Sample Question Paper 03

CHEMISTRY 12

Time : 3 Hrs. **Max. 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.

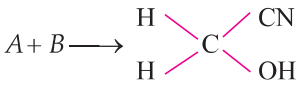
Section A

Question 1 to 16 are multiple choice questions. Only one of the choices is correct. Select and write the correct choice as well as the answer to these questions.

1. Even though starch and cellulose are both polymers of glucose, they differ in digestibility because

(a) cellulose has more glucose units
(b) starch contains α-glucose, cellulose contains β-glucose
(c) enzymes cannot act on polymers
(d) Both contain the same type of glycosidic bond

2. Consider the following reaction.



Identify A and B from the given options.

(a) $A =$ Acetone , $B =$ Methyl cyanide
(b) $A =$ Hydrogen cyanide, $B =$ Formaldehyde
(c) $A =$ Acetonitrile, $B =$ Ethanal
(d) $A =$ Methanol , $B =$ Methyl cyanide

3. Which of the following statement is true ?

(a) Molecularity of a reaction can be zero or a fraction.
(b) Molecularity has no meaning for complex reactions.
(c) Molecularity of a reaction is an experimental quantity.
(d) Reactions with molecularity three are very rare but are fast.

4. Which of the following alkyl halide is hydrolysed by S_N2 mechanism?

(a) $C_6H_5CH_2Br$
(b) CH_3Br
(c) $CH_2{=}CHCH_2Br$
(d) $(CH_3)_3CBr$

5. Out of *o*-chlorophenol, *o*-bromophenol, *o*-iodophenol and *o*-fluorophenol, which is most acidic ?

(a) *o*-bromophenol
(b) *o*-chlorophenol
(c) *o*-iodophenol
(d) *o*-fluorophenol

Stage II : Proficiency Level

6. Which of the following characteristics of the transition metals is associated with their catalytic activity?

(a) Paramagnetic nature
(b) Colour of hydrated ions
(c) High enthalpy of atomisation
(d) Variable oxidation states

7. The vapour pressure of water at 300 K in a closed container is 0.4 atm. If the volume of container is doubled, its vapour pressure at 300 K will be

(a) 0.2 atm
(b) 0.8 atm
(c) 0.4 atm
(d) 0.6 atm

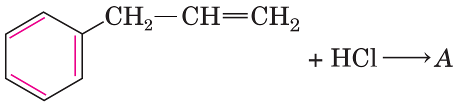
8. Match the magnetic moment with the ions of 3*d*-series.

(i) Cr^{3+}	(p) 5.92 BM
(ii) Mn^{2+}	(q) 3.87 BM
(iii) Fe^{2+}	(r) 4.90 BM
(iv) Sc^{3+}	(s) Zero

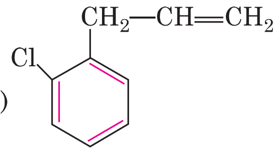
Select the correct option.

(a) (i)-(r), (ii)-(q), (iii)-(p), (iv)-(s)
(b) (i)-(r), (ii)-(s), (iii)-(p), (iv)-(q)
(c) (i)-(q), (ii)-(p), (iii)-(r), (iv)-(s)
(d) (i)-(s), (ii)-(r), (iii)-(p), (iv)-(q)

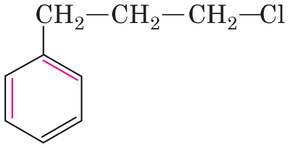
9. What is '*A*' in the following reaction?



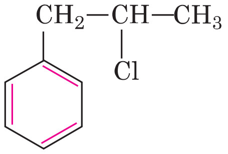
(a)



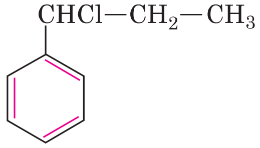
(b)



(c)



(d)



10. An electrolytic cell contains alumina. If we have to obtain 50 g Al by using 105 A of current, the time required is

(a) 1.54 h
(b) 2.15 h
(c) 1.42 h
(d) 1.32 h

11. Which among the following compounds will give a secondary alcohol on reaction with Grignard reagent followed by acid hydrolysis?

(i) HCHO
(ii) C_2H_5CHO
(iii) CH_3COCH_3
(iv) $HCOOCH_3$

Select the correct option.

(a) Only (i) and (iii)
(b) Only (ii) and (iv)
(c) Only (i) and (ii)
(d) Only (iii) and (iv)

12. Lanthanoids form complex with which of the following ligand?

(a) F^-
(b) Br^-
(c) Cl^-
(d) I^-

Direction *For questions number 13 to 16, two statements are given — one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:*

(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.

13. Assertion (A) Acetaldehyde on reaction with dilute NaOH forms an aldol.

Reason (R) Aldehydes and ketones with α-hydrogen undergo aldol reaction due to enolate ion formation.

14. Assertion (A) Galvanised iron does not rust.

Reason (R) Zinc has a more negative electrode potential than iron.

15. Assertion (A) Phenols give *o*- and *p*-nitrophenol on nitration with conc. HNO_3 and H_2SO_4 mixture.

Reason (R) —OH group in phenol is *o*- and *p*-directing.

16. Assertion (A) Vitamins A, D, E and K are stored in liver and adipose tissues.

Reason (R) These vitamins are soluble in water.

Section B

Question No. 17 to 21 are very short answer questions carrying 2 marks each.

17. (a) What is the relationship between osmotic pressure at 273 K, when 10 g of glucose (p_1), 10 g of urea (p_2) and 10 g of sucrose (p_3) are dissolved in 250 mL of water?

(b) A solution containing 4 g of polyvinyl chloride in 1L of dioxane was found to have an osmotic pressure of 6×10^{-4} atm at 300 K. Then, what will be the molar mass of polymer polyvinyl chloride?

18. Attempt either A or B

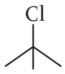
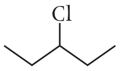
A. Give reason for the following.

(a) *t*-butyl bromide is more reactive towards S_N1 reaction as compared to *n*-butyl bromide.

(b) CH_3CH_2I undergoes S_N2 reaction faster than CH_3CH_2Br.

Or

B. (a) A hydrocarbon C_5H_{12} gives only one monochlorination product. Identify the hydrocarbon.

(b) Out of  and  which one undergoes faster reaction towards S_N1 mechanism?

