Roll No. ☐☐☐☐☐☐☐☐

Q.P. Code 56/4/1

CHEMISTRY (THEORY)

CBSE Class XII Board Examination 2025 — with answers

Time allowed: 3 hours **Maximum Marks: 70**

General Instructions:

1. The paper has 33 questions in five sections (A to E); all of them must be answered.
2. Section A: Q1–16, multiple choice (Q13–16 Assertion-Reason), 1 mark each.
3. Section B: Q17–21, very short answer, 2 marks each.
4. Section C: Q22–28, short answer, 3 marks each.
5. Section D: Q29–30, case-based, 4 marks each.
6. Section E: Q31–33, long answer, 5 marks each.
7. There is no overall choice, but some questions in Sections B to E offer an internal choice (OR). Calculators are not allowed.

SECTION A

Q1–16 are multiple choice questions of 1 mark each (Q13–16 are Assertion-Reason).

1. A cell works on the reaction $2Cu^{+}(aq) + Zn(s) \rightarrow 2Cu(s) + Zn^{2+}(aq)$, with $E°_{cell} = 1.28$ V. What happens to the cell voltage as the reaction goes on? **1**

(A) It stays the same.

(B) It falls as $[Zn^{2+}]$ rises.

(C) It rises as $[Cu^{+}]$ rises.

(D) It rises as $[Zn^{2+}]$ rises.

ANSWER

(B) The voltage decreases as $[Zn^{2+}]$ increases.

Nernst equation: $E = E^{\circ} - \frac{0.059}{2} \log \frac{[Zn^{2+}]}{[Cu^{+}]^2}$.

As the cell runs, Zn^{2+} is produced (numerator grows) and Cu^{+} is used up (denominator shrinks).

So the log term grows and E falls; at equilibrium E becomes zero.

Mistake to avoid: $[Cu^{+}]$ decreases during the reaction, it does not increase.

---

2. Which of these ions is colourless in water: Fe^{3+}, Sc^{3+}, Cr^{3+}, Co^{3+}? (Atomic numbers: Fe 26, Sc 21, Cr 24, Co 27) **1**

(A) Sc^{3+}

(B) Fe^{3+}

(C) Cr^{3+}

(D) Co^{3+}

ANSWER

(A) Sc^{3+}

Colour in transition-metal ions comes from d–d transitions, which need partly filled d orbitals.

Sc^{3+} = [Ar]$3d^0$ – no d electron, so no d–d transition → colourless.

Fe^{3+} ($3d^5$), Cr^{3+} ($3d^3$) and Co^{3+} ($3d^6$) all have unpaired d electrons and are coloured.

---

3. Which compound undergoes the Hoffmann bromamide degradation? **1**

(A) $ArNO_2$

(B) $ArNH_2$

(C) $ArCONH_2$

(D) $ArCH_2NH_2$

ANSWER

(C) $ArCONH_2$

Hoffmann bromamide degradation needs a primary amide: $RCONH_2 + Br_2 + 4NaOH \rightarrow RNH_2 + Na_2CO_3 + 2NaBr + 2H_2O$.

So $ArCONH_2$ (an aromatic amide) gives $ArNH_2$, an amine with one carbon less.

---

4. A Haworth (pyranose) ring of a sugar is drawn with its carbons numbered: C-5 carries the CH_2OH group and is bonded to the ring oxygen; C-1 is on the other side of the ring oxygen and carries an OH and an H; C-2, C-3 and C-4 carry H and OH groups. Which numbered carbon is the anomeric carbon? **1**

(A) 1 **(B)** 2

(C) 3 **(D)** 5

ANSWER

(A) Carbon 1

The anomeric carbon is the former carbonyl carbon that becomes a new chiral centre on ring closure (the hemiacetal carbon).
In an aldohexose like glucose this is C-1: it is bonded to both the ring oxygen and an OH group.
The α and β forms (anomers) differ only in the OH position at this carbon.

---

5. Henry's law constant K_H is: **1**

(A) larger for more soluble gases **(B) larger for less soluble gases**

(C) the same for all gases **(D)** unrelated to gas solubility

ANSWER

(B) Greater for gases with lower solubility

Henry's law: p = K_H·x, so x = p/K_H.
At the same partial pressure, a larger K_H means a smaller mole fraction x in solution, i.e. lower solubility.

---

6. Pick the INCORRECT statement. **1**

(A) La is really an element of the transition series.

(B) Because of lanthanoid contraction, Zr and Hf have nearly the same atomic radii.

(C) Ionic radius decreases from La^{3+} to Lu^{3+}.

(D) Lanthanoids are radioactive.

ANSWER

(D) 'Lanthanoids are radioactive' is incorrect.

