# Class XII Session 2026-27
# Subject - Chemistry
# Sample Question Paper - 2

**Time Allowed: 3 hours** **Maximum Marks: 70**

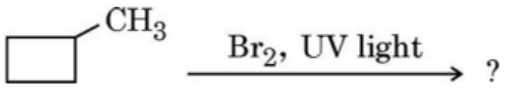
**General Instructions:**

Read the following instructions carefully.

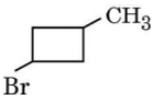
1. There are **33** questions in this question paper with internal choice.
2. SECTION A consists of 16 multiple-choice questions carrying 1 mark each.
3. SECTION B consists of 5 very short answer questions carrying 2 marks each.
4. SECTION C consists of 7 short answer questions carrying 3 marks each.
5. SECTION D consists of 2 case-based questions carrying 4 marks each.
6. SECTION E consists of 3 long answer questions carrying 5 marks each.
7. **All questions are compulsory.**
8. **Use of log tables and calculators is not allowed.**

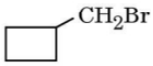
## Section A

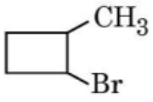
1. Consider the following reaction: **[1]**

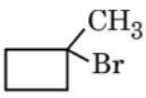



The major product obtained is:

a) 


b) 


c) 


d) 


2. Water soluble vitamins must be supplied regularly in diet because **[1]**

a) they are not widely available.

b) they are readily excreted in urine and cannot be stored (except vitamin $B_{12}$) in our body.

c) they cannot be provided by synthetic means.

d) they get used up very fast in body.

3. The compound which forms acetaldehyde when heated with dilute NaOH is: **[1]**

a) 1 chloroethane

b) 1, 1, 1 trichloroethane

c) 1, 2 dichloroethane

d) 1, 1 dichloroethane

4. Mark the correct statement: **[1]**

a) Ethers behave as Lewis base

b) With cold HI diethyl ether gives ethyl alcohol & ethyl iodide

c) Ethers form coordinated complexes with Lewis acids

d) All of these

5. The number of molecules that react with each other in an elementary reaction is a measure of the: **[1]**

a) activation energy of the reaction

b) order of the reaction

c) stoichiometry of the reaction

d) molecularity of the reaction

6. Match the items given in column I with that in column II: **[1]**

| Column I | Column II |
|---|---|
| (a) $\Omega^{-1}$ $cm^2mol^{-1}$ | (i) Mercury Cell |
| (b) $\alpha_{dissoiation}$ is low | (ii) $\lambda_m$ |
| (c) Decreases with dilution | (iii) Weak Electrolyte |
| (d) Electrolyte is a paste of KOH/ZnO | (iv) Conductivity |

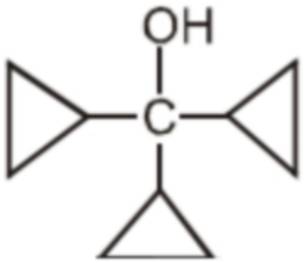
a) (a) - (iii), (b) - (iv), (c) - (i), (d) - (ii)

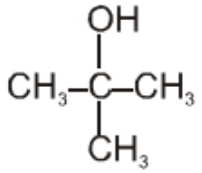
b) (a) - (i), (b) - (ii), (c) - (iii), (d) - (iv)

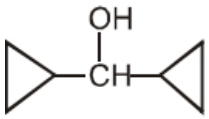
c) (a) - (iv), (b) - (i), (c) - (ii), (d) - (iii)

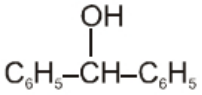
d) (a) - (ii), (b) - (iii), (c) - (iv), (d) - (i)

7. Which one of the following will be most reactive for $S_N1$ reaction? **[1]**

a) 


b) 


c) 


d) 


8. The monomeric unis of starch is / are : **[1]**

a) Glucose and Fructose

b) Glucose

c) Fructose

d) Mannose

9. The activation energy for a reaction at temperature TK was found to be $2.303RTJmol^{-1}$. The ratio of the rate constant to Arrhenius factor is **[1]**

a) $2 \times 10^{-3}$ b) $2 \times 10^{-2}$

c) $10^{-1}$ d) $10^{-2}$

10. Identify Z in the following reaction sequence **[1]**

$$CH_3I \xrightarrow[\text{Ether}]{\text{Mg}} X \xrightarrow[\text{(ii) } H_2O]{\text{(i) Dryice}} Y \xrightarrow[\text{RedP}]{Cl_2} Z :$$

