CHEMISTRY (CODE - 043)
SAMPLE PAPER 1
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. Which of the following pairs of liquids shows positive deviation from Raoult's law?

(A) Chloroform and acetone

(B) Nitric acid and water

(C) Ethanol and acetone

(D) Acetic acid and pyridine

2. The unit of the rate constant for a zero order reaction is:

(A) $mol\ L^{-1}\ s^{-1}$

(B) $L\ mol^{-1}\ s^{-1}$

(C) s^{-1}

(D) $mol^{-2}\ L^{2}\ s^{-1}$

3. Which of the following ions is diamagnetic?

(A) La^{3+}

(B) Ce^{3+}

(C) Pr^{3+}

(D) Nd^{3+}

4. The IUPAC name of $[Co(NH_3)_5Cl]Cl_2$ is:

(A) Pentaamminechloridocobalt(III) chloride

(B) Pentaamminechloridocobalt(II) chloride

(C) Chloridopentaamminecobalt(III) chloride

(D) Pentaamminechloridocobaltate(III) chloride

5. Which of the following haloalkanes reacts fastest by the S_n1 mechanism?

(A) CH_3Cl

(B) $(CH_3)_3C–Cl$

(C) CH_3CH_2Cl

(D) $CH_3CH_2CH_2Cl$

6. Anisole on reaction with excess HI gives:

(A) Phenol and CH_3I

(B) Iodobenzene and CH_3OH

(C) Phenol and CH_3OH

(D) Iodobenzene and CH_3I

7. Which of the following does NOT give a positive iodoform test?

(A) Ethanol

(B) Propan-2-ol

(C) Acetaldehyde

(D) Methanol

8. Among the following, which is the most basic in aqueous solution?

(A) Methylamine

(B) Dimethylamine

(C) Trimethylamine

(D) Aniline

9. Which of the following is a reducing sugar?

(A) Sucrose

(B) Maltose

(C) Both sucrose and maltose

(D) Neither sucrose nor maltose

10. The strength of an oxidising agent is best measured in terms of its:

(A) Standard electrode (reduction) potential

(B) Ionisation enthalpy

(C) Electronegativity

(D) Atomic radius

11. A 5% (by mass) aqueous solution of cane sugar (molar mass 342 g mol^{-1}) is isotonic with a 1% (by mass) solution of solute X. The molar mass of X is:

(A) 34.2 g mol^{-1}

(B) 68.4 g mol^{-1}

(C) 171 g mol^{-1}

(D) 17.1 g mol^{-1}

12. Given $E°(Zn^{2+}/Zn) = -0.76$ V and $E°(Cu^{2+}/Cu) = +0.34$ V, the standard EMF of the cell $Zn(s) \mid Zn^{2+}(aq) \mid\mid Cu^{2+}(aq) \mid Cu(s)$ is:

(A) 0.42 V

(B) 1.10 V

(C) −1.10 V

(D) 0.76 V

13. Assertion (A): The rate of a chemical reaction increases with an increase in temperature. Reason (R): At higher temperature, the activation energy of the reaction decreases.

(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): d-Block elements exhibit a wide range of variable oxidation states. Reason (R): The energy difference between the (n−1)d and ns orbitals in these elements is very small.

(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): Aniline does not undergo the Friedel-Crafts reaction. Reason (R): Aniline is a stronger base than ammonia.

(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 true but R is false because aniline is in fact a weaker base than ammonia.

16. Assertion (A): Glucose does not readily form a bisulphite addition product. Reason (R): In its stable form, glucose exists predominantly as a cyclic hemiacetal rather than an open-chain aldehyde.

(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. Out of chlorobenzene and cyclohexyl chloride, which one undergoes hydrolysis faster and why? [1]

II. Write the IUPAC name of $CH_3–CHCl–CH_2–CH_3$. [1]

OR

(B)

I. Why is potassium iodide solution added while preparing an aqueous solution of iodine? [1]

II. Write the major product formed when chlorobenzene reacts with Cl_2 in the presence of anhydrous $AlCl_3$. [1]

18. Calculate the quantity of electricity (in coulombs) required to reduce 12.3 g of nitrobenzene completely to aniline, assuming only 60% current efficiency. (Molar mass of nitrobenzene = 123 g mol^{-1}; 6 electrons are required per molecule of nitrobenzene reduced.) [2]