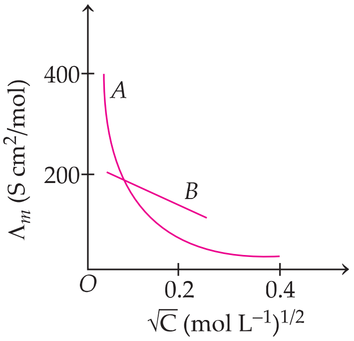
19. (a) Explain why cyclohexanone form cyanohydrin in good yield but 2,2,6-trimethyl cyclohexanone does not.

(b) How will you obtain tertiary butyl alcohol from acetone?

20. (a) Write the outer shell electronic configuration of an element with atomic number 24. Why is this different from the elements that are adjacent to it in the periodic table?

(b) Why is Hg not considered as a transition element?

21. Consider the graph for the reaction,



(a) Which type of electrolytes are used in *A* and *B*?

(b) What happens to molar conductivity (Λ_m) as concentration decreases, and what is its value at infinite dilution called?

Section C

Question No. 22 to 28 are short answer questions, carrying 3 marks each.

22. Answer the following questions.

(a) What is the role of complex compounds in qualitative inorganic analysis? Explain with an example.

(b) Explain why are low spin tetrahedral complexes not formed?

(c) How many geometrical isomers can the tetrahedral complex $[Ni(CO)_4]$ have?

23. (a) Explain strong and weak electrolytes with examples.

(b) Calculate the emf of the cell.

$$Mg(s)|Mg^{2+}(0.1M)||Cu^{2+}(1\times10^{-1}M)|Cu(s)$$

Given : $E^\circ_{Cu^{2+}/Cu} = 0.34V$; $E^\circ_{Mg^{2+}/Mg} = -2.37V$

(c) Arrange the following metals in the order in which they displace each other from the solution of their salts Al, Cu, Fe, Mg and Zn.

24. Write the chemical reaction for the following.

(a) When ethanal is treated with ethyl magnesium bromide followed by hydrolysis.

(b) Phenol is treated with conc. H_2SO_4 and conc. HNO_3.

(c) Phenol kept open in the air.

25. An organic compound $A\,(C_4H_6O_3)$ on treatment with ethyl alcohol gives a carboxylic acid B and compound C. Hydrolysis of C under acidified conditions gives B and D.

Identify A, B, C and D and write all the involved equations.

26. Carry out following conversions. **(Attempt any 3)**

(a) Glucose to gluconic acid

(b) Glucose to *n*-hexane

(c) Glucose to glucose pentaacetate

(d) Glucose to 3-hydroxypropanenitrile

27. In a galvanic cell when the potential difference becomes zero, the cell is said to be in an equilibrium state.

Establish the relation between E° and equilibrium constant at 298 K in a Daniell cell. The E° value of the Daniell cell is 1.10 V.

($R = 8.314$ J/K/mol, $F = 96500$ C)

28. A first order reaction is 20% complete in 10 minutes. Find the time required for 75% completion of the reaction.

Section D

Question No. 29 & 30 are case-based/data-based questions carrying 4 marks each.

29. Coordination Complexes

Complex compounds play an important role in our daily life. These compounds contain central metal and ligands. Ligands can be negatively charged or neutral molecules. Ligands can be differentiated on the basis of the number of donor sites which is simply called as **denticity**. It can be monodentate, didentate, polydentate, ambidentate ligands.

Polydentate ligands are more stable than monodentate ligands.

Complex compounds are named according the IUPAC system. Many approaches have been put forth to explain the nature of bonding in complex compounds. These are **Valence Bond Theory (VBT)**, **Crystal Field Theory (CFT)**, ligand field theory (LFT) and **Molecular Orbital Theory (MOT)**.

Based on the information provided above, answer the following questions.

(a) (i) What is the oxidation state of Cu in $[Cu(NH_3)_4Cl_2]$?

(ii) What is the IUPAC name of the complex $[Ni(NH_3)_6]Cl_2$?

(b) $[Co(CN)_6]^{3-}$ forms low spin complex. Why?

(c) What is the magnetic property and number of unpaired electron in complex $[Co(NH_3)_6]^{3+}$?

Or

What is the hybridisation and geometry of $[Co(NH_3)_6]^{3+}$ complex?

30. Conductivity of Electrolytic Solution

The study of conductivity of electrolytic solution is important for the development of electrochemical devices, for the characterisation of the dissociation equilibrium of weak electrolytes. Typically the conductivity of electrolyte solution is measured for electrolytic solution with concentration in the range of 10^{-3} to 10^{-1} mol L^{-1}.

The molar conductivity of strong electrolyte solution can be given by Kohlrausch's law equation,

$$\Lambda_m = \Lambda_m^{\circ} - \kappa\sqrt{C}.$$

The table given below information about electrical conductivity of strong and weak electrolyte.

Property	Strong electrolyte	Weak electrolyte
Dissociation	Complete	Partial
Conductivity *vs* dilution	Decrease slightly	Increases significantly
Molar conductivity (Λ_m) trend	Linear decrease with $\sqrt{C}$	Sharp increase with dilution

Based on the information provided above, answer the following questions.

(a) Why does the conductivity of a solution decreases with dilution ?

(b) Which of the following pair is an example of strong and weak electrolyte?

(i) KCl and CH_3COOH

(ii) NH_4OH and NaOH

(iii) H_2CO_3 and KCl

(iv) CH_3COOH and HCl

(c) Draw a graph Λ_m *versus* $C^{1/2}$ for strong and weak electrolytes.

Or

X and *Y* are two electrolytes. On dilution molar conductivity of '*X*' increases 2.5 times, while that of *Y* increases 25 times. Which of the two is a weak electrolyte? Explain briefly.

Section E

Question No. 31 to 33 are long answer type questions carrying 5 marks each.

31. Attempt either A or B

A. Answer the following.

(a) Why is the highest oxidation state is exhibited in oxo-anions of transition metals?

(b) Why the transition elements show high melting points?

(c) Why first ionisation enthalpy of Cr is lower than that of Zn?

(d) Explain the observation, although Cr^{3+} and Co^{2+} ions have same number of unpaired electrons but the magnetic moment of Cr^{3+} is 3.87 BM and that of Co^{2+} is 4.87 BM.

(e) What are the misch metals?

Or

B. (a) What happens when $KMnO_4$ reacts with nitrite ion?

(b) What happens when a lanthanoid reacts with water?

