CHEMISTRY (CODE - 043)
SAMPLE PAPER 3
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 osmotic pressure of a solution is given by the expression $\pi = CRT$, where C represents:

(A) Molality of the solution

(B) Molarity of the solution

(C) Mole fraction of solute

(D) Mass percentage of solute

2. The half-life of a first order reaction is 69.3 seconds. Its rate constant is:

(A) 0.01 s^{-1}

(B) 0.1 s^{-1}

(C) 1.0 s^{-1}

(D) 10 s^{-1}

3. Which of the following is NOT a characteristic property of transition elements?

(A) Formation of coloured ions

(B) Variable oxidation states

(C) Diamagnetic behaviour in the elemental state

(D) Catalytic activity

4. The oxidation state of chromium in $K_2Cr_2O_7$ is:

(A) +3

(B) +6

(C) +2

(D) +7

5. Identify the correct order of decreasing dipole moment: chlorobenzene, chloromethane, dichloromethane.

(A) Dichloromethane > chloromethane > chlorobenzene

(B) Chlorobenzene > chloromethane > dichloromethane

(C) Chloromethane > dichloromethane > chlorobenzene

(D) Chlorobenzene > dichloromethane > chloromethane

6. Ethers are relatively unreactive compared to alcohols mainly because:

(A) They lack a polar C–O bond

(B) They have no lone pairs on oxygen

(C) The C–O bond in ethers is difficult to break under normal conditions

(D) They are strongly acidic

7. Which of the following will react with Grignard reagent to give a tertiary alcohol?

(A) Formaldehyde

(B) Any aldehyde

(C) A ketone

(D) Carbon dioxide

8. The Gabriel phthalimide synthesis is used to prepare:

(A) Pure secondary amines

(B) Pure primary aliphatic amines

(C) Aromatic primary amines

(D) Tertiary amines

9. Which of the following is a homopolymer among biomolecules?

(A) Starch

(B) Protein

(C) Nucleic acid

(D) None of these

10. In the electrolytic refining of copper, the anode used is:

(A) Pure copper

(B) Impure copper

(C) Graphite

(D) Platinum

11. Which of the following aqueous solutions will have the highest boiling point (assume equal molal concentration and complete dissociation where applicable)?

(A) Glucose (0.1 m)

(B) NaCl (0.1 m)

(C) $BaCl_2$ (0.1 m)

(D) Urea (0.1 m)

12. The standard EMF of a cell is related to the equilibrium constant K of the cell reaction by:

(A) $E^\circ = (RT/nF) \ln K$

(B) $E^\circ = -(RT/nF) \ln K$

(C) $K = E^\circ/nF$

(D) $E^\circ = nF \ln K$

13. Assertion (A): Zinc has the lowest enthalpy of atomisation among the first-row transition metals. Reason (R): Zinc has a completely filled $3d^{10}\ 4s^2$ configuration, leaving no unpaired d-electrons available for metallic bonding.

(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): Ethylamine is more basic than aniline. Reason (R): In aniline, the lone pair on nitrogen is delocalised into the benzene ring by resonance, reducing its availability for protonation.

(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): Freezing point depression is a colligative property. Reason (R): It depends only on the number of solute particles present, not on their chemical identity.

(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): Vitamin C cannot be stored in the body and must be supplied regularly through diet. Reason (R): Vitamin C is a fat-soluble vitamin and is excreted rapidly through faeces.

(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. Calculate the osmotic pressure of a solution prepared by dissolving 1.0 g of a non-electrolyte solute (molar mass 60 g mol^{-1}) in 500 mL of solution at 300 K. (R = 0.0821 L atm K^{-1} mol^{-1}) [1]

II. What is meant by a hypertonic solution? [1]

OR

(B)

I. Why is the observed molar mass of ethanoic acid in benzene almost double its normal value? [1]

II. State Raoult's law for a solution of a volatile solute in a volatile solvent. [1]

18. The rate of a reaction A + B → C is given by Rate = k[A][B]. If the concentration of A is kept constant and that of B is doubled, how does the rate change? Also, state the overall order of the reaction. [2]