19. Give reasons for the following: [2]

I. Zn^{2+} salts are white whereas Cu^{2+} salts are coloured.

II. Actinoid contraction is greater from element to element than lanthanoid contraction.

20. Arrange the following in increasing order of their reactivity towards the S_n2 mechanism, giving a brief reason: CH_3Br, $(CH_3)_3CBr$, CH_3CH_2Br [2]

21. Define the following terms, giving one example of each: [2]

I. Chelating ligand

II. Ambidentate ligand

SECTION C

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

22. A first order reaction has a rate constant of 2.5×10^{-4} s^{-1}. Calculate the time required for the reaction to reach 75% completion. (Given: log 4 = 0.602) [3]

23. Write the formulas of the following coordination compounds: [3]

I. Tetraamminediaquacobalt(III) chloride

II. Potassium tetracyanidonickelate(II)

III. Hexaamminechromium(III) chloride

24. Explain the following observations: [3]

I. Phenol is more acidic than ethanol.
II. tert-Butyl alcohol reacts with Lucas reagent (conc. $HCl/ZnCl_2$) much faster than n-butyl alcohol.
III. o-Nitrophenol is more volatile (steam-volatile) than p-nitrophenol.

25. Account for the following: [3]

I. Transition metals and their compounds are frequently used as catalysts.
II. The E° value for Mn^{3+}/Mn^{2+} is much more positive than that for Cr^{3+}/Cr^{2+}.
III. Zirconium and hafnium have almost identical atomic radii despite belonging to different periods.

26. An organic compound A (molecular formula C_4H_8O) does not reduce Tollens' reagent, gives a positive iodoform test, and forms an addition product with $NaHSO_3$. Identify A, draw its structure, and write the equation for its reaction with 2,4-dinitrophenylhydrazine. [3]

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

I. Aniline to N-phenylethanamide (acetanilide)
II. Benzonitrile to benzylamine
III. Ethanamine to methanamine
IV. Aniline to phenol

28. Answer the following: [3]

I. Calculate the EMF of the cell Mg(s) | Mg^{2+}(0.001 M) || Cu^{2+}(0.0001 M) | Cu(s) at 298 K, given E°cell = 2.71 V.
II. Why does the conductivity of an electrolytic solution decrease on dilution while its molar conductivity increases?
III. Write the Nernst equation for the cell Ni(s) | Ni^{2+}(aq) || Ag^{+}(aq) | Ag(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]

Fuel cells are galvanic cells in which the reactants are continuously supplied from outside to the electrodes, and the products are continuously removed, allowing the cell to produce electrical energy for as long as reactants are fed in. The hydrogen-oxygen fuel cell is widely used to provide electrical power in spacecraft, and its by-product, water, can be used for drinking. In this cell, hydrogen gas is bubbled through a porous carbon electrode into a concentrated aqueous solution of NaOH or KOH, and oxygen gas is bubbled through a similar electrode. The overall efficiency of a fuel cell (about 70%) is much higher than that of a thermal power plant (about 40%), because a fuel cell converts chemical energy directly into electrical energy, without the intermediate step of generating heat.

I. Write the half-cell reactions occurring at the anode and cathode of the hydrogen-oxygen fuel cell in alkaline medium. [2]
II. Why is the efficiency of a hydrogen-oxygen fuel cell much higher than that of a thermal power plant?

OR

What advantage does a fuel cell offer over a conventional dry cell for continuous use? [1]
III. Suggest one reason why fuel cells are considered more environmentally friendly than fossil-fuel-based power generation. [1]

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

Enzymes are biological catalysts that are highly specific in their action, catalysing only a particular reaction or a class of related reactions. A given enzyme generally works best within a narrow range of temperature and pH, called its optimum temperature and optimum pH. Deviation from these optimum conditions can reduce enzyme activity or, in severe cases, denature the enzyme irreversibly, destroying its catalytic activity. Vitamins, on the other hand, are organic compounds required in small quantities in the diet to perform specific biological functions; many act as coenzymes, assisting enzymes in their catalytic role. A deficiency of a specific vitamin in the diet leads to a characteristic deficiency disease.

I. Why does the activity of an enzyme fall sharply if the temperature is raised well above its optimum value?

OR

What is meant by the term 'optimum pH' of an enzyme? [1]

II. Name the vitamin whose deficiency causes each of the following: (a) Night blindness (b) Scurvy [1]

III. A patient complains of bleeding gums and slow wound healing. Identify the likely vitamin deficiency and name two dietary sources that could help. [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 structure of the product formed in the Cannizzaro reaction of 4-chlorobenzaldehyde.

