AIIMS B.Sc Nursing Chemistry

Sample Paper – 1

Duration: 36 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30 Multiple Choice Questions (single correct answer)**, modelled on the Chemistry section of the **AIIMS B.Sc Nursing** entrance.
- Each correct answer carries **+1 mark**. $\frac{1}{3}$ **mark is deducted** for every wrong answer, and an unattempted question gets **0 marks**.
- Only **one** option is correct. The paper covers physical, inorganic, and organic chemistry.
- Personal calculators, log tables, mobile phones, and other electronic gadgets are strictly prohibited.

Q1. The number of moles present in 11 g of carbon dioxide (CO_2, molar mass $= 44$ g mol^{-1}) is:

(A) 0.25 mol

(B) 0.5 mol

(C) 1 mol

(D) 2 mol

Q2. The number of molecules present in 0.5 mol of nitrogen gas (N_2) is (Avogadro number $= 6.022 \times 10^{23}$):

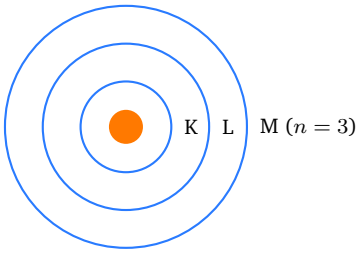
(A) 6.022×10^{23}

(B) 3.011×10^{23}

(C) 1.2×10^{24}

(D) 6.022×10^{22}

Q3. The shells of an atom are shown below. The maximum number of electrons that the M shell ($n = 3$) can hold, given by $2n^2$, is:



(A) 2

(B) 8

(C) 18

(D) 32

Q4. The filling of the $2p$ subshell of an oxygen atom ($Z = 8$, configuration $1s^2\,2s^2\,2p^4$) is shown. The number of unpaired electrons in a ground-state oxygen atom is:

$2p^4$

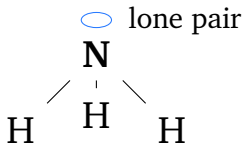
(A) 4

(B) 1

(C) 3

(D) 2

Q5. The structure of an ammonia (NH_3) molecule, with one lone pair on nitrogen, is shown. The shape of the molecule is:



(A) trigonal pyramidal

(B) trigonal planar

(C) tetrahedral

(D) linear

Q6. The hybridization of each carbon atom in an ethene molecule (C_2H_4, which contains a C=C double bond) is:

(A) sp^3

(B) sp^2

(C) sp

(D) sp^3d

Q7. Which one of the following molecules is polar (has a non-zero dipole moment)?

(A) CO_2

(B) CH_4

(C) H_2O

(D) BF_3

Q8. On moving from left to right across a period in the periodic table, the atomic radius of the elements generally:

(A) increases

(B) remains constant

(C) first increases, then decreases

(D) decreases

Q9. Which of the following elements has the highest electronegativity?

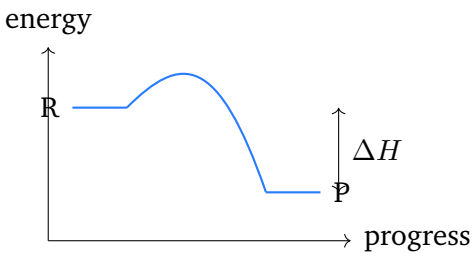
(A) Fluorine

(B) Oxygen

(C) Chlorine

(D) Nitrogen

Q10. The energy profile of a reaction is shown, with the reactants (R) at a higher energy than the products (P). For such an exothermic reaction, the sign of the enthalpy change ΔH is:



(A) positive

(B) negative

(C) zero

(D) cannot be decided

Q11. For a reaction at a certain temperature, $\Delta H = -100$ kJ and $T\Delta S = -40$ kJ. The Gibbs free energy change ΔG ($= \Delta H - T\Delta S$) for the reaction is:

(A) -140 kJ

(B) -100 kJ

(C) -60 kJ

(D) $+60$ kJ

Q12. For the equilibrium $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, increasing the pressure on the system shifts the equilibrium:

(A) towards the reactants

(B) no shift occurs

(C) towards both sides equally

(D) towards the products (ammonia)

Q13. The pH of a 0.01 M solution of hydrochloric acid (a strong acid, fully ionized) is:

(A) 2

(B) 1

(C) 12

(D) 3

Q14. According to the Bronsted–Lowry theory, the conjugate base of water (H_2O) is:

(A) H_3O^+

(B) OH^-

(C) O^{2-}

(D) H_2O

Q15. The oxidation number of manganese in potassium permanganate ($KMnO_4$) is:

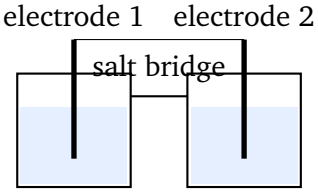
(A) $+2$

(B) $+4$

(C) $+7$

(D) $+6$

Q16. A galvanic (voltaic) cell with two electrodes joined by a salt bridge is shown. In such a cell, oxidation takes place at the:



(A) cathode

(B) salt bridge

(C) electrolyte

(D) anode

Q17. The quantity of charge required to deposit 1 mole of silver from a silver salt solution ($Ag^{+} + e^{-} \rightarrow Ag$) is (Faraday constant $= 96500$ C mol^{-1}):

(A) 96500 C

(B) 193000 C

(C) 48250 C

(D) 9650 C

Q18. The molarity of a solution that contains 0.5 mol of solute dissolved in enough water to make 250 mL of solution is:

(A) 1 M

(B) 2 M

(C) 0.5 M

(D) 4 M

Q19. At constant temperature, the pressure on a fixed mass of an ideal gas is doubled. According to Boyle's law, its volume becomes:

(A) doubled

(B) four times

(C) halved

(D) unchanged

Q20. The oxidation state of iron in the complex ion $[Fe(CN)_6]^{3-}$ (each CN ligand carries a charge of -1) is:

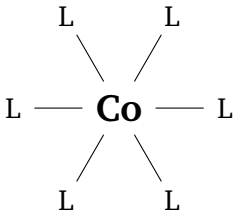
(A) 0

(B) $+2$

(C) $+6$

(D) $+3$

Q21. The complex ion $[Co(NH_3)_6]^{3+}$ has the arrangement of ligands (L) around the central cobalt shown below. The coordination number of cobalt in this complex is:



(A) 6

(B) 3

(C) 4

(D) 2

Q22. Which one of the following elements is a noble gas (group 18)?

(A) Chlorine

(B) Argon

(C) Sodium

(D) Oxygen

Q23. The number of structural (chain) isomers of butane, C_4H_{10}, is:

(A) 4

(B) 3

(C) 2

(D) 1

Q24. The IUPAC name of the compound CH_3–CH_2–OH is:

(A) methanol

(B) methanal

(C) ethanal

(D) ethanol

Q25. The general molecular formula of the alkene homologous series is:

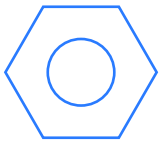
(A) C_nH_{2n}

(B) C_nH_{2n+2}

(C) C_nH_{2n-2}

(D) C_nH_n

Q26. The ring structure shown, with delocalised electrons represented by the inner circle, is the basic skeleton of which aromatic hydrocarbon?



(A) ethane

(B) ethyne

(C) benzene

(D) propene

Q27. The hybridization of each carbon atom in an ethyne (acetylene, C_2H_2) molecule, which contains a C≡C triple bond, is:

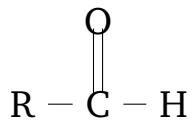
(A) sp^3

(B) sp

(C) sp^2

(D) sp^3d

Q28. The functional group shown below, with a carbon double-bonded to oxygen and also bonded to a hydrogen, is characteristic of which class of compounds?



(−CHO group)

(A) alcohols

(B) carboxylic acids

(C) ketones

(D) aldehydes

Q29. The building-block monomer units of proteins are:

(A) amino acids

(B) glucose molecules

(C) nucleotides

(D) fatty acids

Q30. The functional group present in a carboxylic acid is:

(A) −OH (hydroxyl)

(B) −CHO (aldehyde)

(C) −COOH (carboxyl)

(D) $-NH_2$ (amino)

Detailed Solutions

Q1.

Solution

Concept — The mole and molar mass: The mole is the SI unit for the amount of a substance. One mole of any substance contains Avogadro's number (6.022×10^{23}) of particles and has a mass equal to its molar mass expressed in grams. The number of moles links a measured mass to a count of particles through $n = \dfrac{\text{given mass}}{\text{molar mass}}$. The molar mass of CO_2 is the sum of the atomic masses: C (12)+2×O $(2 \times 16) = 12 + 32 = 44$ g mol^{-1}.

Given: mass $= 11$ g; molar mass $M(CO_2) = 44$ g mol^{-1}.