19. Give reasons for the following: [2]

I. Transition metal ions are generally paramagnetic.

II. Among the lanthanoids, Ce^{3+} is easily oxidised to Ce^{4+}.

20. Write the structures of the major organic product(s) formed when 2-bromopropane is treated with (i) alcoholic KOH, and (ii) aqueous KOH. [2]

21. Give the IUPAC name of $[Pt(NH_3)_2Cl_2]$ and state the type of isomerism it can show, along with the name of one such isomer. [2]

SECTION C

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

22. The rate constant for the decomposition of a certain reactant is 3.0×10^{-5} s^{-1} at 300 K. Calculate (i) the half-life of the reaction, and (ii) the fraction of reactant remaining after 10 hours. [3]

23. Using Werner's theory, explain the bonding in $[Co(NH_3)_6]Cl_3$. In your answer, state the coordination number of cobalt, distinguish between the primary and secondary valences, and identify the ligand(s) present. [3]

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

I. Aniline and N-methylaniline
II. Ethylamine and diethylamine (Hinsberg's test)
III. Acetaldehyde and acetone

25. Account for the following: [3]

I. The $E°(M^{3+}/M^{2+})$ value for europium (Eu) is more negative than expected for its position in the lanthanoid series.
II. Interstitial compounds formed by transition metals are hard and have high melting points.
III. Actinoids show a greater tendency to form complexes than lanthanoids.

26. A carboxylic acid A ($C_2H_4O_2$) reacts with ethanol in the presence of conc. H_2SO_4 to give a sweet-smelling compound B. When A is treated with soda lime, it gives a gas C which burns with a blue flame. Identify A, B, and C, and write the equations for the reactions described. [3]

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

I. Benzoic acid to aniline
II. Acetamide to methylamine
III. Aniline to sulphanilic acid
IV. Nitrobenzene to azobenzene

28. Answer the following: [3]

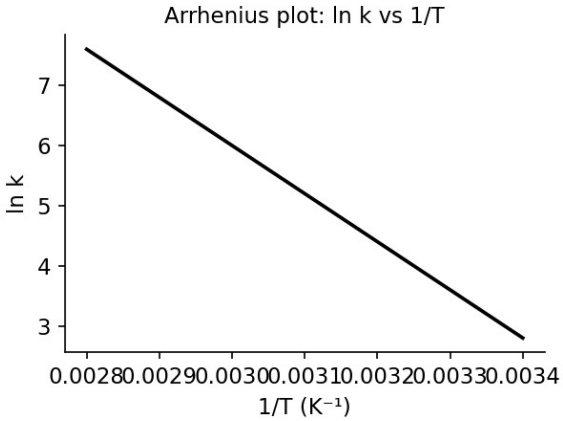
I. Calculate the equilibrium constant for the reaction $Ni(s) + 2Ag^+(aq) \rightarrow Ni^{2+}(aq) + 2Ag(s)$ at 298 K, given $E°cell = 1.05$ V. (Given: 2.303 RT/F = 0.0591 V at 298 K)
II. Define 'limiting molar conductivity'. Why does it have a finite value for both weak and strong electrolytes even though only weak electrolytes show a sharp rise in Λm at low concentration?
III. Two half-cells, Fe^{3+}/Fe^{2+} and Sn^{4+}/Sn^{2+}, are combined to make a cell. Given $E°(Fe^{3+}/Fe^{2+}) = +0.77$ V and $E°(Sn^{4+}/Sn^{2+}) = +0.15$ V, write the cell reaction and calculate E°cell.

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]

The rate of a chemical reaction is found experimentally to depend on the concentration of reactants raised to certain powers, and this relationship, called the rate law, cannot in general be predicted from the stoichiometric (balanced) equation alone - it must be determined experimentally. The order of a reaction with respect to a given reactant is the power to which its concentration term is raised in the rate law, and the overall order is the sum of these powers. A useful graphical method to determine the order of a reaction is to plot an appropriate function of concentration against time: a straight line is obtained for [R] vs t for a zero order reaction, for log[R] vs t for a first order reaction, and for 1/[R] vs t for a second order reaction.



