AIIMS Paramedical Chemistry

Sample Paper – 5

Duration: 30 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry portion of **AIIMS Paramedical** entrance.
- Each correct answer carries **+1 mark**. A penalty of $-\frac{1}{3}$ **mark** is deducted for each incorrect answer. Unattempted questions carry **0** marks (no negative marking).
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 & 12 NCERT Chemistry**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. 5.85 g of NaCl (molar mass 58.5 g mol^{-1}) is dissolved in water and the solution is made up to a final volume of 500 mL. The molarity of the resulting solution is:

(A) 0.1 M

(B) 0.5 M

(C) 0.2 M

(D) 1.0 M

Q2. For the hydrogen atom, the Rydberg constant is $R_H = 1.097 \times 10^7$ m^{-1}. The wavelength of the spectral line for the transition from $n = 3$ to $n = 2$ (first line of the Balmer series) is closest to:

(A) 656 nm

(B) 486 nm

(C) 121 nm

(D) 820 nm

Q3. For a sample of an ideal gas at a given temperature, which of the following correctly orders the root-mean-square speed (u_{rms}), the average speed (u_{av}) and the most-probable speed (u_{mp})?

(A) $u_{mp} > u_{av} > u_{rms}$

(B) $u_{rms} > u_{av} > u_{mp}$

(C) $u_{av} > u_{rms} > u_{mp}$

(D) $u_{rms} = u_{av} = u_{mp}$

Q4. One mole of an ideal gas expands reversibly and isothermally at 300 K from a volume V to a volume $2V$. The entropy change of the gas is (take $R = 8.314$ J K^{-1}mol^{-1}, $\ln 2 = 0.693$):

(A) -5.76 J K^{-1}

(B) 11.5 J K^{-1}

(C) 0 J K^{-1}

(D) 5.76 J K^{-1}

Q5. For the reaction $\mathrm{N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)}$ the equilibrium constant is $K_c = 0.5$. At a certain instant the reaction quotient is found to be $Q_c = 0.2$. In which direction will the reaction proceed to reach equilibrium?

(A) Forward (towards products), since $Q_c < K_c$

(B) Backward (towards reactants), since $Q_c < K_c$

(C) The reaction is already at equilibrium

(D) Forward, since $Q_c > K_c$

Q6. The solubility of sparingly soluble AgCl in water is suppressed when a soluble salt such as NaCl is added. This decrease in solubility is best explained by:

(A) An increase in the value of the solubility product K_{sp}

(B) Formation of a soluble complex of silver

(C) The common-ion effect, which shifts the dissolution equilibrium backward

(D) An increase in the degree of dissociation of AgCl

Q7. In which of the following reactions does the same element undergo both oxidation and reduction (a disproportionation reaction)?

(A) $2\mathrm{H_2} + \mathrm{O_2} \rightarrow 2\mathrm{H_2O}$

(B) $\mathrm{Cl_2} + 2\mathrm{OH^-} \rightarrow \mathrm{Cl^-} + \mathrm{ClO^-} + \mathrm{H_2O}$

(C) $\mathrm{Zn} + \mathrm{CuSO_4} \rightarrow \mathrm{ZnSO_4} + \mathrm{Cu}$

(D) $2\mathrm{KClO_3} \rightarrow 2\mathrm{KCl} + 3\mathrm{O_2}$

Q8. The limiting molar conductivities are $\Lambda^\circ_m(\mathrm{HCl}) = 426$, $\Lambda^\circ_m(\mathrm{CH_3COONa}) = 91$ and $\Lambda^\circ_m(\mathrm{NaCl}) = 126$ (all in S cm^{2}mol^{-1}). Using Kohlrausch's law, $\Lambda^\circ_m(\mathrm{CH_3COOH})$ is:

(A) 217 S cm^{2}mol^{-1}

(B) 461 S cm^{2}mol^{-1}

(C) 126 S cm^{2}mol^{-1}

(D) 391 S cm^{2}mol^{-1}

Q9. For a zero-order reaction, the concentration of the reactant falls from 0.10 mol L^{-1} to 0.04 mol L^{-1} in 30 minutes. The rate constant of the reaction is:

(A) 2×10^{-3} mol L^{-1}min^{-1}

(B) 6×10^{-3} mol L^{-1}min^{-1}

(C) 2×10^{-3} min^{-1}

(D) 1×10^{-3} mol L^{-1}min^{-1}

Q10. For the strong electrolyte $K_4[Fe(CN)_6]$, assuming complete dissociation in dilute aqueous solution, the value of the van't Hoff factor i is:

(A) 4

(B) 5

(C) 2

(D) 6

Q11. Across the third period (Na to Cl), the maximum positive oxidation state shown by the elements in their compounds generally:

(A) Remains constant at $+1$

(B) First decreases and then increases

(C) Increases from $+1$ (Na) up to $+7$ (Cl)