(c) Why are alloys mostly prepared from transition metals?

(d) Write the ionic equation for reaction of KI with acidified $KMnO_4$.

(e) Why do Zn^{2+}, Cd^{2+} and Hg^{2+} ions do not show colour in aqueous solution?

32. Attempt either A or B

A. (a) When 2 g of benzoic acid is dissolved in 25 g benzene, it shows a depression in freezing point equal to 1.62 K. Molal depression constant (K_f) of benzene is 4.9 K kg mol^{-1} and molecular weight of benzoic acid $= 122$ g/mol. What will be the percentage association of the benzoic acid ?

(Benzoic acid forms dimer when dissolved in benzene).

(b) At 27°C, 25 mg of K_2SO_4 was dissolved in 2 L solution. Find out its osmotic pressure. Taking into consideration that K_2SO_4 has dissociated completely.
$(R = 0.082 \text{ L atm K}^{-1} \text{ mol}^{-1})$

Or

B. (a) What do you understand by elevation of boiling point? How it is related to molality?

(b) Heptane and octane form an ideal solution. At 373 K, the vapour pressure of the two liquid components are 105.2 kPa and 46.8 kPa respectively. What will be the vapour pressure of a mixture of 26.0 g of heptane and 35 g of octane ?

33. Attempt either A or B

A. (a) Write structures of different isomers corresponding to the molecular formula, C_3H_9N.

(b) Write IUPAC names of the isomers which will liberate nitrogen gas on treatment with nitrous acid.

Or

B. (a) Krishna took three amines *U*, *V* and *W*. The three amines were added to Hinsberg's reagent. The products were added to *aq*. NaOH and the observations were tabulated as follows

Amines	**Observations after the addition of the products formed to *aq*. NaOH solutions**
U	The product is soluble in *aq*. NaOH
V	The product is insoluble in *aq*. NaOH
W	The product is insoluble in *aq*. NaOH

(i) Which of the amine(s) have the structural formula of $R—NH—R$?

(ii) What does the solubility of the products formed in *aq*. alkali imply?

(iii) Which of the following amines may be prepared by the Gabriel phthalimide process? Give a reason.

(b) How will the following be converted?
(Give chemical equations)

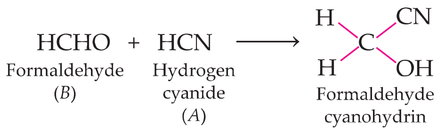
(i) Ethyl bromide to ethyl isocyanide.

(ii) Aniline to benzene diazonium chloride.

Solutions

1. (b) The difference in the type of glucose (α or β) leads to different glycosidic linkages $\alpha(1\rightarrow 4)$ in starch and $\beta(1\rightarrow 4)$ in cellulose. Human digestive enzymes like amylase can break α-glycosidic bonds in starch but cannot hydrolyse β-glycosidic bonds in cellulose, making starch digestible while cellulose passes undigested.

2. (b)



3. (b) Statement (b) is true and the correct form of other given statements are

Statement (a) Molecularity of a reaction is always a whole number.

Statement (c) Molecularity is a theoretical concept.

Statement (d) Reactions with molecularity three are very rare as probability of formation of product is low.

4. (b) S_N2 mechanism involves the back side attack and formation of a transition state. Thus, less hindered alkyl halide readily undergoes S_N2 mechanism. Among the given haloalkanes, CH_3Br (methyl bromide) is less hindered, and hence, gets hydrolysed by S_N2 mechanism.

5. (b) *o*-chlorophenol will be most acidic. Here, *o*-fluorophenol is weakest acid due to strong intramolecular H-bonding. The acidity of other halophenol decreases as the –*I*-effect of halogen decreases.

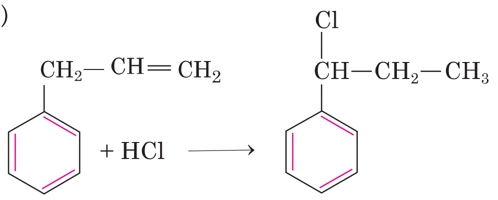
6. (d) Due to the presence of variable oxidation states transition metals have catalytic properties.

7. (c) As the volume of the container is doubled, the pressure due to the remaining gases remain constant. Therefore, the total pressure inside the container also remains constant.

8. (c) The number of unpaired electrons in Cr^{3+}, Mn^{2+}, Fe^{2+} and Sc^{3+} are 3, 5, 4 and 0 respectively. By using formula for magnetic moment, i.e. $\mu = \sqrt{n(n+2)}$ where, n is number of unpaired electrons, the magnetic moment of Cr^{3+}, Mn^{2+}, Fe^{2+} and Sc^{3+} comes out to be 3.87 BM, 5.92 BM, 4.90 BM and 0 respectively.

Thus the correct match is (i)-(q); (ii)-(p); (iii)-(r); (iv)-(s).

9. (d)



(A)

It is an addition reaction and addition occurs according to Markovnikov's rule.

Here, the benzylic carbocation is stabilised by resonance with the benzene ring, favouring this pathway as a result of carbocation rearrangement.

> **Value Point**
> According to Markovnikov's rule, in electrophilic addition, H^+ adds to the carbon with more H atoms, forming the more stable carbocation.

10. (c) $Al^{3+} + 3e^- \longrightarrow Al$

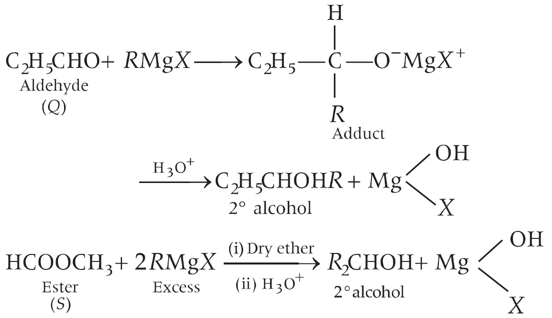
Equivalent weight of Al $= \frac{27}{3} = 9$

From Faraday's first law, $w = Zit = \frac{E}{96500}it$

$$\therefore \quad t = \frac{50\times 96500}{9\times 105} = 5105.82\ s = 1.42\ h$$

11. (b) Secondary alcohols can be prepared by reacting Grignard reagent with aldehydes (except, formaldehyde) and methyl formate.