I. The graph shown above is a plot of ln k versus 1/T for a reaction. What is the name of this type of plot, and what can be obtained from its slope? [1]
II. Why can the order of a reaction not, in general, be deduced merely by inspecting the balanced chemical equation?

OR

Name the graphical method (plot) used to confirm that a reaction is of second order. [1]

III. For a certain reaction, a plot of log[R] against time gives a straight line with a negative slope. Identify the order of the reaction and write its rate law. [2]

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

Nucleic acids (DNA and RNA) are biopolymers made up of repeating units called nucleotides, each consisting of a nitrogenous base, a pentose sugar, and a phosphate group. DNA carries hereditary information and is capable of self-duplication (replication) during cell division, ensuring that the genetic information is faithfully passed on to daughter cells. RNA, on the other hand, primarily plays a role in protein synthesis, existing in three main forms - messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA) - each performing a distinct function in translating the genetic code into proteins. Unlike DNA, most RNA molecules are single-stranded.

I. Name the pentose sugar present in DNA and in RNA respectively.

OR

Name the two purine and two pyrimidine bases found in DNA. [1]

II. What is the biological significance of DNA replication? [1]

III. Name the three types of RNA and briefly state the function of each. [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 when benzaldehyde reacts with acetaldehyde in the presence of dilute NaOH (cross aldol condensation).

II. How does the presence of an electron-donating group (e.g. $-OCH_3$) at the para position affect the reactivity of benzaldehyde towards nucleophilic addition, compared to unsubstituted benzaldehyde?

III. Convert benzene to benzoic acid.

IV. Write the equation for the haloform reaction of acetophenone with I_2/NaOH, naming the product.

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

OR

(B)

I. Write the structure of the product formed in the Clemmensen reduction of acetophenone.

II. Arrange the following in increasing order of their reactivity towards nucleophilic addition reactions, giving a reason: acetaldehyde, acetone, benzaldehyde.

III. Convert ethanoic acid to ethanenitrile, and then to ethanamine.

IV. Write the equation for the reaction of acetic acid with PCl_5, and name the product.

V. Give a chemical test to distinguish between formic acid and acetic acid.

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

(A)

I. Draw the Haworth structure of α-D-glucopyranose (structure need not be to scale; label the anomeric carbon).

II. What is the difference between a nucleoside and a nucleotide?

III. Why is the secondary structure of DNA described as a double helix? Name the scientists credited with this model.

IV. Name the disease caused by a deficiency of Vitamin K, and state its main biological function.

V. What is meant by 'denaturation of protein'? Give one example of a physical agent that causes it.

OR

(B)

I. Distinguish between amylose and amylopectin, the two components of starch, on the basis of structure.

II. Name the sugar and nitrogenous bases present in RNA, and state how they differ from those in DNA.

III. What are enzymes? Explain the 'lock and key' model of enzyme action briefly.

IV. Name the disease caused by a deficiency of Vitamin B_{12}, and state one dietary source of this vitamin.

V. What is the isoelectric point of an amino acid? What happens to the amino acid's net charge and solubility at this point?

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

(A)

I. A first order reaction is 20% complete in 10 minutes. Calculate the time taken for the reaction to be 80% complete. (Given log 1.25 = 0.097, log 5 = 0.699) [3]

II. Distinguish between the order and molecularity of a reaction, with one example each. [2]

OR

(B)

I. The rate constant of a reaction increases by a factor of about 4 when the temperature is raised from 293 K to 313 K. Calculate the activation energy of the reaction. (Given R = 8.314 J K^{-1} mol^{-1}, log 4 = 0.602) [3]

II. What is a pseudo first order reaction? Give one example and explain why it behaves as first order even though more than one species is involved in the rate-determining step. [2]

CHEMISTRY (CODE - 043)
MARKING SCHEME - SAMPLE PAPER 3
CLASS XII

SECTION A

1. (B) Molarity of the solution – osmotic pressure $\pi = CRT$, where C is the molar concentration. [1]