(D) Decreases steadily from $+7$ to $+1$

Q12. Lithium shows several properties similar to magnesium rather than to the other alkali metals. This similarity between Li and Mg is an example of:

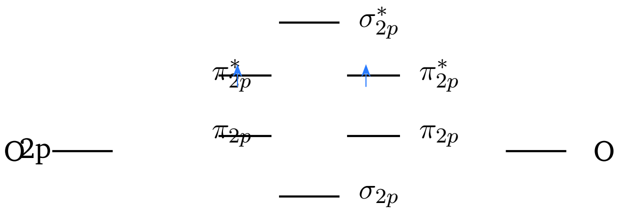
(A) The diagonal relationship

(B) The inert-pair effect

(C) The lanthanoid contraction

(D) Isoelectronic behaviour

Q13. Using molecular orbital theory, the bond order of the oxygen molecule O_2 (14 electrons) is:



(A) 1

(B) 3

(C) 1.5

(D) 2

Q14. According to molecular orbital theory, the molecule O_2 has two unpaired electrons in its antibonding π^* orbitals. The molecule is therefore:

(A) Diamagnetic

(B) Paramagnetic

(C) Ferromagnetic

(D) Non-magnetic with zero bond order

Q15. Among the alkali metal cations, the magnitude of the enthalpy of hydration follows the order:

(A) $Cs^+ > Rb^+ > K^+ > Na^+ > Li^+$

(B) All have equal hydration enthalpy

(C) $K^+ > Na^+ > Li^+$

(D) $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$

Q16. Which statement about the allotropes of oxygen is correct?

(A) Ozone (O_3) is a powerful oxidising agent and decomposes to dioxygen with release of energy

(B) Ozone is diamagnetic and chemically inert

(C) Dioxygen (O_2) is a stronger oxidising agent than ozone

(D) Ozone has a linear, symmetrical structure

Q17. In the Contact process for the manufacture of sulphuric acid, the key catalytic step is the oxidation of SO_2 to SO_3. The catalyst commonly used for this step is:

(A) Finely divided iron

(B) Nickel

(C) Vanadium pentoxide (V_2O_5)

(D) Platinised asbestos only at $1000°C$

Q18. In acidified potassium dichromate, $K_2Cr_2O_7$, the oxidation state of chromium and the nature of the reagent are:

(A) $+3$ and a reducing agent

(B) $+6$ and a strong oxidising agent

(C) $+7$ and a strong oxidising agent

(D) $+2$ and a reducing agent

Q19. The complex ion $[Ni(CN)_4]^{2-}$ is diamagnetic. According to valence bond theory, the hybridisation of nickel and the geometry of the complex are:

(A) sp^3, tetrahedral

(B) sp^3d^2, octahedral

(C) d^2sp^3, octahedral

(D) dsp^2, square planar

Q20. The temporary hardness of water is mainly due to the presence of:

(A) Bicarbonates of calcium and magnesium

(B) Chlorides of calcium and magnesium

(C) Sulphates of calcium and magnesium

(D) Dissolved oxygen and nitrogen

Q21. Which of the following species can act only as a nucleophile?

(A) BF_3

(B) NO_2^+

(C) OH^-

(D) $AlCl_3$

Q22. Diethyl ether ($C_2H_5-O-C_2H_5$) and methyl propyl ether ($CH_3-O-C_3H_7$) have the same molecular formula but a different distribution of carbon atoms on either side of the oxygen. This type of structural isomerism is called:

(A) Chain isomerism

(B) Metamerism

(C) Tautomerism

(D) Functional-group isomerism

Q23. When ethanol is heated with concentrated sulphuric acid at about 443 K ($170°$C), the major organic product is:

(A) Ethene

(B) Diethyl ether

(C) Ethanal

(D) Ethane

Q24. In the Wurtz reaction, an alkyl halide is treated with sodium metal in dry ether. When bromoethane (C_2H_5Br) is used, the main hydrocarbon formed is:

$$C_2H_5{-}Br \quad + 2Na + \quad Br{-}C_2H_5 \xrightarrow{\text{dry ether}} \text{product}$$

(A) Ethane

(B) Ethene

(C) Propane

(D) n-Butane

Q25. When 2-bromobutane is treated with alcoholic KOH, dehydrohalogenation occurs. According to Saytzeff's rule, the major alkene formed is:

(A) 1-Butene

(B) Cyclobutene

(C) 2-Butene (but-2-ene)

(D) Butane

Q26. In the Williamson ether synthesis, an alkyl halide reacts with a sodium alkoxide. To prepare ethyl methyl ether ($CH_3{-}O{-}C_2H_5$) in good yield, the preferred combination of reagents is:

(A) Sodium tert-butoxide and tert-butyl bromide

(B) Sodium methoxide and bromoethane

(C) Sodium ethoxide and 2-bromo-2-methylpropane

(D) Sodium phenoxide and chlorobenzene

Q27. Rosenmund reduction is used to prepare aldehydes. When an acyl chloride ($R{-}COCl$) is hydrogenated over palladium supported on barium sulphate (partially poisoned), the product is:

(A) An aldehyde ($R{-}CHO$)

(B) A primary alcohol ($R{-}CH_2OH$)

(C) A carboxylic acid ($R{-}COOH$)

(D) A ketone ($R{-}CO{-}R$)

Q28. When sodium ethanoate (sodium acetate) is heated with soda lime ($NaOH$ and CaO), the carboxyl group is lost as a carbonate and the hydrocarbon formed is:

(A) Ethene

(B) Ethanol

(C) Propane

(D) Methane

Q29. Gabriel phthalimide synthesis is used to prepare a specific class of amines. The amines obtained by this method are exclusively:

(A) Tertiary amines

(B) Aromatic (aryl) amines

(C) Primary aliphatic amines

(D) Quaternary ammonium salts

Q30. Enzymes are biological catalysts. A characteristic feature of enzyme action is that each enzyme is:

(A) Active over the entire pH range with equal efficiency

(B) Highly specific, catalysing essentially one particular reaction or substrate

(C) Consumed completely during the reaction it catalyses

(D) Effective only at very high temperatures above $100°\text{C}$

Detailed Solutions

Q1.

Solution

Concept — Molarity: Molarity is the number of moles of solute dissolved per litre of solution, $M = \dfrac{n_{solute}}{V_{solution}\text{ (in L)}}$.

Step 1 — Find the moles of NaCl:

$$n = \frac{\text{mass}}{\text{molar mass}} = \frac{5.85}{58.5} = 0.1\text{ mol.}$$

Step 2 — Convert the volume to litres:

$$V = 500\text{ mL} = 0.5\text{ L.}$$

Step 3 — Apply the molarity formula:

$$M = \frac{0.1}{0.5} = 0.2\text{ mol L}^{-1} = 0.2\text{ M.}$$

Why other options are wrong:

- (A) 0.1 M forgets to divide by the 0.5 L volume (treats it as 1 L).
- (B) 0.5 M inverts the moles and volume.
- (D) 1.0 M uses the wrong number of moles.

Final Answer: $M = 0.2\text{ M} \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q 1**

Q2.

Solution

Concept — Rydberg formula: For hydrogen, $\dfrac{1}{\lambda} = R_H\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$ where $n_1 < n_2$. The Balmer series has $n_1 = 2$.

Step 1 — Insert the levels: For the $n = 3 \to n = 2$ line, $n_1 = 2$ and $n_2 = 3$:

$$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = R_H\left(\frac{1}{4} - \frac{1}{9}\right).$$

Step 2 — Evaluate the bracket:

$$\frac{1}{4} - \frac{1}{9} = \frac{9-4}{36} = \frac{5}{36}.$$

Step 3 — Compute λ:

$$\frac{1}{\lambda} = 1.097 \times 10^{7} \times \frac{5}{36} = 1.524 \times 10^{6}\ \text{m}^{-1},$$

$$\lambda = \frac{1}{1.524 \times 10^{6}} \approx 6.56 \times 10^{-7}\ \text{m} = 656\ \text{nm}.$$

Why other options are wrong:

- (B) 486 nm is the $n = 4 \to 2$ line.
- (C) 121 nm is the Lyman $n = 2 \to 1$ line.
- (D) 820 nm does not match any Balmer transition.

Final Answer: $\lambda \approx 656$ nm $\Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q 2**

Q3.

Solution

Concept — Molecular speeds: The three characteristic speeds are $u_{mp} = \sqrt{\frac{2RT}{M}}$, $u_{av} = \sqrt{\frac{8RT}{\pi M}}$ and $u_{rms} = \sqrt{\frac{3RT}{M}}$.

Step 1 — Compare the numerical factors: They go as $\sqrt{2} : \sqrt{8/\pi} : \sqrt{3}$, i.e. $1.414 : 1.596 : 1.732$.

Step 2 — Order the speeds: Since $1.414 < 1.596 < 1.732$,

$$u_{mp} < u_{av} < u_{rms}.$$

Step 3 — State the descending order:

$$u_{rms} > u_{av} > u_{mp}.$$

Why other options are wrong:

- (A) reverses the correct order.

- (C) wrongly places u_{av} above u_{rms}.
- (D) is true only at absolute zero (no motion), not at a finite temperature.

Final Answer: $u_{rms} > u_{av} > u_{mp} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 3

Q4.

Solution

Concept — Entropy of isothermal expansion: For an ideal gas expanding isothermally and reversibly, $\Delta S = nR\ln\dfrac{V_2}{V_1}$.

Step 1 — List the data: $n = 1$ mol, $V_2/V_1 = 2$, $R = 8.314\ \text{J K}^{-1}\text{mol}^{-1}$, $\ln 2 = 0.693$.

