Sample Paper 1 Solutions

Class XII 2023-24

Chemistry

Time: 3 Hours **Max. Marks: 70**

General Instructions:

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

Directions (Q. Nos. 1-16) : The following questions are multiple-choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

1. For the reaction, $2X + Y \longrightarrow X_2Y$
What will be the expression for instantaneous rate of the reaction?

(a) $+\dfrac{1}{2}\dfrac{d(Y)}{dt}$

(b) $-\dfrac{1}{2}\dfrac{d(X_2Y)}{dt}$

(c) $\dfrac{-d(X)}{2dt}$

(d) None of these
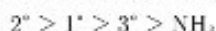
Ans :   (c) $\dfrac{-d(X)}{2dt}$

The expression for instantaneous rate of the reaction is as follows:

$$-\frac{d[N_2]}{dt} = -\frac{d[H_2]}{3dt} = \frac{d[NH_3]}{2dt}$$

2. Out of the following, the strongest base in aqueous solution is:

(a) dimethylamine

(b) aniline

(c) methylamine

(d) trimethylamine

Ans :   (a) dimethylamine

Order of basicity is aqueous solution for amines :

$$2° > 1° > 3° > NH_3$$

3. Which of the following compound will not undergo azo coupling reaction with benzene diazonium chloride?

(a) Phenol

(b) Aniline

(c) Nitrobenzene

(d) Anisole

Ans :   (c) Nitrobenzene

Diazonium cation is a weak electrophile and hence it reacts with electron-rich compounds containing electron-donating groups such as $-OH$, $-NH_2$ and OCH_3 groups and not with compounds containing electron-withdrawing groups such as $-NO_2$ etc.

4. A graph was plotted between molar conductivity of various electrolytes (NaCl, HCl and NH_4OH) and $\sqrt{c}$ (in mol L^{-1}). Which of the following is the correct set?
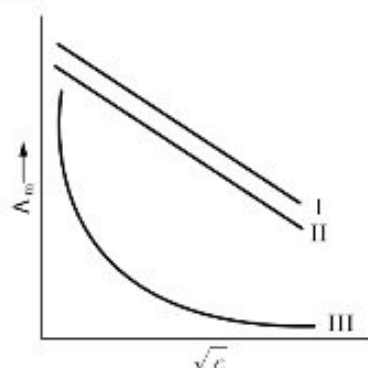
(a) I (NH_4OH), II (HCl), III (NaCl)

(b) I (NaCl), II (HCl), (III) (NH_4OH)

(c) I (HCl), II (NaCl), III (NH_4OH)

(d) I (NH_4OH), II (NaCl), III (HCl)

Ans :   (c) I (HCl), II (NaCl), III (NH_4OH)

In any graph of molar conductivity vs $\sqrt{c}$, a weak electrolyte gives a curved decreasing graph and a strong electrolyte gives straight-line decreasing graph. Since, graph III is curved, it corresponds to NH_4OH which is a weak electrolyte. Graph I and II respectively represent HCl and NaCl HCl is a stronger electrolyte among the two).

5. The role of a catalyst is to change :
    (a) enthalpy of reaction
    (b) Gibbs' energy of reaction
    (c) equilibrium constant
    (d) activation energy of reaction

    Ans :   (d) activation energy of reaction

    The role of a catalyst is to change the activation energy of the reaction. However, catalyst does not changes Gibbs energy of reaction, enthalpy of reaction and equilibrium constant.
    A catalyst provides an alternate pathway of lower activation energy.

6. Out of the following transition elements, the maximum number of oxidation states are shown by:
    (a) Cr $(Z = 24)$ (b) Sc $(Z = 21)$
    (c) Fe $(Z = 26)$ (d) Mn $(Z = 25)$

    Ans :   (d) Mn $(Z = 25)$

 | Transition Element | Oxidation States |
    |---|---|
    | Sc | +3 |
    | Cr | +2, +3, +4, +5, +6 |
    | Mn | +2, +3, +4, +5, +6, +7 |
    | Fe | +2, +3, +4, +6 |

7.

7. The value of K_H for $Ar(g)$, $CO_2(g)$, $HCHO(g)$ and $CH_4(g)$ are 40.39, 1.67, 1.83×10^{-5} and 0.413 respectively. Arrange these gases in increasing order of solubility.
    (a) $Ar < CO_2 < CH_4 < HCHO$
    (b) $Ar < CH_4 < CO_2 < HCHO$
    (c) $HCHO < CH_4 < CO_2 < Ar$
    (d) $HCHO < CO_2 < CH_4 < Ar$

Ans :   (a) $Ar < CO_2 < CH_4 < HCHO$

Higher the value of K_H, lower will be the solubility of gas at given pressure.

8. What is the correct IUPAC name of the given compound?

$$CH_3-\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle COOH}{|}}{C}}-CH_2-CH_3$$
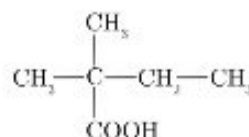
    (a) 2-carboxyl-2-methylpropanoic acid
    (b) 2-ethyl-2-methylpropanoic acid
    (c) 3-methylabutanee carboxylic acid
    (d) 2, 2-dimethylbutanoic acid

    Ans :   (d) 2, 2-dimethylbutanoic acid

9. The boiling points of alcohols are higher than those of hydrocarbons of comparable masses due to:
    (a) ion-dipole interaction
    (b) dipole -dipole interaction
    (c) hydrogen bonding
    (d) vander Waals forces

    Ans :   (c) hydrogen bonding

    Alcohols form intermolecular hydrogen bonds while hydrocarbons do not.