II. How does the presence of a $-NO_2$ group affect the basicity of aniline? Explain briefly.

III. Convert propanoic acid to ethanamine.

IV. Write the steps involved in the preparation of benzamide from benzoyl chloride.

V. Give a chemical test to distinguish between propanal and propanone.

OR

(B)

I. Write the structure of the product formed in the Wolff-Kishner reduction of butan-2-one.

II. How does the presence of a $-NO_2$ group affect the acidity of benzoic acid? Explain briefly.

III. Convert ethanamine to ethanoic acid.

IV. Convert aniline to benzenediazonium chloride, and then to phenol.

V. Give a chemical test to distinguish between benzaldehyde and acetophenone.

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

(A)

I. Identify and give one point of difference between the protein present in hair (keratin) and the protein present in egg white (albumin).

II. Both glucose and sucrose contain no free aldehyde group in sucrose's case; explain why glucose reduces Fehling's reagent but sucrose does not.

III. Why do amino acids exist as zwitterions and behave like salts?

IV. What structural change occurs in milk protein during curdling?

V. A patient is advised more sunlight exposure along with eggs and fish in the diet. Which deficiency disease is most likely being addressed?

OR

(B)

I. Identify and give one point of difference between the carbohydrate present in milk (lactose) and the carbohydrate present in cane sugar (sucrose).

II. Glucose is an aldohexose. Name a mild oxidising agent that oxidises only its aldehydic group without affecting the rest of the molecule.

III. For the amino acid $HOOC-CH_2-CH(NH_2)-COOH$, predict whether its aqueous solution will have pH >7, =7, or <7. Justify.

IV. Name the two major types of secondary structures found in proteins.

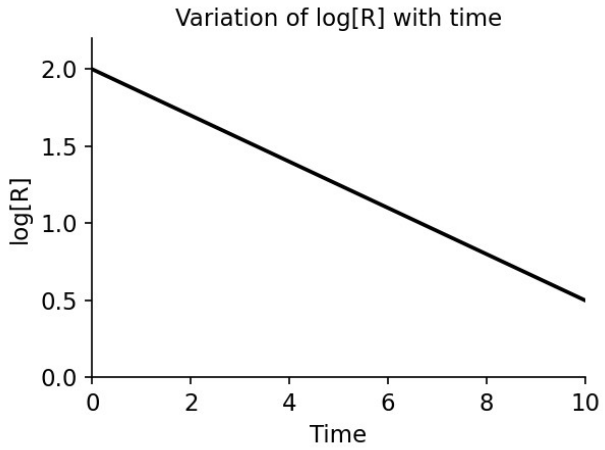
V. A patient shows frequent bleeding gums and is diagnosed with scurvy. Suggest two dietary sources that would help in recovery.

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

(A)

I. The rate constant of a reaction doubles when the temperature rises from 300 K to 310 K. Calculate the energy of activation of the reaction, assuming it does not vary with temperature. (Given $R = 8.314\ J\ K^{-1}\ mol^{-1}$, $\log 2 = 0.301$) [3]

II. Identify the order of the reaction from the graph shown below and write its integrated rate equation, explaining each term. [2]



OR

(B)

I. Consider the first order thermal decomposition of N_2O_5 at constant volume: $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$. If the total pressure of the gases is found to be 250 torr after 20 seconds, and 350 torr upon complete decomposition of N_2O_5, calculate the rate constant. (Given log 3.5 = 0.544, log 2 = 0.301) [3]

II. For a bimolecular elementary reaction A + B → Products, write the Arrhenius expression relating the rate constant to temperature and activation energy, and explain each term. [2]

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SECTION A

1. (C) Ethanol and acetone – disrupts H-bonding of ethanol, weaker A-B interactions than A-A/B-B, hence positive deviation. [1]

2. (A) mol L^{-1} s^{-1} [1]

3. (A) La^{3+} – electronic configuration [Xe]$4f^0$, no unpaired electrons. [1]

4. (A) Pentaamminechloridocobalt(III) chloride [1]

5. (B) $(CH_3)_3C–Cl$ – tertiary carbocation formed is most stable, favouring S_N1. [1]

6. (A) Phenol and CH_3I – nucleophilic attack of I^- occurs at the less hindered CH_3 carbon (SN2). [1]