Step 2 — Substitute:

$$\Delta S = 1 \times 8.314 \times \ln 2 = 8.314 \times 0.693.$$

Step 3 — Evaluate:

$$\Delta S = 5.76\ \text{J K}^{-1}\ (\text{positive, since the gas expands}).$$

Why other options are wrong:

- (A) $-5.76\ \text{J K}^{-1}$ has the wrong sign (compression).
- (B) $11.5\ \text{J K}^{-1}$ doubles the result.
- (C) 0 would hold only if there were no volume change.

Final Answer: $\Delta S = +5.76\ \text{J K}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 4

Q5.

Solution

Concept — Reaction quotient and direction: Comparing Q_c with K_c tells us the direction of net reaction. If $Q_c < K_c$, the reaction moves forward; if $Q_c > K_c$, it moves backward; if $Q_c = K_c$, it is at equilibrium.

Step 1 — Note the values: $K_c = 0.5$ and $Q_c = 0.2$.

Step 2 — Compare: Since $0.2 < 0.5$, we have $Q_c < K_c$.

Step 3 — Conclude the direction: The system has too few products relative to equilibrium, so net reaction proceeds in the forward direction to form more NH_3.

Why other options are wrong:

- (B) gives the wrong direction for $Q_c < K_c$.
- (C) would require $Q_c = K_c$.
- (D) misstates the inequality (Q_c is less than K_c, not greater).

Final Answer: Forward, since $Q_c < K_c \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 5

Q6.

Solution

Concept — Common-ion effect: For the equilibrium $AgCl(s) \rightleftharpoons Ag^+ + Cl^-$, adding a common ion (here Cl^- from NaCl) raises that ion's concentration and, by Le Chatelier's principle, shifts the equilibrium backward, reducing solubility while K_{sp} stays constant.

Step 1 — Write the equilibrium:

$$\mathrm{AgCl(s)} \rightleftharpoons \mathrm{Ag^+(aq)} + \mathrm{Cl^-(aq)}, \qquad K_{sp} = [\mathrm{Ag^+}][\mathrm{Cl^-}].$$

Step 2 — Add the common ion: NaCl supplies extra Cl^-, raising $[Cl^-]$.

Step 3 — Apply Le Chatelier: To keep K_{sp} constant, $[Ag^+]$ must fall, so less AgCl dissolves; solubility decreases.

Why other options are wrong:

- (A) K_{sp} is a constant at fixed temperature; it does not change.
- (B) no soluble complex forms here.
- (D) dissociation is suppressed, not increased.

Final Answer: Common-ion effect $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 6

Q7.

Solution

Concept — Disproportionation: A disproportionation reaction is one in which the same element in a single oxidation state is simultaneously oxidised and reduced to two different states.

Step 1 — Track chlorine in option (B): In Cl_2 the oxidation state of chlorine is 0.

Step 2 — Identify the products: In Cl^- chlorine is -1 (reduced); in ClO^- chlorine is $+1$ (oxidised).

Step 3 — Conclude: The same chlorine goes from 0 to both -1 and $+1$, so this is disproportionation.

Why other options are wrong:

- (A) is a simple combination; H and O change states but no single element splits both ways.
- (C) is a displacement (Zn oxidised, Cu reduced—different elements).
- (D) is decomposition; oxygen is oxidised and chlorine reduced (different elements).

Final Answer: $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q 7

Q8.

Solution

Concept — Kohlrausch's law of independent migration: The limiting molar conductivity of an electrolyte is the sum of the contributions of its ions. We can combine known Λ_m° values to obtain an unknown one.

Step 1 — Set up the combination:

$$\Lambda_m^\circ(CH_3COOH) = \Lambda_m^\circ(CH_3COONa) + \Lambda_m^\circ(HCl) - \Lambda_m^\circ(NaCl).$$

Step 2 — Check the ions cancel: The right side gives $CH_3COO^- + Na^+ + H^+ + Cl^- - Na^+ - Cl^-$, leaving $CH_3COO^- + H^+$, exactly acetic acid.

Step 3 — Substitute the numbers:

$$\Lambda_m^\circ(CH_3COOH) = 91 + 426 - 126 = 391 \text{ S cm}^2\text{mol}^{-1}.$$

Why other options are wrong:

- (A) 217 adds only two of the three terms.
- (B) 461 forgets to subtract $\Lambda^\circ_m(\text{NaCl})$.
- (C) 126 is just the NaCl value.

Final Answer: $391\ \text{S cm}^2\text{mol}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 8

Q9.

Solution

Concept — Zero-order kinetics: For a zero-order reaction the rate is independent of concentration, and $[A]_0 - [A] = kt$, so $k = \dfrac{[A]_0 - [A]}{t}$.

Step 1 — List the data: $[A]_0 = 0.10$ mol L^{-1}, $[A] = 0.04$ mol L^{-1}, $t = 30$ min.