a) $CH_3COCl$ b) $CH_3MgI$

c) $ClCH_2COOH$ d) $CH_3COOH$

11. Grignard reagent ($CH_3MgBr$) on reaction $CH_3OH$ will give: **[1]**

a) Aldehyde b) Ethane

c) Ester d) Methane

12. Anilinium hydrogen sulphate on heating at $453 - 473\ K$ produces which of the following as a major product? **[1]**

a) 2-aminobenzoic acid b) benzene sulphonic acid

c) sulphanilic acid d) 2-aminobenzene sulphonic acid

13. **Assertion (A):** Simple proteins on hydrolysis gives $\alpha$-amino acids. **[1]**
**Reason (R):** Prosthetic group is present in simple proteins.

a) Both A and R are true and R is the correct explanation of A. b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

14. **Assertion (A):** Acetic acid but not formic acid can be halogenated in presence of red P and $Cl_2$. **[1]**

**Reason (R):** Acetic acid is a weaker acid than formic acid.

a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

b) Both Assertion (A) and Reason (R) are true, but Reason (R) is **not** the correct explanation of the Assertion (A).

c) Assertion (A) is true, but Reason (R) is false.

d) Assertion (A) is false, but Reason (R) is true.

15. **Assertion (A):** $S_N1$ reactions are unimolecular. **[1]**

**Reason (R):** $S_N1$ reaction proceed through the formation of the carbocation, which is slow step of the reaction.

a) Both A and R are true and R is the correct explanation of A. b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

16. **Assertion (A):** Tertiary alcohols give turbidity immediately with Lucas reagent **[1]**
**Reason (R):** A mixture of conc. HI+ anhydrous $ZnCl_2$ is called Lucas reagent.

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true but R is not the correct explanation of A.
c) A is true but R is false.
d) A is false but R is true.

**Section B**

17. Calculate the potential of the cell at 298 K : **[2]**

$Cd/Cd^{2+}$ (0.1M) || $H^+$ (0.2M)/Pt, $H_2$ (0.5 atm)

Given $E^{\circ}$ for $Cd^{2+}/Cd$ = -0.403 V, R = 8.314 $J^{-1}$ $mol^{-1}$, F = 96500 C $mol^{-1}$.

OR

Two electrolytic cells containing silver nitrate solution and copper sulphate solution are connected in series. A steady current of 2.5 amp was passed through them till 1.078 g of Ag were deposited. How long did the current flow? What weight of copper will be deposited? (Ag = 107.8 u, Cu = 63.5 u)

18. What happens when pressure greater than osmotic pressure is applied on the solution separated by a semi permeable membrane from the solvent? **[2]**

19. Arrange the following in increasing order of basic character? MnO, $MnO_2$, $Mn_2O_7$ **[2]**

20. **Answer the following:** **[2]**

i. Oxygen is available in plenty in air yet fuels do not burn by themselves at room temperature. Explain. **[1]**

ii. What is the drawback of collision theory? **[1]**

21. What is meant by Aldol Condensation? Give an example. **[2]**

**Section C**

22. Estimate the minimum potential difference needed to reduce $Al_2O_3$ at 500°C. The free energy charge for the decomposition reaction. **[3]**

$\frac{2}{3}Al_2O_3 \rightarrow \frac{4}{3}Al + O_2$ is $\Delta G = +960KJ$ (1 F = 96500 $Cmol^{-1}$)

23. i. Calculate the spin only magnetic moment of the complex $[FeF_6]^{3-}$. (Atomic number of Fe = 26) **[3]**

ii. Write the IUPAC name of the given complex: $[Co(NH_3)_5Cl]Cl_2$

iii. Why is the complex $[Co(en)_3]^{3+}$ more stable than $[CoF_6]^{3-}$?

24. Why is the C-O-H bond angle in alcohols slightly less than the tetrahedral angle whereas the C-O-C bond angle in ether is slightly greater? **[3]**

25. An aliphatic compound 'A' with a molecular formula of $C_3H_6O$ reacts with phenyl hydrazine to give compound 'B'. Reaction of 'A' with $I_2$ in alkaline medium on warming gives yellow precipitate 'C'. Identify the compounds A, B and C. **[3]**

26. What is a Galvanic cell? Give the symbolic representation of the Daniell cell. **[3]**

27. How the following conversions can be carried out? **[3]**

i. 2-Methyl-1-propene to 2-chloro-2-methylpropane

ii. Ethyl chloride to propanoic acid

iii. But-1-ene to n-butyliodide

28. For the reaction $A + B \rightarrow C + D$, the rate of reaction doubles when the concentration of A doubles, provided the concentration of B is constant. To what order does A enter into the rate expression? **[3]**

## Section D

29. **Read the following text carefully and answer the questions that follow:** **[4]**

When a protein in its native form, is subjected to physical changes like change in temperature or chemical changes like change in pH, the hydrogen bonds are disturbed. Due to this, globules unfold and helix gets uncoiled and protein loses its biological activity. This is called the denaturation of protein.

