CHEMISTRY (CODE - 043)
SAMPLE PAPER 2
CLASS XII

Time Allowed: 3 hours **Maximum 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

Question numbers 1 to 16 carry 1 mark each. All questions in this section are multiple choice questions. Select the most appropriate answer from the options given.

1. The van't Hoff factor (i) for a dilute aqueous solution of K_2SO_4 (assuming complete dissociation) is close to:

(A) 1

(B) 2

(C) 3

(D) 4

2. For a reaction A → Products, the rate is found to double when the concentration of A is doubled, and to increase four-fold when the concentration is made four times. The order of the reaction is:

(A) Zero

(B) One

(C) Two

(D) Three

3. Which of the following is used as a catalyst in the Contact Process for the manufacture of sulphuric acid?

(A) Fe

(B) V_2O_5

(C) Ni

(D) Pt only

4. The number of unpaired electrons in $[NiCl_4]^{2-}$ (tetrahedral, Ni^{2+}, d^8) is:

(A) 0

(B) 1

(C) 2

(D) 4

5. When methylmagnesium bromide (CH_3MgBr) is treated with ethanol, the gas evolved is:

(A) Methane

(B) Ethane

(C) Ethene

(D) Hydrogen

6. Which of the following alcohols will react fastest with Lucas reagent at room temperature?

(A) Propan-1-ol

(B) Propan-2-ol

(C) 2-Methylpropan-2-ol

(D) Ethanol

7. The reagent used to distinguish between benzaldehyde and acetophenone is:

(A) Tollens' reagent

(B) Fehling's solution

(C) Iodoform test

(D) 2,4-DNP reagent

8. Aniline reacts with acetic anhydride to give:

(A) Acetanilide

(B) N-methylaniline

(C) Benzanilide

(D) p-Toluidine

9. The two strands of a DNA molecule are held together by:

(A) Peptide bonds

(B) Hydrogen bonds between complementary base pairs

(C) Glycosidic bonds

(D) Disulphide bonds

10. Which of the following cells cannot be recharged?

(A) Lead storage battery

(B) Ni-Cd cell

(C) Dry (Leclanché) cell

(D) Lithium-ion cell

11. The freezing point of a 0.1 molal aqueous solution of a non-electrolyte solute is (Kf for water = 1.86 K kg mol^{-1}):

(A) −0.186 °C

(B) −1.86 °C

(C) +0.186 °C

(D) 0 °C

12. Molar conductivity of a solution:

(A) Increases with dilution for all electrolytes

(B) Decreases with dilution for strong electrolytes

(C) Is independent of concentration

(D) Decreases with dilution for weak electrolytes

13. Assertion (A): Copper does not liberate hydrogen gas from dilute HCl. Reason (R): The standard electrode potential of Cu^{2+}/Cu is higher (more positive) than that of H^+/H_2.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

14. Assertion (A): Cu^{2+} is more stable than Cu^+ in aqueous solution. Reason (R): The hydration enthalpy of Cu^{2+} is much higher than that of Cu^+, more than compensating for the higher second ionisation enthalpy of copper.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and 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. Assertion (A): Grignard reagents must be prepared and used under strictly anhydrous conditions. Reason (R): Grignard reagents react rapidly with water to form the corresponding alkane.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

16. Assertion (A): Sucrose is dextrorotatory, but after hydrolysis the resulting mixture is laevorotatory. Reason (R): Hydrolysis of sucrose gives an equimolar mixture of glucose and fructose, and the strong laevorotation of fructose outweighs the dextrorotation of glucose.

(A) Both A and R are true, and R is the correct explanation of A.

(B) Both A and R are true, and 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

Question numbers 17 to 21 are very short answer questions carrying 2 marks each.