Step 2 — Find the change in concentration:

$$[A]_0 - [A] = 0.10 - 0.04 = 0.06\ \text{mol L}^{-1}.$$

Step 3 — Compute the rate constant:

$$k = \frac{0.06}{30} = 2 \times 10^{-3}\ \text{mol L}^{-1}\text{min}^{-1}.$$

Why other options are wrong:

- (B) 6×10^{-3} forgets to divide by 30 correctly.
- (C) has the wrong units (a zero-order k carries concentration units).
- (D) 1×10^{-3} uses a wrong concentration difference.

Final Answer: $k = 2 \times 10^{-3}\ \text{mol L}^{-1}\text{min}^{-1} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 9

Q10.

Solution

Concept — van't Hoff factor: For a strong electrolyte that dissociates completely, i equals the number of ions produced per formula unit.

Step 1 — Write the dissociation:

$$K_4[Fe(CN)_6] \rightarrow 4K^+ + [Fe(CN)_6]^{4-}.$$

Step 2 — Count the ions: Four potassium ions plus one hexacyanoferrate(II) ion.

Step 3 — Total:

$$i = 4 + 1 = 5.$$

Why other options are wrong:

- (A) 4 counts only the K^+ ions.
- (C) 2 treats it as a simple binary salt.
- (D) 6 wrongly counts the six cyanide groups as free ions (they stay inside the complex).

Final Answer: $i = 5 \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q 10

Q11.

Solution

Concept — Oxidation states across a period: As we move left to right across a period, the number of valence electrons available for bonding rises, so the maximum positive oxidation state generally increases.

Step 1 — Track the group maxima: Na $(+1)$, Mg $(+2)$, Al $(+3)$, Si $(+4)$, P $(+5)$, S $(+6)$, Cl $(+7)$.

Step 2 — Identify the trend: The maximum positive oxidation state climbs steadily from $+1$ at sodium to $+7$ at chlorine.

Step 3 — Conclude: The correct description is an increase from $+1$ to $+7$.

Why other options are wrong:

- (A) it is not constant.
- (B) there is no dip then rise.

- (D) reverses the actual trend.

Final Answer: Increases from $+1$ (Na) to $+7$ (Cl) $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 11

Q12.

Solution

Concept — Diagonal relationship: The first member of a group often resembles the second member of the next group (placed diagonally) because of similar charge-to-size ratios. Li resembles Mg, Be resembles Al, B resembles Si.

Step 1 — Locate the pair: Li (group 1, period 2) and Mg (group 2, period 3) lie diagonally adjacent.

Step 2 — Reason for similarity: The small, highly polarising Li^+ has a charge/size ratio close to that of Mg^{2+}, giving similar chemistry (e.g. both form nitrides, both have covalent character).

Step 3 — Name the effect: This is the diagonal relationship.

Why other options are wrong:

- (B) the inert-pair effect concerns heavy p-block elements.
- (C) the lanthanoid contraction concerns the f-block.
- (D) Li and Mg are not isoelectronic.

Final Answer: Diagonal relationship $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 12

Q13.

Solution

Concept — Bond order from MOT: Bond order $= \dfrac{1}{2}(N_b - N_a)$, where N_b and N_a are the numbers of electrons in bonding and antibonding molecular orbitals.

Step 1 — Fill the MOs for O_2 (14 electrons):

$$\sigma_{1s}^{2}\,\sigma_{1s}^{*2}\,\sigma_{2s}^{2}\,\sigma_{2s}^{*2}\,\sigma_{2p_z}^{2}\,\pi_{2p_x}^{2}\,\pi_{2p_y}^{2}\,\pi_{2p_x}^{*1}\,\pi_{2p_y}^{*1}.$$

Step 2 — Count bonding and antibonding electrons:

$$N_b = 2+2+2+2+2 = 10, \qquad N_a = 2+2+1+1 = 6.$$

Step 3 — Apply the formula:

$$\text{Bond order} = \frac{1}{2}(10-6) = \frac{4}{2} = 2.$$

Why other options are wrong:

- (A) 1 and (C) 1.5 undercount the bonding electrons.
- (B) 3 is the bond order of N_2, not O_2.

Final Answer: Bond order $= 2 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 13

Q14.

Solution

Concept — Magnetic behaviour from MOT: A species with one or more unpaired electrons is paramagnetic (attracted into a magnetic field); a species with all electrons paired is diamagnetic.

Step 1 — Recall the O_2 configuration: The two highest electrons occupy the degenerate π^*_{2p} orbitals singly, by Hund's rule.

Step 2 — Count unpaired electrons: There are two unpaired electrons.

Step 3 — Classify: With unpaired electrons present, O_2 is paramagnetic. This is a notable success of MOT, which explains the observed paramagnetism that simple Lewis structures cannot.

Why other options are wrong:

- (A) diamagnetic would require all electrons paired.
- (C) ferromagnetism is a bulk solid-state property, not a property of an isolated molecule.
- (D) the bond order of O_2 is 2, not zero.

Final Answer: O_2 is paramagnetic $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 14

Q15.