The denaturation causes change in secondary and tertiary structures but primary structures remain intact. Examples of denaturation of protein are coagulation of egg white on boiling, curdling of milk, formation of cheese when an acid is added to milk.

i. Phospholipids form a thin layer on the surface of an aqueous medium. Give reason. (1)

ii. Which structure(s) of proteins remains(s) intact during the denaturation process? (1)

iii. What type of structure is $\alpha$-helix and $\beta$-pleated structures of proteins? (2)

**OR**

Secondary structure of a protein refers to (2)

30. **Read the following text carefully and answer the questions that follow:** **[4]**

Coordination compounds are widely present in the minerals, plant and animal worlds and are known to play many important functions in the area of analytical chemistry, metallurgy, biological systems and medicine. Alfred Werner's theory postulated the use of two types of linkages (primary and secondary), by a metal atom/ion in a coordination compound. He predicted the geometrical shapes of a large number of coordination entities using the property of isomerism. The Valence Bond Theory (VBT) explains the formation, magnetic behaviour and geometrical shapes of coordination compounds. It, however, fails to describe the optical properties of these compounds. The Crystal Field Theory (CFT) explains the effect of different crystal fields (provided by the ligands taken as point charges) on the degeneracy of d-orbital energies of the central metal atom/ion.

i. When a coordination compound $NiCl_2 \cdot 6H_2O$ is mixed with $AgNO_3$ solution, 2 moles of AgCl are precipitated per mole of the compound. Write the structural formula of the complex and secondary valency for Nickel ion. (1)

ii. Write the IUPAC name of the ionisation isomer of $[Co(NH_3)_5(SO_4)]Cl$. (1)

iii. Using Valence Bond Theory, predict the geometry and magnetic nature of: (2)

1. $[Ni(CO)_4]$
2. $[Fe(CN)_6]^{3-}$

[Atomic number : Ni = 28, Fe = 26]

**OR**

Give reasons: (2)

1. Low spin tetrahedral complexes are not formed.
2. $[Co(NH_3)_6]^{3+}$ is an inner orbital complex whereas $[Ni(NH_3)_6]^{2+}$ is an outer orbital complex.

[Atomic number : Co = 27, Ni = 28

**Section E**

31. **Attempt either A or B** **[5]**

i. **Answer the following questions:** **[1]**

i. Write the preparation of sodium dichromate from chromite ore.

ii. Actinoid series members exhibit a large number of oxidation states compared to their corresponding lanthanoids. Why?

iii. How is $KMnO_4$ prepared from pyrolusite? Give steps involved with equations.

iv. Write the general electronic configuration of transition elements or d-block element.

v. Why first ionisation enthalpy of chromium is lower than that of Zn?

ii. **Answer the following questions:** **[1]**

i. How would you account for:

a. The $E^o$ value for the $Mn^{3+}/Mn^{2+}$ couple is much more positive than that for $Cr^{3+}/Cr^{2+}$ couple or $Fe^{3+}/Fe^{2+}$ couple.

b. Complete the following equation:

$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow$

ii. Give the structure of dichromate ion.

iii. Draw and show manganate and permanganate ions, structurally?

iv. $Zn, Cd$ and Hg are soft metals. Why?

v. What is the effect of adding a base to potassium dichromate?

32. **Attempt either A or B** **[5]**

i. **Answer the following questions:** **[1]**

i. Arrange the following in increasing order of base strength in gas phase:

$(C_2H_5)_3N$, $C_2H_5NH_2$, $(C_2H_5)_2NH$

ii. i. Draw the zwitter ion structure for sulphanilic acid.

ii. How can the activating effect of $-NH_2$ group in aniline be controlled?

iii. Write an isomer of $C_3H_9N$ which gives foul smell of isocyanide when treated with chloroform and ethanolic NaOH.

iv. Name a reagent which is used to distinguish between primary, secondary and tertiary amines.

v. Arrange the following in decreasing order of solubility in water:
$(CH_3)_3N$, $(CH_3)_2NH$, $CH_3NH_2$

ii. **Answer the following questions:** **[1]**

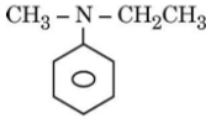
i. Give IUPAC name of sulphanilic acid.