17. Attempt either (A) or (B). [2]

(A)

I. A solution containing 8.19 g of a non-volatile, non-electrolyte solute dissolved in 100 g of water has a vapour pressure of 41.4 mm Hg at a temperature where pure water has a vapour pressure of 42.0 mm Hg. Calculate the molar mass of the solute. [1]

II. Why do gases dissolved in a liquid tend to be expelled on heating the solution? [1]

OR

(B)

I. Define abnormal molar mass, and state under what condition the van't Hoff factor i is greater than 1. [1]

II. Why is the vapour pressure of a solution of a non-volatile solute always lower than that of the pure solvent? [1]

18. For the reaction $2A + B \rightarrow C$, the rate of appearance of C is 2.5×10^{-4} mol L^{-1} s^{-1}. Calculate (i) the rate of the reaction, and (ii) the rate of disappearance of A. [2]

19. Give reasons for the following: [2]

I. Sc^{3+} has no colour in aqueous solution.

II. The $E°(M^{2+}/M)$ values of the first-row transition metals are not a smooth function of atomic number.

20. What happens when chlorobenzene is treated with (a) Na metal in dry ether (Fittig reaction with another haloalkane) and (b) Mg in dry ether? Write the products formed in each case. [2]

21. Using IUPAC norms, write the formula for the following coordination compound and state its oxidation number of the central metal: [2]

Potassium hexacyanidoferrate(III)

SECTION C

Question numbers 22 to 28 are short answer questions carrying 3 marks each.

22. The rate constant for a first order reaction is 6.93×10^{-3} min^{-1}. Calculate (i) the half-life of the reaction, and (ii) the time taken for 90% completion of the reaction. (Given log 10 = 1) [3]

23. Explain the following observations related to coordination compounds: [3]

I. $[Ni(CO)_4]$ is tetrahedral and diamagnetic, but $[NiCl_4]^{2-}$ is tetrahedral and paramagnetic.
II. $[Fe(CN)_6]^{4-}$ is diamagnetic while $[FeF_6]^{3-}$ is paramagnetic.
III. Linkage isomerism is shown by the ligand SCN^- but not by Cl^-.

24. Give simple chemical tests to distinguish between the following pairs of compounds: [3]

I. Ethanol and phenol
II. Bromobenzene and benzyl bromide
III. Propan-2-ol and propan-1-ol

25. Account for the following: [3]

I. Cr^{2+} is a strong reducing agent while Mn^{3+} is a strong oxidising agent, though both have a d^4 configuration.
II. The enthalpy of atomisation of the transition metals is generally high.
III. The lanthanoids show a limited range of oxidation states compared to the actinoids.

26. An aromatic compound A (molecular formula C_7H_6O) gives a violet colouration with neutral $FeCl_3$ solution and reacts with bromine water to give a white precipitate. On treatment with CO_2 and NaOH under pressure at 400 K, followed by acidification, it gives compound B, which is used as a preservative. Identify A and B, and write the relevant equations. [3]

27. Carry out the following conversions (attempt any three): [3]

I. Propan-1-ol to propan-2-ol
II. Phenol to anisole
III. Benzyl chloride to benzyl alcohol
IV. Ethanol to but-2-yne (via ethyne)

28. Answer the following: [3]

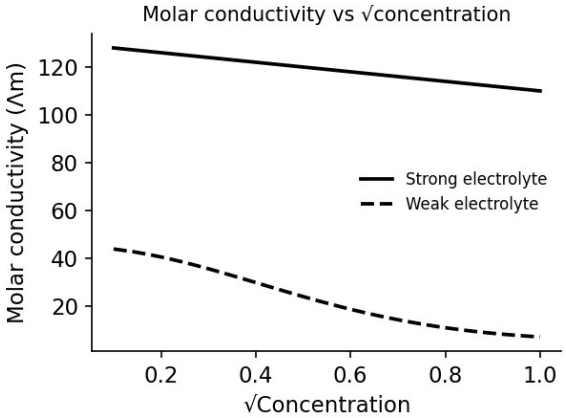
I. A conductivity cell has a cell constant of 1.29 cm^{-1}. When filled with a 0.02 M KCl solution, its resistance was found to be 100 Ω at 298 K. Calculate the conductivity and molar conductivity of the solution.
II. Why is the conductivity of a metallic conductor different in nature from that of an electrolytic conductor, and how does each vary with rise in temperature?
III. Write the Nernst equation for the cell reaction $Zn(s) + 2Ag^+(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$.