The steps involved in the process are as follows



$$\underset{\substack{\text{Aldehyde}\\(Q)}}{C_2H_5CHO} + RMgX \longrightarrow \underset{\text{Adduct}}{C_2H_5-\overset{\overset{\Large H}{|}}{\underset{\underset{\Large R}{|}}{C}}-O^-MgX^+}$$

$$\xrightarrow{H_3O^+} \underset{2°\ \text{alcohol}}{C_2H_5CHOHR} + Mg\begin{matrix}OH\\X\end{matrix}$$

$$\underset{\substack{\text{Ester}\\(S)}}{HCOOCH_3} + \underset{\text{Excess}}{2RMgX} \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) Dry ether}} \underset{2°\text{alcohol}}{R_2CHOH} + Mg\begin{matrix}OH\\X\end{matrix}$$

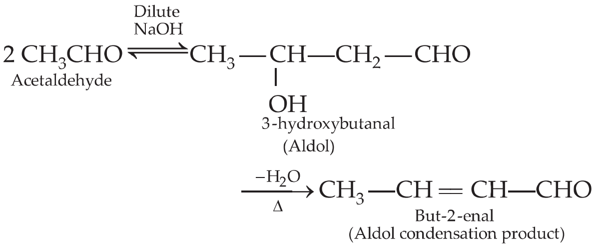
Hence, (b) is the correct option.

12. (a) F^- have small size and high electronegativity thus, it forms complex with lanthanoids easily.

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

Acetaldehyde have 3 α- hydrogen atoms, so it can easily undergo aldol condensation reaction.

In aldol reaction, enolate ion formed from α-hydrogen of aldehyde/ketone attacks another molecule's carbonyl group, forming β -hydroxy product (aldol). Further dehydration gives aldol condensation.



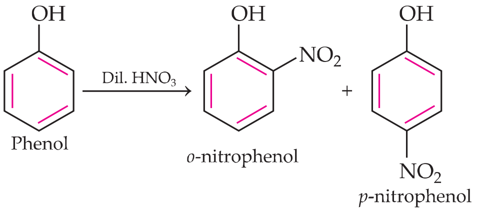
$$\underset{\text{Acetaldehyde}}{2\,CH_3CHO} \overset{\substack{\text{Dilute}\\\text{NaOH}}}{\rightleftharpoons} \underset{\substack{\text{3-hydroxybutanal}\\\text{(Aldol)}}}{CH_3-\underset{\underset{\Large OH}{|}}{CH}-CH_2-CHO}$$

$$\xrightarrow[\Delta]{-H_2O} \underset{\substack{\text{But-2-enal}\\\text{(Aldol condensation product)}}}{CH_3-CH=CH-CHO}$$

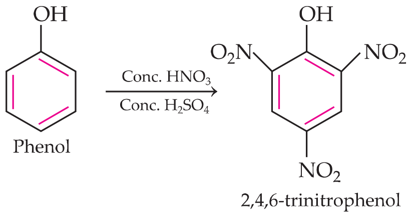
14. (a) Zinc, being more reactive (more negative $E°$), oxidises preferentially and protects iron by sacrificial corrosion, preventing rusting even if the zinc coating is scratched. Thus, Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of Assertion (A).

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

Phenols give *o*- and *p*-nitrophenol on nitration with dil. HNO_3 at 298 K.



When phenol reacts with conc. HNO_3 and H_2SO_4 mixture it gives 2, 4, 6-trinitrophenol.



16. (c) Assertion (A) is true, but Reason (R) is false. The correct form of (R) is as follows

Vitamins A, D, E and K are soluble in fats and oils but insoluble in water.

17. (a) Greater is the molar concentration of solution, more is the osmotic pressure. Also, lesser the molecular weight, more is the osmotic pressure.

$$\pi \propto C;\ \pi \propto \frac{n}{V};\ \pi \propto \frac{1}{M}$$

$\therefore\ p_2$ (urea) $> p_1$ (glucose) $> p_3$ (sucrose) (1)

(b) Given, $w_B = 4\text{ g},\ V = 1\text{ L}$

$$T = 300\text{ K},\ \pi = 6 \times 10^{-4}\text{ atm}$$

We know, $\pi V = \dfrac{w_B}{M_B} RT$

$$6 \times 10^{-4} \times 1 = \frac{4}{M_B} \times 0.082 \times 300$$

$\therefore\ M_B = 1.6 \times 10^5$ g/mol (1)

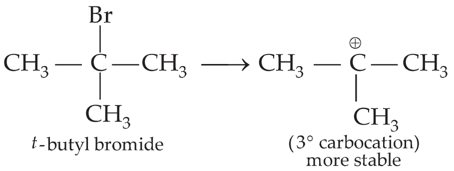
18. A. (a) In S_N1 reaction, reactivity depends upon the stability of carbocation intermediate formed. Let us consider the formation of carbocation of the two given alkyl halides.

$CH_3-CH_2-CH_2-CH_2-Br \longrightarrow$

n-butyl bromide

$CH_3-CH_2-CH_2-\overset{\oplus}{C}H_2$

(1° carbocation) less stable



$$CH_3-\underset{CH_3}{\overset{Br}{C}}-CH_3 \longrightarrow CH_3-\underset{CH_3}{\overset{\oplus}{C}}-CH_3$$

t-butyl bromide (3° carbocation) more stable

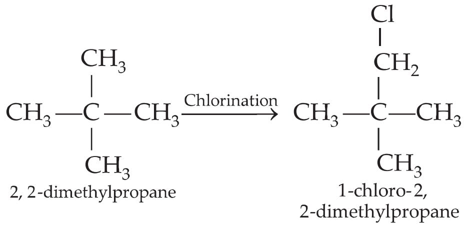
Carbocation formed by *tert*-butyl bromide being tertiary is more stable than *n*-butyl bromide which is primary and hence, *t*-butyl bromide undergoes S_N1 reaction faster. (1)

(b) As I^- ion is a better leaving group than Br^- ion, therefore iodides are more reactive than bromides.