ii. Write IUPAC name of the following compound and classify them into primary secondary and tertiary amine
$C_6H_5NHCH_3$

iii. Give IUPAC name of $H_2N\text{-}CH_2\text{-}CH_2\text{-}CH{=}CH_2$

iv. How is the basic strength of aromatic amines affected by the presence of an electron releasing group?

v. a. Write the IUPAC name for the following organic compounds:




b. Complete the following:

$$C_6H_5NO_2 \xrightarrow{Sn/HCl} A \xrightarrow{Br_2/H_2O} B$$

33. 2 g of benzoic acid ($C_6H_5COOH$) dissolved in 25 g of benzene shows a depression in freezing point equal to 1.62 K. Molal depression constant for benzene is 4.9 K kg $mol^{-1}$. What is the percentage association of acid if it forms a dimer in solution? **[5]**

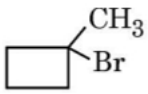
OR

The vapour pressures of ethanol and methanol are 44.5 mm Hg and 88.7 mm Hg respectively. An ideal solution is formed at the same temperature by mixing 60 g of ethanol with 40 g of methanol. Calculate the total vapour pressure of the solution and the mole fraction of methanol in the vapour.

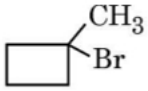
# Solution

## Section A

1.

**(d)** 


**Explanation:**




2.

**(b)** they are readily excreted in urine and cannot be stored (except vitamin $B_{12}$) in our body.

**Explanation:**

B group vitamins and vitamin C are soluble in water so they are grouped together as water soluble vitamins. These must be supplied regularly in diet because they are readily excreted in urine and cannot be stored (except vitamin $B_{12}$) in our body.

3.

**(d)** 1, 1 dichloroethane

**Explanation:**

$CH_3CHCl_2 + OH^- \rightarrow CH_3CH(OH)_2 \rightarrow CH_3CHO + H_2O$

Gem diols like ($CH_3CH(OH)_2$ ) are generally not stable. The 2 -OH group attached to the same C removes $H_2O$ and forms carbonyl compounds.

4.

**(d)** All of these

**Explanation:**

All the statements are correct. Ethers can donate a pair of electrons due to the presence of lone pairs on the oxygen atom, allowing them to act as Lewis bases. Ethers can form coordinated complexes with Lewis acids because the oxygen atom can donate its lone pair to the Lewis acid, forming a bond. When diethyl ether reacts with cold HI, it undergoes cleavage to produce ethyl alcohol and ethyl iodide. Since all statements are accurate, the solution is correct.

5.

**(d)** molecularity of the reaction

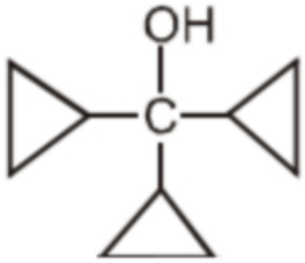
**Explanation:**

molecularity is the number of molecules that come together to react in an elementary (single-step) reaction and is equal to the sum of stoichiometric coefficients of reactants in the elementary reaction with effective collision (sufficient energy) and correct orientation.

6.

**(d)** (a) - (ii), (b) - (iii), (c) - (iv), (d) - (i)
**Explanation:**
(a) - (ii), (b) - (iii), (c) - (iv), (d) - (i)

7. **(a)**




**Explanation:**
The question focuses on the reactivity of different alcohols (or carbocations formed from them) in $S_N1$ reactions. The $S_N1$ mechanism depends heavily on the stability of the carbocation intermediate. Among the options, the one with the most stable carbocation intermediate will be the most reactive. Compound with two phenyl groups ($C_6H_5^-$) attached to the central carbon, can stabilize the carbocation by resonance (benzylic carbocation), making it much more reactive in $S_N1$ reactions than the others, which are either strained or less stabilized. Thus, compound will be the most reactive for an $S_N1$ reaction.

8.

**(b)** Glucose
**Explanation:**
Starch is a polymer of α-glucose.

9.

**(c)** $10^{-1}$
**Explanation:**
The activation energy (Ea) is given as $2.303RTJ\,\text{mol}^{-1}$. According to the Arrhenius equation, the rate constant $k$ is related to the activation energy and the Arrhenius factor (A) by the formula: $k = Ae^{-\frac{Ea}{RT}}$ To find the ratio of the rate constant $k$ to the Arrhenius factor $A$, we can rearrange the equation: $\frac{k}{A} = e^{-\frac{Ea}{RT}}$ Substituting the given activation energy into the equation: $\frac{k}{A} = e^{-\frac{2.303RTJ}{RT}} = e^{-2.303J}$ Since $e^{-2.303} \approx 0.1$, we find that: $\frac{k}{A} \approx 10^{-1}$ T.

