AIIMS Paramedical Chemistry

Sample Paper – 4

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.
- 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. In the reaction $N_2 + 3H_2 \rightarrow 2NH_3$, 28 g of nitrogen is reacted with excess hydrogen and 25.5 g of ammonia is obtained. The percentage yield of the reaction is (atomic masses: N $= 14$, H $= 1$)

(A) 60%

(B) 70%

(C) 75%

(D) 90%

Q2. The energy of a photon of light of frequency 5×10^{14} Hz is (take Planck's constant $h = 6.6 \times 10^{-34}$ J s)

(A) 1.32×10^{-19} J

(B) 3.3×10^{-19} J

(C) 6.6×10^{-19} J

(D) 3.3×10^{-20} J

Q3. Under identical conditions of temperature and pressure, the rate of diffusion of hydrogen gas relative to that of oxygen gas is

(A) $4 : 1$

(B) $1 : 4$

(C) $1 : 16$

(D) $16 : 1$

Q4. The standard enthalpies of formation of $CO_2(g)$ and $H_2O(l)$ are -394 kJ mol^{-1} and -286 kJ mol^{-1}. If the enthalpy of combustion of methane $CH_4(g)$ is -890 kJ mol^{-1}, the standard enthalpy of formation of methane is

(A) -210 kJ mol^{-1}

(B) -156 kJ mol^{-1}

(C) -76 kJ mol^{-1}

(D) $+76$ kJ mol^{-1}

Q5. For the exothermic equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, the forward formation of SO_3 is favoured by

(A) increasing temperature and decreasing pressure

(B) increasing temperature and increasing pressure

(C) decreasing temperature and decreasing pressure

(D) decreasing temperature and increasing pressure

Q6. The solubility of a sparingly soluble salt AB_2 is 1×10^{-3} mol L^{-1}. The solubility product K_{sp} of the salt is

(A) 1×10^{-9}

(B) 4×10^{-9}

(C) 2×10^{-9}

(D) 1×10^{-6}

Q7. In the reaction in which $KMnO_4$ acts as an oxidising agent in acidic medium, Mn changes from the $+7$ to the $+2$ oxidation state. The equivalent weight of $KMnO_4$ (molar mass $= 158$ g mol^{-1}) in this medium is

(A) 31.6 g

(B) 52.7 g

(C) 79.0 g

(D) 158 g

Q8. When a current of 5 A is passed through a solution of copper sulphate for 1930 s, the mass of copper deposited at the cathode is (atomic mass of Cu $= 63.5$, $F = 96500$ C mol^{-1})

(A) 1.6 g

(B) 6.35 g

(C) 3.18 g

(D) 0.318 g

Q9. According to the Arrhenius equation $k = A\,e^{-E_a/RT}$, a plot of $\ln k$ against $1/T$ is a straight line. The activation energy E_a is obtained from the line as

(A) the intercept on the $\ln k$ axis

(B) the slope multiplied by R

(C) the slope divided by R

(D) the slope multiplied by $-R$

Q10. The osmotic pressure of a 0.1 M aqueous solution of a non-electrolyte at 300 K is (take $R = 0.0821$ L atm K^{-1} mol^{-1})

(A) 1.23 atm

(B) 2.46 atm

(C) 4.92 atm

(D) 0.246 atm

Q11. Across a period from left to right in the periodic table, the metallic character of the elements generally

(A) decreases, because nuclear charge and electronegativity increase

(B) increases, because atomic radius increases

(C) remains constant throughout the period

(D) first increases and then decreases

Q12. Within a period, as we move from left to right, the effective nuclear charge experienced by the valence electrons

(A) decreases, because shielding increases sharply

(B) remains nearly constant

(C) decreases, because the atomic size decreases

(D) increases, because the added electrons shield each other poorly

Q13. In the ozone molecule O_3, the central oxygen atom carries a formal charge of

(A) -1

(B) $+1$

(C) 0

(D) $+2$

Q14. Which of the following molecules has a central atom with an *incomplete* octet (fewer than eight electrons around it)?

