Additional Practice Question Paper

(2023 -24)

CHEMISTRY THEORY (043)

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

General Instructions:

Read the following instructions carefully.

(a)   There are **33** questions in this question paper with internal choice.

(b)   SECTION A consists of 16 multiple-choice questions carrying 1 mark each.

(c)   SECTION B consists of 5 short answer questions carrying 2 marks each.

(d)   SECTION C consists of 7 short answer questions carrying 3 marks each.

(e)   SECTION D consists of 2 case-based questions carrying 4 marks each.

(f)   SECTION E consists of 3 long answer questions carrying 5 marks each.

(g)   All questions are compulsory.

(h)   Use of log tables and calculators is not allowed.

SECTION A

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.   What would be the major product formed when $(CH_3)_3$ C– OH is heated at 358 K in the presence of H_3PO_4 :

    (a) $(CH_3)_3COOH$ (b) $(CH_3)_3CHO$

    (c) $(CH_3)_2CH=CH_2$ (d) $(CH_3)_3$ C-O-C-$(CH_3)_3$

2.   The complex $[Co(NH_3)_5 (NO_2)]Cl_2$ is obtained   in yellow and red coloured forms . The difference in colour is attributed to the following type of isomerism:

    (a)   Coordination Isomerism   (b)   Facial isomerism

    (c)   Linkage isomerism   (d)   Solvate isomerism

3.   Which of the following purines (nitrogenous bases with two-ring structure) are common to RNA and DNA?

    (a)   Adenine, Thymine   (b)   Guanine, Thymine

    (c)   Thymine, Cytosine   (d)   Adenine, Guanine

4.   India's first pipeline was laid to transport crude oil in Digboi, Assam. The rusting of these iron pipelines was a cause of concern for the authorities. Which of the following methods would have been used to prevent corrosion of these pipelines?

    (a)   Barrier protection   (b)   Alloying

    (c)   Cathodic protection   (d)   Anodising the material

5.   Which of the following alkyl iodide cannot be produced by the reaction of HI with an appropriate ether:

    (a) $(CH_3)_3$ C – CH_2 – I   (b) $(CH_3)_2CH$ – I   (c) $C_6H_5CH_2$ – I   (d) C_6H_5 – I

6.   What is the order and molecularity of hydrolysis of sucrose if the rate law is

    Rate = $k'[C_{12}H_{22}O_{11}]$?

(a) Order is zero, molecularity is one (b) Order is two, molecularity is two

(c) Order is two, molecularity is one (d) Order is one, molecularity is two

7. The electronic configuration of Ni in complex $Ni(CO)_4$ would be:

(a) $t_2^6 e^4$ (b) $t_2^6 e^2$ (c) $e^4 t_2^6$ (d) $e^4 t_2^4$

8. Ankit has been given four organic compounds: a primary amine, a secondary amine, a secondary alcohol and a tertiary alcohol. Which of the following can Ankit use to identify all the compounds?

(a) Tollen's reagent and bromine water (b) 2,4 DNP and Lucas reagent

(c) Hinsberg's reagent and Lucas reagent (d) Sodium metal and Hinsberg's reagent

9. Which of the following is not true about enzymes?

(a) All enzymes are fibrous proteins

(b) Enzymes are needed in small quantities

(c) Enzymes reduce the magnitude of activation energy.

(d) They are specific for a reaction and the substrate.

10. Identify the products (1) and (2) in the following reactions:

$C_2H_5Cl + KCN \longrightarrow$ (1) and $C_2H_5Cl + KNO_2 \longrightarrow$ (2)

(a) (1) C_2H_5CN (2) $C_2H_5 NO_2$ (b) (1) C_2H_5NC (2) $C_2H_5 NO_2$

(c) (1) C_2H_5CN (2) $C_2H_5 ONO$ (d) (1) C_2H_5NC (2) $C_2H_5 ONO$

11. "Greater number of electrons from (n-1)d in addition to the ns electrons are involved in the interatomic metallic bonding.". Which of the following case is result of the above statement:

(a) Vanadium forms complexes.

(b) Platinum acts as catalyst

(c) Chromium is having higher melting point than Vanadium and Manganese .

(d) Manganese show oxidation states ranging from +2 to +7 .