SECTION D

Question numbers 29 and 30 are case-based questions carrying 4 marks each.

29. Read the passage given below and answer the questions that follow: [4]

Molar conductivity (Λm) of an electrolyte is defined as the conducting power of all the ions produced by one mole of an electrolyte dissolved in a given volume of solution. For strong electrolytes, Λm increases only slightly with dilution and can be extrapolated to infinite dilution to obtain Λ°m using the Kohlrausch plot of Λm versus √c, which is nearly linear. For weak electrolytes, however, Λm increases very sharply at low concentrations and the plot cannot be extrapolated to √c = 0 directly; instead, Λ°m for a weak electrolyte is obtained using Kohlrausch's law of independent migration of ions, from the Λ°m values of related strong electrolytes.



I. Which of the two curves shown, the solid or the dashed line, represents a strong electrolyte? Justify your choice. [1]
II. Why can Λ°_m for a weak electrolyte like acetic acid not be obtained by extrapolating its own Λ_m vs $\sqrt{c}$ plot?

OR

State Kohlrausch's law of independent migration of ions. [1]
III. Using Kohlrausch's law, write the expression to calculate $\Lambda^\circ_m(CH_3COOH)$ from $\Lambda^\circ_m(HCl)$, $\Lambda^\circ_m(CH_3COONa)$, and $\Lambda^\circ_m(NaCl)$. [2]

30. Read the passage given below and answer the questions that follow: [4]

Proteins are polymers of α-amino acids linked by peptide bonds. Their biological function depends critically on their three-dimensional shape, which arises from four levels of structural organisation: primary (sequence of amino acids), secondary (regular folding patterns such as the α-helix and β-pleated sheet held by hydrogen bonding), tertiary (overall three-dimensional folding of a single polypeptide chain), and quaternary (arrangement of two or more polypeptide chains, as in haemoglobin). Any physical or chemical agent that disrupts the hydrogen bonds and other weak interactions stabilising these higher-order structures - such as heat, strong acid or base, or heavy metal ions - causes the protein to lose its native shape, a process called denaturation, usually accompanied by loss of biological activity.

I. What is meant by the primary structure of a protein?

OR

Name the type of bond that links successive amino acids in a protein chain. [1]
II. Why does boiling an egg cause the egg white to turn from a translucent liquid to an opaque solid? [1]
III. Explain why a denatured protein usually loses its biological (e.g. enzymatic) activity even though its primary structure (amino acid sequence) remains unchanged. [2]

SECTION E

Question numbers 31 to 33 are long answer questions carrying 5 marks each.

31. Attempt either (A) or (B). [5]

(A)

I. Write the IUPAC name and structure of the product formed when propan-2-ol is treated with conc. H_2SO_4 at 443 K.
II. Arrange the following in increasing order of their boiling points, giving a reason: propan-1-ol, propane, propanal.
III. Convert phenol to salicylaldehyde (Reimer-Tiemann reaction).
IV. How is picric acid (2,4,6-trinitrophenol) prepared from phenol?
V. Give a chemical test to distinguish between phenol and benzoic acid.

OR

(B)

I. Write the mechanism of acid-catalysed dehydration of ethanol to ethene.
II. Arrange the following in increasing order of acidity, giving a reason: phenol, ethanol, p-cresol.
III. Convert benzene to phenol (any two-step or more route).
IV. How is aspirin prepared from salicylic acid?
V. Give a chemical test to distinguish between primary and tertiary alcohols (Lucas test).

32. Attempt either (A) or (B). [5]

(A)

I. What are essential and non-essential amino acids? Give one example of each.
II. Name the two types of nucleic acids and state one structural difference between them.
III. What is the role of insulin in the human body, and what disease results from its deficiency?
IV. Distinguish between fibrous and globular proteins on the basis of shape and solubility.
V. Name the vitamin whose deficiency causes beri-beri, and state one natural source of it.