Therefore, CH_3-CH_2-I is more reactive than CH_3-CH_2-Br towards S_N2 reaction and thereby, CH_3-CH_2-I would undergo S_N2 reaction faster than CH_3-CH_2-Br. (1)

Or

B. (a) Hydrocarbon, C_5H_{12} which gives only one monochlorination product is 2, 2-dimethylpropane.

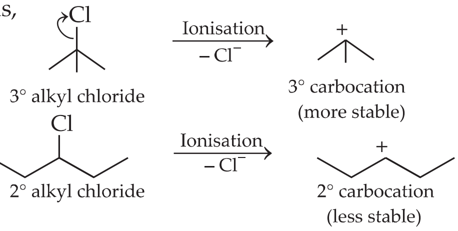


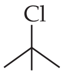
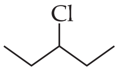
$$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-CH_3 \xrightarrow{\text{Chlorination}} CH_3-\underset{CH_3}{\overset{\overset{Cl}{CH_2}}{C}}-CH_3$$

2, 2-dimethylpropane 1-chloro-2, 2-dimethylpropane (1)

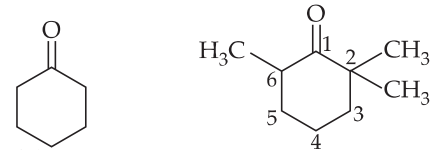
(b) The reactivity towards S_N1 reaction depends upon the stability of the intermediate carbocation which an alkyl halide gives on ionisation.

Thus,

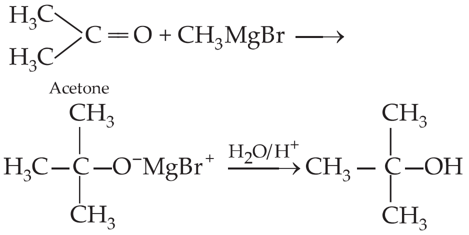


As 3° carbocations are more stable than 2° carbocations, therefore,  will react faster than  through S_N1 reaction. (1)

19. (a) In 2,2,6-trimethyl cyclohexanone, three methyl groups are present at α-position with respect to the ketonic ($>C{=}O$) group. Therefore, these groups cause steric hindrance during the nucleophilic attack of CN^- ion and cyanohydrin is not formed. However, due to the absence of methyl groups in cyclohexanone, there is no steric hindrance and cyanohydrin is formed. (1)



Cyclohexanone 2,2,6-trimethyl cyclohexanone

(b)


Acetone

tert-butyl alcohol

$$(CH_3)_2C{=}O + CH_3MgBr \longrightarrow H_3C-\overset{CH_3}{\underset{CH_3}{C}}-O^-MgBr^+ \xrightarrow{H_2O/H^+} CH_3-\overset{CH_3}{\underset{CH_3}{C}}-OH$$

(1)

20. (a) The element with atomic number 24. Cr, has outer shell electronic configuration $4s^1 3d^5$.

Chromium has an anomalous configuration due to extra stability associated with half-filled orbitals. Instead of the expected $[Ar]\,3d^4 4s^2$, one electron from the 4*s* orbital is promoted to the 3*d* orbital to achieve a half-filled 3*d* subshell, which provides additional exchange energy and symmetry. Final configuration of $Cr = [Ar]3d^5 4s^1$. (1)

(b) Hg has completely filled *d* orbitals $(3d^{10})$ in its ground state as well as in its oxidised state, hence, it is not regarded as a transition element. (1)

Value Point

To obtain maximum marks, one should know that IUPAC defines transition elements are the elements having a partially filled *d*-subshell or an elements that has the ability to form stable cations with an incompletely filled *d*-orbital.

21. (a) In the given graph, '*A*' represents weak electrolyte like CH_3COOH as Λ_m increases steeply on dilution at low concentration region and '*B*' represents strong electrolyte like as Λ_m slowly with dilution. (1)

(b) Molar conductivity increases with dilution and is called limiting molar conductivity (Λ_m°) at infinite dilution. (1)

22. (a) In qualitative inorganic analysis, complex compounds help in identifying specific metal ions by forming coloured or soluble complexes. These complexes often prevent precipitation or enhance selectivity during group separation.

e.g. In Group III analysis, $NH_4OH + NH_4Cl$ provides a weakly basic medium. Here, Al^{3+} forms a soluble complex $[Al(NH_3)_6]^{3+}$, preventing its precipitation as $Al(OH)_3$, while Fe^{3+} and Cr^{3+} still precipitate as hydroxides. (1)

(b) For tetrahedral complexes, the crystal field stabilisation energy is lower than pairing energy, so they are not formed in low spin state. (1)

(c) The relative positions of the unidentate ligands linked to the central metal atom are identical. Thus, no geometrical isomers will form for the specified coordination complex. (1)

23. (a) **Strong electrolytes** These electrolytes completely dissociate into ions at all concentrations. e.g. NaOH, NaCl, KCl etc.

Weak electrolytes The electrolytes which do not ionise completely in aqueous as well as in molten state are called weak electrolytes. e.g. H_2CO_3, $HgCl_2$, CH_3COOH etc. (1)

(b) For the given cell,half-cell reactions are

At anode $Mg(s) \longrightarrow Mg^{2+}(aq) + 2e^-$

At cathode $Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$

As we know,

$$E_{cell} = E^\circ_{cell} - \frac{2.303\,RT}{nF}\log\frac{[Mg^{2+}]}{[Cu^{2+}]}$$

$$\therefore\ E_{cell} = [E^\circ_{Cu^{2+}/Cu} - E^\circ_{Mg^{2+}/Mg}] - \frac{2.303 \times R \times T}{2 \times 96500}\log\frac{[0.1]}{[0.1]}$$

$$= 0.34 - (-2.37) - 0 \qquad (\because \log 1 = 0)$$

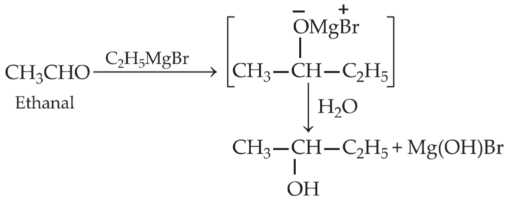
$$\therefore\ E_{cell} = 2.71\ \text{V}$$ (1)

Mistake Alert

Don't make mistake by choosing the wrong anode or cathode of the cell while calculating standard electrode potential will make the answer incorrect.

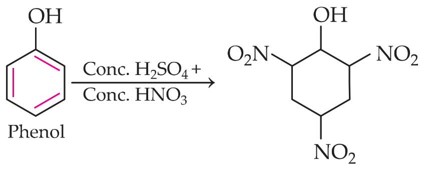
(c) The order in which the given metals displace each other from the solutions of their salts is Mg, Al, Zn, Fe, Cu. (1)

24. (a) When ethanal is treated with ethyl magnesium bromide, then unstable compound is formed which further on hydrolysis, gives final product, i.e. butan-2-ol.