(A) La ($5d^16s^2$) is the first member of the 5d transition series – true.
(B) Lanthanoid contraction makes Hf almost the same size as Zr – true.
(C) Ionic radius falls steadily from La^{3+} to Lu^{3+} – true.
(D) Only promethium (Pm) is radioactive; lanthanoids in general are not – false.

7. Among 2-bromobutane, 1-bromobutane, 2-bromopropane and 1-bromopropane, which molecule is chiral? **1**

(A) 2-Bromobutane

(B) 1-Bromobutane

(C) 2-Bromopropane

(D) 1-Bromopropane

ANSWER

(A) 2-Bromobutane

A chiral molecule needs a carbon with four different groups.
2-Bromobutane: C-2 carries H, Br, CH_3 and C_2H_5 – four different groups → chiral.
2-Bromopropane: C-2 has two CH_3 groups → not chiral. The 1-bromo compounds have no such carbon.

---

8. Aniline is treated with $NaNO_2$/HCl at 0–5 °C to give X, and X is then treated with ethanol to give Y. What is Y? **1**

(A) Phenol (C_6H_5OH)

(B) Benzene (C_6H_6)

(C) Nitrobenzene ($C_6H_5NO_2$)

(D) Benzenediazonium chloride ($C_6H_5N_2^+Cl^-$)

ANSWER

(B) Benzene

Step 1 (diazotisation): $C_6H_5NH_2 + NaNO_2 + 2HCl \rightarrow C_6H_5N_2^+Cl^-$ (X) + NaCl + $2H_2O$.
Step 2: ethanol (a mild reducing agent) replaces $-N_2^+$ by –H: $C_6H_5N_2^+Cl^- + CH_3CH_2OH \rightarrow C_6H_6 + N_2 + CH_3CHO + HCl$.
So Y = benzene. (Warming X with water would give phenol instead.)

---

9. When I^- is oxidised by MnO_4^- in alkaline medium, the product is: **1**

(A) IO_4^-

(B) I_2

(C) IO^-

(D) IO_3^-

ANSWER

(D) IO_3^- (iodate)

In neutral or faintly alkaline solution permanganate oxidises iodide to iodate:
$2MnO_4^- + H_2O + I^- \rightarrow 2MnO_2 + 2OH^- + IO_3^-$.
In acidic medium the product would be I_2 instead.

10. DDT is an important polyhalogen compound. It is a: **1**

(A) greenhouse gas

(B) fertilizer

(C) biodegradable insecticide

(D) non-biodegradable insecticide

ANSWER

(D) Non-biodegradable insecticide

DDT (p,p'-dichlorodiphenyltrichloroethane) is an insecticide.
It is chemically very stable and fat-soluble, so it is not broken down and builds up in food chains – hence non-biodegradable.

---

11. How much charge is needed to reduce 1 mol of MnO_4^- to Mn^{2+}? **1**

(A) 1 F

(B) 5 F

(C) 4 F

(D) 6 F

ANSWER

(B) 5 F

Oxidation state of Mn changes from +7 (MnO_4^-) to +2 (Mn^{2+}): 5 electrons per ion.
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$.
1 mol MnO_4^- needs 5 mol electrons = 5 F.

---

12. Alcohols give alkenes when heated with concentrated H_2SO_4. What is the first step of this reaction? **1**

(A) formation of a carbocation

(B) formation of an ester

(C) protonation of the alcohol

(D) loss of water

ANSWER

(C) Protonation of the alcohol molecule

Mechanism of acid-catalysed dehydration:
Step 1: the –OH oxygen takes a proton → protonated alcohol ($R–OH_2^+$).
Step 2: water leaves → carbocation (slow step).
Step 3: a β-hydrogen is lost as H^+ → alkene.

---

13. Assertion (A): Electrolysis of aqueous NaCl gives H_2 at the cathode and Cl_2 at the anode. **1**
Reason (R): Chlorine has a higher oxidation potential than water.

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

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

(C) A is true but R is false.

(D) A is false but R is true.

ANSWER
(C) A is true, R is false.

A is true: H_2 forms at the cathode, Cl_2 at the anode.
R is false: thermodynamically water is easier to oxidise (E° for O_2 formation 1.23 V vs 1.36 V for Cl_2). Cl_2 is liberated only because oxygen evolution has a high overpotential.

14. Assertion (A): Cuprous salts are diamagnetic. **1**
Reason (R): The cuprous ion has completely filled 3d orbitals.

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

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

(C) A is true but R is false.

(D) A is false but R is true.

ANSWER
(A) Both true; R explains A.

$Cu^+ = [Ar]3d^{10}$ – all d electrons paired, no unpaired electron.
No unpaired electrons → diamagnetic. So R correctly explains A.