10. For the reaction $2H_2O_2 \longrightarrow 2H_2O + O_2$, $r = k[H_2O_2]$. The reaction is of :
    (a) first order   (b) second order
    (c) third order   (d) zero order

    Ans :   (a) first order

    As rate, $r = k[H_2O_2]$
    It is reaction of first order. Also as it is decomposition reaction.

11. The compound obtained by the reaction of nitrous acid on aliphatic primary amine is:
    (a) alkyl nitrite   (b) alcohol
    (c) nitroalkane   (d) secondary amine

    Ans :   (b) alcohol

    $$\underset{1° amine}{R-NH_2} + \underset{Nitrous acid}{HONO} \longrightarrow \underset{1° alcohol}{ROH} + N_2 + H_2O$$

12. A graph was plotted between the molar conductivity Using valence bond theory, the complex $[Cr(NH_3)_6]^{3+}$ can be described as :

    (a) d^2sp^3, inner orbital complex, paramagnetic
    (b) d^2sp^3, outer orbital complex, diamagnetic
    (c) sp^3d^2, outer orbital complex, paramagnetic
    (d) dsp^2, inner orbital complex, diamagnetic

    Ans : (a) d^2sp^3 inner orbital complex, paramagnetic

    Paramagnetic due to presence of three unpaired electrons, it is paramagnetic.

Directions (Q. Nos. 13-16) : Each of the following questions consists of two statements, one is Assertion and the other is Reason. Give answer :

13. **Assertion :** Vanadium had the ability to exhibit a wide range of oxidation states.
    Reason : The standard potentials Vanadium are rather small, making a switch between oxidation states relatively easy.
    (a) Both Assertion and Reason are true but Reason is not a correct explanation of Assertion.
    (b) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
    (c) Assertion is fake but Reason is true.
    (d) Assertion is true but Reason is fake.

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

14. **Assertion :** DNA has a double strand helix structure.
    Reason : The two strands in a DNA molecule are exactly similar.
    (a) Both Assertion and Reason are true but Reason is not a correct explanation of Assertion.
    (b) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
    (c) Assertion is fake but Reason is true.
    (d) Assertion is true but Reason is fake.

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

    Reason is false because the two strands are complementary to each other due to the reason that the hydrogen bonds are formed between specific pairs of bases.

15. **Assertion :** Tertiary butylamine can be prepared by the action of NH_3 on tert-butylbromide.
    Reason : Tertiary butyl bromide being 3° alkyl halide prefers to undergo elimination on the treatment with a base.
    (a) Both Assertion and Reason are true but Reason is not a correct explanation of Assertion.
    (b) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
    (c) Assertion is fake but Reason is true.
    (d) Assertion is true but Reason is fake.

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

    Tertiary butylamine cannot be prepared by the action of NH_3 on tert-butyl bromide. In the basic medium, tertiary butyl bromide prefers to undergo elimination to lose a molecule of HBr to form an alkene rather than undergoing nucleophilic substitution by an amino group.

    Tert. butyl bromide   2-Methyl propene (Isobutylene)

16. **Assertion :** IUPAC name of the compound
    $$CH_3 - \underset{\underset{CH_3}{|}}{CH} - O - CH_2 - CH_2 - CH_3$$
    is 2-Ethoxy-2-methylethane.
    Reason : In IUPAC nomenclature, ether is regarded as hydrocarbon derivative in which a hydrogen atom replaced by —OR or —OAr group [where R = alkyl group and Ar = aryl group]
    (a) Both Assertion and Reason are true but Reason is not a correct explanation of Assertion.
    (b) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
    (c) Assertion is fake but Reason is true.
    (d) Assertion is true but Reason is fake.

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

    The IUPAC name of the given compound is 1-(2-propoxy) propane (or 2-propoxypropane). Therefore, the assertion is false.

SECTION-B

Directions (Q. Nos. 17-21) : This section contains 5 questions with internal choice in one question. The following questions are very short answer type and carry 2 marks each.

17. Time required to decompose SO_2Cl_2 to half of its initial amount is 60 minutes. If the decomposition is a first order reaction, calculate the rate constant of the reaction.
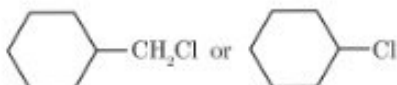
Ans :

Time required to decompose half of a substance is called its half-life ($t_{1/2}$). So here $t_{1/2} = 60$ minutes. For a first order reaction,

Rate constant, $k = \dfrac{0.693}{t_{1/2}} = \dfrac{0693}{60 \text{ minutes}}$

$= 1.15 \times 10^{-2} \text{ minute}^{-1}$

18. Which one of the following pairs of substances undergoes $S_N 2$ substitution reaction faster and why?

(i)

(ii)

Ans :
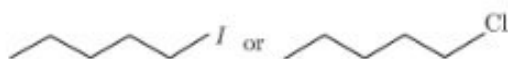
(i) $-CH_2Cl$ being a primary alkyl halide

will react faster as compared to the other substance which is a tertiary alkyl halide. This is on account of lesser steric hindrance involved in the first substance when nucleophile attacks.