10.

**(c)** $ClCH_2COOH$
**Explanation:**
The reaction sequence involves a nucleophilic substitution where a nucleophile reacts with an electrophile. In this case, the presence of a carboxylic acid group (–COOH) suggests that the compound Z must be able to undergo such a reaction. Option $ClCH_2COOH$ contains a chlorine atom that can be replaced by a nucleophile, making it a suitable candidate for the reaction. The other options either do not have a suitable leaving group or do not fit the expected structure after the reaction sequence.

11.

**(d)** Methane
**Explanation:**

$CH_3MgBr$ reacts with $CH_3OH$ and form $CH_4$.
Grignard Reagent act as both base as well as a nucleophile. In the presence of alcohol, $H_2O$ or other groups having acidic hydrogen Grignard reagent act as base and abstract acidic H.

12.
**(c)** sulphanilic acid
**Explanation:**
sulphanilic acid

13.
**(c)** A is true but R is false.
**Explanation:**

Conjugated proteins contain a prosthetic group because conjugated proteins on hydrolysis give in addition to $\alpha$-amino acids a non-protein part called the prosthetic group.

14.
**(c)** Assertion (A) is true, but Reason (R) is false.
**Explanation:**
C – Cl bond is more ionic than C – I bond because of the greater difference in the electronegativities of C and Cl as compared to that of carbon and iodine. Therefore, C – Cl bond is stronger than the C – I bond.

15. **(a)** Both A and R are true and R is the correct explanation of A.
**Explanation:**
Both A and R are true and R is the correct explanation of A.

16.
**(c)** A is true but R is false.
**Explanation:**

A mixture of conc. HCI+ anhyd. $ZnCl_2$ is called Lucas reagent.

## Section B

17. The cell reaction is Cd + $2H^+$ (0.2M) $\longrightarrow$ $Cd^{2+}$ (0.1M) + $H_2$ (0.5 atm)

$E^\circ_{cell} = 0 - (-0.403) = +0.403V$

$E_{cell} = 0.403 - \frac{2.303RT}{nF}\log\frac{[Cd^{2+}]\times P_{H_2}}{[Cd][H^+]^2}$

$= 0.403 - \frac{2.303\times 8.314\times 298}{2\times 96500}\log\frac{0.1\times 0.5}{(0.2)^2}$

$E_{cell}$ = 0.403 - 0.003 = 0.40 V

OR

$w = z \times i \times t$

$t = \frac{w}{z\times i}$

$t = \frac{1.078\times 1\times 96500}{107.8\times 2.5} = 386$ seconds

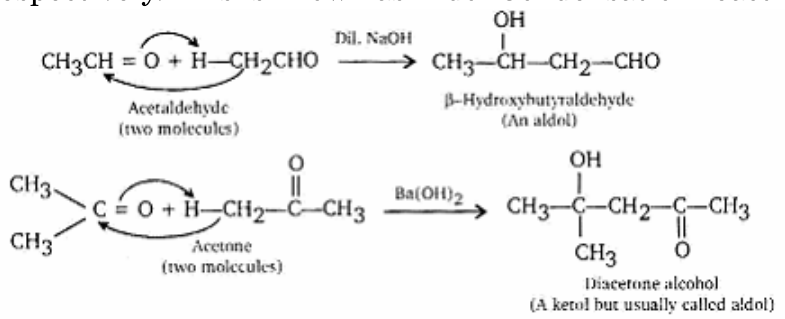
$Cu^{2+} + 2e^- \rightarrow Cu$

$w = \frac{63.5}{2\times 96500}\times 2.5 \times 38$

= 0.3175 gram

18. Reverse osmosis occurs i.e. net flow of the solvent is from solution to solvent. Here the solvent molecules from the solution side would move into pure solvent through semipermeable membrane.
19. $Mn_2O_7 < MnO_2 < MnO$

    Oxides with low oxidation state of metal have less charge density and thus oxides of these metal are basic in nature.
20. Answer the following:
    (a) The activation energy for combustion reactions of fuels is very high at room temperature, therefore, they do not burn by themselves at room temperature.
    (b) The drawback of collision theory is that it considers the molecules to be hard spheres and ignores their structural aspect.
21. Aldehydes and Ketones having at least one alpha-hydrogen undergo a reaction in the presence of dilute alkali as catalysts to form Beta-hydroxy aldehydes (aldol) or Beta-hydroxy ketones (ketol), respectively. This is known as Aldol Condensation reaction. Example is shown below:




**Section C**

22. Applying the formula

    $\Delta G^0 = -nE^0F$

    $\Delta G^0 = +960KJ = 960 \times 10^3 J$

    E° = ?