(A) CH_4

(B) SF_6

(C) BF_3

(D) PCl_5

Q15. When potassium metal is burnt in excess of air (dioxygen), the principal product formed is

(A) the normal oxide K_2O

(B) the hydroxide KOH

(C) the peroxide K_2O_2

(D) the superoxide KO_2

Q16. In the manufacture of ammonia by the Haber process, N_2 and H_2 combine in the presence of a catalyst. The catalyst commonly used is

(A) finely divided iron with molybdenum as promoter

(B) platinum gauze

(C) vanadium pentoxide

(D) nickel

Q17. In the solid state, phosphorus pentachloride PCl_5 exists as an ionic solid composed of

(A) $[PCl_5]^+$ and Cl^-

(B) $[PCl_4]^+$ and $[PCl_6]^-$

(C) $[PCl_2]^+$ and $[PCl_4]^-$

(D) PCl_5 neutral molecules only

Q18. In the laboratory preparation of potassium permanganate, pyrolusite ore MnO_2 is first fused with KOH in the presence of an oxidising agent (air or KNO_3). The green-coloured intermediate formed in this step is

(A) MnO

(B) Mn_2O_3

(C) potassium manganate K_2MnO_4

(D) $MnCl_2$

Q19. The complex $[Co(NH_3)_5Br]SO_4$ and the complex $[Co(NH_3)_5SO_4]Br$ are an example of

(A) linkage isomerism

(B) ionisation isomerism

(C) geometrical isomerism

(D) optical isomerism

Q20. The hydrides formed by the s-block elements of Groups 1 and 2 (such as NaH and CaH_2) are best classified as

(A) ionic (saline) hydrides

(B) covalent (molecular) hydrides

(C) metallic (interstitial) hydrides

(D) electron-deficient hydrides

Q21. The electromeric effect is best described as

(A) a permanent polarisation of sigma bonds along a carbon chain

(B) delocalisation of pi electrons over a conjugated system at all times

(C) a temporary complete shift of a pi-bond electron pair in the presence of an attacking reagent

(D) the inductive withdrawal of electrons by an electronegative atom

Q22. Which of the following pairs are tautomers of each other?

(A) ethanol and dimethyl ether

(B) propan-1-ol and propan-2-ol

(C) but-1-ene and but-2-ene

(D) the keto and enol forms of acetone

Q23. In the nitration of benzene with a mixture of concentrated HNO_3 and concentrated H_2SO_4, the actual electrophile that attacks the benzene ring is

(A) NO_2^-

(B) the nitronium ion NO_2^+

(C) NO^+

(D) HNO_3 molecule itself

Q24. In the Friedel–Crafts alkylation of benzene with chloromethane, the role of the anhydrous $AlCl_3$ catalyst is to

(A) generate the electrophilic carbocation by abstracting chloride from the alkyl halide

(B) act as a reducing agent for the ring

(C) provide protons to the aromatic ring

(D) form a stable complex with the product to drive the reaction

Q25. When bromobenzene and bromoethane are treated together with sodium metal in dry ether (the Wurtz–Fittig reaction), the principal cross-coupled product is

(A) biphenyl

(B) n-butane

(C) ethylbenzene (toluene's homologue)

(D) benzene

Q26. In the Lucas test (concentrated HCl and anhydrous $ZnCl_2$), the alcohol that produces turbidity *most rapidly*, almost immediately, is

(A) methanol

(B) ethanol (a primary alcohol)

(C) propan-2-ol (a secondary alcohol)

(D) 2-methylpropan-2-ol (a tertiary alcohol)

Q27. The conversion of the carbonyl group of acetophenone ($C_6H_5COCH_3$) into a CH_2 group, that is $C_6H_5CH_2CH_3$, can be carried out by the Wolff–Kishner reduction, whose reagents are

(A) zinc amalgam and concentrated HCl

(B) hydrazine followed by KOH/ethylene glycol, with heating

(C) $LiAlH_4$ in dry ether

(D) $NaBH_4$ in methanol

Q28. In the Hell–Volhard–Zelinsky (HVZ) reaction, a carboxylic acid bearing an alpha-hydrogen is treated with Cl_2 (or Br_2) in the presence of a small amount of red phosphorus to give

(A) the alpha-halocarboxylic acid

(B) the acid chloride only

(C) the beta-halocarboxylic acid

(D) a halogen substituted on the carbon farthest from the COOH group

Q29. Aniline is treated with $NaNO_2$ and dilute HCl at 0–$5\,^\circ$C to form benzenediazonium chloride, which is then coupled with phenol in mildly alkaline medium. The coloured product obtained is

(A) nitrobenzene

(B) chlorobenzene

(C) an orange azo dye (p-hydroxyazobenzene)

(D) phenylhydrazine

Q30. In a protein molecule, the specific sequence in which the amino-acid residues are joined together by peptide bonds is referred to as its

(A) secondary structure

(B) tertiary structure

(C) quaternary structure

(D) primary structure

Detailed Solutions

Q1.

Solution

Concept — Percentage yield: Percentage yield $= \dfrac{\text{actual mass obtained}}{\text{theoretical mass expected}} \times 100$. We first find the theoretical (maximum) mass of ammonia from the balanced equation.