15. Assertion (A): n-Butyl chloride boils at a higher temperature than n-butyl bromide. **1**
Reason (R): The C–Cl bond is more polar than the C–Br bond.

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

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

(C) A is true but R is false.

(D) A is false but R is true.

ANSWER
(D) A is false, R is true.

For the same alkyl group, boiling point rises with the size and mass of the halogen: RI > RBr > RCl > RF, because van der Waals forces grow. So n-butyl bromide boils higher – A is false.
R is true: Cl is more electronegative than Br, so C–Cl is more polar.

16. Assertion (A): Acetanilide is a weaker base than aniline. **1**

Reason (R): Acetylation of aniline lowers the electron density on nitrogen.

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

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

(C) A is true but R is false.

(D) A is false but R is true.

ANSWER

(A) Both true; R explains A.

In acetanilide ($C_6H_5NHCOCH_3$) the nitrogen lone pair is delocalised onto the C=O group (resonance with the acetyl group).

So less electron density is available on N to accept a proton → weaker base than aniline. R is the reason for A.

SECTION B

Q17–21 are very short answer questions of 2 marks each.

17. A reactant A decomposes. Its concentration was measured every hour: t = 0 h, [A] = 0.40 M; 1 h, 0.20 M; 2 h, 0.10 M; 3 h, 0.05 M. From these data predict the order of the reaction and write its rate law. **2**

ANSWER

First order; Rate = k[A] ($k = 0.693\ h^{-1}$)

[A] halves every hour: 0.40 → 0.20 → 0.10 → 0.05 M.
A half-life that stays constant (1 h) and does not depend on the starting concentration is the mark of a first-order reaction.
Rate law: Rate = k[A].
$k = 0.693/t_{½} = 0.693/1\ h = 0.693\ h^{-1}$.

OR

$H_2(g)$ and $I_2(g)$ react in a closed container kept at constant temperature, with rate law Rate = $k[H_2][I_2]$. If 1 mole more of $H_2(g)$ is added, what happens to (i) the rate of reaction and (ii) the rate constant?

ANSWER

Rate increases; rate constant k stays the same.

(i) Adding H_2 raises $[H_2]$ in the fixed volume; since rate $\propto [H_2]$, the rate increases.
(ii) The rate constant depends only on temperature (and catalyst), not on concentration. Temperature is constant, so k does not change.

18. A solution of $PtCl_4 \cdot 2KCl$ gives no AgCl precipitate with $AgNO_3$. Write the structural formula of the complex and its IUPAC name. **2**

ANSWER

$K_2[PtCl_6]$ – potassium hexachloridoplatinate(IV)

No AgCl precipitate → no free Cl^- ions; all six Cl are bound to Pt inside the coordination sphere.
Formula: $K_2[PtCl_6]$ (ionises into $2K^+$ and $[PtCl_6]^{2-}$).
Oxidation state of Pt: $x - 6 = -2 \rightarrow x = +4$.
IUPAC name: potassium hexachloridoplatinate(IV).

19. What is a fuel cell? State two advantages of a fuel cell over an ordinary cell. **2**

ANSWER

A galvanic cell that turns the energy of combustion of a fuel (e.g. H_2, CH_4) directly into electricity; high efficiency and pollution-free.

Definition: a fuel cell is a galvanic cell in which the energy of combustion of fuels such as hydrogen or methane is converted directly into electrical energy, the reactants being supplied continuously.
Example: H_2–O_2 cell, $2H_2 + O_2 \rightarrow 2H_2O$.
Advantages: (1) high efficiency (about 70%, vs about 40% for thermal power plants); (2) pollution-free – product is water; also it runs continuously as long as fuel is fed.

20. Write the main products: **2**

(a) Cyclohexanone carrying a $–CH_2CH_2COOCH_3$ group on the carbon next to the C=O (methyl 3-(2-oxocyclohexyl)propanoate) is treated with $NaBH_4$.

(b) $6\ (CH_3)_3C–OH + 2Al \rightarrow$

ANSWER

(a) Methyl 3-(2-hydroxycyclohexyl)propanoate; (b) $2Al[OC(CH_3)_3]_3 + 3H_2$

(a) $NaBH_4$ is a mild reducing agent: it reduces the ketone C=O to CH–OH but does not reduce the ester group. Product: 2-hydroxycyclohexyl ring with the $–CH_2CH_2COOCH_3$ side chain unchanged.
(b) Alcohols are acidic enough to react with active metals, releasing hydrogen: $6(CH_3)_3COH + 2Al \rightarrow 2Al[OC(CH_3)_3]_3$ (aluminium tert-butoxide) + $3H_2$.

21. What are essential amino acids? Why do amino acids behave as amphoteric compounds? **2**

ANSWER

Amino acids the body cannot make and must get from diet; amphoteric because they have both –COOH and $–NH_2$ groups (zwitter ion).