    F = 96500 $Cmol^{-1}$

    $\frac{4}{3}Al^{3+} + 4e^- = \frac{4}{3}Al$

    $\Delta G^0 = -nE^0F$

    $960 \times 10^3 J = -4 \times E^0 \times 96500$

    $E^0_{cell} = \frac{-960\times10^3}{4\times96500}$

    $E^0_{cell} = \frac{-9600}{3860}$

    = - 2.48 V

23. i. $Fe^{3+}$ -No. of unpaired electrons = 5

    $\mu = \sqrt{n(n+2)} = \sqrt{5(5+2)}$

    = 5.916 BM

    ii. Pentaamminechloridocobalt (III) chloride

    iii. $[Co(en)_3]^{3+}$, chelate effect / formation of cyclic structure.

24. The C-O-H bond angle in alcohol is slightly less than the tetrahedral angle (109.5°) because of larger repulsions between the lone pairs of electrons. As we know the order of repulsion is lp-lp > lp-bp > bp-bp that is why the bond pairs lying away from each other as a result the repulsion between them decreases so the bond angle also decreases. For example in methanol C-O-H bond angle is 108.9°. In ethers, the C-O-C bond angle is slightly greater than the tetrahedral angle. For example, in dimethyl ether, the C-O-C bond angle is 111.7°. The larger bond angle in ethers may be because of greater repulsions between bulkier alkyl groups as compared to one H in alcohol.
25. A, B and C are:

    A = Acetone

B = Acetone Phenylhydrazone
C = Idoform
Completed reactions are given below:

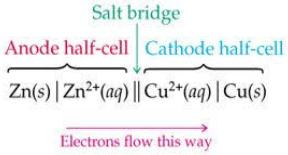
$$\underset{\text{Acetone}}{CH_3-\overset{O}{\overset{\|}{C}}-CH_3}\ +C_6H_5NHNH_2 \rightarrow \underset{'B'}{CH_3-\overset{CH_3}{\overset{|}{C}}=N-NH-C_6H_5}\ +H_2O$$

Acetone phenylhydrazone

$$\underset{\text{Acetone}}{CH_3-\overset{O}{\overset{\|}{C}}-CH_3}\ +3I_2+4NaOH \rightarrow \underset{'C'}{CHI_3}\ +CH_3COONa+3NaI+3H_2O$$

Iodoform

26. **Galvanic cell:** A galvanic cell is an electrochemical cell that converts the chemical energy of a spontaneous redox reaction into electrical energy. In this device, the Gibbs energy of the spontaneous redox reaction is converted into electrical work.
**Symbolic representation of a Daniell cell:**




27. i. 2-Methyl-1-propene to 2-chloro-2-methylpropane

$$\underset{2-Methyl-1-propene}{CH_3-\overset{CH_3}{\overset{|}{C}}=CH_2} \xrightarrow[Mark.Addition]{HCl} \underset{2-Chloro-2-methylpropane}{CH_3-\overset{CH_3}{\overset{|}{\underset{Cl}{\overset{|}{C}}}}-CH_3}$$

ii. Ethyl chloride to propanoic acid

$$\underset{Ethyl\ chloride}{CH_3CH_2Cl} \xrightarrow[\substack{(Nucleophilic\\ substitution)}]{KCN,EtOH-H_2O} \underset{\text{Pr}opanentrite}{CH_3CH_2CN} \xrightarrow[Hydrolysis]{H^+/H_2O} \underset{\text{Pr}opanoic\ acid}{CH_3CH_2COOH}$$

iii. But-1-ene to n-butyliodide

$$\underset{But-1-ene}{CH_3CH_2CH=CH_2} \xrightarrow[Anti-Mark\ Addition]{HBr/RCOOR} CH_3CH_2CH_2CH_2Br$$

$$\xrightarrow[Finkelstein\ reaction]{Nal.acetone} \underset{n-Butyliodide}{CH_3CH_2CH_2CH_2I}$$

28. $A+B \rightarrow C+D$
$Rate = k\,[A]^x$
Rate = 1 when [A] = 1 .....1)
Rate = 2 when [A] = 2 ..... 2)
Dividing equation 2) by 1)
$\frac{2}{1}\alpha\frac{(2)^x}{1^x}$
$2^1\alpha(2)^x$
$\therefore x = 1$
The reaction is first order reaction.

