CHEMISTRY
PAPER 1
(THEORY)

Maximum Marks: 70
Time Allotted: Three Hours
Reading Time: Additional Fifteen Minutes

Instructions to Candidates

1. You are allowed an **additional fifteen minutes** for **only** reading the question paper.
2. You must **NOT** start writing during the reading time.
3. This question paper has **10 printed pages**.
4. It is divided into **four sections** and has **twenty one questions** in all.
5. Answer **all** questions.
6. **Section A** has **fourteen subparts**. Each question carries 1 mark.
7. While attempting **Multiple Choice Questions** in Section A, you are required to **write only ONE option as the answer**.
8. **Section B** has **ten questions**. Each question carries 2 marks.
9. **Section C** has **seven questions**. Each question carries 3 marks.
10. **Section D** has **three questions**. Each question carries 5 marks.
11. ***Internal choices*** have been provided in ***two questions each in Sections B, C and D.***
12. The intended marks for questions are given in brackets [ ].
13. All working, including rough work, should be done on the same sheet as, and adjacent to the rest of the answer.
14. Balanced equations must be given wherever possible and diagrams where they are helpful.
15. When solving numerical problems, all essential workings must be shown.
16. In working out problems, use the following data:

$$\textit{Gas constant } R = 1{\cdot}987 \textit{cal deg}^{-1}\textit{mol}^{-1} = 8{\cdot}314 \textit{JK}^{-1}\textit{mol}^{-1}$$
$$= 0{\cdot}0821 \textit{dm}^3\textit{atmK}^{-1}\textit{mol}^{-1},\ 1\ \textit{l atm} = 1\textit{dm}^3\textit{atm} = 101{\cdot}3\ \textit{J}.$$
$$1\ \textit{faraday} = 96500\ \textit{coulombs, Avogadro's number} = 6{\cdot}023 \times 10^{23}.$$

Instruction to Supervising Examiner

Kindly read **aloud** the Instructions given above to all the candidates present in the examination hall.

Note: The Specimen Question Paper in the subject provides a realistic format of the Board Examination Question Paper and should be used as a practice tool. The questions for the Board Examination can be set from any part of the syllabus, though the format of the Board Examination Question Paper will remain the same as that of the Specimen Question Paper. The weightage allocated to various topics, as given in the syllabus, will be strictly adhered to.

SECTION A - 14 MARKS

Question 1

(A) Fill in the blanks by choosing the appropriate word(s) from those given in the brackets. **[4×1]**

[methyl alcohol, ethyl alcohol, paired, one, Cannizzaro, d-d, salicylaldehyde, Perkin's, unpaired, f-f, salicylic acid, Kolbe's, two, 193000, 96500, Reimer-Tiemann]

(i) Formaldehyde reacts with conc. alkali to give sodium formate and _____ due to the absence of α - hydrogen atom. The reaction is known as _____ reaction. **(Recall)**

(ii) Electrochemical equivalent (Z) is the quantity of substance deposited or discharged by a charge of _____ coulomb, whereas the equivalent conductance (E) is the amount of substance deposited or discharged by a charge of _____ coulombs. **(Understand)**

(iii) The colour of transition metal ions is due to _____ electron(s) in d-subshell and _____ transition. **(Analyse)**

(iv) The product formed when sodium phenoxide is treated with CO_2 at 400K, under 4-7 atm pressure and then acidified with dilute HCl is _____. The reaction is known as _____ reaction. **(Recall)**

(B) Select and write the correct alternative from the choices given below. **[7×1]**

(i) The correct order of freezing point of 0·5M solution of urea, $AlCl_3$, KCl and $MgCl_2$ is: **(Evaluate)**

(a) $AlCl_3 > MgCl_2 > KCl >$ urea

(b) Urea $> KCl > MgCl_2 > AlCl_3$

(c) $MgCl_2 > KCl > AlCl_3 >$ urea

(d) $KCl > MgCl_2 > AlCl_3 >$ urea

(ii) Glucose molecules react with (x) number of molecules of phenyl hydrazine to yield glucosazone. The melting point of glucosazone is 206^0C. The value of (x) is: **(Recall)**

(a) one

(b) two

(c) three

(d) four

(iii) Cobalt (III) chloride forms several octahedral complexes with ammonia. Which of the following will **NOT** give a test for chloride ions with silver nitrate solution at 25^0C? **(Understand)**

(a) $CoCl_3.6NH_3$

(b) $CoCl_3.5NH_3$

(c) $CoCl_3.4NH_3$

(d) $CoCl_3.3NH_3$

(iv) The following data was obtained for a hypothetical reaction $2A+B \longrightarrow 2AB$

S. No.	[A] (mol L^{-1})	[B] (mol L^{-1})	Initial rate (mol L^{-1} sec^{-1})
1	0·5	0·5	$1{\cdot}8 \times 10^{-4}$
2	1·0	0·5	$3{\cdot}6 \times 10^{-4}$
3	1·0	1·0	$3{\cdot}6 \times 10^{-4}$

The rate law expression for this reaction is: **(Apply)**

(a) rate = $k[A]^1[B]^1$

(b) rate = $k[A]^1[B]^0$

(c) rate = $k[A]^2[B]^1$

(d) rate = $k[A]^0[B]^1$

(v) Which of the following reactions will **NOT** give primary amine? **(Understand)**

(a) $C_2H_5NC \xrightarrow{LiAlH_4}$ _____

(b) $C_2H_5CN \xrightarrow{LiAlH_4}$ _____

(c) $C_2H_5CONH_2 \xrightarrow{Br_2/KOH}$ _____

(d) $CH_3CONH_2 \xrightarrow{Br_2/KOH}$ _____

(vi) Given below are two statements marked Assertion and Reason. Read the two statements carefully and select the correct option.