2. (A) 0.01 s^{-1}. For first order, $k = 0.693/t_{1/2} = 0.693/69.3 = 0.01\ s^{-1}$. [1]

3. (C) Diamagnetic behaviour in the elemental state – most transition metals have unpaired d-electrons and are paramagnetic in the elemental state. [1]

4. (B) +6. Let x be the oxidation state of Cr: $2(+1) + 2x + 7(-2) = 0 \Rightarrow 2 + 2x - 14 = 0 \Rightarrow x = +6$. [1]

5. (A) Dichloromethane > chloromethane > chlorobenzene – dichloromethane has two C–Cl dipoles reinforcing each other; chlorobenzene has the lowest dipole moment as the C–Cl bond has partial double bond character (less polar) due to resonance with the ring. [1]

6. (C) The C–O bond in ethers is difficult to break under normal conditions – ethers lack an O–H bond and their C–O bond is not easily cleaved except by strong reagents like HI, making them relatively inert. [1]

7. (C) A ketone – Grignard reagent adds to a ketone to give, after hydrolysis, a tertiary alcohol (two alkyl/aryl groups already on the carbonyl carbon, plus the group from the Grignard reagent). [1]

8. (B) Pure primary aliphatic amines – the phthalimide route avoids over-alkylation and gives only primary amines free from secondary/tertiary amine contamination. [1]

9. (A) Starch – a homopolymer of only α-D-glucose units; proteins and nucleic acids are heteropolymers (of different amino acids/nucleotides). [1]

10. (B) Impure copper – in electrolytic refining, impure copper (blister copper) is made the anode, pure copper is deposited at the cathode, and impurities either dissolve or settle as anode mud. [1]

11. (C) $BaCl_2$ (0.1 m) – dissociates into 3 ions ($i \approx 3$), giving the largest effective particle concentration and hence the greatest boiling point elevation. [1]

12. (A) $E^\circ = (RT/nF) \ln K$ – derived by equating $\Delta G^\circ = -nFE^\circ$ with $\Delta G^\circ = -RT \ln K$. [1]

13. (A) Both true, R is the correct explanation – with a fully filled d^{10} configuration, zinc has no unpaired d-electrons to participate in the delocalised metallic bonding responsible for the strong interatomic attraction seen in other transition metals, giving it the weakest metallic bonding and hence the lowest enthalpy of atomisation in the series. [1]

14. (A) Both true, R is the correct explanation – the delocalisation of the nitrogen lone pair into the aromatic ring in aniline reduces its availability to accept a proton, making aniline a much weaker base than ethylamine, where the lone pair is fully available and further enhanced by the +I effect of the ethyl group. [1]

15. (A) Both true, R is the correct explanation – freezing point depression is a colligative property, meaning it depends on the number of solute particles, not their identity. [1]

16. (C) A is true but R is false – Vitamin C is actually water-soluble (not fat-soluble); being water-soluble, it is not stored in the body in significant amounts and is readily excreted in urine (not primarily faeces), so it must be supplied regularly through the diet. [1]

SECTION B

17 (A). [2]

I. $\pi = (n/V)RT = (w/M)(1/V)RT = (1.0/60) \times (1/0.5) \times 0.0821 \times 300 = (0.0167) \times 2 \times 0.0821 \times 300 \approx 0.821$ atm [1]

II. A hypertonic solution is one that has a higher osmotic pressure (higher solute concentration) than another solution (or than a reference solution, e.g. blood plasma) to which it is compared; when separated by a semi-

permeable membrane, solvent flows out of the cell/solution of lower concentration into the hypertonic solution. [1]

OR (B)

I. Ethanoic acid undergoes dimerisation in benzene (a non-polar solvent) through intermolecular hydrogen bonding between pairs of molecules, effectively doubling the number of particles associated together, so the observed molar mass (calculated from colligative properties) is almost double the normal (monomer) value. [1]

II. Raoult's law for a solution of two volatile liquids states that the partial vapour pressure of each component in the solution is directly proportional to its mole fraction, i.e. pA = p°A × xA and pB = p°B × xB, and the total vapour pressure of the solution is the sum ptotal = pA + pB. [1]

18. [2]

Since Rate = k[A][B], doubling [B] (with [A] constant) doubles the rate. The overall order of the reaction is 2 (first order with respect to A, first order with respect to B, so overall second order).