(1)

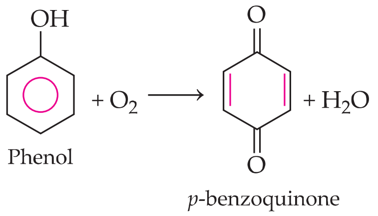
(b) When phenol is treated with conc. H_2SO_4 and conc. HNO_3, the nitration of phenol takes place and 2, 4, 6-trinitrophenol is obtained.



Picric acid
(2, 4, 6-trinitrophenol)

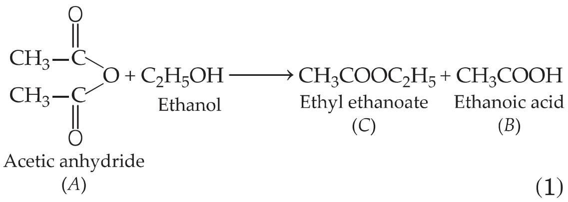
(1)

(c) Phenol gets slowly oxidised to a pink coloured compound *p*-benzoquinone when exposed to air.



(1)

25.



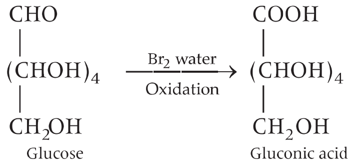
(1)

$$\underset{\substack{\text{Ethyl ethanoate}\\(C)}}{CH_3COOC_2H_5} + H_2O \xrightarrow{H^+} \underset{\substack{\text{Ethanoic acid}\\(B)}}{CH_3COOH} + \underset{\substack{\text{Ethanol}\\(D)}}{CH_3CH_2OH}$$ (1)

Thus, $A = (CH_3CO)_2O$, $B = CH_3COOH$,

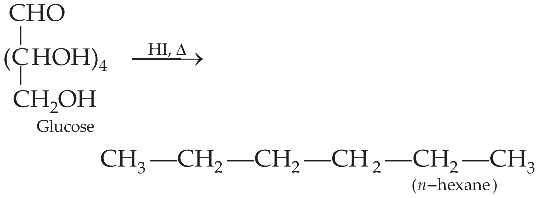
$C = CH_3COOC_2H_5$, $D = CH_3CH_2OH$ (1)

26. (a) Glucose on reaction with bromine water, gets oxidised to form six carbon carboxylic acid, i.e. gluconic acid.

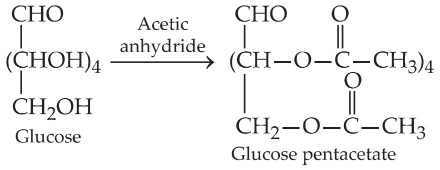


(1)

(b) On prolonged heating with HI, it forms *n*-hexane, suggesting that all the six carbon atoms are linked in a straight chain.

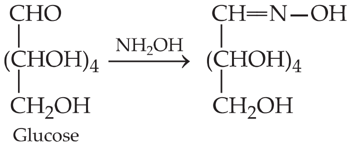


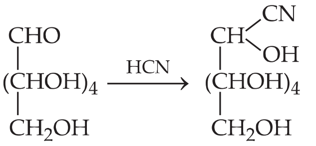
(c) Acetylation of glucose with acetic anhydride gives glucose pentaacetate which confirms the presence of five —OH groups. Since it exists as a stable compound, five —OH groups should be attached to different carbon atoms.



(1)

(d) Glucose reacts with hydroxylamine to form an oxime and adds a molecule of hydrogen cyanide to give cyanohydrin. These reactions confirm the presence of a carbonyl group ($>C=O$) in glucose.





3-hydroxypropanenitrile

(1)

27. Nernst equation (Daniell cell)

$$E^\circ_{\text{cell}} = E^\circ_{\text{cell}} - \frac{2.303\,RT}{nF}\log\frac{[Zn(aq)]^{2+}}{[Cu(aq)]^{2+}}$$

where, $R = 8.314\,\text{J/K/mol}$, $F = 96500\,\text{C mol}^{-1}$,

$T = 298\,\text{K}$

On substituting value

$$E_{\text{cell}} = E^\circ{}_{\text{cell}} - \frac{0.059}{n}\log\frac{[Zn^{2+}]}{[Cu^{2+}]}$$

At equilibrium,

$E_{\text{cell}} = 0$ and $[Zn^{2+}/Cu^{2+}] = \log K_C$

Then, $E^\circ{}_{\text{cell}} = (0.059/n)\times\log K_C$

For Daniell cell

$\Rightarrow$ $E^\circ_{\text{cell}} = 1.10\,\text{V}, n = 2$

So, $1.10 = \left(\frac{0.059}{2}\right)\times\log K_C$

$\Rightarrow$ $\log K_C = 2.20/0.059$

$\Rightarrow$ $\log K_C = 37.28$ (3)

28. For the first order reaction,

$$k = \frac{2.303}{t}\log\frac{a}{a-x} = \frac{2.303}{10}\log\frac{100}{80}$$

$$k = \frac{2.303}{10}\log\frac{10}{8} \qquad \ldots\text{(i)}$$

Also, $$t = \frac{2.303}{k}\log\frac{a}{a-x} \qquad \ldots\text{(ii)}$$

(1)

By substituting value of *k* from Eq. (i) in Eq. (ii),

$$t_{75\%} = \frac{2.303}{\frac{2.303}{10}\log\frac{10}{8}}\times\log\frac{100}{25}$$

$$= \frac{10}{\log 10 - \log 8}\times\log 4 = \frac{10}{1-\log 2^3}\times\log 2^2$$

$$= \frac{10}{1-(3\times 0.3010)}\times 2\times 0.3010$$

$$= \frac{10}{0.097}\times 0.6020 = 62\text{ mins}$$ (2)

29. (a) (i) Let the oxidation state of Cu in $[Cu(NH_3)_4Cl_2]$ be x.