Assertion: When an ether containing a primary alkyl group and tertiary alkyl group is treated with hydrogen iodide, tertiary alkyl iodide is formed.

Reason: The reaction takes place via S_N1 mechanism, and the more stable tertiary carbocation is formed easily which combines with iodide ion to form tertiary alkyl iodide. **(Analyse)**

(a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion.

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

(c) Assertion is true and Reason is false.

(d) Both Assertion and Reason are false.

(vii) Given below are two statements marked Assertion and Reason. Read the two statements carefully and select the correct option.

Assertion: Magnesium metal can liberate H_2 gas from an aqueous solution of HCl.

Reason: Magnesium has positive value of standard reduction electrode potential. **(Analyse)**

(a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion.

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

(c) Assertion is true and Reason is false.

(d) Both Assertion and Reason are false.

(C) Read the passage carefully and answer the questions that follow. **[3×1]**

The hydroxy derivatives of aliphatic hydrocarbons are called alcohols. Ethanol is perhaps the most important aliphatic alcohol. During COVID-19 pandemic alcohol-based sanitizers became an essential protective tool worldwide, reducing the spread of the virus. Nowadays, it is also used as a substitute for petrol in internal combustion engines.

The boiling points of alcohols are considerably higher than those of the corresponding ethers due to the presence of intermolecular hydrogen bonding in alcohols and it increases with increase in molecular mass.

For isomeric alcohols the boiling point follows the order:

Primary (1°) alcohol > Secondary (2°) alcohol > Tertiary (3°) alcohol, which is evident from the following data:

Compound	Propan-1-ol	Butan-1-ol	Butan-2-ol	2-methyl-propan-2-ol
Boiling point	370K	391K	371K	356K

Aliphatic alcohols behave as weak acids and ionize to a small extent. Their acidic strength is even less than that of both water and phenol. Phenols are hydroxy derivatives of arenes and have varied application in manufacturing of dyes, plastics, drugs, explosives, etc. At different concentrations, phenols are used both as a disinfectant and an antiseptic.

(i) The boiling point of 2-methyl-propan-2-ol is much lower than that of butan-1-ol, although both have the same molecular formula. Give a reason to explain such observation. **(Evaluate)**

(ii) Although alcohols are weaker acids than water, phenol is more acidic than alcohols. Justify. **(Evaluate)**

(iii) In what form (i.e. concentration), does phenol act as a disinfectant or an antiseptic? **(Recall)**

SECTION B – 20 MARKS

Question 2 **[2]**

The standard reduction electrode potential (E^o) of some metals is given below:

Metal	E^o
Ag^+/Ag	+0·80V
Mg^{2+} / Mg	-2·37V
Li^+/Li	-3·05V
Cu^{2+}/Cu	+0·34V
Fe^{2+}/Fe	-0·44V

Arrange these metals in the increasing order of their reducing power. Justify the order. **(Apply)**

Question 3 **[2]**

An alkene [A] with molecular formula, C_5H_{10} on ozonolysis and subsequent hydrolysis gives a mixture of two compounds, [B] and [C]. Compound [B] gives positive Fehling's test and also reacts with iodine and NaOH solution. Compound [C] does not give Fehling's test but forms iodoform.

Identify compounds [A], [B] and [C]. Write the iodoform reaction either with compound [B] or [C]. **(Understand)**

Question 4 **[2]**

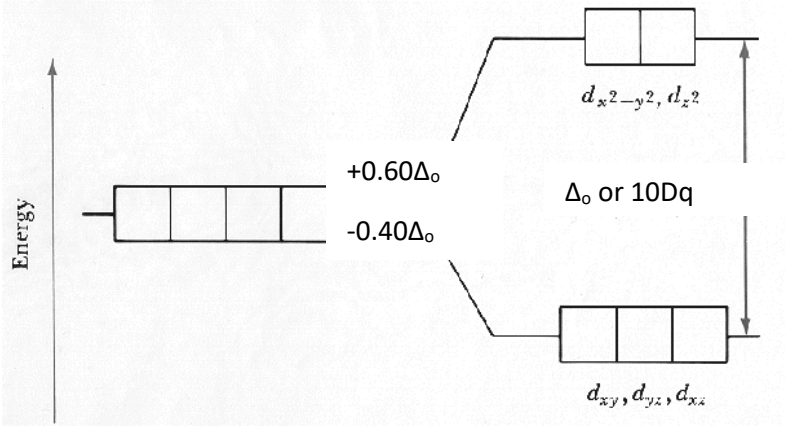
(i) Answer the following questions with respect to the coordination complex ion $[Cr(NH_3)_6]^{3+}$

(a) What is the hybridisation state of the central metal atom? **(Understand)**

(b) Comment on the magnetic nature of the complex ion. **(Analyse)**

OR

(ii) Observe the diagram below of splitting of d-orbital in octahedral field and answer the following questions.



(a) Identify the electronic configuration of d^5 ion, if $\Delta_o < P$. **(Understand)**

(b) Comment on the relationship between crystal field stabilisation energy (Δ_o) and the strength of the ligand. **(Analyse)**

Question 5 **[2]**

Rohan, a patient of thyroid disorder, was given certain amount of radioactive Iodine-131 as a part of his treatment.

What amount of Iodine-131 will be left in Rohan's body after 48 days, if it is known that the half-life period of radioactive iodine-131 is 12 days? Assume that no amount of the isotope was eliminated through biological processes. **(Apply)**

Question 6 **[2]**

How can the following conversions be carried out? (Write the chemical equations):

(i) Aniline to chlorobenzene **(Recall)**

(ii) Chloroethane to n-butane **(Recall)**

Question 7 **[2]**

Substantiate the following statements with reasons.