12. Which of the following reactions can be used to obtain benzaldehyde from benzene?

(a) Rosenmund's Reduction (b) Stephen's Reaction

(c) Etard's Reaction (d) Gatterman-Koch Reaction

13. Given below are two statements labelled as Assertion (A) and Reason (R)

Assertion (A): Phenol on treatment with Br_2 in CS_2 gives ortho and para bromophenol.

Reason (R): Carbon disulphide is a solvent of low polarity, hence leads to monobromination of phenols

Select the most appropriate answer from the options given below:

(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. Given below are two statements labeled as Assertion (A) and Reason (R)

Assertion: At high pressure, decomposition of ammonia on the catalyst surface is a first order reaction.

Reason: At high pressure, on changing the reaction conditions, the concentration of ammonia on the surface of the catalyst does not change.

Select the most appropriate answer from the options given below:

(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.

15. Given below are two statements labeled as Assertion (A) and Reason (R)

Assertion (A): Ionisation enthalpy of Fe^{2+} is lower than the Mn^{2+}

Reason (R): Fe^{2+} has $3d^5 4s^1$ configuration, making the state highly stable

Select the most appropriate answer from the options given below:

(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. Given below are two statements labeled as Assertion (A) and Reason (R)

Assertion (A): Halogens are ortho and para-directing groups

Reason (R): Halogens are electron-withdrawing groups

Select the most appropriate answer from the options given below:

(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

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. Answer the following questions:

(a) Out of Co^{3+} and Cr^{2+}, which one liberates hydrogen from dilute acid and why?

[$E_0 Co^{3+}/Co^{2+}$ = +1.97 V, $E_0 Cr^{3+}/Cr^{2+}$ = –0. 41V]

(b) The transition metals and their compounds are known for their catalytic activity. Give a reason for their effectiveness as catalysts and name the transition element used as a catalyst in Haber's Process.

18. In metal carbonyls, metal-ligand bonds possess both sigma and pi character. Comment, whether the given statement is correct. Give reason for your answer.

19. Give an example of:

(a) an amine each with basic strength greater than and less than N-Methylmethanamine in gaseous state

(b) an isomeric amine each with boiling point less than and more than N-Ethyl ethanamine.

20. Consider the following reaction:

(1) $H_2O_2 + I^- \rightarrow H_2O + IO^-$

(2) $H_2O_2 + IO^- \rightarrow H_2O + I^- + O_2$

In the above reaction, the rate of formation of the intermediate is slow.

(a) Write the rate law.

(b) How will the rate of the reaction be affected if the concentration of peroxide is doubled?

OR

20 The half-life of a sample A ($t_{1/2}$ = 100 days) did not change with concentration of A. The half-life of

another sample B ($t_{1/2}$ = 120 days) decreases with decrease in concentration of B. If the initial concentration of both the samples were 1M, what will be their rate constants?

21. Arrange the following as indicated

   (a) n-Butane, Propan-1-ol, Propanal, Acetone, Methoxymethane (increasing order of boiling point)

   (b) Acetaldehyde, Acetone, Acetophenone, (increasing order of reactivity towards nucleophilic addition)

SECTION C

This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.

22. Observe the potential energy diagram for the hydrogenation of ethene to give ethane.

Hydrogenation reaction Energy Diagram
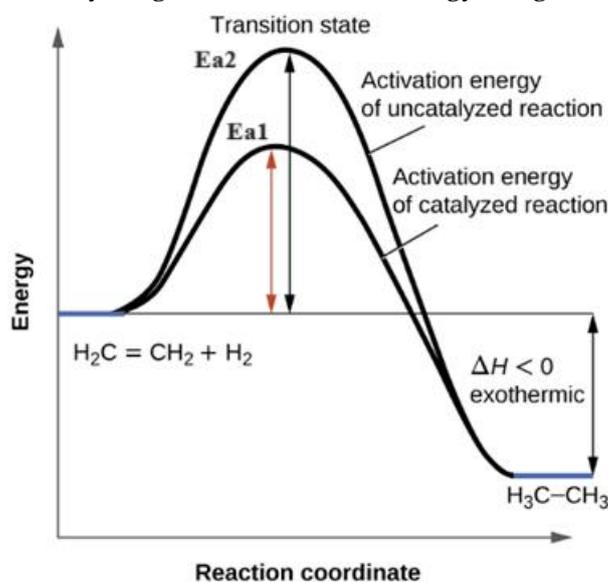
   (a) For the same process, predict why there is a difference in Ea_1 and Ea_2?