7. (D) Methanol – lacks a $CH_3CO–$ or $CH_3CH(OH)–$ group. [1]

8. (B) Dimethylamine – optimum balance of +I effect, steric hindrance, and solvation (H-bonding) in water. [1]

9. (B) Maltose – has a free anomeric –OH/potential free aldehyde carbon; sucrose has none (both anomeric carbons involved in glycosidic bond). [1]

10. (A) Standard electrode (reduction) potential [1]

11. (B) 68.4 g mol^{-1}. Isotonic ⇒ equal molar concentration: 5/342 = 1/M ⇒ M = 342/5 = 68.4 g mol^{-1} [1]

12. (B) 1.10 V. $E°_{cell} = E°_{cathode} – E°_{anode} = 0.34 – (–0.76) = 1.10$ V [1]

13. (C) A is true but R is false – rate increases with temperature because a larger fraction of molecules acquire energy ≥ Ea (per Arrhenius), not because Ea itself decreases. [1]

14. (A) Both true, R is the correct explanation – small energy gap allows electrons to be lost from both ns and (n–1)d, giving variable oxidation states. [1]

15. (D) A is true but R is false – aniline is actually a weaker base than ammonia (lone pair delocalised into the ring); the true reason for A is that $AlCl_3$ (Lewis acid) forms a complex with the $–NH_2$ lone pair, deactivating the ring. [1]

16. (A) Both true, R is the correct explanation – the cyclic hemiacetal form has no free –CHO group available for addition. [1]

SECTION B

17 (A). [2]

I. Cyclohexyl chloride hydrolyses faster. In chlorobenzene, the C–Cl bond has partial double bond character due to resonance (lone pair of Cl delocalised into the ring) and the carbon is sp^2 hybridised, both of which strengthen the C–Cl bond and hinder nucleophilic attack; cyclohexyl chloride has a normal sp^3 C–Cl bond. [1]

II. 2-Chlorobutane [1]

OR (B)

I. KI provides I^- ions which combine with I_2 to form the soluble triiodide ion (I_3^-), since I_2 itself is only sparingly soluble in water. [1]

II. p-Dichlorobenzene (with some o-dichlorobenzene) – electrophilic aromatic substitution directed by the o,p-directing Cl already present. [1]

18. [2]

Moles of nitrobenzene = 12.3/123 = 0.1 mol. Charge required (100% efficiency) = 0.1 × 6 × 96500 = 57,900 C. At 60% current efficiency, actual charge required = 57,900/0.60 = 96,500 C (approx. 9.65×10^4 C).

19. [2]

I. Zn^{2+} has a fully filled $3d^{10}$ configuration; d-d transitions are not possible, so it is colourless (white salts). Cu^{2+} has a $3d^9$ configuration with an unpaired electron, allowing d-d transitions that absorb visible light, giving colour.

II. In actinoids, 5f orbitals are more diffuse and shielded less effectively than 4f orbitals in lanthanoids, so the effective nuclear charge experienced by outer electrons increases more sharply, causing greater contraction per element.

20. [2]

Increasing SN2 reactivity: $(CH_3)_3CBr < CH_3CH_2Br < CH_3Br$. SN2 reactivity decreases with increasing steric hindrance around the carbon bearing the leaving group; the tertiary substrate is most hindered (slowest) and methyl bromide, being least hindered, is fastest.

21. [2]

I. Chelating ligand: A di- or polydentate ligand that binds to the central metal ion through two or more donor atoms simultaneously, forming a ring (chelate). Example: ethane-1,2-diamine (en), $H_2N–CH_2–CH_2–NH_2$.

II. Ambidentate ligand: A ligand that has two different donor atoms but can coordinate to the metal through either one at a time. Example: NO_2^- (can bind through N as nitrito or through O as nitrito-O).

SECTION C

22. [3]

For a first order reaction: $t = (2.303/k) \log([A]_0/[A])$. At 75% completion, [A] = 25% of $[A]_0$, so $[A]_0/[A] = 4$. $t = (2.303 / 2.5\times10^{-4}) \times \log 4 = (2.303 / 2.5\times10^{-4}) \times 0.602 \approx 5548$ s (≈ 1.54 hours)

23. [3]

I. $[Co(NH_3)_4(H_2O)_2]Cl_3$

II. $K_2[Ni(CN)_4]$

III. $[Cr(NH_3)_6]Cl_3$

24. [3]

I. On loss of a proton, phenol forms the phenoxide ion, whose negative charge is delocalised into the benzene ring by resonance, stabilising it. The ethoxide ion from ethanol has no such resonance stabilisation, so phenol is a stronger acid.

