AIIMS Paramedical Chemistry

Sample Paper – 10

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**. An incorrect answer carries **a penalty of** $-\frac{1}{3}$ **mark**, while an unattempted question carries **0 marks**.
- 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. A sample of hard water contains 20 mg of Ca^{2+} ions in 1 kg of water. The concentration of Ca^{2+} ions in ppm is:

(A) 10

(B) 20

(C) 40

(D) 200

Q2. The total number of nodes (radial + angular) present in a $3p$ orbital is:

(A) 0

(B) 1

(C) 2

(D) 3

Q3. A vessel contains 4 g of H_2 and 16 g of O_2 at a total pressure of 1.5 atm. The partial pressure of H_2 in the mixture is: (Atomic masses: $H = 1$, $O = 16$)

(A) 1.2 atm

(B) 1.0 atm

(C) 0.5 atm

(D) 0.3 atm

Q4. When 100 mL of 1 M HCl is mixed with 100 mL of 1 M NaOH, the heat released is 5.72 kJ. The enthalpy of neutralisation per mole of water formed is:

(A) -28.6 kJ

(B) -114.4 kJ

(C) -5.72 kJ

(D) -57.2 kJ

Q5. For the equilibrium $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, 1 mol of PCl_5 is taken in a 1 L vessel and at equilibrium 0.4 mol of Cl_2 is formed. The equilibrium constant K_c is:

(A) 0.16

(B) 0.27

(C) 0.40

(D) 0.60

Q6. The solubility product of AgCl is 1.6×10^{-10}. Its molar solubility in 0.1 M NaCl solution is:

(A) 1.6×10^{-10} M

(B) 1.3×10^{-5} M

(C) 1.6×10^{-9} M

(D) 4.0×10^{-6} M

Q7. When the reaction $\mathrm{MnO_4^- + I^- \rightarrow MnO_2 + I_2}$ is balanced in basic medium, the coefficient of H_2O on the appropriate side is:

(A) 4 (left side)

(B) 2 (left side)

(C) 8 (right side)

(D) 1 (right side)

Q8. Given $E^\circ_{\mathrm{Zn^{2+}/Zn}} = -0.76$ V and $E^\circ_{\mathrm{Cu^{2+}/Cu}} = +0.34$ V, the standard EMF of the Daniell cell and the sign of ΔG° are:

(A) 0.42 V, $\Delta G^\circ > 0$

(B) -1.10 V, $\Delta G^\circ > 0$

(C) 0.42 V, $\Delta G^\circ < 0$

(D) 1.10 V, $\Delta G^\circ < 0$

Q9. For a reaction $\mathrm{A \rightarrow products}$, the concentration of A falls from 0.50 M to 0.38 M in 20 minutes. The average rate of the reaction is:

(A) 3.0×10^{-3} M min^{-1}

(B) 6.0×10^{-3} M min^{-1}

(C) 1.2×10^{-2} M min^{-1}

(D) 2.4×10^{-2} M min^{-1}

Q10. An aqueous solution is 20% by mass of NaOH and has a density of 1.2 g mL^{-1}. The molarity of the solution is: (Molar mass of NaOH $= 40$ g mol^{-1})

(A) 5.0 M

(B) 4.0 M

(C) 6.0 M

(D) 3.0 M

Q11. Among the alkaline earth metals Be, Mg, Ca and Ba, the correct order of reactivity towards water is:

(A) $\mathrm{Ba} > \mathrm{Ca} > \mathrm{Mg} > \mathrm{Be}$

(B) $\mathrm{Be} > \mathrm{Mg} > \mathrm{Ca} > \mathrm{Ba}$

(C) $\mathrm{Mg} > \mathrm{Ca} > \mathrm{Ba} > \mathrm{Be}$

(D) $\mathrm{Ca} > \mathrm{Ba} > \mathrm{Mg} > \mathrm{Be}$

Q12. An element has the ground-state electronic configuration $[\mathrm{Ar}]\,3d^{10}4s^{2}4p^{3}$. Its group and period in the periodic table are:

(A) Group 13, Period 4

(B) Group 15, Period 4

(C) Group 15, Period 3

(D) Group 5, Period 4

Q13. In the $\mathrm{BF_3}$ molecule, the B–F bond length is shorter than expected for a single bond. The best explanation is:

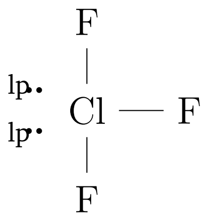
(A) sp^3 hybridisation of boron

(B) Ionic character of the B–F bond

(C) Hydrogen bonding between molecules

(D) $p\pi$–$p\pi$ back bonding from F to the empty $2p$ orbital of B

Q14. Based on VSEPR theory, the shape of the $\mathrm{ClF_3}$ molecule is best described as:



(A) Trigonal planar

(B) Trigonal pyramidal

(C) T-shaped (bent T)

(D) Tetrahedral

Q15. Although lithium has the most negative standard electrode potential among alkali metals, it is the least reactive towards water. The reason is:

(A) Its high hydration enthalpy makes E° very negative, but a high melting point and slow kinetics make the reaction with water gentle

(B) Lithium has the lowest ionisation enthalpy

(C) Lithium forms a peroxide on reaction with water

(D) Lithium has the largest atomic size in the group

Q16. Bleaching powder reacts with dilute hydrochloric acid to liberate a gas X, which is responsible for its bleaching and disinfecting action. The gas X is:

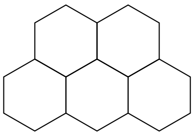
(A) O_2

(B) CO_2

(C) Cl_2

(D) $HOCl$ vapour

Q17. Consider the allotrope of carbon shown below, in which each carbon is bonded to three others in flat sheets:



This allotrope is:

(A) Diamond

(B) Graphite

(C) Fullerene (C_{60})

(D) Carbon black

Q18. Which of the following statements correctly distinguishes actinoids from lanthanoids?

(A) Lanthanoids show a greater number of oxidation states than actinoids

(B) Actinoids do not show any contraction in atomic size

(C) Only lanthanoids are radioactive

(D) Actinoids show a larger number of oxidation states because of the small energy gap between $5f$, $6d$ and $7s$ orbitals

Q19. In the complex $[Co(NH_3)_5Cl]Cl_2$, the primary and secondary valencies of cobalt are respectively:

(A) 3 and 6

(B) 2 and 6

(C) 6 and 3

(D) 3 and 5

Q20. Which of the following is a correct reason for using hydrogen as a clean fuel?

(A) It releases CO_2 on combustion in small amounts

(B) Its combustion produces only water as the by-product

(C) It has the lowest calorific value among common fuels

(D) It cannot be stored or transported in any form

Q21. Which of the following carbanions is the most stable?

(A) $(CH_3)_3C^-$

(B) $(CH_3)_2CH^-$

(C) $C_6H_5CH_2^-$ (benzyl)

(D) $CH_3CH_2^-$

Q22. The degree of unsaturation (number of rings $+ \pi$ bonds) for a compound with molecular formula C_6H_8 is:

(A) 3

(B) 2

(C) 4

(D) 1

Q23. Reductive ozonolysis of but-2-ene, $CH_3{-}CH{=}CH{-}CH_3$, gives:

(A) One molecule of ethanal and one of methanal

(B) Two molecules of ethanal (CH_3CHO)

(C) Two molecules of methanal ($HCHO$)

(D) One molecule of propanal and one of methanal

Q24. Benzene can be prepared by the cyclic polymerisation of which of the following on passing through a red-hot iron tube at 873 K?

(A) Ethene

(B) Methane

(C) Ethane

(D) Ethyne (acetylene)

Q25. Chloroform ($CHCl_3$), on exposure to air and light, slowly oxidises to a poisonous gas. To prevent this, it is stored in dark coloured bottles filled to the brim and with a small amount of:

(A) Ethanol

(B) Conc. H_2SO_4

(C) Water

(D) Phenol

Q26. When phenol is treated with bromine water (excess) at room temperature, the product formed is:

(A) o-bromophenol only

(B) p-bromophenol only

(C) 2,4,6-tribromophenol (white precipitate)

(D) m-bromophenol

Q27. The Perkin reaction involves the condensation of an aromatic aldehyde with an acid anhydride in the presence of the sodium salt of the acid. The product of the reaction of benzaldehyde with acetic anhydride is:

(A) Benzoic acid

(B) Benzyl alcohol

(C) Acetophenone

(D) Cinnamic acid ($C_6H_5CH{=}CHCOOH$)

Q28. Two molecules of benzaldehyde undergo benzoin condensation in the presence of which catalyst to form benzoin?

(A) Dilute NaOH

(B) Sodium or potassium cyanide (CN^-)

(C) Conc. H_2SO_4

(D) Anhydrous $AlCl_3$

Q29. Nitrobenzene is reduced to aniline most conveniently by:

(A) Oxidation with acidic $KMnO_4$

(B) Treatment with bromine water

(C) Sn and concentrated HCl (or H_2/Ni)

(D) Heating with soda lime

Q30. Which of the following statements about starch and cellulose is correct?

(A) Both are made of β-D-glucose units

(B) Cellulose is made of α-D-glucose and starch of β-D-glucose

(C) Both can be digested by humans

(D) Starch contains α-glycosidic linkages while cellulose contains β-glycosidic linkages

Detailed Solutions

Q1.

Solution

Concept — Parts per million (ppm): ppm gives the mass of solute per million parts (by mass) of solution. For dilute aqueous solutions, $\text{ppm} = \dfrac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$.