19. [2]

I. Transition metal ions generally have partially filled d-orbitals (except for d^0 and d^{10} configurations), so they possess unpaired electrons, making them paramagnetic.

II. Ce^{3+} ([Xe]$4f^1$) readily loses its single 4f electron to attain the [Xe]$4f^0$ configuration of Ce^{4+}, which has the extra stability of an empty (fully vacant) f-subshell, so Ce^{3+} is easily oxidised to Ce^{4+}.

20. [2]

(i) With alcoholic KOH: elimination (dehydrohalogenation, following Saytzeff's rule) occurs to give propene ($CH_3–CH=CH_2$) as the major product. (ii) With aqueous KOH: nucleophilic substitution occurs to give propan-2-ol ($CH_3–CH(OH)–CH_3$).

21. [2]

IUPAC name: Diamminedichloridoplatinum(II). This square planar complex can show geometrical (cis-trans) isomerism; the two isomers are cis-diamminedichloridoplatinum(II) (cisplatin, used as an anticancer drug) and trans-diamminedichloridoplatinum(II).

SECTION C

22. [3]

(i) $t_{1/2} = 0.693/k = 0.693/(3.0 \times 10^{-5}) \approx 23{,}100$ s (≈ 6.4 hours) (ii) 10 hours = 36,000 s. Using $\ln([A]_0/[A]) = kt$: $\ln([A]_0/[A]) = 3.0 \times 10^{-5} \times 36{,}000 = 1.08$ $[A]/[A]_0 = e^{-1.08} \approx 0.34$, so about 34% of the reactant remains after 10 hours.

23. [3]

In $[Co(NH_3)_6]Cl_3$, cobalt shows two types of valence: the primary valence (+3, ionisable, satisfied by the three Cl^- ions which are held outside the coordination sphere and can be precipitated by $AgNO_3$) and the secondary valence (6, non-ionisable, satisfied by the six NH_3 ligands directly and permanently bonded to the central Co^{3+} ion, directed towards fixed positions in space - here, octahedral). The coordination number of cobalt is 6, and NH_3 is the ligand present (a neutral, monodentate ligand).

24. [3]

I. Carry out the carbylamine test (add $CHCl_3$ and alcoholic KOH, warm): N-methylaniline (a secondary amine) gives no reaction; aniline (a primary amine) gives an offensive-smelling isocyanide (carbylamine).

II. Perform Hinsberg's test (add benzenesulphonyl chloride, then NaOH): ethylamine (primary) gives a product that dissolves in excess NaOH (soluble sulphonamide salt); diethylamine (secondary) gives a precipitate that is insoluble in NaOH.

III. Perform the iodoform test (I_2/NaOH): both acetaldehyde and acetone are methyl carbonyl compounds and would both give a positive iodoform test, so instead use Tollens' reagent: acetaldehyde gives a silver mirror; acetone (a ketone) gives no reaction.

25. [3]

I. For Eu, the +2 oxidation state (Eu^{2+}, $4f^7$) has extra stability due to the exactly half-filled f-subshell, so Eu^{3+} is more easily reduced to Eu^{2+} than expected, making $E°(Eu^{3+}/Eu^{2+})$ more negative (i.e. reduction is thermodynamically more favourable) compared to neighbouring lanthanoids.

II. Small atoms like H, C, B, and N can occupy the interstitial voids within the close-packed metal lattice without disrupting it significantly; this strengthens the metallic lattice, increasing hardness, and the strong interstitial bonding raises the melting point of these compounds.