(i) Cobalt is attracted in a magnetic field whereas Zinc is not. **(Understand)**
(Atomic number of Co = 27 and Zn =30)

(ii) The melting points and boiling points of Zn, Cd and Hg are low. **(Understand)**
(Atomic number of Zn = 30, Cd = 48 and Hg = 80)

Question 8 **[2]**

Write the Nernst equation and calculate the emf of the following cell at 298K.

$$Mg_{(s)} / Mg^{2+} (1x10^{-3}M) // Cu^{2+}(1x10^{-4}M) / Cu_{(s)}$$

Given: $E^{\circ}_{(Mg^{2+}/Mg)} = -2{\cdot}373V$, $E^{\circ}_{(Cu^{2+}/Cu)} = +0{\cdot}337V$ **(Apply)**

Question 9 **[2]**

(i) Illustrate the following reactions with an example in each case:

(a) Coupling reaction **(Recall)**

(b) Balz-Schiemann reaction **(Recall)**

OR

(ii) An organic compound [A] with molecular formula C_3H_7NO forms compound [B] on heating with Br_2 and KOH. Compound [B] on heating with $CHCl_3$ and alcoholic KOH produces a pungent smelling compound [C]. Compound [B] on reacting with $C_6H_5SO_2Cl$ forms compound [D] which is soluble in alkali.
Write the structures of compounds [A], [B], [C] and [D]. **(Understand)**

Question 10 **[2]**

In general, it is observed that the rate of a reaction becomes double with every 10°C rise in temperature. If this generalisation holds true for a reaction, calculate the value of activation energy when temperature changes from 295 K to 305 K. **(Apply)**

Question 11 **[2]**

The students of Class XII were on a study trip. They visited a nearby lake and took some water samples which were rich in sodium chloride salt. The boiling point of lake water was found to be 373·032 K.

If 500 g of lake water sample was used which contained 0·45 g of NaCl, what is the observed molecular weight of NaCl in the lake sample? Assume that NaCl ionises completely in lake water.

(Given: k_b of water = 0·52K kg mol^{-1}, boiling point of pure water = 373 K) **(Analyse)**

SECTION C – 21 MARKS

Question 12 **[3]**

Two students Rehan and Ananya were given the same compound, alkyl halide (C_2H_5Cl) by their chemistry teacher and asked to perform different reactions.

- Rehan was instructed to use alcoholic KCN as a reagent and Ananya was instructed to use alcoholic AgCN.
- Rehan observed a compound was formed that could be converted to a carboxylic acid on hydrolysis but Ananya could not obtain the same acid.
- The teacher explained that the difference was due to the bonding behaviour of cyanide ions in the reagents.

Write the chemical equations of the reactions and the IUPAC names of the compounds formed by Rehan and Ananya. **(Understand)**

Question 13 **[3]**

(i) For a given first order reaction, it takes 5 minutes for the initial concentration of 0·6 moles $litre^{-1}$ to become 0·2 moles $litre^{-1}$. Calculate the rate constant for this reaction. **(Apply)**

(ii) Find the overall order of the reactions which have the following rate law expression: **(Understand)**

(a) Rate = $k[A]^{1/2}[B]^{3/2}$

(b) Rate = $k[A]^{3/2}[B]^{-1}$

(c) Rate = $k[A]^{1}[B]^{2}$

Question 14 **[3]**

(i) Compounds [X] and [Y] are functional isomers of each other with molecular formula C_2H_6O.

(a) Draw the structural formula of both the isomers. **(Understand)**

(b) Which of the compounds will have a lower boiling point and why? **(Understand)**

(ii) Methanol does not give yellow precipitate of iodoform when heated with iodine and alkali, but ethanol gives iodoform test with the same reagents. Explain. **(Understand)**

OR

(iii) How will the following be converted? (Give chemical equations) **(Recall)**

(a) Diethyl ether from sodium ethoxide

(b) Propan-2-ol from Grignard's reagent

(c) Phenol from Cumene

Question 15 **[3]**

(i) Complete and balance the following chemical equation.

$KMnO_4 + H_2SO_4 + H_2S \rightarrow$ _____ + _____ + _____ + _____ **(Understand)**

(ii) Why do transition metals form alloys? **(Understand)**

(iii) Potassium dichromate ($K_2Cr_2O_7$) acts as a powerful oxidising agent in acidic medium. Explain. **(Analyse)**

Question 16 **[3]**

(i) Identify the non-reducing sugar which on hydrolysis gives two reducing monosaccharides. **(Understand)**

(ii) Which structure of protein is normally unaffected during denaturation of protein? **(Recall)**

(iii) Name the vitamins whose deficiency cause the following diseases. **(Recall)**

(a) Rickets

(b) Night blindness

Question 17 **[3]**

(i) Three electrolytic cells (X), (Y) and (Z) containing solutions of $AgNO_3$, $CuSO_4$ and $ZnSO_4$ respectively are connected in series. A steady current of 1·5 ampere is passed through these electrolytic cells until 1·45g of silver is deposited at the cathode of cell (X).

(Atomic weight of Ag =108, Cu = 63·5 and Zn = 65·3)

(a) How much of charge is given to the electrolyte solution? **(Apply)**

(b) What mass of copper and zinc is deposited at the respective cathode? **(Analyse)**

OR

(ii) The molar conductivities at infinite dilution for NaI, CH_3COONa and $(CH_3COO)_2Mg$ are 126·9, 91·0 and 187·8 $ohm^{-1}\ cm^2\ mol^{-1}$ respectively at 25°C. Find out the molar conductivity of MgI_2 at infinite dilution by using Kohlrausch's law of independent migration of ions. **(Apply)**

Question 18 **[3]**

Write the chemical equations for the following conversions: **(Recall)**

(i) Nitrobenzene to benzene

(ii) Aniline to bromobenzene

(iii) Methyl cyanide to ethylamine

SECTION D – 15 MARKS

Question 19 **[5]**

(i) An organic compound [A] with molecular formula $C_2Cl_3O_2H$ is obtained when compound [B] reacts with red phosphorous and Cl_2. The organic compound [B] can be obtained on the reaction of methyl magnesium bromide with carbon dioxide followed by acid hydrolysis. Upon partial reduction, compound [B] forms compound [C] with molecular formula C_2H_4O, which gives yellow precipitate of iodoform on heating with iodine in presence of sodium hydroxide. Compound [C] also reacts with dilute NaOH to form compound [D].