Step 1 — Moles of nitrogen taken: Molar mass of $N_2 = 2 \times 14 = 28$ g mol^{-1}.

$$n(N_2) = \frac{28}{28} = 1 \text{ mol}.$$

Step 2 — Theoretical moles of ammonia: From $N_2 + 3H_2 \rightarrow 2NH_3$, 1 mol N_2 gives 2 mol NH_3.

$$n(NH_3) = 2 \text{ mol}.$$

Step 3 — Theoretical mass of ammonia: Molar mass of $NH_3 = 14 + 3 = 17$ g mol^{-1}.

$$\text{theoretical mass} = 2 \times 17 = 34 \text{ g}.$$

Step 4 — Percentage yield:

$$\text{yield} = \frac{25.5}{34} \times 100 = 75\%.$$

Why other options are wrong:

- 60% and 70%: would correspond to actual masses of 20.4 g and 23.8 g, not 25.5 g.
- 90%: would correspond to 30.6 g of ammonia.

Final Answer: yield $= 75\% \Rightarrow$ C

Answer: (C) Go Back to Q 1

Q2.

Solution

Concept — Planck's relation: The energy of a single photon is $E = h\nu$, where h is Planck's constant and ν is the frequency of the radiation.

Step 1 — List the values: $h = 6.6 \times 10^{-34}$ J s and $\nu = 5 \times 10^{14}$ Hz.

Step 2 — Substitute into $E = h\nu$:

$$E = (6.6 \times 10^{-34}) \times (5 \times 10^{14}).$$

Step 3 — Multiply the coefficients:

$$6.6 \times 5 = 33.$$

Step 4 — Combine the powers of ten:

$$E = 33 \times 10^{-34+14} = 33 \times 10^{-20} = 3.3 \times 10^{-19} \text{ J}.$$

Why other options are wrong:

- 1.32×10^{-19} J and 6.6×10^{-19} J: arise from using a wrong frequency factor.
- 3.3×10^{-20} J: a power-of-ten error of one order.

Final Answer: $E = 3.3 \times 10^{-19}$ J $\Rightarrow$ B

Answer: (B) Go Back to Q 2

Q3.

Solution

Concept — Graham's law of diffusion: At the same temperature and pressure, the rate of diffusion of a gas is inversely proportional to the square root of its molar mass,

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}.$$

Step 1 — List the molar masses: $M(\text{H}_2) = 2$ g mol^{-1} and $M(\text{O}_2) = 32$ g mol^{-1}.

Step 2 — Substitute into Graham's law:

$$\frac{r_{H_2}}{r_{O_2}} = \sqrt{\frac{32}{2}} = \sqrt{16}.$$

Step 3 — Simplify:

$$\frac{r_{H_2}}{r_{O_2}} = 4 \quad \Rightarrow \quad r_{H_2} : r_{O_2} = 4 : 1.$$

Why other options are wrong:

- $1 : 4$: this is the inverse ratio; hydrogen, being lighter, diffuses faster, not slower.
- $16 : 1$ and $1 : 16$: come from forgetting to take the square root of the mass ratio.

Final Answer: $r_{H_2} : r_{O_2} = 4 : 1 \Rightarrow$ A

Answer: (A) Go Back to Q 3

Q4.

Solution

Concept — Hess's law for combustion: For the combustion $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$,

$$\Delta H_c = \left[\Delta H_f(CO_2) + 2\,\Delta H_f(H_2O)\right] - \Delta H_f(CH_4).$$

Step 1 — Insert the known values:

$$-890 = \left[(-394) + 2(-286)\right] - \Delta H_f(CH_4).$$

Step 2 — Evaluate the bracket:

$$(-394) + (-572) = -966.$$

Step 3 — Rearrange for $\Delta H_f(CH_4)$:

$$-890 = -966 - \Delta H_f(CH_4).$$

$$\Delta H_f(CH_4) = -966 - (-890) = -966 + 890.$$

Step 4 — Final value:

$$\Delta H_f(\mathrm{CH_4}) = -76 \text{ kJ mol}^{-1}.$$

Why other options are wrong:

- $+76$ kJ mol^{-1}: a sign slip; methane formation is exothermic.
- -210 and -156 kJ mol^{-1}: arithmetic errors in the bracket sum.

Final Answer: $\Delta H_f(\mathrm{CH_4}) = -76$ kJ mol^{-1} $\Rightarrow$ C

Answer: (C) Go Back to Q 4

Q5.

Solution

Concept — Le Chatelier's principle: A system at equilibrium shifts to oppose any imposed change. We consider the effects of pressure and temperature separately for $2\mathrm{SO_2} + \mathrm{O_2} \rightleftharpoons 2\mathrm{SO_3}$ (exothermic).

Step 1 — Pressure effect: The forward side has 3 moles of gas $(2 + 1)$ and the product side has 2 moles. Increasing the pressure shifts the equilibrium towards fewer moles, that is towards $\mathrm{SO_3}$.

