \\
 &= 0.28068 \text{ V} \approx 0.281 \text{ V}
 \end{aligned}$$

OR

(ii)

Ans.: (a) Given: $E_{\text{Ag}^+/\text{Ag}}^{\circ} = +0.80 \text{ V}$; $E_{\text{Cu}^{2+}/\text{Cu}}^{\circ} = 0.34 \text{ V}$

$[\text{Cu}^{2+}] = 0.01 \text{ M}$, $[\text{Ag}^+] = ?$

$$\begin{aligned}
 E_{\text{cell}}^{\circ} &= E_{\text{Ag}^+/\text{Ag}}^{\circ} - E_{\text{Cu}^{2+}/\text{Cu}}^{\circ} \\
 &= [0.80 - (+0.34)] \text{ V} = 0.46 \text{ V}
 \end{aligned}$$



From Nernst Equation,

$$\begin{aligned}
 E_{\text{cell}} &= E_{\text{cell}}^{\circ} - \frac{0.0591}{n} \log \frac{[\text{Products}]}{[\text{Reactants}]} \\
 E_{\text{cell}} &= E_{\text{cell}}^{\circ} - \frac{0.0591}{2} \log \frac{[\text{Cu}^{2+}]}{[\text{Ag}^+]^2} \\
 0.422 &= 0.46 - \frac{0.0591}{2} \log \frac{[0.1]}{[\text{Ag}^+]^2} \\
 \log \frac{0.1}{[\text{Ag}^+]^2} &= 1.2881 \\
 [\text{Ag}^+]^2 &= 0.0051 \\
 [\text{Ag}^+] &= 7.1 \times 10^{-2} \text{ M}
 \end{aligned}$$

$$(b) m = ZIt$$

$$= \frac{108}{96500} \times 0.5 \times 2 \times 3600$$

$$= 4.029 \text{ g}$$

$$d = \frac{m}{V} \Rightarrow V = \frac{m}{d}$$

$$V = \frac{4.029}{10.5 \text{ g cm}^{-3}} = 0.3837 \text{ cm}^3$$

Let the thickness of silver deposited be x cm

$$V = A \times x$$

$$\Rightarrow x = \frac{V}{A} = \frac{0.3837}{500} = 7.67 \times 10^{-4} \text{ cm}$$

Hence, the thickness of silver deposited is 7.67×10^{-4} cm

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