**Section D**

29. i. Phospholipids form a thin layer on the surface of an aqueous medium due to the simultaneous presence of both polar and non-polar groups in the molecule. As a result, the phospholipid molecules may arrange themselves in a double-layered membrane in aqueous media.
ii. Primary structure remain intact during the denaturation process.

iii. secondary structure

**OR**

Secondary structure refers as regular folding patterns of continuous portions of the polypeptide chain

30. i. $[Ni(H_2O)_6]Cl_2$, 6

ii. Pentaamminechloridocobalt(III)sulphate

iii. 1. $[Ni(CO)_4]$ - tetrahedral, diamagnetic

2. $[Fe(CN)_6]^{3-}$ - octahedral, paramagnetic

**OR**

1. Because $\Delta_t$ is not sufficient for the pairing of electrons/Crystal field splitting energy (CFSE) is not sufficient for pairing of electrons.
2. $NH_3$ being a strong field ligand can pair up the electrons to form $d^2sp^3$ but cannot pair up in $Ni^{2+}$ as two vacant d-orbitals are not available.

$\therefore$ $sp^3d^2$ is formed.

**Section E**

31. Attempt either A or B

(a) Answer the following questions:

i. Fusion of chromite ore ($FeCr_2O_4$) with sodium or potassium carbonate in free access of air to form sodium chromate

$4\ FeCr_2O_4 + 8\ Na_2CO_3 + 7\ O_2 \rightarrow 8\ Na_2CrO_4 + 2\ Fe_2O_3 + 8\ CO_2$

On acidification of Sodium chromate with sulphuric acid to form sodium dichromate

$2\ Na_2CrO_4 + 2\ H^+ \rightarrow Na_2Cr_2O_7 + 2\ Na^+ + H_2O$

ii. Due to comparable energies of 5f, 6d and 75 levels members of actinoid series exhibit a large number of oxidation states.

iii. i. When pyrolusite is fused with KOH in presence of air or oxidizing agent, potassium manganate is produced.

$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$

ii. Potassium manganate upon further oxidation or disproportionation in a neutral or acidic medium gives potassium permanganate.

$$3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O/$$

$$MnO_4^{2-} \xrightarrow[\text{alkaline solution}]{\text{Electrolytic oxidation in}} MnO_4^-$$

iv. (n - 1) $d^{1\text{-}10}ns^{1\text{-}2}$

v. The electronic configuration of chromium and zinc are respectively:

Cr(24) = [Ar] $3d^5 4s^2$

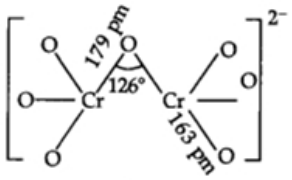
Zn(30) = [Ar]$3d^{10} 4s^2$

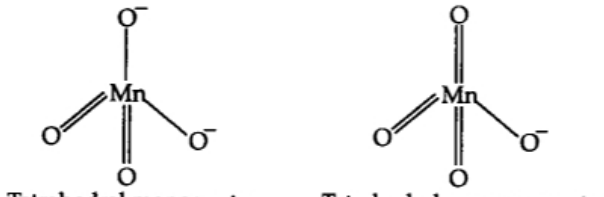
It is easy to remove electron from 4 $s^1$ -orbital (unpaired) rather than from $4s^2$ -orbital (paired). Therefore, first ionisation enthalpy of Cr is less than Zn.

(b) Answer the following questions:

i. a. $Mn^{3+}$ changes to $Mn^{2+}$ stable half-filled d5 configuration/much larger third ionization enthalpy of Mn whereas $Cr^{3+}$ and $Fe^{3+}$ have stable configuration.

b. $2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

ii. 


iii. 


Tetrahedral manganate ion (Green) Tetrahedral permanganate ion (Purple)

iv. Due to completely filled d-orbitals/ weak metallic bonding.

v. The chromates and dichromates are interconvertible in aqueous solution depending upon pH of the solution. The oxidation state of chromium in chromate and dichromate is the same.

$2\ CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$

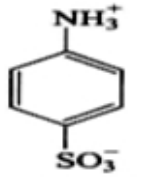
$Cr_2O_7^{2-} + 2\ OH^- \rightarrow 2\ CrO_4^{2-} + H_2O$

So, Clearly when a base is added to orange dichromate ion ($Cr_2O_7^{2-}$) its colour changes to yellow due to formation of chromate ( $CrO_4^{2-}$).