OR

(B)

I. What is meant by the term 'invert sugar'? Why is honey referred to as invert sugar?

II. Differentiate between DNA and RNA on the basis of the sugar and one nitrogenous base present.
III. Define the terms 'hormone' and give one example of a hormone that regulates blood glucose level.
IV. What is the difference between fibrous and globular proteins in terms of biological function, with one example of each?
V. Name the vitamin stored in the liver whose deficiency causes xerophthalmia (night blindness), and state one source.

33. Attempt either (A) or (B). [5]

(A)

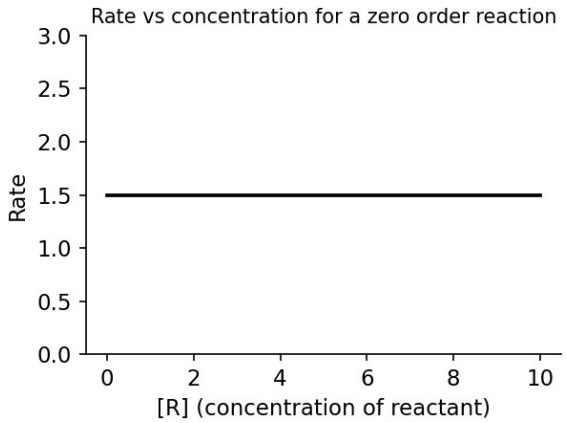
I. Derive the integrated rate equation for a first order reaction, clearly stating the assumptions and defining each term. [3]

II. For a reaction, the rate law is found to be Rate = $k[A][B]^2$. If the concentration of A is doubled and that of B is tripled, by what factor does the rate increase? [2]

OR

(B)

I. The decomposition of a certain reactant follows zero order kinetics with rate constant 2.0×10^{-2} mol L^{-1} s^{-1}. If the initial concentration of the reactant is 1.0 mol L^{-1}, calculate the time required for the reaction to go to completion, and the time taken for the concentration to reduce to 0.5 mol L^{-1}. [3]



II. From the graph of rate vs concentration shown, identify the order of the reaction and justify your answer. [2]

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SECTION A

1. (C) 3 – K_2SO_4 dissociates completely into $2K^+ + SO_4^{2-}$, giving i ≈ 3. [1]

2. (B) One – rate is directly proportional to $[A]^1$ (doubling concentration doubles rate; the four-fold data point is also consistent with first order, since $4^1 = 4$). [1]

3. (B) V_2O_5 – catalyses oxidation of SO_2 to SO_3 in the Contact Process. [1]

4. (C) 2 – tetrahedral complexes have very small crystal field splitting (Δt), so all four d-orbitals fill following Hund's rule for a d^8 ion, giving 2 unpaired electrons. [1]

5. (A) Methane – Grignard reagents react with compounds having active hydrogen (e.g. alcohols) via $CH_3MgBr + C_2H_5OH \rightarrow CH_4 + C_2H_5OMgBr$; the methane comes from the CH_3 group of the Grignard reagent. [1]

6. (C) 2-Methylpropan-2-ol – a tertiary alcohol forms a stable carbocation instantly with Lucas reagent (turbidity at once). [1]

7. (A) Tollens' reagent – benzaldehyde (an aldehyde) gives a silver mirror; acetophenone (a ketone) does not. [1]

8. (A) Acetanilide [1]

9. (B) Hydrogen bonds between complementary base pairs (A=T and G≡C) [1]

10. (C) Dry (Leclanché) cell – a primary cell; the reaction is not reversible. [1]

11. (A) –0.186 °C. $\Delta T_f = K_f \times m = 1.86 \times 0.1 = 0.186$ K, so freezing point = 0 – 0.186 = –0.186 °C. [1]

12. (A) Increases with dilution for all electrolytes (though the increase is gradual for strong electrolytes and sharp for weak electrolytes). [1]

13. (A) Both true, R is the correct explanation – since $E°(Cu^{2+}/Cu) > E°(H^+/H_2)$, Cu cannot reduce H^+ to H_2. [1]

14. (A) Both true, R is the correct explanation – although the second ionisation enthalpy of Cu is high, the much greater hydration enthalpy of the smaller, more highly charged Cu^{2+} ion more than compensates for it, making Cu^{2+} the thermodynamically more stable species in water. [1]