II. Lucas reagent reacts by an SN1 mechanism via carbocation formation. tert-Butyl alcohol forms a stable tertiary carbocation rapidly (turbidity appears immediately), whereas n-butyl alcohol would need to form a much less stable primary carbocation, so it reacts far more slowly (needs heating).

III. In o-nitrophenol, intramolecular hydrogen bonding occurs between the –OH and adjacent $–NO_2$ group, so the molecules exist as discrete units with weaker net intermolecular association; in p-nitrophenol, only intermolecular H-bonding is possible, causing molecular association and a higher boiling point/lower volatility. Hence o-nitrophenol is more steam-volatile.

25. [3]

I. Transition metals show variable oxidation states, can form complexes with reactants, provide a large surface area (in the case of finely divided metals), and their d-orbitals allow them to donate/accept electrons easily, providing an alternative low energy pathway for reactions and hence catalytic activity.

II. Mn^{3+} ($3d^4$) is reduced to Mn^{2+} ($3d^5$), which has an extra stability due to the exactly half-filled d-subshell, making the reduction of Mn^{3+} very favourable and its E° highly positive. For Cr^{3+} ($3d^3$), reduction to Cr^{2+} ($3d^4$) does not give any comparable extra stability, so its E° is much less positive (in fact negative).

III. Due to lanthanoid contraction, the atomic radius of Hf (following the 14 lanthanoids) is almost the same as that of Zr immediately above it in the group, as the steady decrease in radii across the lanthanoid series almost exactly compensates for the expected increase on descending the group.

26. [3]

A is butan-2-one, $CH_3–CO–CH_2–CH_3$. It does not reduce Tollens' reagent because it is a ketone, not an aldehyde. It gives a positive iodoform test because it has a $CH_3CO–$ group attached to a carbon bearing at least one H. It also forms a bisulphite addition product typical of methyl ketones and aldehydes. Reaction with 2,4-DNP: $CH_3COCH_2CH_3 + H_2N–NH–C_6H_3(NO_2)_2 \rightarrow CH_3C(=N–NH–C_6H_3(NO_2)_2)CH_2CH_3 + H_2O$ (an orange-yellow 2,4-dinitrophenylhydrazone precipitate is formed).

27. [3]

(Any three)

I. Aniline + $(CH_3CO)_2O \rightarrow$ N-phenylethanamide (acetanilide) + CH_3COOH (acetylation, e.g. with acetic anhydride/pyridine).

II. Benzonitrile (C_6H_5CN) is reduced with $LiAlH_4$ (or H_2/Ni catalytic hydrogenation) to give benzylamine ($C_6H_5CH_2NH_2$).

III. Ethanamine ($CH_3CH_2NH_2$) → ($NaNO_2$/HCl, 273 K, diazotisation-hydrolysis) → ethanol (CH_3CH_2OH) → (oxidation, alkaline $KMnO_4$) → ethanoic acid (CH_3COOH) → (NH_3, Δ, then P_2O_5) → acetamide (CH_3CONH_2) → (Hofmann bromamide degradation, Br_2/NaOH) → methanamine (CH_3NH_2), since this degradation removes the carbonyl carbon and shortens the chain by one carbon.

IV. Aniline → ($NaNO_2$/HCl, 273-278K) → benzenediazonium chloride → (H_2O, warm/H^+) → phenol + N_2.

28. [3]

I. Ecell = E°cell – (0.0591/n) log($[Mg^{2+}]/[Cu^{2+}]$); n = 2 Ecell = 2.71 – (0.0591/2) log(0.001/0.0001) = 2.71 – (0.02955)(1) = 2.71 – 0.0296 ≈ 2.68 V

II. On dilution, the number of ions per unit volume decreases, so conductivity (κ) decreases. However, molar conductivity (Λm) is conductivity per mole of electrolyte present, and on dilution the degree of dissociation (for weak electrolytes) or the ionic mobility (for strong electrolytes, due to reduced inter-ionic attraction) increases enough that Λm increases despite κ falling.