   (b) Assuming both the reaction are reversible then in which case the backward reaction will be faster?

   (c) Will the ΔG value of this reaction be different in the above two paths? Explain.

(for visually challenged learners)

   (a) What will be the effect on Ea and ΔG for a given reaction in the presence of a catalyst. Justify your answer.

   (b) According to the collision theory, what are the criterions to determine effective collision?

23. Answer the following questions:

   (a) Give an example of the liquids which when mixed result in an endothermic process, What will be the change in volume when the liquids are mixed?

   (b) At 300K, what is the relation between the osmotic pressure of two equimolar solutions, one whose Van't Hoff factor is 2 and for the other is ½?

   (c) Which of the two aqueous solutions has a higher melting point: 2molal glucose solution or 3 molal sucrose solution? Why?

24. Give reason for the following:

   (a) The complex formed by Ca^{2+} with EDTA is more stable than the complex formed by Ca^{2+} with ethylene diamine.

(b) In d^4 complexes, ligands for which $\Delta o < P$,form high spin complexes.

(c) On removal of water from $[Ti(H_2O)_6]Cl_3$ on heating, it become colourless.

OR

24. (a) What will the colour of precipitate obtained when ionization isomer of compound

$[Co(NH_3)_5Br] SO_4$, reacts with $AgNO_3$?

(b) An element M forms complex 'A' with ligand-ethane-1,2-diamine and complex 'B' with chlorido having coordination number six.

(i) Out of the two complexes which one will be more stable and why?

(ii) If metal forms d^4 ion, which complex will have higher magnetic moment?

25. An organic compound 'A' is having a molecular formula C_7H_8O. On oxidation with acidified $KMnO_4$ it forms compound 'B' .Compound 'B' can also be obtained from compound C, on its reaction with NaOH and then with CO_2 followed by hydrolysis. Compound C can be easily formed when butylphenylether is made to react with HI.

Identify the compound A,B and C . Write the chemical reactions involved.

26. Rohan was carrying out the reaction of potassium iodide with Potassium permanganate in the acidic medium . The Iodine gas was liberated from potassium iodide , during the reaction . When he repeated the reaction for further study ,he forgot to add acid . He observed, the products released during the second case were different from the previous .

(i) Give the possible chemical reactions in both the cases .

(ii) Give reason for the difference in observation.

(iii) Give the structure of MnO_4^-

27. Answer the following questions:

On passing current type 'X' through aqueous $CuSO_4$ solution, electrolysis was observed. When current type 'Y' was used, the conductivity of the solution could be measured.

(a) Identify 'X' and 'Y' type of current used.

(b) Write the electrolysis products of aqueous $CuSO_4$ solution on passing 'X'.

28. Convert Propanamide to the following compounds in not more than two steps:

(a) N- Ethylpropanamine

(b) Ethanol

(c) N-Propylethanamide

SECTION D

The following questions are case-based questions. Each question has an internal choice and carries 4 (1+1+2) marks each. Read the passage carefully and answer the questions that follow.

29. **Temperature dependence of Henry's law constant**

Henry's law and Henry's law constant are widely used in chemical and environmental engineering. Unfortunately, many people do not appreciate that Henry's constant is not a true constant but has a significant non-linear temperature dependence. Figure 1 illustrates some typical behavior of *Henry's constant vs temperature* for several solutes in water.

The Henry's constant typically increases with temperature at low temperatures, reaches a maximum, and then decreases at higher temperatures. The temperature at which the maximum occurs depends on the specific solute-solvent pair.