(ii) I will react faster as compared to the other substance since the cleavage of C-I bond is easier as compared to that of C-I bond due to less bond dissociation enthalpy.

19. A cell is constructed between copper and silver

$$Cu(s) \mid Cu^{2+}(aq) \parallel Ag^{+}(aq) \mid Ag(s)$$

If the two half-cells are working under standard condition, then calculate the emf of the cell.

$$E^{\circ}_{Cu^{2+}/Cu} = +0.34 \text{ V}, \ E^{\circ}_{Ag^{+}/Ag} = +0.80 \text{ V}$$

Ans :

In standard conditions, E_{cell} is called E° cell and for this cell,

$$E^{\circ}_{cell} = E^{\circ}_{Ag^{+}/Ag} - E^{\circ}_{Cu^{2+}/Cu}$$
$$= 0.80 - (+0.34) \text{ V} = +0.46 \text{ Volt}$$

20. Identify compounds (A) and (B) in the following reactions and write the related balanced chemical equation :

$$CH_3CONH_2 \xrightarrow[\Delta]{P_2O_5} (A) \xrightarrow[Sn+HCl]{4[H]} (B)$$

Ans :
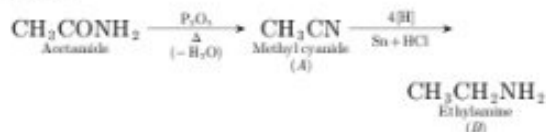
or

Complete and name the following reaction:

(i) $RNH_2 + CHCl_3 + 3KOH \longrightarrow$

(ii) $RCONH_2 + Br_2 + 4NaOH \longrightarrow$

Ans :

(i) $RNH_2 + CHCl_3 + 3KOH (alc.) \xrightarrow{(Warm)}$

$$RN = C + 3KCL + 3H_2O$$

(Alkyl isocyanide)

The reaction is known as carbyl amine reaction.

(ii) $RCONH_2 + Br_2 + 4NaOH (alc.) \xrightarrow{Heat} RNH_2$

(Acid amide) — (Primary amine)

$$+ Na_2CO_3 + 2NaBr + 2H_2O$$

21. (i) Sketch the zwitter ionic form of α-amino acetic acid.

(ii) What type of linkage holds together the monomers in DNA?

Ans :

(i) $\overset{..}{N}H_2 - CH_2 - COOH \Leftrightarrow \overset{+}{N}H_3 - CH_2 - COO^{-}$

(ii) Monomers in DNA are linked by phosphate linkages.

SECTION-C

Directions (Q. Nos. 22-28) : This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.

22. A zinc rod is dipped in 0.1 M solution of $ZnSO_4$. The salt is 95% dissociated at this dilution at 298K. Calculate the electrode potential.
$[E^\circ_{(Zn^{2+}/Zn)} = -0.76 \text{ V}]$

Ans :

The electrode reaction written at reduction reaction is,

$$Zn^{2+} + 2e^- \longrightarrow Zn \qquad (n = 2)$$

Applying Nernst equation, we get

$$E^\circ_{Zn^{2+}/Zn} = E^\circ_{Zn^{2+}/Zn} - \frac{0.0591}{2} \log \frac{1}{[Zn^{2+}]}$$

As 0.1 M $ZnSO_4$ solution is 95% dissociated, this means that in the solution,

$$[Zn^{2+}] = \frac{95}{100} \times 0.1 = 0.095 \text{ M}$$

Hence, $E_{Zn^{2+}/Zn} = -0.76 - \frac{0.0591}{2} \log \frac{1}{0.095}$

$$= -0.76 - 0.02955 (3 - 1.9777)$$

$$= -0.79021 \text{ Volt}$$

23. (i) Give the electronic configuration of the d-orbitals of Ti in $[Ti(H_2O)_6]^{3+}$ ion and explain why this complex is coloured ? [At. No. of Ti = 22]

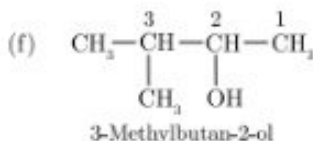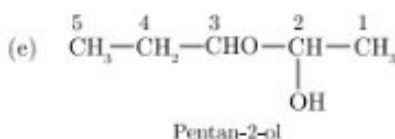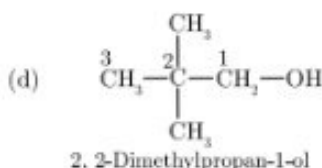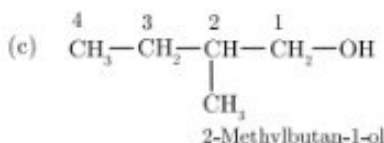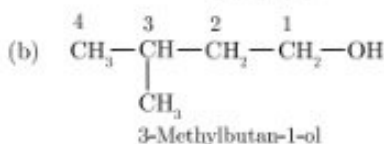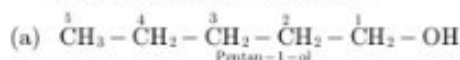(ii) Write IUPAC name of $[Cr(NH_3)_3(H_2O)_3]Cl_3$.