15. (A) Both true, R is the correct explanation – Grignard reagents are destroyed by even traces of moisture, forming the alkane R–H. [1]

16. (A) Both true, R is the correct explanation – hydrolysis of sucrose (specific rotation +66.5°) gives glucose (+52.5°) and fructose (–92°); the large negative rotation of fructose dominates, making the mixture net laevorotatory (invert sugar). [1]

SECTION B

17 (A). [2]

I. By Raoult's law: $(p° - p)/p° = n_2/n_1$ (dilute solution approximation) = $(w_2/M_2)/(w_1/M_1)$ $(42.0 - 41.4)/42.0 = (8.19/M_2)/(100/18)$ $0.0143 = (8.19 \times 18)/(100 \times M_2)$ $M_2 = (8.19 \times 18)/(100 \times 0.0143) \approx 103$ g mol^{-1} [1]

II. Gas solubility decreases with rising temperature (dissolution of a gas in a liquid is exothermic), so heating a solution provides energy that overcomes gas-liquid attractive forces, driving dissolved gas out of solution. [1]

OR (B)

I. Abnormal molar mass is the molar mass of a solute calculated from colligative property data that does not match its normal (expected) molar mass, occurring due to association or dissociation of solute particles in solution. The van't Hoff factor i is greater than 1 when the solute dissociates into more than one particle in solution (e.g. electrolytes). [1]

II. Some solvent molecules at the surface are replaced by non-volatile solute particles, which do not evaporate; this reduces the number of solvent molecules escaping into the vapour phase per unit time, lowering the vapour pressure relative to the pure solvent. [1]

18. [2]

Rate = (1/2)(d[C]/dt) is not correct here; using stoichiometry: Rate = −(1/2)(d[A]/dt) = −(d[B]/dt) = (d[C]/dt) (i) Rate of reaction = rate of appearance of C = 2.5×10^{-4} mol L^{-1} s^{-1} (ii) Rate of disappearance of A = 2 × rate of reaction = $2 \times 2.5 \times 10^{-4} = 5.0 \times 10^{-4}$ mol L^{-1} s^{-1}

19. [2]

I. Sc^{3+} has the configuration [Ar]$3d^0$ (no d electrons), so no d-d transition is possible, hence it is colourless in aqueous solution.

II. The $E°(M^{2+}/M)$ values depend on a combination of factors - enthalpy of atomisation (sublimation), ionisation enthalpy, and hydration enthalpy of M^{2+} - which do not vary uniformly across the series; irregularities (e.g. at Mn and Zn) arise from extra stability of half-filled/fully-filled d-subshells, so E° is not a smooth function of atomic number.

20. [2]

(a) With Na metal in dry ether (Wurtz-Fittig reaction with another haloalkane, e.g. CH_3Cl): chlorobenzene couples to give a substituted biphenyl/toluene-type product, e.g. $C_6H_5–CH_3$ (toluene) plus NaCl. (b) With Mg in dry ether: chlorobenzene forms phenylmagnesium chloride (C_6H_5MgCl), a Grignard reagent.

21. [2]

Formula: $K_3[Fe(CN)_6]$. Oxidation number of Fe: let $x + 6(-1) + 3(+1) = 0 \Rightarrow x - 6 + 3 = 0 \Rightarrow x = +3$, i.e. Fe(III).

SECTION C

22. [3]

(i) $t_{1/2} = 0.693/k = 0.693/(6.93 \times 10^{-3}) = 100$ min (ii) For first order, $t = (2.303/k) \log([A]_0/[A])$. At 90% completion, [A] = 10% of $[A]_0$, so $[A]_0/[A] = 10$, log 10 = 1. $t = (2.303/6.93\times10^{-3}) \times 1 \approx 332.3$ min

23. [3]

I. In $[Ni(CO)_4]$, CO is a strong field ligand causing pairing of all electrons in Ni(0) ($3d^{10}$ configuration already has no unpaired electrons, so it remains diamagnetic regardless); in $[NiCl_4]^{2-}$, Cl^- is a weak field ligand and in the tetrahedral geometry (small Δt) electrons remain unpaired (Ni^{2+}, d^8, 2 unpaired electrons), giving paramagnetism.