Clearly, the use of a Henry's constant that was derived at 25°C at a different temperature could lead to serious errors during manufacturing. Even a variation as small as 10 K can cause the Henry's constant to change by a factor of two, which could have a serious impact on many process designs.
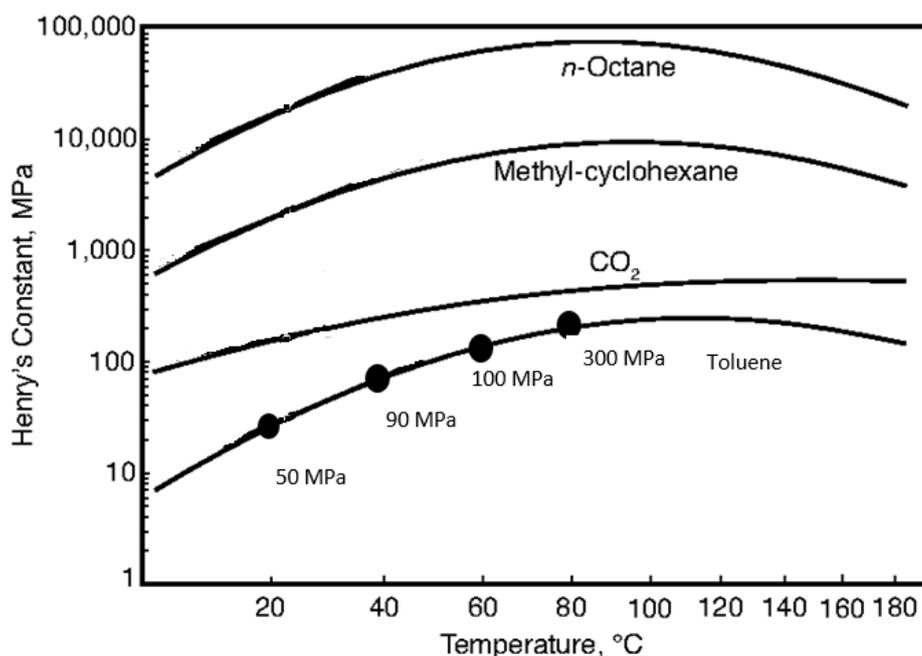
Temperature dependence of Henry's constant for several solutes in water.

(a) Which of the following is not a true constant like Henry's constant

    (i) speed of light (c)

    (ii) Planck's constant (h)

    (iii) rate constant (k)

    (iv) gas constant (R)

(b) How will the solubility of n-octane vary with a change in temperature, provided the pressure is kept constant?

OR

Rishita works in an aerated drinks factory. To increase the fizz in the drink, she proposes to bottle the aerated drinks at 40°C instead of 20°C. Do you support her proposal? Why or why not?

(c) Find the ratio of solubility of toluene in water at 20°C and 60°C.

(for visually challenged learners)

Henry's law and Henry's law constant are widely used in chemical and environmental engineering. Unfortunately, many people do not appreciate that Henry's constant is not a true constant but has a significant non-linear temperature dependence. The Henry's constant typically increases with temperature at low temperatures, reaches a maximum, and then decreases at higher temperatures. The temperature at which the maximum occurs depends on the specific solute-solvent pair. For example, the temperature at which maxima occurs for n-octane-water pair is nearly 90°C.

(a) Which of the following is not a true constant like Henry's constant

    (i) speed of light (c)

    (ii) Planck's constant (h)

    (iii) rate constant (k)

    (iv) gas constant (R)

i.   (b) How will the solubility of n-octane vary with a change in temperature, provided the pressure is kept constant?

Rishita works in an aerated drinks factory. She is aware that the temperature at which maxima occurs for carbon dioxide-water pair is above 80°C.

Rishita proposes to bottle the aerated drinks at 40°C instead of 20°C, this will increase the fizz in the drink. Do you support her proposal? Why or why not?

(c) If the pressure is constant, the ratio of solubility of n-octane in water at 20°C and 60°C will be:

(i) greater than 1 (ii) less than 1 (iii) equal to 1? Give reason for your choice.

30. **Nucleophilic Substitution Reactions**

In nucleophilic substitution reactions, a bond between carbon and a leaving group (C–LG) is broken, and a new bond between carbon and a nucleophile (C–Nu) is formed. Nucleophilic substitution reactions of alkyl halides occur through two main pathways: S_N1 and S_N2.

One way to visualize the differences between these two mechanisms is to sketch out their reaction coordinate diagrams, where we plot changes in potential energy (vertical axis), the starting materials pass along the "reaction coordinate" toward their conversion into products (horizontal axis) In these diagrams the "peaks" (local maxima) represent transition states whereas "valleys" (local minima) represent intermediates.

The reaction coordinate diagram of the S_N1 reaction has two peaks, representing the two transition states (Step 1 and Step 2, respectively) flanking a single "valley" representing the carbocation intermediate.

Each step of the process has an activation energy represented by the difference in energy between the reactant and the transition state.