Step 1 — Express masses in the same unit: Mass of $\text{Ca}^{2+} = 20\text{ mg} = 20 \times 10^{-3}$ g.

Step 2 — Mass of solution: The water mass is $1\text{ kg} = 1000$ g. As the solution is dilute, total mass ≈ 1000 g.

Step 3 — Apply the formula:

$$\text{ppm} = \frac{20 \times 10^{-3}}{1000} \times 10^6 = \frac{20 \times 10^{-3} \times 10^6}{1000} = \frac{20 \times 10^3}{1000} = 20.$$

Why other options are wrong:

- (A) 10: arises from dividing the mass by 2 in error.
- (C) 40: results from doubling the solute mass.
- (D) 200: arises from using 100 g of solution instead of 1000 g.

Final Answer: The concentration is 20 ppm $\Rightarrow \boxed{\text{B}}$

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

Q2.

Solution

Concept — Nodes in an orbital: For an orbital with principal quantum number n and azimuthal quantum number l: angular nodes $= l$, radial nodes $= n - l - 1$, and total nodes $= n - 1$.

Step 1 — Identify the quantum numbers for $3p$: $n = 3$ and for a p orbital $l = 1$.

Step 2 — Count the nodes:

$$\text{Angular nodes} = l = 1, \qquad \text{Radial nodes} = n - l - 1 = 3 - 1 - 1 = 1.$$

Step 3 — Total nodes:

$$\text{Total} = n - 1 = 3 - 1 = 2.$$

Why other options are wrong:

- (A) 0: would apply to a $1s$ orbital.
- (B) 1: counts only one type of node.
- (D) 3: overcounts; total nodes can never exceed $n - 1$.

Final Answer: Total nodes $= 2 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 2

Q3.

Solution

Concept — Dalton's law and mole fraction: The partial pressure of a gas equals its mole fraction times the total pressure: $p_i = x_i\, P_{\text{total}}$.

Step 1 — Find moles of each gas:

$$n_{H_2} = \frac{4}{2} = 2 \text{ mol}, \qquad n_{O_2} = \frac{16}{32} = 0.5 \text{ mol}.$$

Step 2 — Total moles:

$$n_{\text{total}} = 2 + 0.5 = 2.5 \text{ mol}.$$

Step 3 — Mole fraction of H_2:

$$x_{H_2} = \frac{2}{2.5} = 0.8.$$

Step 4 — Partial pressure:

$$p_{H_2} = x_{H_2} \times P_{\text{total}} = 0.8 \times 1.5 = 1.2 \text{ atm}.$$

Why other options are wrong:

- (B) 1.0 atm: assumes equal moles of the two gases.
- (C) 0.5 atm: this is the partial pressure of O_2.
- (D) 0.3 atm: uses the wrong mole fraction.

Final Answer: $p_{H_2} = 1.2$ atm $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 3

Q4.

Solution

Concept — Enthalpy of neutralisation: It is the heat released when one mole of water is formed from the neutralisation of an acid by a base. It is expressed per mole of water.

Step 1 — Moles of acid and base:

$$n_{\text{HCl}} = 1 \times 0.100 = 0.1 \text{ mol}, \qquad n_{\text{NaOH}} = 1 \times 0.100 = 0.1 \text{ mol}.$$

Step 2 — Moles of water formed: They react in $1:1$ ratio, so 0.1 mol of water is formed.

Step 3 — Heat per mole of water:

$$\Delta H = \frac{-5.72 \text{ kJ}}{0.1 \text{ mol}} = -57.2 \text{ kJ mol}^{-1}.$$

The negative sign shows the process is exothermic.

Why other options are wrong:

- (A) -28.6 kJ: divides by 0.2 mol instead of 0.1 mol.
- (B) -114.4 kJ: multiplies instead of using the correct moles.
- (C) -5.72 kJ: reports the total heat, not the per-mole value.

Final Answer: $\Delta H_{\text{neut}} = -57.2 \text{ kJ mol}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 4

Q5.

Solution

Concept — Equilibrium constant from an ICE table: For $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$, write initial, change, and equilibrium concentrations, then apply $K_c = \dfrac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]}$.

Step 1 — Set up the ICE table (volume $= 1$ L, so moles $=$ concentration): Initially $[\text{PCl}_5] = 1$, others $= 0$. At equilibrium $[\text{Cl}_2] = 0.4$, so 0.4 mol of PCl_5 has dissociated.

Step 2 — Equilibrium concentrations:

$$[\mathrm{PCl_5}] = 1 - 0.4 = 0.6, \quad [\mathrm{PCl_3}] = 0.4, \quad [\mathrm{Cl_2}] = 0.4.$$

Step 3 — Apply the expression:

$$K_c = \frac{(0.4)(0.4)}{0.6} = \frac{0.16}{0.6} = 0.267 \approx 0.27.$$

Why other options are wrong:

- (A) 0.16: forgets to divide by $[\mathrm{PCl_5}]$.
- (C) 0.40: equals the dissociation amount, not K_c.
- (D) 0.60: equals $[\mathrm{PCl_5}]$ at equilibrium.