Ans :

(i) Oxidation state of Ti : $x + 6(0) = +3$
Configuration of Ti^{3+} ion $= (Ar) 3d^1 4s^0$
Complex is coloured due to the presence of an unpaired electron leading to d-d transition.

(ii) Triamminetriaquachromium (III) chloride.

24. (i) Draw the structural formulas and write IUPAC names of all the isomeric alcohols with the molecular formula $C_5H_{12}O$.

(ii) Classify the isomers of alcohols given in part (a) as primary, secondary and tertiary alcohols.

Ans :

(i) The molecular formula $C_5H_{12}O$ represents eight isomeric alcohols. These are :

(a) $\overset{5}{C}H_3 - \overset{4}{C}H_2 - \overset{3}{C}H_2 - \overset{2}{C}H_2 - \overset{1}{C}H_2 - OH$
Pentan-1-ol

(b) $\overset{4}{C}H_3 - \overset{3}{C}H - \overset{2}{C}H_2 - \overset{1}{C}H_2 - OH$
  |
  CH_3
3-Methylbutan-1-ol

(c) $\overset{4}{C}H_3 - \overset{3}{C}H_2 - \overset{2}{C}H - \overset{1}{C}H_2 - OH$
  |
  CH_3
2-Methylbutan-1-ol

(d) $\overset{3}{C}H_3 - \overset{2}{C} - \overset{1}{C}H_2 - OH$
  | |
  CH_3 CH_3
2, 2-Dimethylpropan-1-ol

(e) $\overset{5}{C}H_3 - \overset{4}{C}H_2 - \overset{3}{C}HO - \overset{2}{C}H - \overset{1}{C}H_3$
  |
  OH
Pentan-2-ol

(f) $\overset{3}{C}H_3 - \overset{2}{C}H - \overset{1}{C}H - CH_3$
  | |
  CH_3 OH
3-Methylbutan-2-ol

(g) $\overset{1}{C}H_3 - \overset{2}{C} - \overset{3}{C}H_2 - \overset{4}{C}H_3$
  |
  CH_3
  |
  OH
2-Methylbutan-2-ol

(h) $\overset{5}{C}H_3 - \overset{4}{C}H_2 - \overset{3}{C}H - \overset{2}{C}H_2 - \overset{1}{C}H_3$
  |
  OH
Pentan-3-ol
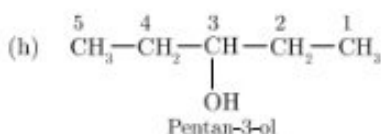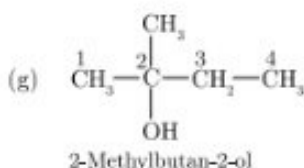
(ii) Primary : (a), (b), (c), (d); Secondary : (e), (f), (h); Tertiary : (g)

25. Answer the following questions :   (Any three)

(i) What do you mean by depression in freezing point?

(ii) How can the molecular weight of a non-volatile substance be calculated by freezing point

depression method? Only give the formula.

(iii) Measurement of osmotic pressure method is preferred for the determination of molar mass of macromolecules such as proteins and polymers.

(iv) Elevation of boiling point of 1M KCl solution is nearly double than that of 1 M sugar solution.

Ans :

(i) When a non-volatile, non-electrolyte is dissolved in a solvent, its freezing point decreases. The decrease in freezing point is called depression in freezing point. It is directly proportional to amount (molality) of solute.

Depression in freezing point (ΔT_f)

= Freezing point of solvent

− Freezing point of solution

$$\Delta T_f = T_f^0 - T_f$$

(ii) The molecular weight of a non-volatile substance can be calculated from depression in freezing point by using the following relation :

$$m = \frac{1000 \times K_f \times w}{\Delta T_f \times W}$$

where, m = molecular weight of solute

K_f = molal depression constant of solvent,

w = weight of solute,

W = weight of solvent,

ΔT_f = depression in freezing point.

(iii) The osmotic pressure method has the advantage over other methods as pressure measurement is around the room temperature and the molarity of the solution is used instead of molality.

(iv) Elevation in boiling point is directly proportional to i, $T_b \propto i$. Now as given in the question, elevation of boiling point of 1 M KCl solution is nearly double than that of 1M sugar solution. It is because KCl being ionic, dissociates into K^+ and Cl^- and therefore. It is van't Hoff factor, i is 2 whereas for sugar solution, van't Hoff factor is 1 as it does not undergo such a dissociation.

26. (i) Write the IUPAC name of the following complex :
$[Co(NH_3)_4(H_2O)Cl]Cl_2$

(ii) What is the difference between an Ambidentate ligand and a Bidentate ligand?

(iii) Out of $[Fe(NH_3)_6]^{3+}$ and $[Fe(C_2O_4)_3]^{3-}$, which complex is more stable and why ?

Ans :

(i) Tetraammineaquachloro cobalt III chloride.

(ii) A ligand which has two different donor atoms but only one of them forms a coordinate bond at a time with central metal/ion is called ambidentate ligand. On the other hand, ligand which can bind through two donor atoms is said to be bidentate ligand.

(iii) $[Fe(C_2O_4)_3]^{3-}$ is a chelate complex and $[Fe(NH_3)_6]^{3+}$ is a complex containing unidentate ligand.

We know that chelate complexes are more stable than similar complexes containing unidentate ligands. Thus, $[Fe(C_2O_4)_3]^{3-}$ is more stable.