Essential amino acids: those that cannot be synthesised in the body and must be taken in through food (e.g. valine, leucine, lysine).
Amphoteric nature: an amino acid contains an acidic –COOH group and a basic $–NH_2$ group; in solution it exists as a zwitter ion $H_3N^+–CHR–COO^-$, so it reacts with both acids (COO^- takes H^+) and bases (NH_3^+ gives H^+).

SECTION C

Q22–28 are short answer questions of 3 marks each.

22. Explain: **3**

(i) Allyl chloride is hydrolysed faster than n-propyl chloride.

(ii) Alkyl halides give isocyanides with silver cyanide.

(iii) In an SN2 reaction with OH^-, methyl chloride reacts faster than t-butyl chloride.

ANSWER

(i) Resonance-stabilised allylic carbocation; (ii) AgCN is covalent – only N can donate; (iii) less steric hindrance in CH_3Cl.

(i) Allyl chloride ionises to the allyl carbocation $CH_2{=}CH{-}CH_2^+$, which is stabilised by resonance; n-propyl carbocation has no such stabilisation. So allyl chloride hydrolyses more readily.
(ii) AgCN is mainly covalent: the carbon is tied to Ag, so the lone pair on nitrogen attacks the alkyl carbon → R–N≡C (isocyanide). (KCN is ionic and gives nitriles.)
(iii) In SN2 the nucleophile attacks from the back side. In CH_3Cl the carbon is unhindered; in $(CH_3)_3CCl$ three bulky methyl groups block the approach, so CH_3Cl reacts faster.

OR

Give the structures of A and B:

(i) $CH_3CH{=}CH_2$ + HBr (peroxide) → A; A + aq. KOH → B

(ii) $CH_3CH_2CH(Cl)CH_3$ + alc. KOH → A; A + HBr → B

(iii) A + Mg (dry ether) → CH_3CH_2MgCl; $CH_3CH_2MgCl + H_2O/H^+$ → B (main product)

ANSWER

(i) A = $CH_3CH_2CH_2Br$, B = $CH_3CH_2CH_2OH$; (ii) A = $CH_3CH{=}CHCH_3$, B = $CH_3CH_2CHBrCH_3$; (iii) A = CH_3CH_2Cl, B = CH_3CH_3

(i) With peroxide, HBr adds anti-Markovnikov (Kharasch effect): A = 1-bromopropane $CH_3CH_2CH_2Br$. Aqueous KOH substitutes Br by OH: B = propan-1-ol.
(ii) Alcoholic KOH causes dehydrohalogenation; by Saytzeff's rule the more substituted alkene forms: A = but-2-ene $CH_3CH{=}CHCH_3$. HBr adds to give B = 2-bromobutane $CH_3CH_2CHBrCH_3$.
(iii) Grignard reagent CH_3CH_2MgCl comes from A = chloroethane CH_3CH_2Cl. Water protonates the carbanion part: B = ethane CH_3CH_3 (+ Mg(OH)Cl).

23. A voltaic cell is made at 25 °C from the half-cells Al/Al^{3+}(0.001 M) and Ni/Ni^{2+}(0.1 M). Given $E°(Ni^{2+}/Ni) = -0.25$ V and $E°(Al^{3+}/Al) = -1.66$ V, calculate the cell voltage. **3**

ANSWER

$E_{cell} \approx 1.44$ V

Al has the lower E°, so Al is the anode: $2Al + 3Ni^{2+} \rightarrow 2Al^{3+} + 3Ni$; n = 6.
$E°_{cell} = E°_{cathode} - E°_{anode} = -0.25 - (-1.66) = 1.41$ V.
Nernst: $E = E^\circ - \frac{0.059}{6} \log \frac{[Al^{3+}]^2}{[Ni^{2+}]^3}$.
$Q = (10^{-3})^2/(10^{-1})^3 = 10^{-6}/10^{-3} = 10^{-3}$, $\log Q = -3$.
$E = 1.41 - (0.059/6)(-3) = 1.41 + 0.0295 = 1.4395 \approx 1.44$ V.
Mistake to avoid: use n = 6 (LCM of 2 and 3) and raise concentrations to their coefficients.

24. Explain: **3**

(a) Mn^{3+} and Cr^{2+} are both d^4 ions, yet Mn^{3+} is an oxidising agent while Cr^{2+} is a reducing agent.

(b) The contraction from one element to the next is greater among actinoids than among lanthanoids.

(c) Transition metals form many interstitial compounds with H, B, C and N.

ANSWER

(a) $Mn^{3+} \rightarrow Mn^{2+}$ gives stable d^5; $Cr^{2+} \rightarrow Cr^{3+}$ gives stable t_2g^3 (d^3); (b) 5f electrons shield worse than 4f; (c) small atoms fit into the metal lattice voids.