Step 2 — Temperature effect: The forward reaction is exothermic, releasing heat. Lowering the temperature removes heat and shifts the equilibrium forward, favouring $\mathrm{SO_3}$.

Step 3 — Combine the two: Maximum $\mathrm{SO_3}$ is obtained at *low temperature and high pressure*.

Why other options are wrong:

- Increasing temperature shifts the exothermic equilibrium backward, lowering the $\mathrm{SO_3}$ yield.
- Decreasing pressure favours the side with more gas moles, that is the reactants.

Final Answer: decreasing temperature and increasing pressure $\Rightarrow$ D

Answer: (D) Go Back to Q 5

Q6.

Solution

Concept — Solubility product: For a salt AB_2 that dissolves as $AB_2 \rightarrow A^{2+} + 2B^-$, if the solubility is s, then $[A^{2+}] = s$ and $[B^-] = 2s$, so

$$K_{sp} = [A^{2+}][B^-]^2 = s\,(2s)^2 = 4s^3.$$

Step 1 — Insert the solubility: $s = 1 \times 10^{-3}$ mol L^{-1}.

Step 2 — Cube the solubility:

$$s^3 = (1 \times 10^{-3})^3 = 1 \times 10^{-9}.$$

Step 3 — Multiply by the factor 4:

$$K_{sp} = 4 \times 10^{-9}.$$

Why other options are wrong:

- 1×10^{-9}: omits the factor of 4 from the $(2s)^2$ term.
- 2×10^{-9}: uses a factor of 2 instead of 4.
- 1×10^{-6}: uses s^2 rather than s^3.

Final Answer: $K_{sp} = 4 \times 10^{-9} \Rightarrow$ B

Answer: (B) Go Back to Q 6

Q7.

Solution

Concept — Equivalent weight of an oxidant: The equivalent weight equals the molar mass divided by the n-factor, where the n-factor of an oxidising agent is the number of electrons gained per formula unit.

Step 1 — Find the n-factor: In acidic medium Mn goes from $+7$ to $+2$, a change of 5 electrons.

$$n = 7 - 2 = 5.$$

Step 2 — Apply the formula:

$$\text{equivalent weight} = \frac{\text{molar mass}}{n} = \frac{158}{5}.$$

Step 3 — Divide:

$$\frac{158}{5} = 31.6 \text{ g}.$$

Why other options are wrong:

- 52.7 g: uses $n = 3$ (the change to $+4$, neutral medium).
- 79.0 g: uses $n = 2$.
- 158 g: uses $n = 1$, ignoring the electron change.

Final Answer: equivalent weight $= 31.6$ g $\Rightarrow$ A

Answer: (A) Go Back to Q 7

Q8.

Solution

Concept — Faraday's first law: The mass deposited is

$$m = \frac{M\, I\, t}{nF},$$

where M is the molar mass, I the current, t the time, n the number of electrons per ion, and F the Faraday constant.

Step 1 — Charge passed:

$$Q = I\, t = 5 \times 1930 = 9650 \text{ C}.$$

Step 2 — Moles of electrons:

$$\frac{Q}{F} = \frac{9650}{96500} = 0.1 \text{ mol electrons}.$$

Step 3 — Moles of copper: For $Cu^{2+} + 2e^- \rightarrow$ Cu, $n = 2$.

$$n(\text{Cu}) = \frac{0.1}{2} = 0.05 \text{ mol}.$$

Step 4 — Mass of copper:

$$m = 0.05 \times 63.5 = 3.18 \text{ g}.$$

Why other options are wrong:

- 6.35 g: ignores the factor $n = 2$.
- 0.318 g: a power-of-ten slip.
- 1.6 g: an incorrect intermediate division.

Final Answer: $m = 3.18$ g $\Rightarrow$ C

Answer: (C) Go Back to Q 8

Q9.

Solution

Concept — Linear form of the Arrhenius equation: Taking the natural logarithm of $k = A\,e^{-E_a/RT}$ gives

$$\ln k = \ln A - \frac{E_a}{R} \cdot \frac{1}{T}.$$

Step 1 — Identify the straight-line form: Comparing with $y = c + mx$, with $y = \ln k$ and $x = 1/T$, the slope is

$$m = -\frac{E_a}{R}.$$

Step 2 — Solve for E_a:

$$E_a = -m\,R = (\text{slope}) \times (-R).$$

Step 3 — Interpret: Since the slope is negative, $-R$ times the slope gives a positive activation energy, as expected.

Why other options are wrong:

- Intercept on the $\ln k$ axis: this gives $\ln A$, not E_a.
- Slope times R or slope divided by R: both give the wrong magnitude or sign for E_a.