27. What happens when :

(i) N-ethylethanamine reacts with benzenesulphonyl chloride.

(ii) Benzylchloride is treated with ammonia followed by the reaction with Chloromethane.

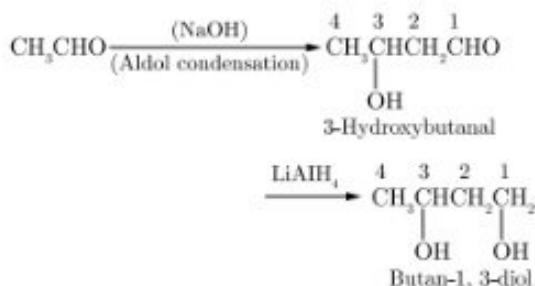(iii) Aniline reacts with chloroform in the presence of alcoholic potassium hydroxide.

Ans :

(i) When N-ethylethanamine reacts with benzenesulphonyl chloride, N, N-diethyl benzenesulphonamide is formed.

(ii) When benzylchloride is treated with ammonia, benzylamine is formed which on reaction with chloromethane yields a secondary amine, N-methylbenzylamine.

(iii) When aniline reacts with chloroform in the presence of alcoholic potassium hydroxide, phenyl isocyanides or phenyl isonitrile is formed.
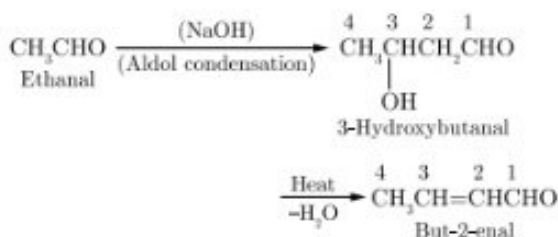
28. How will you convert ethanal to the following compounds?

(i) Butane-1, 3-diol

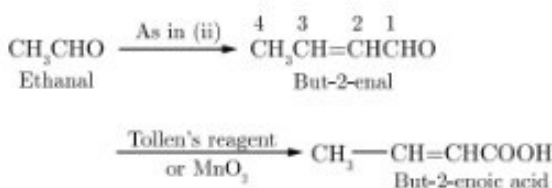(ii) But-2-enal

(iii) But-2-enoic acid

Ans :

(i) Ethanal to Butane-1, 3-diol

$$CH_3CHO \xrightarrow[\text{(Aldol condensation)}]{\text{(NaOH)}} \underset{\overset{|}{OH}}{\overset{4 \quad 3 \quad 2 \quad 1}{CH_3CHCH_2CHO}}$$

3-Hydroxybutanal

$$\xrightarrow{\text{LiAIH}_4} \underset{\overset{|}{OH} \quad \overset{|}{OH}}{\overset{4 \quad 3 \quad 2 \quad 1}{CH_3CHCH_2CH_2}}$$

Butan-1, 3-diol

(ii) Ethanal to But-2-enal

$$\underset{\text{Ethanal}}{CH_3CHO} \xrightarrow[\text{(Aldol condensation)}]{\text{(NaOH)}} \underset{\overset{|}{OH}}{\overset{4 \quad 3 \quad 2 \quad 1}{CH_3CHCH_2CHO}}$$

3-Hydroxybutanal

$$\xrightarrow[-H_2O]{\text{Heat}} \overset{4 \quad 3 \quad 2 \quad 1}{CH_3CH=CHCHO}$$

But-2-enal

(iii) Ethanal to But-2-enoic acid

$$\underset{\text{Ethanal}}{CH_3CHO} \xrightarrow{\text{As in (ii)}} \overset{4 \quad 3 \quad 2 \quad 1}{CH_3CH=CHCHO}$$

But-2-enal

$$\xrightarrow[\text{or MnO}_2]{\text{Tollen's reagent}} CH_3\!-\!CH=CHCOOH$$

But-2-enoic acid

SECTION-D

Directions (Q. Nos. 29-30) : The following questions are case-based questions. Each question has an internal choice and carries 4 marks each. Read the passage carefully and answer the questions that follow.

29. The rate law for a chemical reaction relates the reaction rate with the concentrations or partial pressures of the reactants. For a general reaction $aA + bB \longrightarrow C$ with no intermediate steps in its reaction mechanism, meaning that it is an elementary reaction, the rate law is given by $r = k[A]^x[B]^y$, where [A] and [B] express the concentrations of A and B in moles per litre.

Exponents x and y vary for each reaction and are determined experimentally. The value of k varies with conditions that affect reaction rate, such as temperature, pressure, surface area, etc. The sum of these exponents is known as overall reaction order. A zero order reaction has a constant rate that is independent of the concentration of the reactants. A first order reaction depends on the concentration of only one reactant. A reaction is said to be second order when the overall order is two. Once we have determined the order of the reaction, we can go back and plug in one set of our initial values and solve for k.

In the context of the given passage, answer the following questions :

(i) Calculate the overall order of a reaction which has the following rate expression :
Rate $= k[A]^{1/2}[B]^{3/2}$

(ii) What is the effect of temperature on rate of reaction?