(a) Mn^{3+} ($3d^4$) gains an electron to become Mn^{2+} ($3d^5$), an extra-stable half-filled configuration → it is easily reduced, so it oxidises others. Cr^{2+} ($3d^4$) loses an electron to become Cr^{3+} ($3d^3$ = half-filled t_2g^3), which is very stable → it reduces others.

(b) 5f orbitals are more diffuse and shield the outer electrons more poorly than 4f orbitals, so the effective nuclear charge rises more per element → larger contraction in actinoids.

(c) H, B, C and N atoms are very small and get trapped in the empty spaces (interstitial sites) of the metal crystal lattice, forming interstitial compounds like TiC, Fe_3H.

25. For an aqueous NaOH solution, the molar mass found from osmotic pressure measurement at 27 °C was 25 g mol^{-1}. Calculate the percentage dissociation of NaOH. (Na = 23, O = 16, H = 1) **3**

ANSWER

α = 0.6, i.e. 60% dissociation

Normal molar mass of NaOH = 23 + 16 + 1 = 40 g mol^{-1}.

Van't Hoff factor i = normal molar mass / observed molar mass = 40/25 = 1.6.

$NaOH \rightarrow Na^+ + OH^-$, so n = 2 ions: $\alpha = (i - 1)/(n - 1) = (1.6 - 1)/(2 - 1) = 0.6$.

Percentage dissociation = 60%.

26. Arrange as directed: **3**

(a) $C_2H_5NH_2$, $(C_2H_5)_2NH$, $C_6H_5NHCH_3$, $C_6H_5NH_2$ – decreasing pKb

(b) C_2H_5OH, $C_2H_5NH_2$, $(CH_3)_2NH$ – increasing boiling point

(c) $C_6H_5NH_2$, $(C_2H_5)_2NH$, $C_2H_5NH_2$ – increasing solubility in water

ANSWER

(a) $C_6H_5NH_2 > C_6H_5NHCH_3 > C_2H_5NH_2 > (C_2H_5)_2NH$; (b) $(CH_3)_2NH < C_2H_5NH_2 < C_2H_5OH$; (c) $C_6H_5NH_2 < (C_2H_5)_2NH < C_2H_5NH_2$

(a) Higher pKb = weaker base. Aryl amines are weak (lone pair delocalised in ring); N-methyl group makes $C_6H_5NHCH_3$ slightly stronger than aniline. Aliphatic amines are stronger; in water $(C_2H_5)_2NH$ is the strongest. So pKb: $C_6H_5NH_2 > C_6H_5NHCH_3 > C_2H_5NH_2 > (C_2H_5)_2NH$.

(b) Secondary amine has one N–H (weaker H-bonding) < primary amine with two N–H < alcohol (O–H bond more polar, stronger H-bonds).

(c) Solubility depends on H-bonding with water versus the size of the hydrocarbon part: aniline (large phenyl) least; diethylamine (bigger alkyl, one N–H) next; ethylamine most soluble.

27. Aromatic compound A (C_8H_8O) gives a positive 2,4-DNP test and a yellow precipitate B with sodium hypoiodite. A does not react with Tollens' or Fehling's reagent. Strong oxidation of A with $KMnO_4$ gives a carboxylic acid C. Identify A, B and C and give their IUPAC names. **3**

ANSWER

A = $C_6H_5COCH_3$ (1-phenylethan-1-one); B = CHI_3 (triiodomethane); C = C_6H_5COOH (benzoic acid)

Positive 2,4-DNP → carbonyl compound. No Tollens'/Fehling's → not an aldehyde, so a ketone. Iodoform (yellow ppt) with NaOI → contains a $CH_3CO–$ group.
C_8H_8O aromatic ketone with $CH_3CO–$ = acetophenone $C_6H_5COCH_3$ (A), IUPAC: 1-phenylethan-1-one.
$C_6H_5COCH_3 + 3NaOI \rightarrow C_6H_5COONa + CHI_3\downarrow$ (B = triiodomethane, iodoform) + 2NaOH.
Vigorous oxidation removes the side chain to –COOH: C = benzoic acid, C_6H_5COOH (IUPAC: benzenecarboxylic acid).

28. (a) Can t-butyl ethyl ether be made from sodium ethoxide and t-butyl chloride? Explain, and suggest the right starting materials for making this ether. **3**
(b) Give the IUPAC name of this ether.