Final Answer: $E_a = \text{slope} \times (-R) \Rightarrow$ D

Answer: (D) Go Back to Q 9

Q10.

Solution

Concept — Osmotic pressure: For a dilute solution, the osmotic pressure is

$$\pi = CRT,$$

where C is the molar concentration, R the gas constant, and T the absolute temperature. For a non-electrolyte the van't Hoff factor is 1.

Step 1 — List the values: $C = 0.1$ mol L^{-1}, $R = 0.0821$ L atm K^{-1} mol^{-1}, $T = 300$ K.

Step 2 — Substitute:

$$\pi = 0.1 \times 0.0821 \times 300.$$

Step 3 — Multiply step by step:

$$0.1 \times 0.0821 = 0.00821.$$

$$0.00821 \times 300 = 2.463 \approx 2.46 \text{ atm}.$$

Why other options are wrong:

- 1.23 atm: uses half the concentration or $T = 150$ K.
- 4.92 atm: doubles the result (would suit a $1{:}2$ electrolyte, but this is a non-electrolyte).
- 0.246 atm: a power-of-ten error.

Final Answer: $\pi = 2.46$ atm $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 10

Q11.

Solution

Concept — Periodic trend in metallic character: Metallic character reflects the tendency of an atom to lose electrons. It depends on atomic size, nuclear charge, and ionisation energy.

Step 1 — Trend across a period: Moving left to right, nuclear charge increases and atomic radius decreases, so the valence electrons are held more tightly.

Step 2 — Consequence: Ionisation energy and electronegativity rise, making it

harder to lose electrons, so metallic character *decreases* across a period (metals on the left, non-metals on the right).

Why other options are wrong:

- Increasing across a period: contradicts the rise in ionisation energy.
- Constant: ignores the clear left-to-right change.
- First increasing then decreasing: not the observed monotonic trend across a period.

Final Answer: metallic character decreases across a period $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 11

Q12.

Solution

Concept — Effective nuclear charge: The effective nuclear charge $Z_{\text{eff}} = Z - \sigma$, where Z is the nuclear charge and σ is the screening (shielding) by inner electrons.

Step 1 — Across a period: Electrons are added to the same valence shell while protons are added to the nucleus. Electrons in the same shell shield one another only weakly.

Step 2 — Net effect: Since Z rises faster than σ, the effective nuclear charge *increases* from left to right, drawing the valence electrons closer.

Why other options are wrong:

- Decreasing (either reason given): contradicts the rise in Z_{eff}; size decreases as a *result* of greater Z_{eff}.
- Nearly constant: ignores the steady increase along a period.

Final Answer: Z_{eff} increases because same-shell electrons shield poorly $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 12

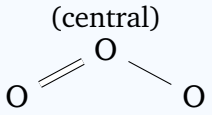
Q13.

Solution

Concept — Formal charge: The formal charge on an atom is

$$\text{FC} = (\text{valence electrons}) - (\text{lone-pair electrons}) - \tfrac{1}{2}(\text{bonding electrons}).$$

The central O of ozone is shown below with one single and one double bond.



Step 1 — Count for the central O: It has 6 valence electrons; one lone pair (2 electrons); it forms a double bond (4 bonding electrons) and a single bond (2 bonding electrons), so 6 bonding electrons in total.

Step 2 — Apply the formula:

$$\text{FC} = 6 - 2 - \tfrac{1}{2}(6) = 6 - 2 - 3 = +1.$$

Why other options are wrong:

- -1: that is the formal charge on the singly bonded terminal oxygen, not the central one.
- 0: would require equal sharing with no charge separation, which ozone does not have.
- $+2$: overcounts the bonding contribution.

Final Answer: central O carries $+1 \Rightarrow$ B

Answer: (B) Go Back to Q 13

Q14.

Solution

Concept — Octet-rule exceptions: Some central atoms are stable with fewer than eight valence electrons (incomplete octet), while others expand beyond eight (expanded octet).

Step 1 — Examine each molecule: In BF_3, boron forms three bonds and has only 6 electrons around it, an *incomplete* octet.

Step 2 — Contrast the others: CH_4 has a complete octet; SF_6 (12 electrons) and

PCl_5 (10 electrons) have *expanded* octets.

Why other options are wrong:

- CH_4: carbon has exactly eight electrons.
- SF_6 and PCl_5: these exceed the octet rather than fall short of it.

Final Answer: BF_3 has an incomplete octet $\Rightarrow$ C

Answer: (C) Go Back to Q 14

Q15.

Solution

Concept — Group 1 oxides in air: The heavier alkali metals form increasingly oxygen-rich products on burning. Lithium gives the normal oxide, sodium the peroxide, and potassium (and the heavier metals) give the superoxide.