Final Answer: $K_c \approx 0.27 \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q 5

Q6.

Solution

Concept — Common-ion effect on solubility: In the presence of a common ion, the solubility of a sparingly soluble salt is suppressed. For AgCl, $K_{sp} = [\mathrm{Ag^+}][\mathrm{Cl^-}]$.

Step 1 — Let the molar solubility be s: Then $[\mathrm{Ag^+}] = s$. The chloride comes mainly from 0.1 M NaCl, so $[\mathrm{Cl^-}] \approx 0.1$ M (since s is tiny).

Step 2 — Apply K_{sp}:

$$K_{sp} = s \times 0.1 = 1.6 \times 10^{-10}.$$

Step 3 — Solve for s:

$$s = \frac{1.6 \times 10^{-10}}{0.1} = 1.6 \times 10^{-9}\ \mathrm{M}.$$

Why other options are wrong:

- (A) 1.6×10^{-10}: forgets to divide by 0.1.
- (B) 1.3×10^{-5}: this is the solubility in pure water, $\sqrt{K_{sp}}$.
- (D) 4.0×10^{-6}: an arithmetic slip.

Final Answer: $s = 1.6 \times 10^{-9}\ \mathrm{M} \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q 6

Q7.

Solution

Concept — Balancing redox in basic medium: Balance the half-reactions, equalise electrons, then balance O and H using H_2O and OH^-.

Step 1 — Reduction half-reaction:

$$MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-.$$

Step 2 — Oxidation half-reaction:

$$2I^- \rightarrow I_2 + 2e^-.$$

Step 3 — Equalise electrons (multiply reduction by 2, oxidation by 3):

$$2MnO_4^- + 4H_2O + 6e^- \rightarrow 2MnO_2 + 8OH^-,$$

$$6I^- \rightarrow 3I_2 + 6e^-.$$

Step 4 — Add and read off coefficients:

$$2MnO_4^- + 6I^- + 4H_2O \rightarrow 2MnO_2 + 3I_2 + 8OH^-.$$

The coefficient of H_2O is 4 on the left side.

Why other options are wrong:

- (B) 2 (left): correct only before balancing all electrons.
- (C) 8 (right): that is the coefficient of OH^-, not water.
- (D) 1 (right): not consistent with the balanced equation.

Final Answer: H_2O coefficient $= 4$ on the left $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q 7

Q8.

Solution

Concept — Cell EMF and spontaneity: $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$ and $\Delta G^\circ = -nFE^\circ_{\text{cell}}$. A positive EMF gives a negative ΔG° (spontaneous).

Step 1 — Identify electrodes: In the Daniell cell, Zn is the anode (oxidation) and Cu is the cathode (reduction).

Step 2 — Compute the EMF:

$$E^\circ_{\text{cell}} = E^\circ_{\text{Cu}^{2+}/\text{Cu}} - E^\circ_{\text{Zn}^{2+}/\text{Zn}} = 0.34 - (-0.76) = 1.10 \text{ V}.$$

Step 3 — Sign of ΔG°: Since $E^\circ_{\text{cell}} = +1.10$ V is positive, $\Delta G^\circ = -nFE^\circ < 0$, so the cell reaction is spontaneous.

Why other options are wrong:

- (A) 0.42 V: subtracts incorrectly.
- (B) -1.10 V: reverses cathode and anode.
- (C) 0.42 V: wrong EMF value.

Final Answer: $E^\circ_{\text{cell}} = 1.10$ V, $\Delta G^\circ < 0 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 8

Q9.

Solution

Concept — Average rate of reaction: For $\text{A} \rightarrow \text{products}$, the average rate is the magnitude of the change in concentration of A divided by the time interval: rate $= -\dfrac{\Delta[\text{A}]}{\Delta t}$.

Step 1 — Change in concentration:

$$\Delta[\text{A}] = 0.38 - 0.50 = -0.12 \text{ M}.$$

Step 2 — Time interval: $\Delta t = 20$ min.

Step 3 — Compute the rate:

$$\text{rate} = -\frac{-0.12}{20} = \frac{0.12}{20} = 6.0 \times 10^{-3} \text{ M min}^{-1}.$$

Why other options are wrong:

- (A) 3.0×10^{-3}: divides the change by 40.
- (C) 1.2×10^{-2}: forgets to divide by time.
- (D) 2.4×10^{-2}: arithmetic error.

Final Answer: Rate $= 6.0 \times 10^{-3}$ M min^{-1} $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 9

Q10.