III. For Ni(s) | Ni^{2+}(aq) || Ag^+(aq) | Ag(s), the cell reaction is Ni(s) + $2Ag^+$(aq) → Ni^{2+}(aq) + 2Ag(s), n = 2. Ecell = E°cell – (0.0591/2) log($[Ni^{2+}]/[Ag^+]^2$)

SECTION D

29. [4]

I. Cathode (reduction): $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ Anode (oxidation): $2H_2(g) + 4OH^-(aq) \rightarrow 4H_2O(l) + 4e^-$ [2]

II. Because a fuel cell converts the chemical energy of the fuel directly into electrical energy in a single step, avoiding the heat-engine intermediate step (with its inherent Carnot-type thermodynamic losses) that a thermal power plant must go through.

OR: A fuel cell can operate continuously as long as fuel (H_2 and O_2) is supplied, without needing recharging or replacement of electrodes, unlike a dry cell whose reactants are consumed and cannot be replenished. [1]

III. Fuel cells produce only water as a by-product (no CO_2, SO_2, or particulate emissions), so they do not contribute to air pollution or greenhouse gas emissions the way fossil-fuel combustion does. [1]

30. [4]

I. At temperatures well above the optimum, the enzyme (a protein) begins to denature – its tertiary/secondary structure unfolds as hydrogen bonds and other weak interactions holding its specific shape are disrupted. Since enzyme action depends on the precise shape of its active site, denaturation destroys catalytic activity.

OR: Optimum pH is the pH at which an enzyme shows its maximum catalytic activity; activity falls off on either side of this value. [1]

II. (a) Night blindness – Vitamin A. (b) Scurvy – Vitamin C. [1]

III. Likely deficiency: Vitamin C (ascorbic acid), which causes scurvy (bleeding gums, poor wound healing). Dietary sources: citrus fruits (e.g. amla, orange, lemon) and fresh leafy vegetables/guava. [2]

SECTION E

31 (A). [5]

I. Cannizzaro reaction of an aldehyde with no α-hydrogen (4-chlorobenzaldehyde) gives, on treatment with concentrated NaOH, a mixture of 4-chlorobenzyl alcohol (4-Cl-C_6H_4-CH_2OH) and sodium 4-chlorobenzoate (4-Cl-C_6H_4-COONa), by disproportionation (one molecule reduced, one oxidised).

II. A $-NO_2$ group is strongly electron-withdrawing (by both –I and resonance). When present on the ring (especially at o/p positions) it reduces electron density on the $-NH_2$ nitrogen, making the lone pair less available for protonation, and it also delocalises the lone pair further into the ring; hence a nitro-substituted aniline is a much weaker base than aniline itself.

III. Propanoic acid (CH_3CH_2COOH) → (NH_3, Δ then P_2O_5) → propanamide ($CH_3CH_2CONH_2$) → (Hofmann bromamide degradation, Br_2/NaOH) → ethanamine ($CH_3CH_2NH_2$); this degradation removes the carbonyl carbon, shortening the chain by one carbon.

IV. Benzoyl chloride (C_6H_5COCl) + excess NH_3 → benzamide ($C_6H_5CONH_2$) + NH_4Cl.

V. Add Tollens' reagent (ammoniacal $AgNO_3$) to both and warm: propanal (an aldehyde) gives a bright silver mirror; propanone (a ketone) gives no reaction.

OR (B)

I. Wolff-Kishner reduction of butan-2-one ($CH_3COCH_2CH_3$) with NH_2NH_2/KOH-ethylene glycol reduces the C=O to CH_2, giving butane ($CH_3CH_2CH_2CH_3$).

II. A $-NO_2$ group is electron-withdrawing; when substituted on benzoic acid (especially at o/p) it stabilises the conjugate base (benzoate ion) by withdrawing electron density and delocalisation, thereby increasing acidity relative to benzoic acid.

III. Ethanamine ($CH_3CH_2NH_2$) → ($NaNO_2$/HCl, 273 K, diazotisation followed by hydrolysis of the unstable aliphatic diazonium salt) → ethanol (CH_3CH_2OH) → (oxidation with acidified $KMnO_4$ or $K_2Cr_2O_7$) → ethanoic acid (CH_3COOH).

IV. Aniline → ($NaNO_2$/HCl, 273-278 K) → benzenediazonium chloride → (warm with H_2O/H^+) → phenol.

V. Add Tollens' reagent to both and warm: benzaldehyde gives a silver mirror (positive test); acetophenone (a ketone) does not.