III. In actinoids, the 5f, 6d, and 7s orbitals are close in energy and less effectively shielded than the 4f orbitals in lanthanoids, so 5f electrons are more available for bonding with ligands; this greater orbital overlap gives actinoids a stronger tendency to form complexes than lanthanoids.

26. [3]

A is ethanoic acid (acetic acid, CH_3COOH, $C_2H_4O_2$). With ethanol and conc. H_2SO_4 (Fischer esterification), it gives B, ethyl acetate ($CH_3COOC_2H_5$), a sweet-smelling ester. $CH_3COOH + C_2H_5OH \rightarrow (\text{conc. } H_2SO_4) \rightarrow CH_3COOC_2H_5 + H_2O$ With soda lime (NaOH/CaO) on heating (decarboxylation), it gives C, methane (CH_4), which burns with a blue flame. $CH_3COONa + NaOH \rightarrow (\text{soda lime}, \Delta) \rightarrow CH_4 + Na_2CO_3$

27. [3]

(Any three)

I. Benzoic acid (C_6H_5COOH) → (NH_3, Δ, then P_2O_5 to dehydrate) → benzamide ($C_6H_5CONH_2$) → (Br_2/NaOH, Hofmann bromamide degradation) → aniline ($C_6H_5NH_2$).

II. Acetamide (CH_3CONH_2) → (Br_2/NaOH, Hofmann bromamide degradation) → methylamine (CH_3NH_2).

III. Aniline ($C_6H_5NH_2$) → (conc. H_2SO_4, heat - 'baking') → sulphanilic acid (4-aminobenzenesulphonic acid, a zwitterion, p-$H_2N–C_6H_4–SO_3H$).

IV. Nitrobenzene ($C_6H_5NO_2$) → (Zn/NH_4Cl, partial reduction) → phenylhydroxylamine → (further controlled reduction/coupling under alkaline conditions with another nitrobenzene-derived fragment) → azobenzene ($C_6H_5–N=N–C_6H_5$), via reductive coupling of two nitrobenzene-derived nitrogen fragments using Zn/NaOH.

28. [3]

I. $E°cell = (0.0591/n) \log K$, n = 2 1.05 = (0.0591/2) log K log K = (1.05 × 2)/0.0591 ≈ 35.5 K ≈ $10^{35·5}$ (a very large equilibrium constant, showing the reaction goes essentially to completion)

II. Limiting molar conductivity (Λ°m) is the molar conductivity of an electrolyte at infinite dilution (zero concentration), i.e. when the ions are so far apart that they no longer influence one another's mobility. It has a finite value for both strong and weak electrolytes because it represents the intrinsic maximum conducting ability of each individual ion; the sharp rise in Λm at low concentration for weak electrolytes reflects only how quickly this maximum is approached (rapid increase in degree of dissociation) as concentration falls, not a difference in the existence of a limiting value itself.

III. Fe^{3+} has the higher (more positive) reduction potential, so it acts as the cathode (reduction): $Fe^{3+} + e^- \rightarrow Fe^{2+}$; Sn^{2+} is oxidised at the anode: $Sn^{2+} \rightarrow Sn^{4+} + 2e^-$. Overall cell reaction: $2Fe^{3+}(aq) + Sn^{2+}(aq) \rightarrow 2Fe^{2+}(aq) + Sn^{4+}(aq)$ $E°cell = E°cathode – E°anode = 0.77 – 0.15 = 0.62$ V

SECTION D

29. [4]

I. This is an Arrhenius plot. Its slope equals –Ea/R (a negative slope), from which the activation energy (Ea) of the reaction can be calculated once the slope is measured. [1]

II. The rate law depends on the actual reaction mechanism (the sequence of elementary steps and, in particular, the rate-determining step), which is not necessarily the same as the overall balanced equation; a balanced equation only shows the overall stoichiometry, not how the reaction proceeds at the molecular level, so the order must be found experimentally.