(iii) A first order reaction takes 77.78 minutes for 50% completion. Calculate the time required for 30% completion of this reaction log 10 = 1, log 7 = 0.8450.

or

(iv) A first order reaction has a rate constant 1×10^{-3} per sec. How long will 5g of this reactant take to reduce to 3 g?
(log 3 = 0.4771; log 5 = 0.6990)

Ans :

(i) Overall order of reaction $= \frac{1}{2} + \frac{3}{2} + \frac{4}{2} = 2$

(ii) The rate of reaction increases on increasing the temperature.

(iii) For first order reaction,

$$t_{50\%} = t_{1/2} = \frac{0.693}{k}$$

$$77.78 = \frac{0.693}{k}$$

$$k = \frac{0.693}{77.78} = 0.009$$

and

$$t_{30\%} = \frac{2.303}{k}\log\frac{a}{(a-x)}$$

$$= \frac{2.303}{0.009}\log\frac{100}{(100-30)}$$

$$= 255.89(\log 10 - \log 7)$$

$$= 255.89(1 - 0.8450)$$

$$= 39.66 \text{ minutes}$$

or

(iv) Given,

$$[A]_0 = 5\,g, \quad [A] = 3\,g$$

and

$$k = 1 \times 10^{-3}\,\text{Per sec}$$

Using,

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

$$= \frac{2.303}{1 \times 10^{-3}}\log\frac{5}{3}$$

$$= 2.303 \times 10^3(\log 5 - \log 3)$$

$$= 2.303(0.6990 - 0.4771)$$

$$\approx 511\,\text{sec}$$

30. An amino acid is a compound that contains both carboxyl group and an amino group. Although, many types of amino acids are known, the α-amino acids are the most significant in the biological world because they are the monomers from which proteins are constructed. A general structural formula of an α-amino acid is shown in figure below.

(a) Unionised form   (b) Internal salt (Zwitter ion) form

An α- amino acid

Although, figure (a) is a common way of writing structural formulas for amino acids, it is not accurate because it shows an acid (—COOH) and a base (—NH$_2$) within the same molecule. These acidic and basic groups react with each other to form a dipolar ion or internal salt (figure (b). The internal salt of an amino acid is given the special name Zwitter ion. Note that a Zwitter ion has no net charge, it contains one positive charge and one negative charge.

Because they exist as Zwitter ions, amino acids have many of the properties associated with salts. They are crystalline solids with high melting points and are fairly soluble in water but insoluble in non-polar organic solvents such as ether and hydrocarbon solvents.

According to the above passage, answer the following questions :

(i) Amino acids are usually colourless, crystalline solids. They behave like salts rather than simple amines or carboxylic acids. Why amino acids show such a behaviour?

(ii) Amino acids are essential and non-essential depending upon their need. One of the essential amino acid is lysine. Can you say why lysine is considered an essential amino acid?

(iii) Here are given some amino acids—lysine, Tyrosine, Glycine, Alamine. One of these amino acids is not optically active. Which one is that amino acid? Also, provide the reason.

or

(iv) The pk_{a_1} and pk_{a_2} of an amino acid are 2.3 and 9.7 respectively. What would be the isoelectric point of the amino acid? Calculate by defining it.

Ans :

(i) Amino acids behave like salts rather than simple amines due to the presence of both acidic (—COON) and basic (—NH$_2$) groups.

(ii) Lysine is considered an essential amino acid as it cannot be formed in the body and has to be supplemented to the body through the diet.

(iii) Among the given amino acids, glycine is not optically active. It is the only amino acid which do not have asymmetrical carbon atom and is the simplest amino acid.

or

(iv) The isoelectric point is the pH at which the amino acid does not migrate in an electric field. This means that it is the pH at which the amino acid is neutral i.e., the Zwitter ion form is dominant.

$$\text{Isoelectric point} = \frac{pk_{a_1} + pk_{a_2}}{2}$$

$$= \frac{2.3 + 9.7}{2} = \frac{12.0}{2} = 6.0$$

So, the isoelectric point of the amino acid = 6.0

SECTION-E

Directions (Q. Nos. 31-33) : The following questions are long answer type and carry 5 marks each. Two questions have an internal choice.

31. (i) The cell in which the following reaction occurs:
$$2Fe^{3+}(aq) + 2I^-(aq) \longrightarrow 2Fe^{2+}(aq) + I_2(s)$$
has $E°_{cell} = 0.236$ Volt at 298K. Calculate the standard Gibbs energy of the cell reaction. (Given : 1F = 96,500 C mol^{-1})

(ii) How many electrons flow through a metallic wire if a current of 0.5 A is passed for 2 hours? (Given : 1F = 96,500 C mol^{-1})

(iii) Explain the following with reason :

   (a) Chlorine can displace iodine from KI solution but iodine can not displace bromine from KBr solution.

   (b) Following reaction is possible or not.
   $$Hg + H_2SO_4 \longrightarrow HgSO_4 + H_2$$

Ans :

(i) Standard Gibbs free energy is given by the following expressions :
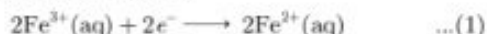
$$\Delta_r G^\circ = -nFE^\circ_{Cell} \text{ where,}$$

n = number of makes of electrons transferred,

F = Faraday's constant = $96500\ C\ mol^{-1}$,

$\quad E^\circ_{Cell}$ = cell constant.