(a) Identify the compounds [A], [B], [C] and [D]. **(Understand)**

(b) Write down the reaction for the formation of [A] from [B]. What is the reaction called? **(Recall)**

(c) Write the chemical test to distinguish between compound [C] and acetone. **(Analyse)**

(d) Which will be more acidic, compound [A] or [B]? Why? **(Evaluate)**

OR

(ii) Identify the compounds [A], [B] and [C] in the following reactions: **(Analyse)**

(a) $CH_3C{\equiv}N \xrightarrow[H_2O]{SnCl_2/HCl} [A] \xrightarrow[H_2O]{CH_3MgBr} [B] \xrightarrow[K_2Cr_2O_7]{Acidified} [C]$

(b) $H-C\equiv C-H \xrightarrow[Hg^{2+}\,/\,H_2SO_4]{H_2O} [A] \xrightarrow[K_2Cr_2O_7+H_2SO_4]{[O]} [B] \xrightarrow{PCl_5} [C]$

(iii) Write chemical equations to convert the following: **(Recall)**

(a) Acetone to propene

(b) Benzaldehyde to cinnamic acid

Question 20 **[5]**

(i) The compound $[PtCl_2(NH_3)_2]$ also known as cis-platin, is used in chemotherapy. It also demonstrates how coordination geometry impacts medical science.

(a) Write its IUPAC name and the type of isomerism it exhibits. **(Recall)**

(b) What is the geometry of the compound? **(Recall)**

(ii) What type of structural isomers are $[Pt(NH_3)_3Br]NO_3$ and $[Pt(NH_3)_3(NO_3)]Br$? How can they be distinguished by using a chemical test? **(Analyse)**

(iii) A coordination compound $CoCl_3.4H_2O$ precipitates silver chloride when treated with silver nitrate. The molar conductance of its solution corresponds to a total of two ions. Write the structural formula of the compound and name it. **(Evaluate)**

Question 21 **[5]**

(i) Answer the following:

(a) 300 ml of aqueous solution of protein contains 1·85g of protein, the osmotic pressure of the solution at 25°C is found to be $3{\cdot}05 \times 10^{-3}$atm. Calculate the molar mass of the protein. **(Apply)**

(b) Phenol (C_6H_5OH) associates in benzene to form a dimer. A solution of 2·5g of phenol in 120g of benzene lowers its freezing point by 0·85K. Calculate the degree of association of phenol.
(k_f for benzene = 5·12 K kg mol^{-1}, molecular mass of phenol = 94 g mol^{-1})
(Apply)

(c) The molecular weight of potassium chloride and sucrose is determined by the depression of freezing point method. Compared to their theoretical molecular weight, what will be their observed molecular weights when determined by the above method? Justify your answer. **(Evaluate)**

OR

(ii) (a) Arrange the following aqueous solutions in increasing order of osmotic pressure. Give reasons in support of your answer. **(Analyse)**

(1) 6·0g per litre of urea solution (molecular weight of urea = 60g mol^{-1})

(2) 72·0g per litre of glucose solution (molecular weight of glucose = 180g mol^{-1})

(3) 5·85g per litre of sodium chloride solution (molecular weight of sodium chloride = 58·5g mol^{-1})

(b) Calculate the mole fraction (x) of ethanol and water if 92g of ethanol is dissolved in 540g of water.
(Atomic mass of C = 12, O = 16 and H = 1) **(Apply)**

(c) What type of azeotropic mixture will be formed by a solution of chloroform and acetone? Justify your answer based on strength of intermolecular interactions that develops in the solution. **(Evaluate)**

CHEMISTRY PAPER 1
(THEORY)
ANSWER KEY

SECTION A - 14 MARKS

Question 1

(A) **[4×1]**

(i) Methyl alcohol, Cannizzaro

(ii) One, 96,500

(iii) Unpaired, d-d

(iv) Salicylic acid, Kolbe's

(B) **[7×1]**

(i) (b) Urea > KCl > $MgCl_2$ > $AlCl_3$

(ii) (c) three

(iii) (d) $CoCl_3.3NH_3$

(iv) (b) $k[A]^1[B]^0$

(v) (a) $C_2H_5NC \xrightarrow{LiAlH_4}$ _____

(vi) (a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion.

(vii) (c) Assertion is true and Reason is false.

(C) **[3×1]**

(i) The boiling point of 2-methyl propan-2-ol is much lower than that of butan-1-ol. This is due to the fact that with branching the surface area decreases. Consequently, boiling point also decreases.

(ii) The greater acidic character of phenol as compared to alcohols can be explained on the basis of resonance. The oxygen attracts the electron pair of O-H bond strongly towards itself, weakens the O-H bond and therefore facilitates the release of H^+ more easily.

(iii) A 0·2% of phenol acts as an antiseptic, whereas its 1% solution is used as a disinfectant.

SECTION B – 20 MARKS

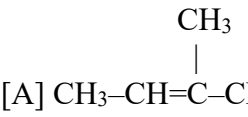
Question 2 **[2]**

Increasing order of reducing power of metals is Ag < Cu < Fe < Mg < Li

Reducing power = $\frac{1}{\text{Reduction potential}}$

i.e., as the reduction potential (value of metal) decreases, reducing power of metal increases.