The rate-determining step of a reaction is the step requiring the highest activation energy, that is, the largest change in potential energy from reactant to transition state.
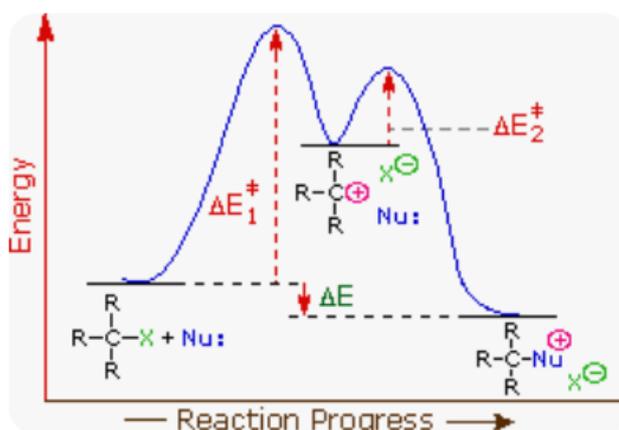
(Source: James Ashenhurst, Comparing the S_N1 and S_N2 Reactions, Master Organic Chemistry)

(a) On the basis of the activation energies for step 1 and step 2 for S_N1 reaction, identify the rate-determining step and justify your answer.

(b) If the alkyl group in the alkyl halide used as an example in figure 1 is the same but the halogen bromine is replaced by chlorine, which of the following is correct and why?

(i) Ea for step 2 will be more than shown in the figure 1

(ii) Ea for step 2 will be less than shown in the figure 1

(iii) Ea for step 2 will be same as shown in the figure 1

OR

Plot rate of reaction vs. concentration of nucleophile for S_N1 reaction.

(c) Draw the reaction coordinate diagram for S_N^2 reaction.

(*For visually challenged candidates*)

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S_N^1 occurs in two steps. Each step of the process has an activation energy represented by the difference in energy between the reactant and the transition state. The rate-determining step of a reaction is the step requiring the highest activation energy.

(a) What is the difference in energy of the reactants and that of the transition state called?

(b) A reaction occurs in two steps. If step 1 of the reaction has a greater activation energy than step 2, which will be the rate-determining step and why?

OR

The slowest step in a complex reaction requires the highest activation energy. Account for the above statement on the basis of the information provided about the nucleophilic substitution reactions.

(a) In the following reaction, identify the leaving group and the nucleophile:

CH_3CH_2Cl + aq KOH → CH_3CH_2OH + KCl

$CH_3CH_2CH_2CH_2Br$ + AgF → $CH_3CH_2CH_2CH_2F$ + AgBr
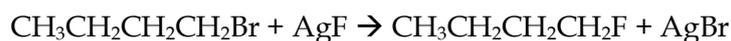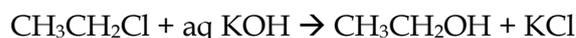
SECTION E

The following questions are long answer type and carry 5 marks each. All questions have an internal choice.

31. *Answer the following questions:*

(a) Draw the structure of the ethylene ketal of hexan-3-one.

(b) Between Benzoic acid and acetic acid which is more acidic and why?

(c) An optically active organic compound 'A', with molecular formula, $C_5H_{10}O_2$ when treated with Chlorine in the presence of Red Phosphorous forms compound 'B', $C_5H_9O_2Cl$, whereas when it is treated with thionyl chloride forms compound 'C', C_5H_9OCl. Compound C, on further hydrogenation with palladium on $BaSO_4$ in the presence of S, forms compound D, $C_5H_{10}O$. Compound D gives positive Tollen's test and regenerates A. A can also be obtained by base hydrolysis and further acidification of C. Write the reaction for the formation of 'A' from 'C' and Identify A, B, C, D.

OR

Answer the following questions:

31. (a) Bring about the following conversions:

(i) Propanal to 2-methyl pentanol

(ii) Iodobenzene to benzoic acid

(b) Though Carboxylic acids have >C=O group in their structure, but they are not prone to nucleophilic addition reactions. Why?

(c) An organic compound A, with molecular formulae C_9H_{12} is oxidized to monocarboxylic acid B, $C_7H_6O_2$ on vigorous oxidation with Potassium permanganate, whereas when oxidized in presence of air and further treated with dilute acid forms phenol. Sodium salt of B finds use as a food preservative and esters of B are used in perfumery. Identify A and B and write the

reactions involved.