Step 1 — Identify potassium's product: Burning potassium in excess oxygen gives potassium superoxide:

$$K + O_2 \rightarrow KO_2.$$

Step 2 — Reason: The large K^+ ion stabilises the large superoxide ion O_2^-, so KO_2 is the main product.

Why other options are wrong:

- K_2O: the normal oxide is the main product for lithium, not potassium.
- K_2O_2: the peroxide is characteristic of sodium.
- KOH: forms on reaction with water, not on burning in dry air.

Final Answer: potassium gives the superoxide KO_2 $\Rightarrow$ D

Answer: (D) Go Back to Q 15

Q16.

Solution

Concept — Haber process catalyst: The industrial synthesis $N_2 + 3H_2 \rightleftharpoons 2NH_3$ is slow without a catalyst. A heterogeneous iron-based catalyst is used.

Step 1 — Identify the catalyst: Finely divided iron is the catalyst, with molybdenum (or K_2O and Al_2O_3) acting as a promoter to improve its activity.

Step 2 — Conditions: The reaction is run at about 200 atm and 700 K to balance rate and yield.

Why other options are wrong:

- Platinum gauze: used in the Ostwald process for oxidising ammonia, not for making it.
- Vanadium pentoxide: catalyst for the Contact process (SO_2 to SO_3).
- Nickel: used for catalytic hydrogenation of unsaturated organic compounds.

Final Answer: finely divided iron with a molybdenum promoter $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 16

Q17.

Solution

Concept — Solid-state structure of PCl_5: Although PCl_5 is a trigonal bipyramidal molecule in the gas phase, in the solid state it adopts an ionic lattice.

Step 1 — Identify the ions: Solid PCl_5 consists of tetrahedral cations and octahedral anions:

$$PCl_5 \text{ (solid)} = [PCl_4]^+[PCl_6]^-.$$

Step 2 — Reason for the structures: $[PCl_4]^+$ is tetrahedral (sp^3) and $[PCl_6]^-$ is octahedral (sp^3d^2); this ionic packing is energetically favourable in the solid.

Why other options are wrong:

- $[PCl_5]^+$ and Cl^-: do not correspond to the known lattice ions.
- $[PCl_2]^+$ and $[PCl_4]^-$: incorrect chlorine counts.
- Neutral molecules only: true for the gas phase, not the solid.

Final Answer: solid $PCl_5 = [PCl_4]^+[PCl_6]^- \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 17

Q18.

Solution

Concept — Preparation of $KMnO_4$: Pyrolusite is first converted to potassium manganate, which is then oxidised to permanganate.

Step 1 — Fusion step: MnO_2 is fused with KOH and an oxidant (air or KNO_3):

$$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O.$$

The green potassium manganate K_2MnO_4 (Mn in $+6$) is the intermediate.

Step 2 — Oxidation step: The manganate is then oxidised (electrolytically or chemically) to purple permanganate $KMnO_4$ (Mn in $+7$).

Why other options are wrong:

- MnO and Mn_2O_3: lower oxides, not formed in this alkaline oxidation.
- $MnCl_2$: a manganese(II) salt unrelated to the fusion route.

Final Answer: the green intermediate is $K_2MnO_4 \Rightarrow$ C

Answer: (C) Go Back to Q 18

Q19.

Solution

Concept — Ionisation isomerism: Ionisation isomers give different ions in solution because the groups inside and outside the coordination sphere are interchanged.

Step 1 — Compare the two complexes: In $[Co(NH_3)_5Br]SO_4$, bromide is bound to cobalt and sulphate is the counter-ion. In $[Co(NH_3)_5SO_4]Br$, sulphate is bound and bromide is the counter-ion.

Step 2 — Identify the type: The ligand and the counter-ion have swapped places, which is the defining feature of ionisation isomerism. The two would give different precipitation tests (one releases free SO_4^{2-}, the other free Br^-).

Why other options are wrong:

- Linkage isomerism: needs an ambidentate ligand bonding through different atoms.
- Geometrical / optical isomerism: relate to spatial arrangement, not to swapping ligand and counter-ion.

Final Answer: the pair shows ionisation isomerism $\Rightarrow$ B

Answer: (B) Go Back to Q 19

Q20.

Solution

Concept — Classification of hydrides: Binary hydrides are grouped as ionic (saline), covalent (molecular), and metallic (interstitial), based on the electronegativity difference with hydrogen.

Step 1 — Nature of NaH and CaH_2: The strongly electropositive s-block metals transfer an electron to hydrogen, forming the hydride ion H^-. These are ionic (saline) hydrides.

Step 2 — Supporting evidence: On electrolysis of molten NaH, hydrogen is liberated at the anode, confirming the presence of H^-.