32 (A). [5]

I. Keratin (hair) is a fibrous protein, insoluble in water, with polypeptide chains held in an α-helix stabilised by hydrogen bonds and disulphide linkages; albumin (egg white) is a globular protein, water-soluble, with the polypeptide chain folded into a compact spherical shape.

II. Sucrose is a non-reducing sugar because both its anomeric carbons (C1 of glucose and C2 of fructose) are involved in the glycosidic bond, leaving no free aldehyde/hemiacetal group to reduce Fehling's reagent. Glucose retains a free (masked but interconvertible) aldehyde group in its open-chain form, so it reduces Fehling's reagent.

III. Amino acids contain both a basic $-NH_2$ group and an acidic –COOH group in the same molecule. In aqueous/solid state, the –COOH proton is transferred internally to the $-NH_2$ group, giving a dipolar zwitterion ($^+H_3N–CHR–COO^-$), which behaves like a salt (high melting point, water solubility, existing as ions).

IV. Curdling of milk is caused by denaturation and coagulation of milk protein (casein), where its secondary and tertiary structure unfolds (e.g. due to acid or bacterial fermentation), causing it to precipitate out.

V. Vitamin D deficiency (rickets in children / osteomalacia in adults) – sunlight aids the body's synthesis of vitamin D, and fish/egg yolk are rich dietary sources.

OR (B)

I. Lactose (milk sugar) is a disaccharide of glucose and galactose linked by a β-1,4-glycosidic bond and is a reducing sugar (has a free anomeric OH); sucrose (cane sugar) is a disaccharide of glucose and fructose and is a non-reducing sugar (both anomeric carbons involved in the glycosidic linkage).

II. Bromine water (Br_2/H_2O) selectively oxidises only the aldehydic (–CHO) group of glucose to a –COOH group (giving gluconic acid) without affecting the –OH groups.

III. $HOOC–CH_2–CH(NH_2)–COOH$ (aspartic acid) has two –COOH groups and only one $–NH_2$ group, so its solution will be acidic, i.e. pH < 7.

IV. α-helix and β-pleated sheet.

V. Vitamin C rich sources: citrus fruits (orange, lemon, amla) and fresh green leafy vegetables/guava.

33 (A). [5]

I. Using the Arrhenius equation: $\log(k_2/k_1) = [Ea/2.303R] \times (1/T_1 - 1/T_2)$ $T_1 = 300$ K, $T_2 = 310$ K, $k_2/k_1 = 2$, so $\log 2 = 0.301$ $1/T_1 - 1/T_2 = 1/300 - 1/310 = 10/93000 = 1.075 \times 10^{-4}$ K^{-1} $0.301 = [Ea / (2.303 \times 8.314)] \times 1.075 \times 10^{-4}$ $0.301 = [Ea / 19.15] \times 1.075 \times 10^{-4}$ $Ea = (0.301 \times 19.15) / (1.075 \times 10^{-4}) \approx 53{,}600$ J $mol^{-1} \approx 53.6$ kJ mol^{-1} [3]

II. A straight line is obtained on plotting log[R] against time, which is characteristic of a first order reaction. Its integrated rate equation is $k = (2.303/t) \log([R]_0/[R])$, where k is the rate constant, t is time, $[R]_0$ is the initial concentration of reactant, and [R] is the concentration remaining at time t. [2]

OR (B)

I. $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$. Let initial pressure of $N_2O_5 = P_0$. On complete decomposition, 2 mol N_2O_5 gives 5 mol of gaseous products (4 NO_2 + 1 O_2), so total final pressure = $2.5P_0 = 350$ torr, giving $P_0 = 140$ torr. At t = 20 s, let x torr of N_2O_5 have decomposed. Total pressure = $(P_0 - x) + 2x + x/2 = P_0 + 1.5x = 250$ torr $\Rightarrow 1.5x = 110 \Rightarrow x = 73.3$ torr $P(N_2O_5)$ remaining = $P_0 - x = 140 - 73.3 = 66.7$ torr $k = (2.303/t) \log(P_0/P) = (2.303/20) \times \log(140/66.7) = (2.303/20) \times \log(2.1) = (2.303/20)(0.322) \approx 0.0371$ s^{-1} [3]

II. k = A e^(–Ea/RT), where k is the rate constant, A is the Arrhenius (pre-exponential/frequency) factor related to the frequency of effective collisions, Ea is the activation energy, R is the gas constant, and T is the absolute temperature. [2]