II. CN^- is a strong field ligand causing pairing of all electrons in Fe^{2+} (d^6) in the octahedral $[Fe(CN)_6]^{4-}$, giving zero unpaired electrons (diamagnetic); F^- is a weak field ligand and does not cause pairing in $[FeF_6]^{3-}$ (Fe^{3+}, d^5), leaving 5 unpaired electrons (paramagnetic).

III. SCN^- is an ambidentate ligand with two different donor atoms (S and N), so it can bind through either atom, giving linkage isomers. Cl^- has only one type of donor atom, so it cannot show linkage isomerism.

24. [3]

I. Add neutral $FeCl_3$ solution: phenol gives a violet/purple colouration; ethanol gives no colour change.

II. Add $AgNO_3$ solution: benzyl bromide (an alkyl halide, sp^3 C–Br) gives an immediate precipitate of AgBr on warming; bromobenzene (aryl halide, C–Br has partial double bond character) does not react under these mild conditions.

III. Add Lucas reagent (conc. $HCl/ZnCl_2$): propan-2-ol (secondary) gives turbidity within about 5 minutes; propan-1-ol (primary) shows no turbidity at room temperature (requires heating).

25. [3]

I. Cr^{2+} (d^4) is readily oxidised to Cr^{3+} (d^3), which has the extra stability of a half-filled t2g level, so Cr^{2+} is a strong reducing agent. Mn^{3+} (d^4) is readily reduced to Mn^{2+} (d^5), which has the extra stability of an exactly half-filled d-subshell, so Mn^{3+} is a strong oxidising agent.

II. Transition metals have strong metallic bonding involving both ns and (n−1)d electrons in the delocalised electron sea, leading to stronger interatomic attraction and hence high enthalpies of atomisation.

III. In lanthanoids, the 4f orbitals are deeply buried and well shielded, so the energy difference between oxidation states is large, favouring the common +3 state; in actinoids, the 5f, 6d, and 7s orbitals are comparable in energy, so electrons from more than one subshell can be involved in bonding, giving a much wider range of oxidation states.

26. [3]

A is phenol (C_6H_5OH): gives a violet colouration with neutral $FeCl_3$ (characteristic of phenols) and reacts with bromine water to give 2,4,6-tribromophenol as a white precipitate. Kolbe's reaction: $C_6H_5OH + NaOH \rightarrow C_6H_5ONa$; $C_6H_5ONa + CO_2$ (400 K, 4-7 atm) → sodium salicylate → (acidification, H^+) → B = salicylic acid (2-hydroxybenzoic acid), used as a preservative (and as the precursor of aspirin).

27. [3]

(Any three)

I. Propan-1-ol → (oxidation, PCC or $K_2Cr_2O_7/H^+$) → propanal → not applicable for this rearrangement directly; standard route: propan-1-ol → (dehydration, conc. H_2SO_4, 443 K) → propene → (Markovnikov addition of H_2O, dil. H_2SO_4) → propan-2-ol.

II. Phenol → (NaOH) → sodium phenoxide → (CH_3I, Williamson ether synthesis) → anisole ($C_6H_5OCH_3$).

III. Benzyl chloride ($C_6H_5CH_2Cl$) → (aq. NaOH, hydrolysis) → benzyl alcohol ($C_6H_5CH_2OH$).

IV. Ethanol → (dehydration, conc. H_2SO_4) → ethene → (Br_2, then alcoholic KOH × 2, or directly) → ethyne ($HC\equiv CH$) → ($NaNH_2$, then CH_3Br) → but-2-yne ($CH_3–C\equiv C–CH_3$).

28. [3]

I. Conductivity κ = cell constant / resistance = 1.29 / 100 = 0.0129 S cm^{-1} Molar conductivity $\Lambda m = \kappa \times 1000 / c$ (c in mol L^{-1}) = (0.0129 × 1000)/0.02 = 645 S cm^2 mol^{-1}

II. In a metallic conductor, conduction is by delocalised electrons, and conductivity decreases with rise in temperature (increased lattice vibrations impede electron flow). In an electrolytic conductor, conduction is by ions, and conductivity increases with rise in temperature (increased ionic mobility and, for weak electrolytes, increased dissociation).