ANSWER

(a) No – elimination dominates; use sodium t-butoxide + chloroethane; (b) 2-ethoxy-2-methylpropane

(a) No. In Williamson synthesis the halide must be primary. Ethoxide is a strong base as well as a nucleophile; with tertiary t-butyl chloride it removes a β-H, so elimination wins and 2-methylpropene forms instead of the ether.
Correct route: $(CH_3)_3CONa + CH_3CH_2Cl \rightarrow (CH_3)_3C–O–CH_2CH_3 + NaCl$ (SN2 on the primary halide).
(b) $(CH_3)_3C–O–C_2H_5$ = 2-ethoxy-2-methylpropane.

SECTION D

Q29–30 are case-based questions of 4 marks each. Read the case and answer the questions that follow.

29. *The case discusses ideal solutions: in an ideal mixture the attractions between like and unlike molecules are equal. Truly ideal mixtures are rare, but very dilute solutions behave ideally towards the solvent, which is why Raoult's law describes them.* **4**

(a) Give one example of a pair of miscible liquids showing negative deviation from Raoult's law. Why does such deviation occur? (2)

(b) (i) State Raoult's law for a solution of volatile components. (1)

(c) Write two characteristics of an ideal solution. (1)

ANSWER

(a) Chloroform + acetone – A–B attractions stronger than A–A and B–B; (b) partial vapour pressure of each component ∝ its mole fraction; (c) ΔmixH = 0 and ΔmixV = 0.

(a) Example: chloroform + acetone (also HNO_3 + water). Reason: new A–B attractions (here H-bond between $CHCl_3$ and the C=O of acetone) are stronger than A–A and B–B, so molecules escape less and vapour pressure is lower than predicted.

(b) Raoult's law: in a solution of volatile liquids, the partial vapour pressure of each component equals its mole fraction times the vapour pressure of the pure component, $p_1 = p_1^\circ x_1$.

(c) Ideal solution: ΔmixH = 0, ΔmixV = 0 (and it obeys Raoult's law at all concentrations).

OR

(b) Raoult's law is a special case of Henry's law. Comment.

(ii)

ANSWER

Both say p ∝ x; Raoult's law is Henry's law with K_H = p°.

Henry's law: p = K_H·x. Raoult's law: p = p°·x.

Both state that the partial pressure of a component is proportional to its mole fraction in solution. When K_H becomes equal to p° (the vapour pressure of the pure component), Henry's law becomes Raoult's law – so Raoult's law is a special case of Henry's law.

30. *The case describes ribose and 2-deoxyribose, sugars of great biological importance, whose phosphate derivatives at the 5′ position matter a lot; purine and pyrimidine bases joined to these sugars form nucleosides.* **4**

(a) What products are formed when DNA is hydrolysed? Give one structural difference between DNA and RNA. (2)

(b) Distinguish between a nucleotide and a nucleoside. (1)

(c) (i) Mention two important functions of nucleic acids. (1)

ANSWER

(a) 2-deoxyribose, phosphoric acid and nitrogen bases (A, G, C, T); DNA double helix, RNA single strand; (b) nucleotide = sugar + base + phosphate, nucleoside = sugar + base; (c) carry genetic information and direct protein synthesis.

(a) Complete hydrolysis of DNA gives 2-deoxy-D-ribose, phosphoric acid and the bases adenine, guanine, cytosine and thymine.
Structural difference: DNA is a double-stranded helix; RNA is single-stranded (also DNA sugar is deoxyribose, RNA has ribose; DNA has T, RNA has U).
(b) Nucleoside = pentose sugar + nitrogenous base. Nucleotide = nucleoside + phosphate group (sugar + base + phosphate).
(c) Functions: DNA stores and passes on hereditary (genetic) information; nucleic acids (RNA) carry out protein synthesis.

OR

(c) (ii) Name the linkage that joins two nucleotides. Name the base present in RNA nucleotides but not in DNA.

ANSWER

Phosphodiester linkage; uracil

Nucleotides are joined through a phosphate that links C-3′ of one sugar to C-5′ of the next – a phosphodiester linkage.
RNA contains uracil (U) in place of thymine (T) found in DNA.

SECTION E

Q31–33 are long answer questions of 5 marks each.

31. (i) Write the main products: **5**

(I) Cyclohexanone + $H_2NCONHNH_2$ (semicarbazide) →

(II) $(CH_3)_2Cd + 2CH_3COCl$ →

(III) Benzoyl chloride (C_6H_5COCl) + H_2 / Pd–$BaSO_4$ →

(ii) Give a simple chemical test to distinguish:

(I) ethyl benzoate and benzoic acid

(II) propanal and propanone

ANSWER

(I) cyclohexanone semicarbazone; (II) $2CH_3COCH_3 + CdCl_2$; (III) C_6H_5CHO; tests: $NaHCO_3$ for benzoic acid, Tollens' for propanal.