Why other options are wrong:

- Covalent (molecular) hydrides: formed by p-block elements such as CH_4 and NH_3.
- Metallic (interstitial) hydrides: formed by many d- and f-block metals.
- Electron-deficient hydrides: typified by boron hydrides like B_2H_6.

Final Answer: NaH and CaH_2 are ionic (saline) hydrides $\Rightarrow$ A

Answer: (A) Go Back to Q 20

Q21.

Solution

Concept — Electromeric effect: The electromeric effect is a *temporary* electronic effect seen in molecules with a multiple bond, occurring only in the presence of an attacking reagent.

Step 1 — Define it: When a reagent approaches, the complete pair of pi electrons shifts to one of the doubly bonded atoms, producing a momentary charge separation. The effect disappears once the reagent is removed.

Step 2 — Distinguish from related effects: It is instantaneous and reversible, unlike the permanent inductive and mesomeric (resonance) effects.

Why other options are wrong:

- Permanent polarisation of sigma bonds: that is the inductive effect.
- Delocalisation of pi electrons at all times: that is the mesomeric/resonance effect.
- Inductive withdrawal by an electronegative atom: again the inductive effect.

Final Answer: a temporary complete pi-electron shift in the presence of a reagent $\Rightarrow$ C

Answer: (C) Go Back to Q 21

Q22.

Solution

Concept — Tautomerism: Tautomers are constitutional isomers in rapid equilibrium that differ in the position of a hydrogen atom and a double bond, most commonly the keto–enol pair.

Step 1 — Examine acetone: Acetone exists in equilibrium between its keto form CH_3COCH_3 and its enol form $CH_3C(OH)=CH_2$, interconverting by migration of an alpha-hydrogen.

Step 2 — Confirm: This proton shift accompanied by a double-bond shift is the hallmark of tautomerism.

Why other options are wrong:

- Ethanol and dimethyl ether: functional-group isomers, not tautomers (no rapid equilibrium).
- Propan-1-ol and propan-2-ol: position isomers.
- But-1-ene and but-2-ene: position isomers of the double bond, not tautomers.

Final Answer: the keto and enol forms of acetone are tautomers $\Rightarrow$ D

Answer: (D) Go Back to Q 22

Q23.

Solution

Concept — Electrophilic aromatic nitration: Benzene undergoes electrophilic substitution. The active electrophile is generated from the nitrating mixture.

Step 1 — Generate the electrophile: Sulphuric acid protonates nitric acid, which then loses water to give the nitronium ion:

$$HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+.$$

Step 2 — Attack on the ring: The nitronium ion NO_2^+ attacks the benzene ring, forming nitrobenzene after loss of a proton.

Why other options are wrong:

- NO_2^- and the neutral HNO_3: not electrophilic enough to attack the ring.
- NO^+: this is the nitrosonium ion, the electrophile in nitrosation, not nitration.

Final Answer: the electrophile is $NO_2^+ \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q 23

Q24.

Solution

Concept — Friedel–Crafts alkylation: Benzene reacts with an alkyl halide in the presence of a Lewis acid catalyst to give an alkylbenzene.

Step 1 — Role of $AlCl_3$: The Lewis acid $AlCl_3$ abstracts the halide from the alkyl halide, generating the electrophilic carbocation:

$$CH_3Cl + AlCl_3 \rightarrow CH_3^+ + [AlCl_4]^-.$$

Step 2 — Substitution: The methyl cation attacks benzene, and loss of a proton restores aromaticity, giving toluene.

Why other options are wrong:

- Reducing agent: $AlCl_3$ does not reduce the ring.
- Provides protons: it is a Lewis acid, not a proton source here.
- Complexes with the product: the catalyst is regenerated, not consumed by the product.

Final Answer: $AlCl_3$ generates the electrophilic carbocation $\Rightarrow$ A

Answer: (A) Go Back to Q 24

Q25.

Solution

Concept — Wurtz–Fittig reaction: An aryl halide and an alkyl halide react with sodium in dry ether to couple the aryl and alkyl groups, giving an alkylarene.

Step 1 — Identify the coupling: Bromobenzene (C_6H_5Br) couples with bromoethane (C_2H_5Br):

$$C_6H_5Br + C_2H_5Br + 2Na \rightarrow C_6H_5C_2H_5 + 2NaBr.$$

Step 2 — Name the product: The cross product is ethylbenzene ($C_6H_5C_2H_5$), the desired alkylarene.

Why other options are wrong:

- Biphenyl: the homocoupling of two aryl halides (a side product).
- n-Butane: the homocoupling of two ethyl groups (a side product).
- Benzene: would require simple reduction, not coupling.