III. $E_{cell} = E°_{cell} – (0.0591/2) \log([Zn^{2+}]/[Ag^+]^2)$

SECTION D

29. [4]

I. The solid line represents the strong electrolyte. Its molar conductivity is high even at higher concentrations and increases only gradually (near-linearly with √c) as concentration decreases, unlike the weak electrolyte's sharply rising dashed curve at low concentration. [1]

II. For a weak electrolyte, Λm rises very steeply as concentration approaches zero (because dissociation increases sharply on dilution), and the plot becomes essentially vertical near √c = 0, so it cannot be reliably extrapolated to obtain Λ°m.

OR: Kohlrausch's law of independent migration of ions states that the limiting molar conductivity of an electrolyte can be expressed as the sum of the individual contributions of its constituent ions, each ion migrating independently of the other and contributing a fixed value to the total molar conductivity, regardless of the nature of the other ion it is associated with. [1]

III. $\Lambda°m(CH_3COOH) = \Lambda°m(CH_3COONa) + \Lambda°m(HCl) – \Lambda°m(NaCl)$ [2]

30. [4]

I. The primary structure of a protein is the specific linear sequence in which the various amino acids are arranged, linked to one another through peptide bonds, in a polypeptide chain.

OR: A peptide bond (amide linkage, –CO–NH–). [1]

II. Boiling disrupts the hydrogen bonds and other weak interactions maintaining the native secondary/tertiary structure of the egg albumin protein, causing it to denature and its constituent polypeptide chains to unfold and aggregate/coagulate, which scatters light and makes the protein appear opaque and solid. [1]

III. The biological (e.g. enzymatic) activity of a protein depends on its precise three-dimensional shape, particularly the exact geometry of its active site, which is determined by its secondary and tertiary structure. Although denaturation does not break the peptide bonds of the primary structure (the amino acid sequence remains the same), it destroys the higher-order folding, so the active site's shape is lost and the protein can no longer perform its specific biological function. [2]

SECTION E

31 (A). [5]

I. Propan-2-ol with conc. H_2SO_4 at 443 K undergoes acid-catalysed dehydration to give propene ($CH_3–CH=CH_2$), IUPAC name prop-1-ene.

II. Increasing order of boiling points: propane < propanal < propan-1-ol. Propane has only weak van der Waals forces; propanal is polar (dipole-dipole interactions, higher boiling point than propane); propan-1-ol can additionally form intermolecular hydrogen bonds, giving it the highest boiling point.

III. Phenol → (NaOH) → sodium phenoxide → ($CHCl_3$ + NaOH, Reimer-Tiemann reaction, 340 K, then acidification) → salicylaldehyde (2-hydroxybenzaldehyde).

IV. Phenol is treated with concentrated HNO_3 (with dilute H_2SO_4) to introduce three $–NO_2$ groups at the 2, 4, and 6 positions, giving 2,4,6-trinitrophenol (picric acid); milder nitration (dilute HNO_3) followed by further nitration is typically used to control the reaction.

V. Add neutral $FeCl_3$ solution: phenol gives a violet/purple colouration; benzoic acid gives no such colouration (it may give a buff-coloured precipitate on prolonged reaction, but no violet colour).

OR (B)

I. Mechanism (E1): Step 1: protonation of –OH by H_2SO_4 to give an oxonium ion, $CH_3CH_2OH_2^+$. Step 2: loss of water to form a carbocation, $CH_3CH_2^+$. Step 3: loss of a β-hydrogen (by a base, e.g. HSO_4^-) to form the alkene, $CH_2=CH_2$, regenerating the H_2SO_4 catalyst.

II. Increasing acidity: ethanol < p-cresol < phenol. The phenoxide ion is resonance stabilised (more so than the p-cresol anion, since the electron-donating $–CH_3$ group in p-cresol destabilises the negative charge slightly through +I effect); ethanol's ethoxide ion has no such delocalisation and is the weakest acid of the three.