Question 3 **[2]**



[A] $CH_3–CH=C–CH_3$ or 2-methyl but-2-ene

[B] CH_3CHO or acetaldehyde or ethanol

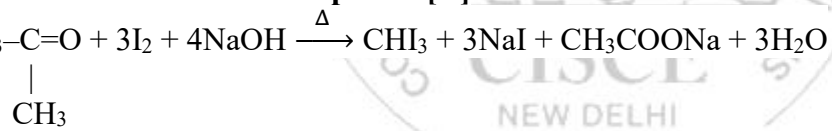
[C] $CH_3–C(=O)–CH_3$ or propanone or acetone

Iodoform reaction with compound [B]

$$CH_3CHO + 3I_2 + 4NaOH \xrightarrow{\Delta} CHI_3 + 3NaI + HCOONa + 3H_2O$$

Or

Iodoform reaction with compound [C]



$$CH_3–C(=O)–CH_3 + 3I_2 + 4NaOH \xrightarrow{\Delta} CHI_3 + 3NaI + CH_3COONa + 3H_2O$$

Question 4 **[2]**

(i) For the coordination complex ion $[Cr(NH_3)_6]^{3+}$

(a) Type of hybridisation; d^2sp^3

(b) Magnetic behaviour; paramagnetic

Reason: There are three unpaired electrons.

OR

(ii) (a) $t_{2g}^3 eg^2$

(b) If the value of CFSE (Δ_0) is more, ligand is strong. (i.e. low spin complex)

Question 5 **[2]**

Given: $t_{1/2}$ = 12 days, t = 48 days

Number of half lives = $\frac{\text{Total time}}{\text{Half life period}} = \frac{48}{12} = 4$

Amount left after 4 half lives

$A = A_o \times \left(\frac{1}{2}\right)^4$

$A = A_o \times \frac{1}{16}$

i.e. ; $\frac{1}{16}$ of the initial amount

Question 6 **[2]**

(i) Aniline to chlorobenzene

$C_6H_5N_2Cl \xrightarrow{Cu_2Cl_2/HCl} C_6H_5Cl + N_2$

or

$C_6H_5N_2Cl \xrightarrow{Cu/HCl} C_6H_5Cl + N_2$

(ii) Chloroethane to n-butane

$C_2H_5Cl + 2Na + ClC_2H_5 \xrightarrow{ether} C_2H_5–C_2H_5 + 2NaCl$

n-butane

Question 7 **[2]**

(i) Cobalt has d^7 electrons in the outer shell and therefore, has three unpaired electrons. Therefore, it will be attracted in a magnetic field.

Zinc has completely filled d^{10} configuration and therefore, will not be attracted by the magnetic field.

(ii) In Zn, Cd and Hg, all the electrons in d-subshell are paired. Hence, the metallic bonds present in them are weak. Therefore, they have low melting and boiling points.

Question 8 **[2]**

$E_{cell} = E^o_{cell} - \frac{0{\cdot}059}{n} \log \frac{[Mg^{2+}_{(aq)}]}{[Cu^{2+}_{(aq)}]}$ (Nernst Equation)

$E^o_{cell} = E^o_{cathode} - E^o_{anode}$

$= 0{\cdot}337V - (-2{\cdot}373\ V)$

$E^o_{cell} = +\ 2{\cdot}71\ V$

$E_{cell} = 2{\cdot}71 - \frac{0.059}{2} \log \frac{1 \times 10^{-3}}{1 \times 10^{-4}}$ or

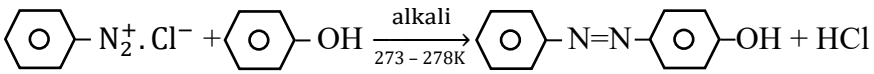
$= 2{\cdot}71 - 0{\cdot}0295 \log 10$ or

$= 2{\cdot}71 - 0{\cdot}0295 \times 1$

$E_{cell} = 2{\cdot}6805\ V$

Question 9 **[2]**

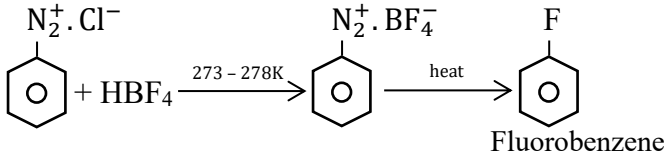
(i) (a) Coupling reaction



p-hydroxyazobenzene

(or any other correct example)

(b) Balz-Schiemann reaction



Fluorobenzene

(or any other correct example)

OR

(ii) [A] $C_2H_5CONH_2$

[B] $C_2H_5NH_2$

[C] $C_2H_5N{\equiv}C$

[D] $C_6H_5SO_2–N(H)–C_2H_5$

Question 10 **[2]**

Given: $T_1 = 295K$, $T_2 = 305K$

$$\log\frac{k_2}{k_1} = 2$$

$$\log\frac{k_2}{k_1} = \frac{E_a}{2{\cdot}303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right] \text{ or}$$

$$\log 2 = \frac{E_a}{2{\cdot}303 \times 8{\cdot}314}\left[\frac{1}{295} - \frac{1}{305}\right] \text{ or}$$

$$0{\cdot}3010 = \frac{E_a}{19{\cdot}147} \times \frac{10}{295 \times 305} \text{ or}$$

$$E_a = \frac{0{\cdot}3010 \times 19{\cdot}147 \times 295 \times 305}{10}$$

$$= 151854{\cdot}8 \text{ J K}^{-1} \text{ mol}^{-1} \text{ or}$$

$$E_a = 151{\cdot}854 \text{ kJ mol}^{-1}$$

Question 11 **[2]**

Given: $\Delta T_b = 0{\cdot}032$ K, w = 0·45g, W = 500g

$K_b = 0{\cdot}52$ K kg mol^{-1}, $NaCl \longrightarrow Na^+ + Cl^-$, i = 2

$$M_{(obs)} = \frac{i \times 1000 \times k_b \times w}{\Delta T_b \times W}$$

$$M_{(obs)} = \frac{2 \times 1000 \times 0{\cdot}52 \times 0{\cdot}45}{0{\cdot}032 \times 500}$$

$$M_{(obs)} = 29{\cdot}25 \text{ g mol}^{-1}$$

SECTION C – 21 MARKS

Question 12 **[3]**

Rehan's Reaction:

$C_2H_5Cl + KCN \longrightarrow C_2H_5CN + KCl$

(alc) Propane nitrile

Ananya's Reaction:

$C_2H_5Cl + AgCN \longrightarrow C_2H_5NC + AgCl$

(alc) Ethyl carbylamine

Question 13 **[3]**

(i) Given; t = 5 minutes, a = 0·6 moles litre^{-1}

(a – x) = 0·2 moles litre^{-1}

$K = \frac{2{\cdot}303}{t} \log_{10} \frac{a}{(a-x)}$

$= \frac{2{\cdot}303}{5} \log_{10} \frac{0{\cdot}6}{(0{\cdot}2)}$

$= \frac{2{\cdot}303}{5} \log 3$

$= \frac{2{\cdot}303}{t} \times 0 \cdot 477$

$K = 0{\cdot}2197 \text{ min}^{-1}$

(ii) The overall order of the following reactions are as follows:

(a) Rate = $k[A]^{1/2}[B]^{3/2}$

overall order of reaction = $\frac{1}{2} + \frac{3}{2} = 2$

(b) Rate = $k[A]^{3/2}[B]^{-1}$

overall order of reaction = $\frac{3}{2} - 1 = \frac{1}{2}$

(c) Rate = $k[A]^1[B]^2$

overall order of reaction = 1 + 2 = 3

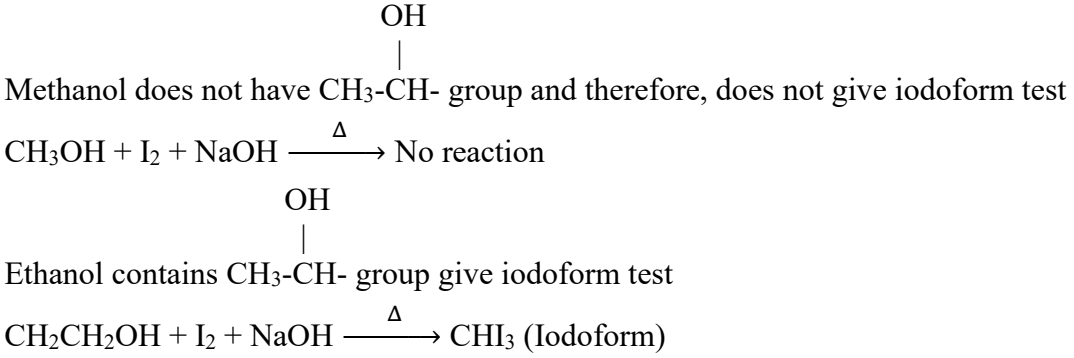
Question 14 **[3]**

(i) (a) Functional isomers

[X] = CH_3CH_2OH and [Y] = CH_3-O-CH_3

(b) Compound [Y] will have lower boiling point as it is an ether which cannot form associated molecules by intermolecular hydrogen bond.

(ii)



Methanol does not have CH_3-CH- group and therefore, does not give iodoform test

$CH_3OH + I_2 + NaOH \xrightarrow{\Delta}$ No reaction

Ethanol contains CH_3-CH- group give iodoform test

$CH_2CH_2OH + I_2 + NaOH \xrightarrow{\Delta} CHI_3$ (Iodoform)

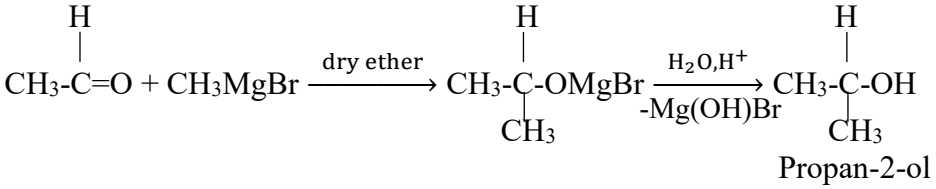
OR

(iii) (a) Diethyl ether from sodium ethoxide

$$C_2H_5ONa + BrC_2H_5 \xrightarrow{330K} C_2H_5\text{-}O\text{-}C_2H_5 + NaBr$$

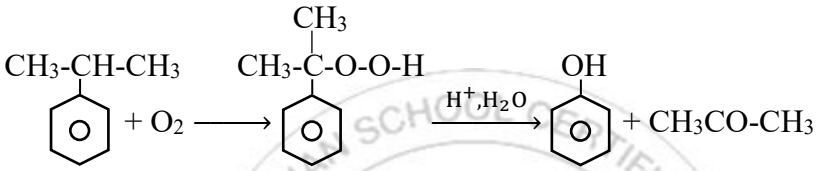
Diethyl ether

(b) Propan-2-ol from Grignard's reagent



Propan-2-ol

(c) Phenol from Cumene



Cumene Phenol

Question 15 **[3]**

(i) $2KMnO_4 + 3H_2SO_4 + 5H_2S \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5S$

(ii) Atoms of transition metal can easily take place in the crystal lattice of another metal in the molten state and are miscible with each other and thus form alloys.

(iii) Potassium dichromate ($K_2Cr_2O_7$) acts as a powerful oxidising agent in acidic medium. In the presence of dilute sulphuric acid, $K_2Cr_2O_7$ liberates nascent oxygen and therefore, acts as an oxidising agent.