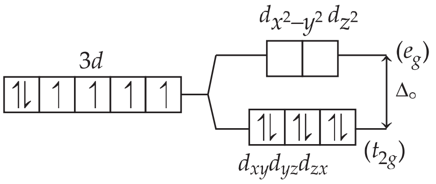
$\Rightarrow$ $x + 0\times 4 + (-1\times 2) = 0 \Rightarrow x = +2$

Thus, oxidation state of Cu is + 2. (1)

(ii) IUPAC name of the complex $[Ni(NH_3)_6]Cl_2$ is hexaamminenickel (II) chloride. (1)

(b) In the complex $[Co(CN)_6]^{3-}$, Co is in +3 oxidation state. The electronic configuration of Co^{3+} is $[Ar]3d^6$.

The splitting of *d*-orbitals into two sets of orbitals in the given complex is represented as



Since, CN^- is a strong field ligand and therefore pairing of electrons takes places giving rise to low spin complex. (1)

(c) In the complex $[Co(NH_3)_6]^{3+}$, the oxidation state of Co is +3. It has the electronic configuration as $[Ar]3d^6$. NH_3 ligand in this case behave as a strong field ligand. So, it causes pairing of electrons in 3*d*-orbital.

As a result, there are no unpaired electrons present in the complex. So, the complex is diamagnetic in nature. (1)

Or

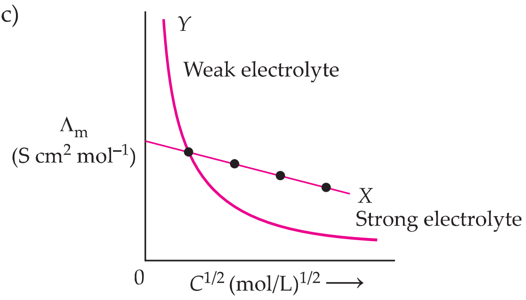
In, $[Co(NH_3)_6]^{3+}$, Co is in +3 oxidation state. Its electronic configuration is $[Ar]3d^6$. NH_3 is a strong field ligand, which causes pairing of electrons in 3*d* orbitals.

So, this complex involves d^2sp^3-hybridisation. The complex has octahedral geometry. (1)

30. (a) Conductivity of an electrolytic solution decreases with dilution because the number of ions per unit volume furnished by an electrolyte decreases with dilution. (1)

(b) (i) KCl is a strong electrolyte as it completely dissociates into its ions in aqueous solution and CH_3COOH is a weak electrolyte as it partially dissociates into its ions in aqueous solution. In rest of the options initially weak electrolyte is given followed by strong electrolyte. So, these options are incorrect. (1)

(c)



(2)

Or

Y is a weak electrolyte. On dilution, complete dissociation of weak electrolyte occurs and thus, there is a steep increase in molar conductivity.

However, in case of strong electrolyte, it is already dissociated completely and therefore on dilution, the rise in conductivity is not very much. (2)

31. A. (a) The ability of oxygen to form multiple bonds with transition metals is responsible for the high oxidation state of transition metal in oxoanions. (1)

(b) Due to involvement of greater number of electrons in the interatomic bonding from $(n-1)$ *d*-orbitals in addition to *ns*-electrons.

Thus, transition elements have large number of unpaired electron which are responsible for high strength of metallic bond and hence high melting point. (1)

(c) First, ionisation enthalpy of Cr is less than that of Zn because Cr^+ has stable d^5 configuration. In case of zinc, electron comes out from completely filled 4*s*-orbital.

So, removal of electron from zinc requires more energy as compared to the chromium. (1)

(d) Magnetic moment of any metal ion can be decided on the basis of spin as well as orbital contribution of electron. Due to symmetrical electronic configuration, there is no orbital contribution in Cr^{3+} ion.

However, appreciable orbital contribution takes place in Co^{2+} ion. (1)

(e) Misch metal is an alloy which consists of a lanthanoid metal (~ 95%), iron (upto 5%) and traces of S, C, Ca and Al. It is used in Mg based alloy to produce bullets, shell and lighter-flint. (1)

Or

B. (a) $2MnO_4^- + \underset{\text{Nitrite ion}}{5NO_2^-} + 6H^+ \longrightarrow 2Mn^{2+} + \underset{\text{Nitrate ion}}{5NO_3^-} + 3H_2O$ (1)

(b) When a lanthanoid reacts with water, it forms hydroxide.

$$Ln + 3H_2O \longrightarrow Ln\,(OH)_3 + H_2 \quad (1)$$

(c) Transition metals form closely packed crystal lattices and have similar atomic sizes, allowing them to mix easily to form homogenous alloys. Their high tensile strength, malleability and resistance to corrosion also make them ideal for alloy preparation. (1)

(d) The ionic equation for the reaction between KI and acidified $KMnO_4$ is

$$10I^- + 2MnO_4^- + 16H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 5I_2 \quad (1)$$

(e) Zn^{2+}, Cd^{2+}, and Hg^{2+} have fully filled d^{10} electronic configurations, so no $d-d$ electronic transitions are possible. Hence, they appear colourless in aqueous solutions. (1)

32. A. (a) Given, $W_{\text{benzoic acid}} = 2\text{ g}$, $K_f = 4.9\text{ K kg mol}^{-1}$

$w_{\text{benzene}} = 25\text{ g}$, $\Delta T_f = 1.62\text{ K}$.

Now, $$\Delta T_f = K_f \times \frac{W_{\text{benzoic acid}} \times 1000}{M_{\text{benzoic acid}} \times w_{\text{benzene}}}$$

$$1.62 = \frac{4.9 \times 2\text{ g} \times 1000}{M_{\text{benzoic acid}} \times 25\text{ g}}$$

$$M_{\text{benzoic acid}} = \frac{4.9 \times 2 \times 1000}{1.62 \times 25} = 241.98\text{ g/mol.}$$

$$2C_6H_5COOH \rightleftharpoons (C_6H_5COOH)_2$$

At $t = 0$ $\quad x \quad 0$

At $t = t$ $\quad 1 - x \quad \frac{x}{2}$

If x is the degree of association, $(1 - x)$ mole of benzoic acid is left undissociated and corresponding $\frac{x}{2}$ as associated moles of C_6H_5COOH at equilibrium.