(i)(I) Carbonyl + semicarbazide → semicarbazone (loss of H_2O): C_6H_{10}=N–NH–CO–NH_2 (cyclohexanone semicarbazone).

(II) Dialkylcadmium converts acid chlorides to ketones: $(CH_3)_2Cd + 2CH_3COCl \rightarrow 2CH_3COCH_3$ (propanone) + $CdCl_2$.

(III) Rosenmund reduction: $C_6H_5COCl + H_2$ ($Pd/BaSO_4$) → C_6H_5CHO (benzaldehyde) + HCl. $BaSO_4$ poisons Pd so the aldehyde is not reduced further.

(ii)(I) Add $NaHCO_3$ solution: benzoic acid gives brisk effervescence of CO_2; ethyl benzoate (ester) does not.

(II) Warm with Tollens' reagent: propanal gives a silver mirror; propanone does not. (Iodoform test also works: propanone gives yellow CHI_3, propanal does not.)

OR

(i) Complete each synthesis by giving the missing starting material, reagent or product:

(I) Ethylbenzene → (i) $KMnO_4$, KOH (ii) H_3O^+ → ?

(II) Methylenecyclohexane (C_6H_{10}=CH_2) → ? → cyclohexanecarbaldehyde ($C_6H_{11}CHO$)

(III) 4-Oxocyclohexane-1-carbaldehyde (ring with C=O at C-4 and –CHO at C-1) + $[Ag(NH_3)_2]^+$ → ?

(ii) Carry out the conversions:

(I) benzaldehyde to benzophenone

(II) benzaldehyde to 3-phenylpropanol

ANSWER

(I) benzoic acid; (II) B_2H_6 then H_2O_2/OH^- then PCC; (III) 4-oxocyclohexane-1-carboxylic acid; conversions via Grignard + oxidation and via aldol + H_2/Ni.

(i)(I) Alkaline $KMnO_4$ oxidises the whole side chain of an alkylbenzene to $–COO^-$; acidifying gives benzoic acid C_6H_5COOH.

(II) Hydroboration–oxidation adds water anti-Markovnikov: $(BH_3)_2$ then H_2O_2/OH^- gives cyclohexylmethanol $C_6H_{11}CH_2OH$; PCC then oxidises the primary alcohol to the aldehyde $C_6H_{11}CHO$.

(III) Tollens' reagent oxidises only the aldehyde group; the ketone is untouched → 4-oxocyclohexane-1-carboxylic acid (as its salt, with a silver mirror).

(ii)(I) $C_6H_5CHO + C_6H_5MgBr$, then H_3O^+ → $(C_6H_5)_2CHOH$ (diphenylmethanol); oxidise with PCC or CrO_3 → $(C_6H_5)_2CO$ (benzophenone).

(II) Cross aldol (Claisen–Schmidt): $C_6H_5CHO + CH_3CHO$, dil. NaOH, heat → $C_6H_5CH{=}CHCHO$ (cinnamaldehyde); H_2/Ni reduces both C=C and C=O → $C_6H_5CH_2CH_2CH_2OH$ (3-phenylpropan-1-ol).

32. (i) Give reasons: **5**

(I) $[Ni(CO)_4]$ is diamagnetic but $[NiCl_4]^{2-}$ is paramagnetic. (Ni = 28)

(II) CO is a stronger complexing agent than NH_3.

(III) The trans isomer of $[Co(en)_2Cl_2]^+$ is optically inactive.

(ii) Using crystal field theory, give the number of unpaired electrons in an octahedral Fe^{3+} complex with (I) a strong field ligand, (II) a weak field ligand. (Fe = 26)

ANSWER

(I) CO pairs the electrons (no unpaired e^-), Cl^- does not (2 unpaired); (II) CO forms σ + π (back) bonds; (III) trans form has a plane of symmetry; Fe^{3+}: strong field 1, weak field 5 unpaired.

(i)(I) In $[Ni(CO)_4]$, Ni is 0 ($3d^8 4s^2$). CO is a strong field ligand: the 4s electrons are pushed into 3d → $3d^{10}$, sp^3 hybrid, no unpaired electron → diamagnetic. In $[NiCl_4]^{2-}$, Ni^{2+} is $3d^8$; Cl^- is weak field and causes no pairing → 2 unpaired electrons, sp^3 → paramagnetic.

(II) CO donates a lone pair (σ bond) and also accepts metal d electrons into its empty π* orbitals (π back-bonding). This synergic bonding makes the M–CO bond strong; NH_3 forms only a σ bond.

(III) In trans-$[Co(en)_2Cl_2]^+$ the two Cl are opposite; the ion has a plane of symmetry, so its mirror image is superimposable → optically inactive.

(ii) $Fe^{3+} = 3d^5$.

(I) Strong field ($\Delta o > P$): $t_2g^5\ eg^0$ → 1 unpaired electron (low spin).