Or

$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$

Question 16 **[3]**

(i) Sucrose

(ii) Primary structure

(iii) (a) Rickets – Vitamn D

(b) Night blindness – Vitamin A

Question 17 **[3]**

(i) Cell [X] contains $AgNO_3$

The reaction may be represented as follows

$AgNO_3 \Longleftrightarrow Ag^+ + NO_3^-$

$Ag^+ + e^- \Longleftrightarrow Ag$ (at cathode)

(a) 1 mole or 108 g of Ag is deposited by 96500 coulombs

1·45 g of Ag is deposited by $\frac{96500 \times 1{\cdot}45}{108}$ = 1295·6 coulombs

(b) In cell [Y] the electrode reaction is:

$Cu^{2+} + 2e^- \longrightarrow Cu$

2 x 96500 coulombs of current will deposit 63·5 g of Cu

1295·6 coulombs of current will deposit $\frac{63{\cdot}5 \times 1295{\cdot}6}{2 \times 96500}$ = 0·426 g of Cu

In cell [Z] the electrode reaction is:

$Zn^{2+} + 2e^- \longrightarrow Zn$

2 x 96500 coulombs of current will deposit 65·3 g of Zn

1295·6 coulombs of current will deposit $\frac{65.x\ 1295{\cdot}6}{2 \times 96500}$ = 0·438 g of Zn

OR

(ii) Given; $\Lambda^o_m(NaI) = 126.9\ ohm^{-1}\ cm^2\ mol^{-1}$

$\Lambda^o_m(CH_3COONa) = 91{\cdot}0\ ohm^{-1}\ cm^2\ mol^{-1}$

$\Lambda^o_m(CH_3COO)_2Mg = 126{\cdot}9\ ohm^{-1}\ cm^2\ mol^{-1}$

The molar conductivity at infinite dilution for MgI_2 may be calculated as:

$\Lambda^o_m(MgI_2) = \Lambda^o_m(CH_3COO)_2Mg + 2\Lambda^o_m(NaI) - 2\Lambda^o_m(CH_3COONa)$

= 187·8 + 2(126·9) – 2(91·0)

$= 259{\cdot}6\ ohm^{-1}\ cm^2\ mol^{-1}$

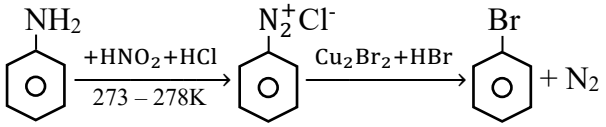
Question 18 **[3]**

(i) Nitrobenzene to benzene

$$C_6H_5NO_2 + 6[H] \xrightarrow{Sn/HCl} C_6H_5NH_2 \xrightarrow[273-278K]{HNO_2+HCl} C_6H_5N_2^+Cl^- \xrightarrow{H_3PO_2+H_2O} C_6H_6$$

(or any other correct reaction)

(ii) Aniline to bromobenzene



(or any other correct reaction)

(iii) Methylcyanide to ethylamine

$$CH_3CN + 4[H] \xrightarrow[\text{or } H_2/Ni]{Na/alcohol} CH_3CH_2NH_2$$

SECTION D – 15 MARKS

Question 19 **[5]**

(i) (a) Identify the compounds A, B, C and D

[A] Cl_3C-COOH or trichloroacetic acid

[B] CH_3COOH or acetic acid

[C] CH_3CHO or acetaldehyde

[D] $CH_3–\underset{\displaystyle H}{\overset{\displaystyle OH}{\underset{|}{\overset{|}{C}}}}–CH_2–CHO$ or 2-hydroxybutan-al

(b) $CH_3COOH + 3Cl_2 \xrightarrow{Red\ P} Cl_3C\text{-}COOH + 3HCl$

[B]

Hell-Volhard-Zelinsky (HVZ) reaction

(c) Compound [C] acetaldehyde gives Tollen's reagent test (silver mirror), Fehling's solution test (Red ppt of Cu_2O), Schiff's reagent test (pink colour), whereas acetone does not response to these tests. *(or any other correct test)*

(d) Compound [A] i.e. trichloroacetic acid will be more acidic due to the electron withdrawing tendency of Cl atoms (-I effect). It stabilises the carboxylate anion by dispersing the negative charge and therefore, strengthening the acid. Compound [B] i.e. acetic acid is less acidic due to the absence of -I effect.

OR

(ii) (a) [A] CH_3CHO

[B] $CH_3CHOHCH_3$

[C] CH_3COCH_3

(b) [A] CH_3CHO

[B] CH_3COOH

[C] CH_3COCl

(iii) (a) Acetone to Propene

$$\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\diagdown\!\diagup}}C{=}O \xrightarrow{LiAlH_4} \underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\diagdown\!\diagup}}\overset{\displaystyle H}{\overset{\displaystyle OH}{\diagdown\!\diagup}}C \xrightarrow[H_2SO_4]{443K} CH_3–CH{=}CH_2 + H_2O$$

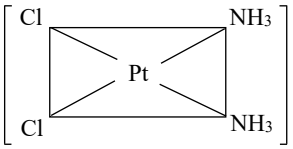
(b) Benzaldehyde to cinnamic acid

$$C_6H_5CHO + (CH_3CO)_2O \xrightarrow[H_2O,\ boil]{(I)CH_3COONa} C_6H_5CH{=}CHCOOH + CH_3COOH$$

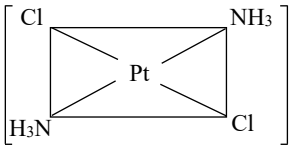
Cinnamic acid

Question 20 **[5]**

(i) (a) diamminedichloridoplatinum (II)



cis-diamminedichlorido platinum(II)



trans- diamminedichlorido platinum(II)

Geometrical isomerism

(b) Square planar geometry

(ii) Ionisation isomers

$[Pt(NH_3)_3Br]NO_3 \longrightarrow [Pt(NH_3)_3Br]^+ + NO_3^-$

Aqueous solution of this isomer when heated strongly with conc. H_2SO_4 gives brown fumes of NO_2. It also gives brown ring test with freshly prepared $FeSO_4$ solution and conc. H_2SO_4.