32. (a) Calculate the current and the thickness of the coating if the current was passed for 1hr. to deposit 2g silver on metal object of area 1 cm². (Ag = 108, 1 Faraday = 96500 coulombs, density of silver=10.5g/cc).

(b) Calculate the electrode potential of Cr^{3+}/Cr electrode at $[Cr^{3+}]$ = 0.001 M.

Given: $Cr^{3+} + 3e^- \rightarrow Cr$ $\qquad$ E° = – 0.74 V

OR

32. (a) The half-cell reactions of an electrochemical cell are given below:

$Mn^{3+}(0.1\ M) + e^- \longrightarrow Mn^{2+}(0.01M)$ $\qquad$ E° = 1.50V

$Ag^+(0.001\ M) + e^- \longrightarrow Ag(s)$ $\qquad$ E° = 0.80 V

(i) Formulate a galvanic cell using the above data.

(ii) Calculate the emf of the cell at 25°C.

(b) The graph represents the variation of molar conductivity of an electrolyte with respect to concentration. Identify the type of electrolyte and also determine the value for A.
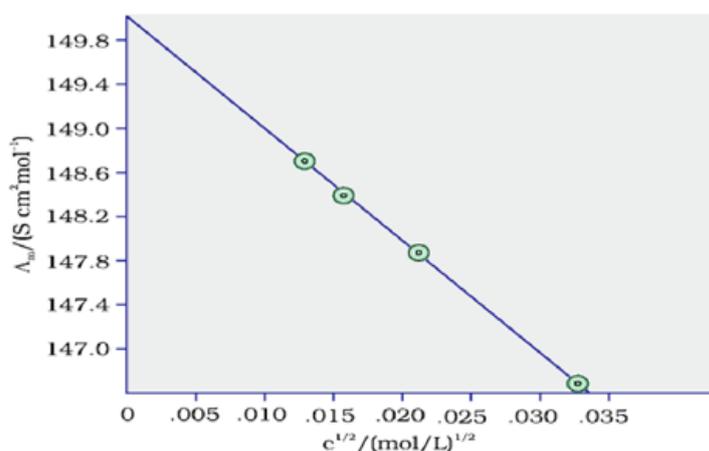
(for visually challenged learners)

32. (a) Calculate the current and the thickness of the coating if the current was passed for 1hr. to deposit 2g silver on metal object of area 1 cm². (Ag = 108, 1 Faraday = 96500 coulombs, density of silver=10.5g/cc).

(b) Calculate the electrode potential of Cr^{3+}/Cr electrode at $[Cr^{3+}]$ = 0.001 M.

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$Ag^+(0.001\ M) + e^- \longrightarrow Ag(s)$ $\qquad$ E° = 0.80 V

(i) Formulate a galvanic cell using the above data.

(ii) Calculate the emf of the cell at 25°C.

(b) The molar conductivity of an electrolyte decreases slowly with increase in concentration.

(i) Identify the type of electrolyte and give the equation with which we can represent this change in molar conductivity.

(ii) Calculate the slope of the electrolyte if the intercept on the y axis and x axis at 150 and 0.034 respectively.

33. Answer the following questions:

(a) (i) Name an important carbohydrate which makes the cell wall of bacteria and plants. What is the basic unit of this carbohydrate?

(ii) How are these basic units linked to each other, name the linkage.

(iii) Draw the Haworth structure of the basic unit.

(b) Identify the disaccharide with molecular formulae, $C_{12}H_{22}O_{11}$, which produces 2 moles of α-D(+) Glucose on hydrolysis. What will be the observation when Tollen's reagent is added to such a disaccharide.

(c) Change in optical rotation is observed when sucrose is hydrolysed. What is the reason for the inversion of configuration observed?

OR

33. *Answer the following questions:*

(a) (i) A polynucleotide chain is seen to produce pentose sugar, phosphoric acid, Adenine, Guanine, Cytosine and Thymine on complete hydrolysis. Name the nucleic acid having such a polynucleotide chain. How are the bases paired in this polynucleotide?

(ii) What links these nucleotides together in a polynucleotide?

(iii) Give one important function and one application of the above nucleic acid .

(b) Keratin is a hair protein. What kind of tertiary protein is this? Describe the structure and links present in this protein. Comment on its solubility in water?