Solution

Concept — Molarity from mass percentage and density: Take 100 g of solution, find the mass of solute, convert to moles, find the solution volume from density, then divide.

Step 1 — Mass of NaOH in 100 g solution: A 20% solution contains 20 g NaOH per 100 g solution.

Step 2 — Moles of NaOH:

$$n = \frac{20}{40} = 0.5 \text{ mol}.$$

Step 3 — Volume of 100 g solution:

$$V = \frac{\text{mass}}{\text{density}} = \frac{100}{1.2} = 83.33 \text{ mL} = 0.08333 \text{ L}.$$

Step 4 — Molarity:

$$M = \frac{n}{V} = \frac{0.5}{0.08333} = 6.0 \text{ M}.$$

Why other options are wrong:

- (A) 5.0 M: uses density $= 1.0$ instead of 1.2.
- (B) 4.0 M: arithmetic slip in volume.
- (D) 3.0 M: halves the result in error.

Final Answer: Molarity $= 6.0$ M $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 10

Q11.

Solution

Concept — Reactivity trend in Group 2: Reactivity towards water increases down the group as ionisation enthalpy falls and the metal loses electrons more readily.

Step 1 — Order the metals by position: Down the group: $\mathrm{Be} < \mathrm{Mg} < \mathrm{Ca} < \mathrm{Ba}$ in reactivity.

Step 2 — Write the reactivity order: Therefore the decreasing order of reactivity is

$$\mathrm{Ba} > \mathrm{Ca} > \mathrm{Mg} > \mathrm{Be}.$$

Be does not react with water even on heating; Mg reacts only with hot water/steam; Ca and Ba react readily with cold water.

Why other options are wrong:

- (B): exactly reversed.
- (C) and (D): the relative positions of the metals are jumbled.

Final Answer: $\mathrm{Ba} > \mathrm{Ca} > \mathrm{Mg} > \mathrm{Be} \Rightarrow \boxed{\mathrm{A}}$

Answer: (A) Go Back to Q 11

Q12.

Solution

Concept — Locating an element from its configuration: The period number equals the highest principal quantum number n. For a p-block element, the group number $= 10 +$ (number of valence $s + p$ electrons).

Step 1 — Find the period: The configuration $[\mathrm{Ar}]3d^{10}4s^{2}4p^{3}$ has its highest $n = 4$, so the element is in Period 4.

Step 2 — Count valence electrons: Valence electrons in $4s$ and $4p$ are $2 + 3 = 5$.

Step 3 — Find the group: As a p-block element, group $= 10 + 5 = 15$.

Why other options are wrong:

- (A) Group 13: counts only 3 valence electrons.
- (C) Period 3: ignores the $n = 4$ shell.
- (D) Group 5: this would be a d-block (transition) assignment, which is incorrect here.

Final Answer: Group 15, Period $4 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 12

Q13.

Solution

Concept — Back bonding in $\mathrm{BF_3}$: Boron in $\mathrm{BF_3}$ is electron-deficient (sp^2, empty $2p$ orbital). A filled $2p$ orbital of fluorine donates electron density into this empty orbital, forming a $p\pi$–$p\pi$ back bond.

Step 1 — Recognise the electron deficiency: Boron has only six electrons around it in $\mathrm{BF_3}$ and an empty $2p$ orbital perpendicular to the molecular plane.

Step 2 — Identify the donor: Each fluorine has lone pairs; one filled $2p$ orbital overlaps sideways with boron's empty $2p$ orbital.

Step 3 — Consequence: This back bonding gives partial double-bond character, so the B–F bond is shorter and stronger than a pure single bond.

Why other options are wrong:

- (A) sp^3: boron is sp^2, not sp^3, in $\mathrm{BF_3}$.
- (B) Ionic character: does not explain bond shortening.
- (C) Hydrogen bonding: there is no H present.

Final Answer: $p\pi$–$p\pi$ back bonding from F to B $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 13

Q14.

Solution

Concept — VSEPR for $\mathrm{ClF_3}$: The shape is decided by the number of bond pairs and lone pairs on the central atom.

Step 1 — Count electron domains: Cl has 7 valence electrons; 3 are used in Cl–F bonds, leaving 4 electrons $= 2$ lone pairs. So there are 3 bond pairs $+2$ lone pairs $= 5$ electron domains.

Step 2 — Base geometry: Five domains give a trigonal bipyramidal electron geometry.

Step 3 — Place lone pairs: The two lone pairs occupy equatorial positions (least repulsion), leaving the three fluorines in a distorted arrangement that gives a **T-**

shaped molecule, as sketched.

Why other options are wrong:

- (A) Trigonal planar: ignores the lone pairs.
- (B) Trigonal pyramidal: that is the shape with one lone pair (e.g., NH_3).
- (D) Tetrahedral: requires four bond pairs and no lone pairs.

Final Answer: ClF_3 is T-shaped $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q 14

Q15.