Solution

Concept — Hydration enthalpy and ionic size: The smaller the cation, the higher its charge density, the more strongly it attracts water molecules, and the larger the magnitude of its hydration enthalpy.

Step 1 — Order the ionic sizes: Down group 1, size increases: $\mathrm{Li^+ < Na^+ < K^+ < Rb^+ < Cs^+}$.

Step 2 — Relate to hydration: The smallest ion, $\mathrm{Li^+}$, has the greatest charge density and so the most negative (largest magnitude) hydration enthalpy.

Step 3 — Write the trend:

$$\mathrm{Li^+ > Na^+ > K^+ > Rb^+ > Cs^+} \text{ (magnitude of hydration enthalpy)}.$$

Why other options are wrong:

- (A) reverses the order.
- (B) the enthalpies are clearly different.
- (C) is incomplete and omits the smaller ions wrongly.

Final Answer: $\mathrm{Li^+ > Na^+ > K^+ > Rb^+ > Cs^+} \Rightarrow \boxed{\mathrm{D}}$

Answer: (D) **Go Back to Q 15**

Q16.

Solution

Concept — Ozone as an oxidiser: Ozone is a bent, polar allotrope of oxygen that is thermodynamically unstable relative to O_2. It decomposes exothermically and acts as a powerful oxidising agent.

Step 1 — Decomposition:

$$2O_3 \rightarrow 3O_2, \qquad \Delta H < 0 \text{ (energy released)}.$$

Step 2 — Oxidising power: The nascent oxygen released, $O_3 \rightarrow O_2 + [O]$, makes ozone a much stronger oxidiser than ordinary dioxygen.

Step 3 — Conclude: Statement (A) correctly captures both the strong oxidising character and the energy-releasing decomposition.

Why other options are wrong:

- (B) ozone is reactive, not inert.
- (C) ozone is the stronger oxidiser, not O_2.
- (D) ozone is bent (angular), not linear.

Final Answer: Ozone is a powerful oxidiser that decomposes exothermically $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 16

Q17.

Solution

Concept — Contact process: Sulphuric acid is made by oxidising SO_2 to SO_3, then absorbing SO_3 in concentrated H_2SO_4 to form oleum. The catalytic oxidation step needs a suitable catalyst.

Step 1 — Write the catalytic step:

$$2SO_2 + O_2 \xrightarrow{\text{catalyst}} 2SO_3.$$

Step 2 — Identify the catalyst: The modern Contact process uses vanadium(V) oxide, V_2O_5, which is cheaper and less easily poisoned than platinum.

Step 3 — Conclude: The catalyst is V_2O_5.

Why other options are wrong:

- (A) iron is used in the Haber process, not here.
- (B) nickel is a hydrogenation catalyst.
- (D) platinised asbestos was the old catalyst but is easily poisoned; V_2O_5 is the standard answer.

Final Answer: $V_2O_5 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 17

Q18.

Solution

Concept — Oxidation state in dichromate: In $Cr_2O_7^{2-}$ each oxygen is -2. Letting the chromium oxidation state be x and balancing the charge gives its value, and dichromate in acid is a well-known oxidiser.

Step 1 — Balance the charge:

$$2x + 7(-2) = -2 \Rightarrow 2x - 14 = -2.$$

Step 2 — Solve for x:

$$2x = 12 \Rightarrow x = +6.$$

Step 3 — Note the reagent's nature: In acidic medium, $Cr_2O_7^{2-}$ is reduced to Cr^{3+} ($+6 \to +3$), so it is a strong oxidising agent.

Why other options are wrong:

- (A) $+3$ is the reduced product, not the state in dichromate, and it is not a reducing agent.
- (C) $+7$ would over-balance the charge.
- (D) $+2$ is far too low.

Final Answer: Cr is $+6$ and a strong oxidiser $\Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q 18**

Q19.

Solution

Concept — VBT and complex geometry: In valence bond theory, a diamagnetic four-coordinate complex of a d^8 metal uses dsp^2 hybridisation, giving a square-planar shape; sp^3 would give a tetrahedral, paramagnetic complex.

Step 1 — Oxidation state and configuration: In $[Ni(CN)_4]^{2-}$, Ni is $+2$, a d^8 ion.

Step 2 — Use the diamagnetism clue: The complex is diamagnetic, so all d electrons are paired; the strong-field CN^- forces pairing and frees one $3d$ orbital.

Step 3 — Assign hybridisation and shape: One $3d$, one $4s$ and two $4p$ orbitals combine as dsp^2, giving a square-planar geometry.

Why other options are wrong:

- (A) sp^3 tetrahedral would be paramagnetic.
- (B) and (C) are six-coordinate octahedral schemes, not four-coordinate.

Final Answer: dsp^2, square planar $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 19

Q20.

Solution

Concept — Temporary hardness: Hardness of water that can be removed simply by boiling is called temporary hardness; it is due to the dissolved bicarbonates of calcium and magnesium.