OR: A plot of 1/[R] versus time gives a straight line for a second order reaction. [1]

III. Order = first order (since log[R] vs t is linear for a first order reaction). Rate law: Rate = k[R]. [2]

30. [4]

I. DNA contains 2-deoxyribose; RNA contains ribose.

OR: The two purine bases in DNA are adenine and guanine; the two pyrimidine bases are cytosine and thymine. [1]

II. DNA replication ensures that genetic information is accurately copied and passed on from a parent cell to its daughter cells (and from one generation to the next), maintaining the continuity and stability of hereditary characteristics. [1]

III. mRNA (messenger RNA) carries the genetic code from DNA (in the nucleus) to the ribosomes for protein synthesis. tRNA (transfer RNA) carries specific amino acids to the ribosome and helps in reading the genetic code during translation. rRNA (ribosomal RNA) forms a structural and functional part of the ribosomes, the site of protein synthesis. [2]

SECTION E

31 (A). [5]

I. Cross aldol condensation of benzaldehyde (no α-H) with acetaldehyde (has α-H) in dilute NaOH gives cinnamaldehyde: $C_6H_5–CH=CH–CHO$ (via aldol addition followed by dehydration).

II. An electron-donating group like $–OCH_3$ at the para position increases electron density at the carbonyl carbon, making it less electrophilic; this decreases its reactivity towards nucleophilic addition compared to unsubstituted benzaldehyde.

III. Benzene → (CH_3Cl/anhydrous $AlCl_3$, Friedel-Crafts alkylation) → toluene → (alkaline $KMnO_4$, oxidation, then acidify) → benzoic acid.

IV. $CH_3COC_6H_5 + 3I_2 + 4NaOH \rightarrow C_6H_5COONa$ (sodium benzoate) + CHI_3 (iodoform, yellow precipitate) + 3NaI + $3H_2O$.

V. Add Fehling's solution and warm: acetaldehyde gives a brick-red precipitate of Cu_2O; benzaldehyde (an aromatic aldehyde) does not react with Fehling's solution.

OR (B)

I. Clemmensen reduction of acetophenone ($CH_3COC_6H_5$) with Zn(Hg)/conc. HCl reduces the C=O to CH_2, giving ethylbenzene ($C_6H_5CH_2CH_3$).

II. Increasing order of reactivity towards nucleophilic addition: benzaldehyde < acetone < acetaldehyde. Steric hindrance and +I effect of alkyl/aryl groups reduce electrophilicity of the carbonyl carbon; benzaldehyde is least reactive due to resonance stabilisation by the ring, while acetaldehyde (smallest alkyl group, least steric hindrance) is most reactive.

III. Ethanoic acid (CH_3COOH) → (P_2O_5, dehydration) → ethanoic anhydride is a side product; correct route: CH_3COOH → (NH_3 then P_2O_5/Δ, dehydration of amide) → ethanenitrile (CH_3CN) → ($LiAlH_4$ or H_2/Ni, reduction) → ethanamine ($CH_3CH_2NH_2$).

IV. $CH_3COOH + PCl_5 \rightarrow CH_3COCl$ (acetyl chloride/ethanoyl chloride) + $POCl_3$ + HCl.

V. Add Tollens' reagent and warm: formic acid (HCOOH, which has an aldehydic-type –CHO group as part of its structure) gives a silver mirror (positive test, as it can act as a reducing agent); acetic acid (CH_3COOH) gives no reaction.

32 (A). [5]

I. α-D-glucopyranose is drawn as a six-membered (pyranose) ring with O in the ring between C1 and C5; the –OH on the anomeric carbon (C1) is drawn below the plane of the ring (in the Haworth projection) to denote the α-configuration. (Structure to be drawn showing C1 as the anomeric carbon with –OH oriented downward, C6 as the CH_2OH group above the ring.)

II. A nucleoside consists of only a nitrogenous base linked to a pentose sugar (no phosphate group); a nucleotide consists of a nitrogenous base, a pentose sugar, and a phosphate group (i.e. a nucleoside plus a phosphate group).

III. The DNA molecule consists of two polynucleotide chains coiled around a common axis in a spiral (helical) manner, with the two strands running antiparallel and held together by hydrogen bonds between complementary base pairs; this twisted, ladder-like structure is described as a double helix. The model was proposed by James Watson and Francis Crick.