III. Benzene → (conc. H_2SO_4/SO_3, then fuse with NaOH, acidify) → phenol; alternatively, benzene → ($Cl_2/FeCl_3$) → chlorobenzene → (NaOH, 623 K, 300 atm, then acidify) → phenol.

IV. Salicylic acid + acetic anhydride (or CH_3COCl) in presence of a small amount of conc. H_2SO_4 → aspirin (acetylsalicylic acid) + acetic acid.

V. Add Lucas reagent (conc. HCl/anhydrous $ZnCl_2$): a tertiary alcohol gives turbidity immediately; a primary alcohol shows no turbidity at room temperature and requires heating to react.

32 (A). [5]

I. Essential amino acids cannot be synthesised by the body and must be obtained from the diet, e.g. valine. Non-essential amino acids can be synthesised by the body, e.g. glycine.

II. DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). DNA contains deoxyribose sugar and the base thymine; RNA contains ribose sugar and the base uracil in place of thymine.

III. Insulin is a peptide hormone that regulates the blood glucose (blood sugar) level by promoting glucose uptake into cells; its deficiency (or ineffective action) results in diabetes mellitus.

IV. Fibrous proteins have elongated, thread-like molecules with polypeptide chains lying parallel and held by hydrogen and disulphide bonds; they are generally insoluble in water (e.g. keratin, myosin). Globular

proteins have polypeptide chains folded into a compact spherical shape and are usually soluble in water (e.g. insulin, albumin).

V. Vitamin B_1 (thiamine); natural sources include whole grain cereals, pulses, and yeast.

OR (B)

I. Invert sugar is the equimolar mixture of glucose and fructose obtained on hydrolysis of sucrose, so called because the hydrolysis inverts the sign of optical rotation from dextrorotatory (sucrose) to laevorotatory (the mixture). Honey largely consists of this glucose-fructose mixture (formed naturally by inversion of nectar sugars), so it is called invert sugar.

II. DNA contains deoxyribose sugar and the base thymine; RNA contains ribose sugar and the base uracil (in place of thymine).

III. A hormone is a chemical messenger secreted directly into the bloodstream by an endocrine gland, which regulates the activity of specific target cells/organs. Insulin, secreted by the pancreas, regulates blood glucose level.

IV. Fibrous proteins mainly perform structural roles (e.g. keratin in hair/nails, providing mechanical strength); globular proteins perform dynamic biological functions such as catalysis and transport (e.g. haemoglobin, which transports oxygen).

V. Vitamin A (retinol), stored in the liver; sources include carrots, milk, and fish liver oil.

33 (A). [5]

I. For a first order reaction A → Products, rate = $-d[A]/dt = k[A]$. Rearranging: $d[A]/[A] = -k\,dt$. Integrating between t=0 ($[A]=[A]_o$) and t=t ($[A]=[A]$): $\ln[A] - \ln[A]_o = -kt \Rightarrow \ln([A]_o/[A]) = kt \Rightarrow k = (2.303/t)\log([A]_o/[A])$ where k is the rate constant, t is time, $[A]_o$ is the initial concentration, and [A] is the concentration remaining at time t. This assumes the reaction strictly follows first order kinetics throughout, with rate depending only on the first power of [A]. [3]

II. New rate = $k[2A][3B]^2 = k \times 2[A] \times 9[B]^2 = 18 \times k[A][B]^2$. The rate increases 18-fold. [2]

OR (B)

I. For zero order kinetics, $[A] = [A]_o - kt$. Time for completion ([A] = 0): $t = [A]_o/k = 1.0/(2.0\times10^{-2}) = 50$ s. Time for [A] to fall to 0.5 mol L^{-1}: $t = ([A]_o - [A])/k = (1.0 - 0.5)/(2.0\times10^{-2}) = 25$ s. [3]

II. The graph shows rate remaining constant (a horizontal line) as concentration changes, which is characteristic of a zero order reaction, since rate = $k[R]^0 = k$, independent of the concentration of the reactant. [2]