Two half-reactions for the given redox reaction can be written as :

$$2Fe^{3+}(aq) + 2e^- \longrightarrow 2Fe^{2+}(aq) \qquad ...(1)$$
$$2I^-(aq) \longrightarrow I_2(s) + 2e^-$$

2 moles of electrons are involved in the reaction, hence $n = 2$

Therefore, by substituting all the values in equation (1), we get

$$\Delta_r G^\circ = -(2mol) \times (96500\ C\ mol^{-1})$$
$$\times (0.236\ V)$$
$$= -45548\ J$$
$$\Delta_r G^\circ = -45.55\ kJ$$

(ii) Given,

Current, $I = 0.5\ A$

Time, $t = 2h$

Quantity of charge (Q) passed = $i \times t$

$$= (0.5\ A) \times (2h)$$
$$= (0.5A) \times (2 \times 60 \times 60\ s)$$
$$= 3600\ C$$

Again, $Q = ne^-$

where, n = number of electrons

       e^- = charge on electron

Hence, $n = \dfrac{Q}{e^-}$

$$= \dfrac{3600\ C}{1.6 \times 10^{-19}\ C}$$
$$= 2250 \times 10^{19}$$

Thus, number of electrons = 2.250×10^{22}

(iii)

(a) Chlorine is a stronger oxidising agent as compared to iodine because its standard electrode potential is lower than that of the iodine. So, chlorine can displace iodine from KI solution.

$$2KI + Cl_2 \longrightarrow 2KCl + I_2$$

Iodine is a weaker oxidising agent as compared to bromine because the value of standard electrode potential of bromine is lower than that of the iodine. So, iodine can not displace bromine from KBr solution.

$$KBr + I_2 \longrightarrow No\ reaction.$$
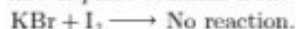
(b) $Hg + H_2SO_4 \longrightarrow HgSO_4 + H_2$

This reaction is not possible because the standard electrode potential of Hg is lower (negative value) than that of the hydrogen. However, according to electrochemical series, only those metals can displace hydrogen from the dilute solution of hydroacids which have standard electrode potential higher than that of the hydrogen i.e., which are placed below hydrogen in the electrochemical series.

32. (i) Account for the following :

(a) Transition metals from large number of complex compounds.

(b) The lowest oxide of transition metal is basic whereas the highest oxide is amphoteric or acidic.

(c) E° value for the Mn^{3+}/Mn^{2+} couple is highly positive (+1.57 V) as compare to Cr^{3+}/Cr^{2+}.

(ii) Write one similarity and one difference between the chemistry of lanthanoid and actinoid elements.

Ans :

(i)

(a) Due to the comparatively smaller size of the metal ions, high ionic charges and the availability of vacant d-orbitals for bond formation, transition metals for a large number of complex compounds.

(b) In lower oxidation states, transition metals behave like metals and metal oxides are basic in nature. Thus, in lower oxidation states, transition metal oxides are basic. As the oxidation state increases, its metallic character, decreases due to decrease in size, thus, it becomes less metallic or more non-metallic. Oxides of a non-metal may be acidic or neutral. Thus, in higher oxidation states transition metal oxides are amphoteric or acidic.

(c) The comparatively high E° value for Mn^{3+}/Mn^{2+} is due to the fact that Mn^{2+} (d^5) is quite stable where as comparatively low value for Cr^{3+}/Cr^{2+} is because of the extra stability of Cr^{3+}. Therefore, Cr^{3+} cannot be reduced to Cr^{2+}.

(ii) **Similarity** : Both lanthanoid and actinoid elements show a common oxidation state $+3$ and both are electropositive and very reactive.
Difference : Lanthanoid have less tendency to form complexes whereas actinoids have greater tendency to form complexes.

or

(i) (a) How is the variability in oxidation states of transition metals different from that of the p-block elements ?

(b) Out of Cu^+ and Cu^{2+}, which ion is unstable in aqueous solution and why ?

(c) Orange colour of $Cr_2O_7^{2-}$ ion changes to yellow colour when treated with an alkali. Why ?

(ii) Chemistry of actinoids is complicated as compared to lanthanoids. Give two reasons.

Ans :

(i)

(a) The variability in oxidation states of transition metal is due to the incomplete filling of d-orbitals in such a way, that their oxidation states differ from each other by unity, for example, Fe^{2+} and Fe^{3+} etc. In case of p-block elements, the oxidation state differ by units by two, for example, $+3$ and $+5$. Moreover, in transition elements, the higher oxidation states are more stable for heavier elements in a group. For example, Mo^{6+} is more stable than Cr^{4+}. In p-block elements, the lower oxidation states are more stable for heavier members due to inert pair effect, for example, Pb^{2+} is more stable than Pb^{4+}.

(b) Cu^+ ion is unstable in aqueous solution than Cu^{2+}. This is because, although second ionisation enthalpy of copper is large, but hydration enthalpy for Cu^{2+} is much more negative than that for Cu^+ and hence, it is more than compensates for the second ionisation enthalpy of copper. Therefore, many Cu^+ compounds are unstable in aqueous solution and undergo disproportionation.
$$2Cu^+ \longrightarrow Cu^{2+} + Cu$$

(c) Orange colour of $Cr_2O_7^{2-}$ ion changes to yellow colour when treated with an alkali because of the formation of chromate ions.
$$\underset{\substack{\text{Dichromatic ion} \\ \text{(orange)}}}{Cr_2O_7^{2-}} + 2OH^- \longrightarrow \underset{\substack{\text{Chromatic ion} \\ \text{(yellow)}}}{2CrO_4^{2-}} + H_2O$$

(ii) Chemistry of actinoids is complicated as compared to lanthanoids because of the following reasons :

(a) Actinoids show a wide range of oxidation states i.e., $+3$, $+4$, $+5$ and $+6$ due to small energy difference between $5f$, $6d$ and $7s$ sub-shells of actinoids.