Solution

Concept — Electrode potential vs reactivity for Li: The very negative E° of lithium comes from its exceptionally high hydration enthalpy (small Li^+ ion). However, reactivity with water also depends on kinetics, melting point, and the activation of the metal surface.

Step 1 — Explain the negative E°: The small Li^+ ion is strongly hydrated, releasing a large hydration enthalpy, which makes the overall oxidation in solution very favourable (most negative E°).

Step 2 — Explain the gentle reaction: Lithium has the highest melting point among alkali metals and reacts relatively slowly (kinetically), so its reaction with water is the least vigorous despite the favourable thermodynamics.

Why other options are wrong:

- (B): Li actually has the highest ionisation enthalpy in the group, not the lowest.
- (C): Li forms an oxide (Li_2O), not a peroxide, and this does not explain the trend.
- (D): Li has the smallest atomic size in the group, not the largest.

Final Answer: High hydration enthalpy plus slow kinetics $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q 15

Q16.

Solution

Concept — Bleaching powder with acid: Bleaching powder, $Ca(OCl)Cl$ (or $CaOCl_2$), reacts with dilute acids to release chlorine gas, which is the active bleaching/disinfecting species.

Step 1 — Write the reaction:

$$CaOCl_2 + 2HCl \rightarrow CaCl_2 + H_2O + Cl_2 \uparrow.$$

Step 2 — Identify the gas: The liberated gas is Cl_2, a greenish-yellow gas responsible for bleaching and disinfection.

Why other options are wrong:

- (A) O_2: released only on heating with a catalyst, not with dilute HCl.
- (B) CO_2: not a product here.
- (D) HOCl vapour: HOCl forms with a weak/insufficient acid such as CO_2+H_2O; with dilute HCl the product is Cl_2.

Final Answer: Gas X is $Cl_2 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 16

Q17.

Solution

Concept — Allotropes of carbon: In graphite each carbon is sp^2 hybridised, bonded to three others in flat hexagonal sheets, with delocalised electrons between layers, exactly as the figure shows.

Step 1 — Read the structure: The diagram shows flat, joined hexagonal rings, characteristic of layered sheets.

Step 2 — Match to the allotrope: Three bonds per carbon in planar sheets identifies graphite (in diamond each carbon is sp^3, bonded to four others in a 3D network).

Why other options are wrong:

- (A) Diamond: each carbon is bonded to four others in a tetrahedral network, not flat sheets.
- (C) Fullerene: a closed cage (C_{60}), not infinite flat sheets.

- (D) Carbon black: amorphous, lacks the ordered hexagonal sheet structure shown.

Final Answer: The allotrope is graphite $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 17

Q18.

Solution

Concept — Actinoids vs lanthanoids: In actinoids the $5f$, $6d$ and $7s$ orbitals lie close in energy, so a larger number of oxidation states is possible compared with lanthanoids, which are dominated by the $+3$ state.

Step 1 — Oxidation states: Lanthanoids show mainly $+3$ (with a few $+2/+4$), whereas actinoids show a wide range ($+3$ to $+6$ and beyond) due to the small $5f$–$6d$–$7s$ energy gap.

Step 2 — Other features: Both series show contraction (lanthanoid and actinoid contraction). All actinoids are radioactive.

Why other options are wrong:

- (A): actinoids, not lanthanoids, show more oxidation states.
- (B): actinoids do show actinoid contraction.
- (C): both actinoids and some heavier lanthanoid-related species are radioactive; actinoids are the radioactive series, so the statement is wrong as worded.

Final Answer: Small $5f$–$6d$–$7s$ gap gives more oxidation states $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 18

Q19.

Solution

Concept — Werner's primary and secondary valencies: Primary valency equals the oxidation state of the metal (satisfied by negative ions); secondary valency equals the coordination number (satisfied by ligands directly bonded to the metal).

Step 1 — Find the oxidation state of Co: In $[\text{Co(NH}_3)_5\text{Cl]Cl}_2$, the two outer Cl^- give -2; the coordinated Cl^- gives -1; NH_3 is neutral. So $\text{Co} + (-1) + (-2) = 0 \Rightarrow \text{Co} = +3$. Primary valency $= 3$.

Step 2 — Find the coordination number: The ligands directly bonded are five NH_3 and one Cl, total 6. Secondary valency $= 6$.

Why other options are wrong:

- (B) 2 and 6: wrong oxidation state for Co.
- (C) 6 and 3: swaps the two valencies.
- (D) 3 and 5: omits the coordinated chloride from the count.

Final Answer: Primary $= 3$, secondary $= 6 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 19

Q20.

Solution

Concept — Hydrogen as a clean fuel: Hydrogen burns in oxygen to give water only, with no carbon-containing pollutants, making it an environmentally clean fuel with a high calorific value.