IV. Deficiency of Vitamin K causes increased blood clotting time (impaired coagulation), leading to excessive bleeding; its main biological function is to assist in blood clotting.

V. Denaturation of a protein is the loss of its native secondary and tertiary structure (and hence its biological activity) due to disruption of the hydrogen bonds and other weak interactions holding it in its natural folded shape, without breaking the peptide bonds of the primary structure. Example of a physical agent: heat (e.g. boiling).

OR (B)

I. Amylose is the water-soluble component of starch, consisting of a long unbranched chain of α-D-glucose units linked by α-1,4-glycosidic bonds; amylopectin is the water-insoluble component, a branched-chain polymer of α-D-glucose with α-1,4-glycosidic linkages in chains and α-1,6-glycosidic linkages at branch points.

II. RNA contains ribose sugar and the bases adenine, guanine, cytosine, and uracil; this differs from DNA, which contains deoxyribose sugar and has thymine in place of uracil.

III. Enzymes are biological catalysts (mostly proteins) that speed up specific biochemical reactions. In the lock and key model, the enzyme's active site has a specific three-dimensional shape (the 'lock') that precisely fits only its specific substrate molecule (the 'key'); this specific fit allows the reaction to proceed efficiently, explaining why enzymes act only on particular substrates.

IV. Deficiency of Vitamin B_{12} causes pernicious anaemia; dietary sources include meat, eggs, and dairy products.

V. The isoelectric point is the specific pH at which an amino acid exists predominantly as a neutral zwitterion, carrying no net electric charge. At this pH, the amino acid has minimum solubility in water and does not migrate towards either electrode under an electric field.

33 (A). [5]

I. For a first order reaction, $k = (2.303/t) \log([A]_0/[A]_0 - x)$. At 20% completion in 10 min: $[A]_0/[A] = 100/80 = 1.25$ $k = (2.303/10) \log(1.25) = (2.303/10)(0.097) = 0.02234\ min^{-1}$ For 80% completion: $[A]_0/[A] = 100/20 = 5$ $t = (2.303/k) \log 5 = (2.303/0.02234)(0.699) \approx 72.1$ min [3]

II. The order of a reaction is the sum of the powers of concentration terms in the experimentally determined rate law (can be zero, fractional, or a whole number), e.g. for $Rate = k[A][B]^2$, order = 3. Molecularity is the number of reactant species (atoms, ions, or molecules) that must collide simultaneously in a single elementary step of a reaction mechanism (always a whole number, never zero or fractional), e.g. for the elementary bimolecular step $2HI \rightarrow H_2 + I_2$, molecularity = 2. [2]

OR (B)

I. Using the Arrhenius equation: $\log(k_2/k_1) = [Ea/2.303R] \times (1/T_1 - 1/T_2)$ $T_1 = 293$ K, $T_2 = 313$ K, $k_2/k_1 = 4$, $\log 4 = 0.602$ $1/T_1 - 1/T_2 = 1/293 - 1/313 = 20/(293 \times 313) = 20/91709 = 2.18 \times 10^{-4}$ $0.602 = [Ea/(2.303 \times 8.314)] \times 2.18 \times 10^{-4}$ $0.602 = [Ea/19.15] \times 2.18 \times 10^{-4}$ $Ea = (0.602 \times 19.15)/(2.18 \times 10^{-4}) \approx 52{,}900\ J\ mol^{-1} \approx 52.9\ kJ\ mol^{-1}$ [3]

II. A pseudo first order reaction is one that, although actually of a higher order based on its mechanism (involving two or more reactants), experimentally behaves as a first order reaction because one of the reactants is present in such large excess that its concentration remains effectively constant throughout the reaction. Example: acid hydrolysis of ethyl acetate ($CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOH + C_2H_5OH$) in the presence of a large excess of water; although the reaction is second order overall (first order in ester, first order in water), the huge excess of water keeps $[H_2O]$ essentially constant, so the rate depends only on the concentration of the ester, making it appear first order. [2]