(II) Weak field ($\Delta o < P$): $t_2g^3\ eg^2$ → 5 unpaired electrons (high spin).

OR

(i) Name the type of isomerism shown by each, and draw/write the corresponding isomers:

(I) $[Co(NH_3)_6][Cr(CN)_6]$

(II) $[Co(en)_3]^{3+}$

(III) $[Co(NH_3)_3(NO_2)_3]$

(ii) Differentiate between weak field and strong field ligands. How does ligand strength affect the spin of a complex?

ANSWER

(I) coordination isomerism – $[Cr(NH_3)_6][Co(CN)_6]$; (II) optical isomerism – d and l forms; (III) geometrical – fac and mer; strong field → large Δo → low spin, weak field → small Δo → high spin.

(i)(I) Coordination isomerism – ligands swap between the cationic and anionic metal centres: isomer $[Cr(NH_3)_6][Co(CN)_6]$.

(II) Optical isomerism – $[Co(en)_3]^{3+}$ has no plane of symmetry; the three en rings can twist either way, giving two non-superimposable mirror images, d (dextro) and l (laevo).

(III) Geometrical (fac–mer) isomerism – fac: the three NH_3 (and three NO_2) on one triangular face of the octahedron; mer: the three like ligands lie in a plane around the meridian.

(ii) Weak field ligands (I^-, Cl^-, F^-, H_2O) cause small splitting of d orbitals (small Δo); strong field ligands (CN^-, CO, en, NH_3) cause large splitting (large Δo).

Effect on spin: with strong field ligands $\Delta o > P$, electrons pair in t_2g → fewer unpaired electrons → low-spin complex. With weak field ligands $\Delta o < P$, electrons enter eg before pairing → more unpaired electrons → high-spin complex.

33. (i) For the first-order reaction $N_2O_5(g) \rightarrow 2NO_2(g) + \frac{1}{2}O_2(g)$ at 318 K, $[N_2O_5]$ fell from 1.2×10^{-2} mol L^{-1} to 0.2×10^{-2} mol L^{-1} in 60 minutes. Calculate the rate constant. (log 6 = 0.778) **5**

(ii) Explain:

(I) The order of a reaction cannot be found from its balanced equation.

(II) A bimolecular reaction can behave as first order under a certain condition.

ANSWER

k ≈ 2.99×10^{-2} min^{-1} (0.0299 min^{-1}); order is experimental; one reactant in large excess → pseudo first order.

(i) $k = \frac{2.303}{t} \log \frac{[R]_0}{[R]}$.

$[R]_0/[R] = (1.2 \times 10^{-2})/(0.2 \times 10^{-2}) = 6$.

k = (2.303/60 min) × log 6 = (2.303 × 0.778)/60 = 1.7917/60 = 0.0299 $min^{-1} \approx 2.99 \times 10^{-2}$ min^{-1}.

(ii)(I) Order depends on the actual mechanism (the slow step), not on the stoichiometric coefficients; it must be found experimentally.

(II) If one reactant is taken in large excess (e.g. water in hydrolysis of an ester), its concentration stays nearly constant, so rate depends on the other reactant only → pseudo first-order reaction.

OR

(i) The rate of a reaction doubles when the temperature is raised by 10 K from 298 K. Calculate the activation energy Ea. (2.303R = 19.15 J K^{-1} mol^{-1}, log 2 = 0.3)

(ii) For $2H_2O_2 \rightarrow 2H_2O + O_2$ (catalysed by I^-), the proposed mechanism is:

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

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

(1) Write the rate law. (2) Give the overall order and the molecularity.

ANSWER

Ea ≈ 52.7 kJ mol^{-1}; Rate = $k[H_2O_2][I^-]$; order 2, molecularity 2.

(i) $\log \frac{k_2}{k_1} = \frac{E_a}{2.303R}\left(\frac{T_2 - T_1}{T_1 T_2}\right)$, with $k_2/k_1 = 2$, $T_1 = 298$ K, $T_2 = 308$ K.

0.3 = (Ea/19.15) × (10/(298 × 308)).

Ea = 0.3 × 19.15 × 298 × 308 / 10 = 0.3 × 19.15 × 9178.4 = 52 730 J $mol^{-1} \approx 52.7$ kJ mol^{-1}.

(ii)(1) The slow step decides the rate: Rate = $k[H_2O_2][I^-]$.

(2) Overall order = 1 + 1 = 2; the slow step involves two species, so molecularity = 2 (bimolecular).

Note: I^- is a catalyst – used in step I and regenerated in step II.

— END —

Questions restated from the CBSE Class XII Board Examination 2025 (set 56/4/1) for practice. Reading passages and map items are described, not reproduced.