Step 1 — Combustion reaction:

$$2H_2 + O_2 \rightarrow 2H_2O, \qquad \Delta H < 0.$$

Step 2 — Identify the benefit: The only by-product is water, so no CO_2 or soot is produced, unlike fossil fuels.

Why other options are wrong:

- (A): hydrogen combustion produces no CO_2 at all.
- (C): hydrogen has one of the highest calorific values, not the lowest.
- (D): hydrogen can be stored as compressed gas, liquid, or in metal hydrides.

Final Answer: Combustion gives only water $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 20

Q21.

Solution

Concept — Stability of carbanions: A carbanion is stabilised by electron-withdrawing groups and by resonance (delocalisation of the negative charge). Alkyl groups destabilise carbanions (electron-donating $+I$ effect).

Step 1 — Compare the options: Among the alkyl carbanions, more alkyl substitution destabilises the carbanion, so $CH_3CH_2^-$ is more stable than $(CH_3)_2CH^-$, which is more stable than $(CH_3)_3C^-$.

Step 2 — Identify the resonance-stabilised carbanion: The benzyl carbanion $C_6H_5CH_2^-$ delocalises its negative charge into the aromatic ring through resonance, making it the most stable of the four.

Why other options are wrong:

- (A) tert-butyl: most destabilised by three $+I$ methyl groups.
- (B) isopropyl: destabilised by two methyl groups.
- (D) ethyl: stabilised relative to the branched ones but lacks resonance.

Final Answer: Benzyl carbanion is the most stable $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 21

Q22.

Solution

Concept — Degree of unsaturation (DoU): For a hydrocarbon C_nH_m, DoU $= \frac{2n+2-m}{2}$. Each ring or π bond contributes one to the DoU.

Step 1 — Identify n and m: For C_6H_8, $n = 6$ and $m = 8$.

Step 2 — Apply the formula:

$$\text{DoU} = \frac{2(6)+2-8}{2} = \frac{12+2-8}{2} = \frac{6}{2} = 3.$$

Step 3 — Interpret: The molecule has three units of unsaturation, for example one ring plus two double bonds, or three double bonds.

Why other options are wrong:

- (B) 2: would correspond to C_6H_{10}.
- (C) 4: would correspond to C_6H_6 (benzene).

- (D) 1: would correspond to C_6H_{12}.

Final Answer: DoU $= 3 \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q 22

Q23.

Solution

Concept — Reductive ozonolysis: Ozonolysis cleaves a $C{=}C$ double bond. With a reductive work-up (Zn/H_2O), each doubly bonded carbon becomes a carbonyl (aldehyde or ketone).

Step 1 — Locate the double bond: In but-2-ene, $CH_3{-}CH{=}CH{-}CH_3$, the double bond is between C2 and C3.

Step 2 — Cleave and add oxygen: Each $= CH{-}CH_3$ fragment becomes CH_3CHO (ethanal).

Step 3 — Write the products:

$$CH_3CH{=}CHCH_3 \xrightarrow{\text{(i) } O_3 \text{ (ii) } Zn/H_2O} 2\,CH_3CHO.$$

Why other options are wrong:

- (A): methanal would require a terminal $= CH_2$, which is absent.
- (C): two methanal molecules would come from ethene, not but-2-ene.
- (D): propanal/methanal would come from but-1-ene, not but-2-ene.

Final Answer: Two molecules of ethanal $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q 23

Q24.

Solution

Concept — Cyclic polymerisation to benzene: Three molecules of ethyne (acetylene), on passage through a red-hot iron tube at 873 K, undergo cyclic trimerisation to give benzene.

Step 1 — Write the reaction:

$$3\,C_2H_2 \xrightarrow{\text{red-hot Fe tube, 873 K}} C_6H_6.$$

Step 2 — Reason: Three C≡C units join head to tail to build the six-membered aromatic ring.

Why other options are wrong:

- (A) Ethene: polymerises to polyethene, not benzene.
- (B) Methane: does not cyclise to benzene this way.
- (C) Ethane: saturated; does not undergo this trimerisation.

Final Answer: Ethyne trimerises to benzene $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 24

Q25.

Solution

Concept — Storage of chloroform: Chloroform is slowly oxidised by air and light to the poisonous gas phosgene ($COCl_2$). To prevent oxidation it is stored in dark bottles filled to the brim and a small amount of ethanol (1%) is added.

Step 1 — The hazard:

$$2CHCl_3 + O_2 \xrightarrow{\text{light}} 2COCl_2 + 2HCl.$$

Step 2 — Role of ethanol: Ethanol converts any phosgene formed into harmless, non-volatile diethyl carbonate, and the dark bottle filled to the brim limits exposure to light and air.

Why other options are wrong:

- (B) Conc. H_2SO_4: a dehydrating, reactive acid; not used here.
- (C) Water: does not stop phosgene formation.
- (D) Phenol: not the additive used for chloroform storage.