(b) Actinoids are radioactive due to that, their chemistry is complicated.

33. (i) Write the product (s) in the following reactions:

(a) $+ HCN \longrightarrow$?

(b) $+ NaOH \xrightarrow{\text{CaO}\\\Delta}$

(c) $CH_3 - CH = CH - CN \xrightarrow[\text{(b) H}_2\text{O}]{\text{(a) DIBAL–H}}$?
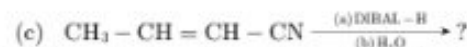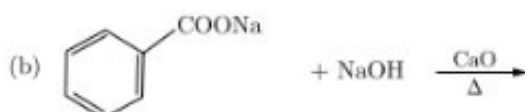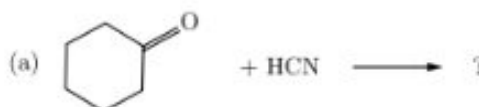
(ii) Give simple chemical test to distinguish between the following pairs of compounds :

(a) Butanal and Butan-2-one.

(b) Benzoic acid and Phenol.

Ans :

(i)

(a) Cyclohexanone reacts with hydrogen cyanide (HCN) to form cyclohexanone cyanohydrin.

Cyclohexanone   Cyclohexanone cyanohydrin
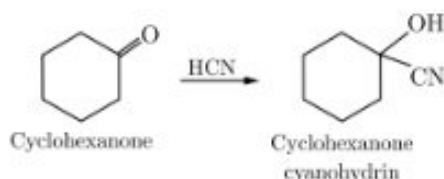
(b) The sodium benzoate reacts with soda lime to give benzene.

Sodium benzoate   Benzene
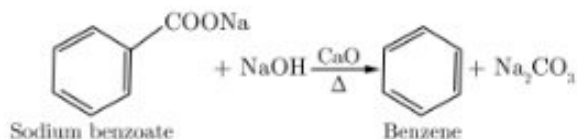
(c) But-2-en-1-nitrile on reaction with DIBAL-H followed by water gives but-2-en-1-ol.

$$CH_3-CH=CH-CN \xrightarrow[\text{(b) H}_2\text{O}]{\text{(a) DIBAL-H}}$$
But-2-en-1-nitrile

$$CH_3CH=CH-CHO$$
But-2-en-1-ol

(ii)

(a) Butanal being an aldehyde reduces Tollen's reagent to shiny silver mirror but butan-2-one being a ketone does not reduces Tollen's reagent.

$$CH_3CH_2CH_2CHO + 2[Ag(NH_3)_2]^+ + 3\bar{O}H \xrightarrow{\Delta}$$
Butanal   Tollen's reagent

$$CH_3CH_2CH_2COO^- + 2Ag\downarrow + 4NH_3 + 2H_2O$$
Silver mirror

$$CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3 \xrightarrow{\text{Tollen's reagent}} \text{No silver mirror}$$

(b) Benzoic acid and phenol can be distinguished by ferric chloride test. Phenol with neutral $FeCl_3$ to form ferric phenoxide complex giving violet colouration.

$$6C_6H_5OH + FeCl_3 \rightarrow [Fe(OC_6H_5)_6]^{3-} + 6H^+ + 3Cl^-$$
Iron-phenol complex (Violet colour)

But benzoic acid reacts with neutral $FeCl_3$ to give a buff coloured precipitate of ferric benzoate.

$$3C_6H_5COOH + FeCl_3 \rightarrow (C_6H_5COO)_3Fe + 3HCl$$
Ferric benzoate (buff colour ppt)

or

(i) An organic compound (A) with molecular formula C_3H_7NO on heating with Br_2 and KOH forms a compound (B), compound (B), on heating with $CHCl_3$ and alcoholic KOH produces a foul smelling compound (C) and on reacting with $C_6H_5SO_2Cl$ forms a compound (D) which is soluble in alkali. Write the structures of (A), (B), (C) and (D).

(ii) Give reasons to support the answer :

(a) Presence of alpha hydrogen in aldehydes and ketones is essential for aldol condensations.

(b) 3-Hydroxy pentan-2-one shows positive result to Tollen's test.

Ans :

(i)   A $\longrightarrow CH_3-CH_2-\overset{O}{\overset{\|}{C}}-NH_2$

B $\longrightarrow CH_3-CH_2-NH_2$
C $\longrightarrow CH_3-CH_2-NC$
D $\longrightarrow CH_3-CH_2-NH-SO_2-C_6H_5$

(ii)

(a) The alpha hydrogen atoms are acidic in nature due to presence of electron withdrawing carbonyl group. These can be easily removed by a base and the carbanion formed is resonance stabilised.

(b) Tollen's reagent is a weak oxidising agent not capable of breaking the C—C bond in Ketones. Thus, ketones cannot be oxidised using Tollen's reagent itself gets reduced to Ag.