Final Answer: the cross-coupled product is ethylbenzene $\Rightarrow$ C

Answer: (C) Go Back to Q 25

Q26.

Solution

Concept — Lucas test: The Lucas reagent (concentrated HCl with anhydrous $ZnCl_2$) distinguishes alcohols by the rate at which they form an insoluble alkyl chloride (turbidity), which depends on carbocation stability.

Step 1 — Order of reactivity: The reaction proceeds via a carbocation, so tertiary $>$ secondary $>$ primary. Tertiary alcohols react immediately.

Step 2 — Apply to the options: 2-Methylpropan-2-ol is a tertiary alcohol; it gives turbidity almost at once, because its tertiary carbocation is the most stable.

Why other options are wrong:

- Methanol and ethanol (primary): give no turbidity at room temperature.

- Propan-2-ol (secondary): gives turbidity only after about five minutes, not immediately.

Final Answer: the tertiary alcohol 2-methylpropan-2-ol reacts fastest $\Rightarrow$ D

Answer: (D) Go Back to Q 26

Q27.

Solution

Concept — Wolff–Kishner reduction: This reaction reduces the carbonyl group (C=O) of aldehydes and ketones to a methylene group (CH_2).

Step 1 — Identify the reagents: The carbonyl compound is first converted to its hydrazone with hydrazine (NH_2NH_2); the hydrazone is then heated with a strong base such as KOH in a high-boiling solvent (ethylene glycol).

Step 2 — Result: The carbonyl carbon is reduced to CH_2, so acetophenone becomes ethylbenzene.

Why other options are wrong:

- Zinc amalgam and concentrated HCl: these are the Clemmensen reagents (an acidic alternative), not Wolff–Kishner.
- $LiAlH_4$ or $NaBH_4$: these reduce C=O only to an alcohol (CHOH), not all the way to CH_2.

Final Answer: hydrazine then KOH/glycol with heat $\Rightarrow$ B

Answer: (B) Go Back to Q 27

Q28.

Solution

Concept — Hell–Volhard–Zelinsky reaction: Carboxylic acids that have at least one alpha-hydrogen react with Cl_2 or Br_2 in the presence of a little red phosphorus to give alpha-halogenated acids.

Step 1 — Site of halogenation: The halogen is introduced specifically at the alpha-carbon (the carbon next to the COOH group):

$$\text{R-CH}_2\text{-COOH} \xrightarrow{\text{Cl}_2/\text{P}} \text{R-CHCl-COOH}.$$

Step 2 — Role of phosphorus: Red phosphorus forms a small amount of acid halide in situ, which enolises readily and so undergoes alpha-halogenation.

Why other options are wrong:

- Acid chloride only: that is an intermediate, not the final isolated product.
- Beta-halo acid or halogen on the farthest carbon: the HVZ reaction is selective for the alpha position.

Final Answer: the product is the alpha-halocarboxylic acid $\Rightarrow$ A

Answer: (A) Go Back to Q 28

Q29.

Solution

Concept — Diazotisation and coupling: A primary aromatic amine is converted to a diazonium salt at low temperature, which then couples with an activated aromatic ring to give an azo dye.

Step 1 — Diazotisation: Aniline with $NaNO_2$ and dilute HCl at 0–$5\,^\circ C$ gives benzenediazonium chloride:

$$C_6H_5NH_2 \xrightarrow{NaNO_2/HCl,\,0\text{–}5\,^\circ C} C_6H_5N_2^+Cl^-.$$

Step 2 — Coupling with phenol: The diazonium ion couples at the para position of phenol in mild alkali to give an orange azo dye, p-hydroxyazobenzene.

Why other options are wrong:

- Nitrobenzene and chlorobenzene: products of different reactions, not of azo coupling.
- Phenylhydrazine: formed by reduction of the diazonium salt, not by coupling.

Final Answer: an orange azo dye (p-hydroxyazobenzene) is formed $\Rightarrow$ C

Answer: (C) Go Back to Q 29

Q30.

Solution

Concept — Levels of protein structure: Proteins are described at four structural levels: primary, secondary, tertiary, and quaternary.

Step 1 — Define the primary structure: The primary structure is the exact linear sequence of amino-acid residues joined by peptide bonds in the polypeptide chain.

Step 2 — Contrast with higher levels: The secondary structure refers to local folding (alpha-helix, beta-pleated sheet); the tertiary to the overall three-dimensional fold; the quaternary to the assembly of several chains.

Why other options are wrong:

- Secondary structure: describes coiling/pleating, not the residue sequence.
- Tertiary and quaternary structures: describe three-dimensional folding and subunit assembly, not the bare sequence.

Final Answer: the amino-acid sequence is the primary structure $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 30

Answer Key

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