Step 1 — Identify the species: Temporary hardness arises from $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$.

Step 2 — Removal on boiling:

$$Ca(HCO_3)_2 \xrightarrow{\text{heat}} CaCO_3 \downarrow + H_2O + CO_2.$$

Step 3 — Conclude: Temporary hardness is due to bicarbonates of Ca and Mg.

Why other options are wrong:

- (B) and (C) chlorides and sulphates cause permanent hardness, not removed by boiling.
- (D) dissolved gases do not cause hardness.

Final Answer: Bicarbonates of Ca and Mg $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 20

Q21.

Solution

Concept — Nucleophiles vs electrophiles: A nucleophile is electron-rich and donates a lone pair or negative charge; an electrophile is electron-deficient and accepts electrons.

Step 1 — Examine the species: OH^- carries a negative charge and lone pairs on oxygen.

Step 2 — Classify: Being electron-rich, OH^- donates electrons and acts purely as a nucleophile (a Lewis base).

Step 3 — Compare with the others: BF_3 and $AlCl_3$ have electron-deficient central atoms (electrophiles/Lewis acids), and NO_2^+ is a positively charged electrophile.

Why other options are wrong:

- (A) and (D) are electron-deficient electrophiles.
- (B) NO_2^+ is the nitronium electrophile used in nitration.

Final Answer: OH^- is the nucleophile $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q 21

Q22.

Solution

Concept — Metamerism: Metamerism is a type of structural isomerism arising from a different distribution of carbon atoms (alkyl groups) on either side of a functional group such as $-O-$ in ethers or $-CO-$ in ketones, with the same molecular formula.

Step 1 — Compare the two ethers: Both $C_2H_5{-}O{-}C_2H_5$ and $CH_3{-}O{-}C_3H_7$ have the formula $C_4H_{10}O$.

Step 2 — Note the difference: The alkyl groups around the oxygen differ ($2+2$ carbons versus $1+3$ carbons).

Step 3 — Name the isomerism: Different alkyl groups about the same functional group is metamerism.

Why other options are wrong:

- (A) chain isomerism concerns the carbon skeleton, not partition about a functional group.
- (C) tautomerism involves a movable hydrogen and dynamic equilibrium.
- (D) functional-group isomerism would change the functional group (e.g. ether vs alcohol).

Final Answer: Metamerism $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q 22

Q23.

Solution

Concept — Acid-catalysed dehydration: Heating an alcohol with concentrated H_2SO_4 at high temperature removes a molecule of water across two adjacent carbons (an elimination), giving an alkene. Temperature decides the product.

Step 1 — Write the reaction:

$$CH_3CH_2OH \xrightarrow{\text{conc. } H_2SO_4,\ 443\,\text{K}} CH_2{=}CH_2 + H_2O.$$

Step 2 — Note the role of temperature: At about 443 K the elimination (alkene) dominates; at the lower 413 K the substitution product diethyl ether forms instead.

Step 3 — Conclude: The major product at 443 K is ethene.

Why other options are wrong:

- (B) diethyl ether forms at the lower temperature (413 K).
- (C) ethanal requires oxidation, not dehydration.
- (D) ethane would require reduction.

Final Answer: Ethene $\Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q 23**

Q24.

Solution

Concept — Wurtz reaction: Two molecules of an alkyl halide react with sodium in dry ether, coupling the two alkyl groups to give a symmetrical alkane with double the carbon count of the alkyl group.

Step 1 — Write the coupling:

$$2\,C_2H_5Br + 2Na \xrightarrow{\text{dry ether}} C_2H_5{-}C_2H_5 + 2NaBr.$$

Step 2 — Identify the product: Joining two ethyl (C_2H_5-) groups gives a four-carbon chain, $CH_3CH_2CH_2CH_3$.

Step 3 — Name it: This is n-butane.

Why other options are wrong:

- (A) ethane would need methyl halide.

- (B) ethene is an alkene, not a Wurtz product.
- (C) propane (three carbons) cannot arise from coupling two identical ethyl groups.

Final Answer: n-Butane $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 24

Q25.

Solution

Concept — Saytzeff's rule: In dehydrohalogenation with alcoholic KOH (an E2 elimination), the major product is the more substituted, more stable alkene—the one formed by removing the β-hydrogen from the carbon with fewer hydrogens.

Step 1 — Identify the substrate: 2-Bromobutane is $CH_3{-}CHBr{-}CH_2{-}CH_3$.

Step 2 — Choose the β-hydrogen: Removing a β-H from the internal CH_2 (C3) gives the more substituted but-2-ene; removing from the terminal CH_3 (C1) gives but-1-ene.

Step 3 — Apply Saytzeff: The more substituted (more stable) alkene, but-2-ene, is the major product.

Why other options are wrong:

- (A) 1-butene is the minor (Hofmann) product.
- (B) cyclobutene cannot form from an open chain.
- (D) butane would require reduction, not elimination.