Final Answer: A small amount of ethanol is added $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 25

Q26.

Solution

Concept — Bromination of phenol: The $-\mathrm{OH}$ group is strongly activating and o,p-directing. With bromine water (a polar medium, excess $\mathrm{Br_2}$), all three activated positions (2,4,6) are brominated.

Step 1 — Effect of the medium: In bromine water the reaction is fast and not easily stopped at mono-substitution.

Step 2 — Product: Phenol gives 2,4,6-tribromophenol, which separates as a white precipitate.

Step 3 — Note: If a non-polar solvent like $\mathrm{CS_2}$ at low temperature is used, mono-substituted (mainly para) products form instead, but that is not the case here.

Why other options are wrong:

- (A) and (B): mono-substituted products form only in non-polar solvents at low temperature.
- (D) m-bromophenol: meta substitution is not favoured because $-\mathrm{OH}$ is o,p-directing.

Final Answer: 2,4,6-tribromophenol $\Rightarrow \boxed{\mathrm{C}}$

$\boxed{\textbf{Answer: (C)}}$ Go Back to Q 26

Q27.

Solution

Concept — Perkin reaction: An aromatic aldehyde condenses with an aliphatic acid anhydride in the presence of the sodium salt of the corresponding acid to give an α, β-unsaturated aromatic acid.

Step 1 — Reactants: Benzaldehyde ($\mathrm{C_6H_5CHO}$) reacts with acetic anhydride in the presence of sodium acetate.

Step 2 — Product: The condensation forms cinnamic acid:

$$\mathrm{C_6H_5CHO + (CH_3CO)_2O \xrightarrow{CH_3COONa} C_6H_5CH{=}CHCOOH.}$$

Why other options are wrong:

- (A) Benzoic acid: an oxidation product, not the Perkin product.
- (B) Benzyl alcohol: a reduction product.

- (C) Acetophenone: a Friedel–Crafts acylation product, unrelated to the Perkin reaction.

Final Answer: The product is cinnamic acid $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 27

Q28.

Solution

Concept — Benzoin condensation: Two molecules of an aromatic aldehyde (such as benzaldehyde) couple in the presence of cyanide ion (CN^-) as catalyst to give an α-hydroxy ketone called benzoin.

Step 1 — Role of cyanide: CN^- adds to one benzaldehyde, generating a stabilised carbanion that attacks a second benzaldehyde molecule.

Step 2 — Product:

$$2\,C_6H_5CHO \xrightarrow{CN^-} C_6H_5CH(OH)COC_6H_5 \text{ (benzoin)}.$$

Why other options are wrong:

- (A) Dilute NaOH: catalyses aldol/Cannizzaro reactions, not benzoin condensation.
- (C) Conc. H_2SO_4: not the catalyst for this reaction.
- (D) Anhydrous $AlCl_3$: a Friedel–Crafts catalyst, not used here.

Final Answer: Cyanide ion catalyses benzoin condensation $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 28

Q29.

Solution

Concept — Reduction of nitro group to amine: Nitrobenzene is reduced to aniline by metal/acid systems such as Sn (or Fe) with concentrated HCl, or by catalytic hydrogenation (H_2/Ni).

Step 1 — Write the reduction:

$$C_6H_5NO_2 \xrightarrow{\text{Sn/conc. HCl}} C_6H_5NH_2.$$

Step 2 — Reason: The metal/acid supplies the electrons and protons (nascent hydrogen) needed to reduce the $-NO_2$ group to $-NH_2$.

Why other options are wrong:

- (A) Acidic $KMnO_4$: an oxidising agent; it will not reduce the nitro group.
- (B) Bromine water: an electrophilic/oxidative reagent, not a reductant.
- (D) Soda lime: used for decarboxylation, not for reducing nitro groups.

Final Answer: Sn and conc. HCl (or H_2/Ni) reduces it to aniline $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q 29

Q30.

Solution

Concept — Starch vs cellulose: Both are polymers of glucose, but they differ in the type of glucose unit and glycosidic linkage. Starch is built from α-D-glucose joined by α-glycosidic linkages; cellulose is built from β-D-glucose joined by β-glycosidic linkages.

Step 1 — Compare monomers and linkages: Starch (α-glucose, α-1,4 links) is digestible by humans; cellulose (β-glucose, β-1,4 links) is not, because humans lack the enzyme to hydrolyse β-linkages.

Step 2 — Choose the correct statement: Only the statement that starch has α-glycosidic linkages and cellulose has β-glycosidic linkages is correct.

Why other options are wrong:

- (A): they are not both made of β-D-glucose.
- (B): the assignment of α and β is reversed.
- (C): humans cannot digest cellulose.

Final Answer: Starch has α- and cellulose has β-glycosidic linkages $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q 30

Answer Key

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