So, total no. of moles of particles at equilibrium

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

Total number of moles of particles at equilibrium equals to van't Hoff factor (i). But we know that,

$$i = \frac{\text{Normal molecular mass}}{\text{Abnormal molecular mass}}$$

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

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

$\Rightarrow \quad x = 0.992$

$\Rightarrow \quad 99.2\%$ (3)

(b) Given, Mass of solute $(w_2) = 25\text{ mg} = 25 \times 10^{-3}$ g

Volume of solution $= 2$ L

Temperature $(T) = 273 + 27 = 300$ K

$$R = 0.082\text{ L atm K}^{-1}\text{mol}^{-1}$$

$$\because \quad \pi = \frac{i \times w_2 \times RT}{V \times M_2}$$

$$\therefore \quad \pi = \frac{3 \times 25 \times 10^{-3} \times 0.082 \times 300}{2 \times 174} \quad (\because i = 3)$$

$$= 0.0053\text{ atm}$$ (2)

Or

B. (a) **Elevation of boiling point** (ΔT_b) On mixing, any non-volatile solute in solvent, the vapour pressure of solution decreases.

As a result, boiling point of solution increases. The increase in boiling point of a solvent is known as elevation in boiling point (ΔT_b).

In mathematical form, $\Delta T_b = T_s - T_0$

where, T_s and T_0 is boiling point of solution and pure solvent, respectively.

Relationship between elevation in boiling point and molality

Elevation in boiling point $= K_b \times$ molality

where, $K_b =$ molal elevation constant. (2)

(b) Number of moles of octane

$$(n_A) = \frac{\text{Mass}}{\text{Molar mass}} = \frac{35\text{g}}{114\text{g mol}^{-1}} = 0.307\text{ mol}$$

[Molar mass of octane, $C_8H_{18} = (12 \times 8) + (1 \times 18)$
$= 114\text{g mol}^{-1}$

Number of moles of heptane

$$(n_B) = \frac{26\text{g}}{100\text{g mol}^{-1}} = 0.26\text{ mol}$$

[Molar mass of heptane, $C_7\,H_{16} = (12 \times 7) + 16]$
$= 100\text{g mol}^{-1}$

Mole fraction of octane,

$$(\chi_A) = \frac{n_A}{n_A + n_B} = \frac{(0.307\text{ mol})}{(0.307 + 0.26)\text{ mol}} = 0.541$$

Mole fraction of heptane,

$$(\chi_B) = \frac{n_B}{n_A + n_B} = \frac{(0.26\text{ mol})}{(0.307 + 0.26)\text{ mol}} = 0.459$$

Vapour pressure of pure heptane $(p_B^\circ) = 105.2$ kPa

Vapour pressure of pure octane $(p_A^\circ) = 46.8$ kPa

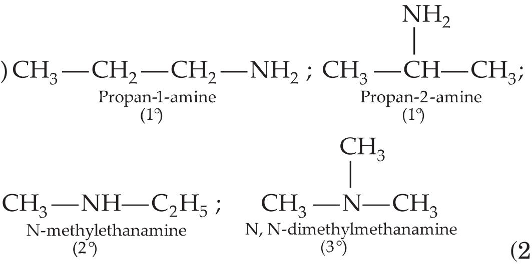
In the mixture of 26.0g heptane and 35.0g octane

(i) Vapour pressure of heptane $(p_B) = p_B^\circ x_B$
$= (105.2\text{ kPa} \times 0.459) = 48.28\text{ kPa}$

(ii) Vapour pressure of octane
$(p_A) = p_A^\circ \chi_A = (46.8\text{ kPa} \times 0.541) = 25.32\text{ kPa}$

(iii) Total vapour pressure of the mixture
$(p) = p_A^\circ + p_B^\circ = 25.32 + 48.18 = 73.5\text{ kPa}$ (3)

33. A. (a)



$$CH_3{-}CH_2{-}CH_2{-}NH_2 \;;\; CH_3{-}\underset{}{\overset{NH_2}{\overset{|}{C}H}}{-}CH_3;$$

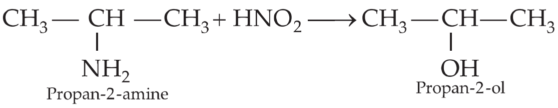
Propan-1-amine (1°) ; Propan-2-amine (1°)

$$CH_3{-}NH{-}C_2H_5 \;;\; CH_3{-}\overset{CH_3}{\overset{|}{N}}{-}CH_3$$

N-methylethanamine (2°) ; N, N-dimethylmethanamine (3°) (2)

(b) Only primary amines (1°) which are mentioned above will liberate nitrogen gas on treatment with nitrous acid.

$$\underset{\text{Propan-1-amine}}{CH_3CH_2CH_2NH_2} + HNO_2 \longrightarrow \underset{\text{Propan-1-ol}}{CH_3CH_2CH_2OH} + N_2\uparrow + HCl$$



$$\underset{\text{Propan-2-amine}}{CH_3{-}\underset{NH_2}{\underset{|}{C}H}{-}CH_3} + HNO_2 \longrightarrow \underset{\text{Propan-2-ol}}{CH_3{-}\underset{OH}{\underset{|}{C}H}{-}CH_3} + N_2\uparrow + HCl$$ (3)

Or

B. (a) (i) Amine V and W have the structural formula of $R{-}NH{-}R$. (1)

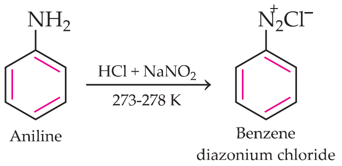
(ii) The hydrogen attached to nitrogen in the product formed after the amine U reacts with Hinsberg's reagent is strongly acidic due to the presence of a strong electron-withdrawing sulphonyl group. Hence, it is soluble in *aq*. NaOH. However, amine *V* and *W* do not contain any hydrogen atom attached to the nitrogen atom in the product formed and hence, insoluble in *aq*. NaOH. (1)

(iii) Amine *U* is soluble in *aq*. NaOH. So, it is a primary amine. Gabriel phthalimide synthesis is used for the preparation of primary amines. (1)

(b) (i) Ethyl bromide will react with alcoholic AgCN to give ethyl isocyanide ($C_2H_5—NC$). (1)

$$C_2H_5—Br + AgCN \xrightarrow{aq.\ EtOH} C_2H_5—NC + AgBr$$

(ii) When aniline reacts with dil. HCl and *aq*. solution of sodium nitrite ($NaNO_2$) at 273-278 K, it will form benzene diazonium chloride and the reaction is called diazotisation reaction. (1)



My Reflection & Problem Points

Write down any difficulties, doubts, or mistakes you faced in this paper.

Discuss these points with your teacher and sort them out.

Concept(s) I got stuck on ....

....

Question(s) I couldn't complete ....

....

What confused me most ....

....

Time issue faced in ....