$[Pt(NH_3)_3NO_3]Br \longrightarrow [Pt(NH_3)_3NO_3]^+ + Br^-$

Aqueous solution of this isomer when reacts with $AgNO_3$ solution gives yellow precipitate of AgBr which is sparingly soluble in excess of NH_4OH.

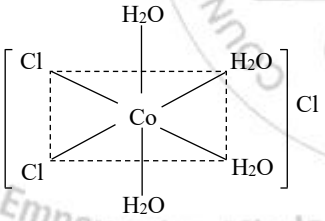
(iii) Structural formula of compound is

$[Co(H_2O)_4Cl_2]Cl \longrightarrow [Co(H_2O)_4Cl_2]^+ + Cl^-$

$AgNO_3 + Cl^- \longrightarrow AgCl + NO_3^-$

(aq) ppt

Formula:



IUPAC Name – tetraaquadichlorocobalt(III)chloride

Question 21 **[5]**

(i) (a) Given; $\pi = 3{\cdot}05 \times 10^{-3}$ atm, T = 298K

$V = \frac{300}{1000} = 0.3$Lit, w = 1.85 g

$\pi = CRT = \frac{w \times R \times T}{m \times V}$

$m = \frac{1{\cdot}85 \times 0{\cdot}0821 \times 298}{3{\cdot}05 \times 10^{-3} \times 0{\cdot}3}$

$m = 49466$ g mol^{-1}

(b) Given; $k_f = 5{\cdot}12$ k kg mol^{-1}, $\Delta T_f = 0{\cdot}85k$,

$m = 94$ g mol^{-1}, $w = 2{\cdot}5$ g, $W = 120$ g

$n = 2$

$$m_{(observed)} = \frac{1000 \times k_f \times w}{\Delta T_f \times W}$$

$$m_{(obs)} = \frac{1000 \times 5{\cdot}12 \times 2{\cdot}5}{0{\cdot}85 \times 120}$$

$= 125{\cdot}49$ g mol^{-1}

$$(i) = \frac{M_{(normal)}}{M_{(observed)}} = \frac{94}{125{\cdot}49} = 0{\cdot}749$$

$$\alpha \text{ (degree of association)} = \frac{1-i}{1-\frac{1}{n}} = \frac{1-0{\cdot}749}{1-\frac{1}{2}}$$

$$= \frac{0{\cdot}251}{0{\cdot}5} = 0{\cdot}502 \text{ or } 50{\cdot}2\%$$

(c) The observed molecular mass of potassium chloride will be half of its theoretical molecular mass. The depression in freezing point is a colligative property which depends upon the number of solute particles present in solution. KCl is a strong electrolyte, it furnishes two ions $KCl \longrightarrow K^+ + Cl^-$.

The observed molecular mass of sucrose as determined by depression in freezing point method will be same as the theoretical molecular mass.

OR

(ii) (a) Osmotic pressure is a colligative property which depends upon the number of solute particles.

Osmotic pressure $\propto$ No. of solute particles

(1) Moles of urea $= \frac{\text{wt. of urea}}{\text{mol. wt. of urea}} = \frac{6}{60} = 0{\cdot}1$ moles

1 mole of urea $= 6{\cdot}023 \times 10^{23} \times 0{\cdot}1 = 6{\cdot}023 \times 10^{22}$ particles

(2) Moles of glucose $= \frac{\text{wt. of glucose}}{\text{mol. wt. of glucose}} = \frac{72}{180} = 0{\cdot}4$ moles $= 6{\cdot}023 \times 10^{23} \times 0{\cdot}4$

$= 24{\cdot}092 \times 10^{22}$ particles

(3) Moles of sodium chloride $= \frac{\text{wt. of NaCl}}{\text{mol. wt. of NaCl}} = \frac{5{\cdot}85}{58{\cdot}5} = 0{\cdot}1$ moles

1 mole of NaCl $= 2 \times 6{\cdot}023 \times 10^{23}$ particles, $NaCl \longrightarrow Na^+ + Cl^-$

$0{\cdot}1$ mole of NaCl $= 2 \times 6{\cdot}023 \times 10^{23} \times 0{\cdot}1 = 12{\cdot}046 \times 10^{22}$ particles

Therefore, increasing order of their osmotic pressure is:

Urea < NaCl < glucose

(b) Given: wt. of $C_2H_5OH = 92$ g, wt. of $H_2O = 540$ g

mol. wt. of $C_2H_5OH = 46$ g mol^{-1}, mol. wt. of $H_2O = 18$ g

No. of moles of C_2H_5OH (n) $= \frac{92}{46} = 2$ moles

No. of moles of H_2O (N) $= \frac{540}{18} = 30$ moles

Mole fraction of $C_2H_5OH = \frac{n}{n+N} = \frac{2}{2+30} = \frac{2}{32}$

$$X_{(C_2H_5OH)} = 0.0625$$

Mole fraction of water (H_2O) $= \frac{N}{n+N} = \frac{30}{2+30} = \frac{30}{32}$

$$X_{(H_2O)} = 0{\cdot}9375$$

(c) The mixture of chloroform and acetone is an example of maximum boiling azeotrope. It shows negative deviation from Raoult's Law because of the increase in intermolecular forces of attraction between chloroform and acetone, since they form hydrogen bonds between them.