Final Answer: But-2-ene $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 25

Q26.

Solution

Concept — Williamson ether synthesis: An alkoxide ($R{-}O^-Na^+$) attacks an alkyl halide by S_N2. For a good yield the halide should be primary (least steric hindrance); bulky tertiary halides give elimination instead.

Step 1 — Target the ether: Ethyl methyl ether is $CH_3{-}O{-}C_2H_5$.

Step 2 — Pick the best S_N2 pair: Use sodium methoxide ($CH_3O^-Na^+$) with the primary halide bromoethane (C_2H_5Br):

$$CH_3O^-Na^+ + C_2H_5Br \rightarrow CH_3{-}O{-}C_2H_5 + NaBr.$$

Step 3 — Conclude: The primary halide combination (B) gives the high-yield S_N2 ether.

Why other options are wrong:

- (A) and (C) use bulky tertiary halides that mainly eliminate.
- (D) chlorobenzene (aryl halide) does not undergo S_N2 here.

Final Answer: Sodium methoxide + bromoethane $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q 26

Q27.

Solution

Concept — Rosenmund reduction: An acyl chloride is hydrogenated to an aldehyde over palladium on barium sulphate. The catalyst is deliberately poisoned (with sulphur or quinoline) so that reduction stops cleanly at the aldehyde stage.

Step 1 — Write the reaction:

$$R{-}COCl + H_2 \xrightarrow{Pd/BaSO_4} R{-}CHO + HCl.$$

Step 2 — Role of the poison: Without poisoning, the aldehyde would be reduced further to a primary alcohol; the poisoned catalyst prevents over-reduction.

Step 3 — Conclude: The product is the aldehyde $R{-}CHO$.

Why other options are wrong:

- (B) the primary alcohol forms only on over-reduction, which the poison prevents.
- (C) a carboxylic acid is the starting-material level, not a reduction product.
- (D) a ketone requires two carbon chains on the carbonyl.

Final Answer: Aldehyde $R{-}CHO \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q 27

Q28.

Solution

Concept — Decarboxylation: Heating the sodium salt of a carboxylic acid with soda lime ($NaOH/CaO$) removes the $-COOH$ group as carbonate, giving a hydrocarbon with one carbon fewer than the acid.

Step 1 — Write the reaction:

$$CH_3COONa + NaOH \xrightarrow{CaO,\ heat} CH_4 + Na_2CO_3.$$

Step 2 — Count the carbons: The acetate (CH_3COO^-, two carbons) loses one carbon as carbonate, leaving a one-carbon hydrocarbon.

Step 3 — Identify the product: The hydrocarbon formed is methane.

Why other options are wrong:

- (A) ethene would require a two-carbon unsaturated product, not formed here.
- (B) ethanol is not a hydrocarbon.
- (C) propane has too many carbons.

Final Answer: Methane $\Rightarrow \boxed{D}$

Answer: (D) **Go Back to Q 28**

Q29.

Solution

Concept — Gabriel phthalimide synthesis: Potassium phthalimide is alkylated with an alkyl halide and then hydrolysed, releasing a primary amine. Because the nitrogen starts with two acyl groups, only one alkyl group can attach, so the product is a primary amine.

Step 1 — Outline the steps: Phthalimide → potassium phthalimide → N-alkyl phthalimide (with $R-X$) → hydrolysis.

Step 2 — Note the restriction: Aryl halides do not react in the S_N2 alkylation, so only primary *aliphatic* amines are obtained, free from secondary/tertiary contamination.

Step 3 — Conclude: The method gives pure primary aliphatic amines.

Why other options are wrong:

- (A) tertiary amines cannot form (only one alkyl group attaches).
- (B) aromatic amines are not made, since aryl halides fail the alkylation.
- (D) quaternary salts are not products.

Final Answer: Primary aliphatic amines $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 29

Q30.

Solution

Concept — Enzyme specificity: Enzymes are protein catalysts with an active site whose shape matches a particular substrate. This gives them high specificity, so each enzyme typically catalyses one reaction (or one class of substrate).

Step 1 — Recall the lock-and-key idea: The active site fits the substrate like a lock and key, accelerating only that reaction.

Step 2 — Note that enzymes are not consumed: As catalysts, they are regenerated and act at mild temperature and a specific optimum pH.

Step 3 — Conclude: The defining feature among the options is high specificity.

Why other options are wrong:

- (A) enzymes work best near an optimum pH, not equally over all pH.
- (C) catalysts are not consumed.
- (D) most enzymes are denatured (destroyed) above about 40–$50°$C, not active above $100°$C.

Final Answer: Enzymes are highly specific $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 30

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	A	3	B	4	D	5	A
6	C	7	B	8	D	9	A	10	B
11	C	12	A	13	D	14	B	15	D
16	A	17	C	18	B	19	D	20	A
21	C	22	B	23	A	24	D	25	C
26	B	27	A	28	D	29	C	30	B