32. Attempt either A or B

(a) Answer the following questions:

i. $C_2H_5NH_2 < (C_2H_5)_2N < (C_2H_5)_3N$

ii. i. 


(Zwitter ion)

ii. Activating effect can be controlled by Protecting/deactivating -$NH_2$ group by acetylation or acylation.

iii. $CH_3 - CH_2 - CH_2 - NH_2$

iv. Benzenesulphonyl chloride (Hinsberg reagent) is used as a reagent to distinguish between primary, secondary and tertiary amines. However these days benzenesulphonyl chloride is replaced by p- toluenesulphonyl chloride.

v. $CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N$

(b) Answer the following questions:

i. 4-Aminobenzene sulphonic acid.

ii. N-Methylbenzenamine or N-Methylaniline (2°)

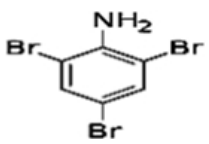
iii. $\overset{1}{H_2N} - \overset{2}{C}H_2 - \overset{3}{C}H_2 - \overset{4}{C}H = CH_2$

The IUPAC name is But-3-en-1-amine.

iv. Basic strength increases due to increase in electron density on nitrogen, which makes easy availability of lone pair of electrons.

v. a. N-Ethyl-N-methylaniline/N-Ethyl-N-Methylbenzenamine

b. A = $C_6H_5NH_2$

B = 

33. The given quantities are: $w_2$ = 2g; (Molar depression constant of benzene) $K_f$ = 4.9 K kg $mol^{-1}$; $w_1$ = 25 g

Depression in freezing point equal to

$\Delta T_f$ = 1.62 K

Substituting these values in equation (2.36) we get:

$M_1 = \frac{4.9 K kg mol^{-1} \times 2g \times 1000 g kg^{-1}}{25g \times 1.62K}$ = 241.98 g $mol^{-1}$

Thus, the experimental molar mass of benzoic acid in benzene is

= 241.98 g $mol^{-1}$

Now consider the following equilibrium for the acid:

$2C_6H_5COOH\} \rightleftharpoons (C_6H_5\{COOH)_2$

If x represents the degree of association of the solute then we would have (1 - x) mol of benzoic acid left in unassociated form and correspondingly $\frac{x}{2}$ as associated moles of benzoic acid at equilibrium. Therefore, the total number of moles of particles at equilibrium is:

1 - x + $\frac{x}{2} = 1 - \frac{x}{2}$

Thus, the total number of moles of particles at equilibrium equals van't Hoff factor i.

But i = $\frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$

= $\frac{122 g mol^{-1}}{241.98 g mol^{-1}}$

or $\frac{x}{2} = 1 - \frac{122}{241.98}$ = 1 - 0.504 = 0.496

or x = 2 $\times$ 0.496 = 0.992

Therefore, degree of association of benzoic acid in benzene is 99.2 %

OR

Mass of ethanol = 60 g

Molecular mass of ethanol ($C_2H_5OH$) = (12 $\times$ 2) + (1 $\times$ 5) + 16 + 1= 46

$\therefore$ Number of moles of ethanol $= \frac{60}{46} = 1.304$

Given mass of methanol = 40 g

Molecular mass of methanol ($CH_3OH$) = (12 $\times$ 1) + (1 $\times$ 3) + 16 + 1 = 32

$\therefore$ Number of moles of methanol $= \frac{40}{32} = 1.250$

Mole fraction of ethanol $= \frac{1.304}{1.304+1.250} = 0.51$

Mole fraction of methanol = 1 - 0.51 = 0.49

Vapour pressure of pure ethanol $p^{\circ}_{C_2H_3OH}$ = 44.5 mm

Vapour pressure of pure methanol $p^{\circ}{}_{CH_3OH} = 88.7$ mm

Vapour pressure due to ethanol

$p_{C_2H_3OH} = p^{\circ}_{C_2H_3OH} \times 0.51$

= 44.5 mm $\times$ 0.51 = 22.69 mm

Vapour pressure due to methanol,

$p_{CH_3OH} = p^{\circ}_{CH_3OH} \times 0.49$

= 88.7 mm $\times$ 0.49 = 43.46 mm

Total Vapour pressure

$= p_{C_2H_3OH} + p_{CH_3OH}$

= 22.69 + 43.46 = 66.15 mm

Mole fraction of methanol in the vapour state

$= \frac{p_{CH,OH}}{\text{Total vapour pressure}} = \frac{43.46}{66.15}$ = 0.657