Step 1 — Write the formula: $n = \dfrac{m}{M}$.

Step 2 — Substitute the data with units: $n = \dfrac{11 \text{ g}}{44 \text{ g mol}^{-1}}$.

Step 3 — Evaluate: the grams cancel, leaving $n = 0.25$ mol.

Why each other option is wrong:

- (B) 0.5 mol would correspond to $0.5 \times 44 = 22$ g of CO_2, not 11 g.
- (C) 1 mol is the full molar mass, 44 g.
- (D) 2 mol would be 88 g.

Key point: Always work out the molar mass first by summing the atomic masses. A common slip is to forget the two oxygen atoms or to use 22 instead of 44.

Final Answer: 0.25 mol $\Rightarrow$ A

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Avogadro's number: Avogadro's number, $N_A = 6.022 \times 10^{23}$, is the number of particles (atoms, molecules, or ions) present in exactly one mole. To convert a number of moles into a number of molecules, multiply by N_A: number of molecules $= n \times N_A$. Here the gas is N_2, and each N_2 unit counts as one molecule even though it contains two nitrogen atoms.

Given: $n = 0.5$ mol of N_2; $N_A = 6.022 \times 10^{23}$.

Step 1 — Formula: number of molecules $= n \times N_A$.

Step 2 — Substitute: $= 0.5 \times 6.022 \times 10^{23}$.

Step 3 — Evaluate: $= 3.011 \times 10^{23}$ molecules.

Why each other option is wrong:

- (A) 6.022×10^{23} is the number in one full mole, not half a mole.
- (C) 1.2×10^{24} is about two moles' worth, double the correct value.
- (D) 6.022×10^{22} corresponds to 0.1 mole, ten times too small.

Key point: If the question had asked for the number of *atoms*, you would multiply once more by 2 (each N_2 has two atoms) to get 6.022×10^{23} atoms. Since it asks for molecules, stop at 3.011×10^{23}.

Final Answer: 3.011×10^{23} molecules $\Rightarrow$ B

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — Capacity of a shell: Electrons around a nucleus occupy shells labelled by the principal quantum number n ($n = 1$ is K, $n = 2$ is L, $n = 3$ is M, $n = 4$ is N). The maximum number of electrons a shell can hold is $2n^2$. This comes from the number of orbitals in the shell (n^2) multiplied by two electrons per orbital (Pauli's exclusion principle).

Step 1 — Identify n: the M shell is the third shell, so $n = 3$.

Step 2 — Apply $2n^2$: $2 \times (3)^2 = 2 \times 9$.

Step 3 — Evaluate: $= 18$ electrons.

Why each other option is wrong:

- (A) 2 is the capacity of the K shell ($n = 1$): $2 \times 1^2 = 2$.
- (B) 8 is the L shell ($n = 2$): $2 \times 2^2 = 8$.
- (D) 32 is the N shell ($n = 4$): $2 \times 4^2 = 32$.

Key point: $2n^2$ gives the theoretical maximum (K= 2, L= 8, M= 18, N= 32). The order in which electrons actually fill also follows the aufbau principle, but a shell's total capacity is always fixed at $2n^2$.

Final Answer: 18 electrons $\Rightarrow$ C

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Filling orbitals (aufbau, Pauli, Hund): Electrons fill orbitals by three rules: the aufbau principle (lowest-energy orbitals first), Pauli's exclusion principle (at most two electrons per orbital, with opposite spins), and Hund's rule of maximum multiplicity (degenerate orbitals are filled singly with parallel spins before any pairing). Oxygen has $Z = 8$, so its ground-state configuration is $1s^2\,2s^2\,2p^4$.

Step 1 — Write the configuration: $1s^2\,2s^2\,2p^4$. The $1s$ and $2s$ subshells are completely filled (all paired); the deciding part is the $2p^4$.

Step 2 — Distribute the four $2p$ electrons among the three $2p$ orbitals using Hund's rule: first place one electron in each of the three orbitals (three unpaired electrons), then the fourth electron must pair up in the first orbital, giving $\uparrow\downarrow|\uparrow|\uparrow$.

Step 3 — Count the unpaired electrons: two orbitals each contain a single (unpaired) electron, so there are 2 unpaired electrons.

Why each other option is wrong:

- (A) 4 would require all four $2p$ electrons to stay unpaired, impossible with only three $2p$ orbitals.
- (B) 1 and (C) 3 ignore the correct pairing pattern of a p^4 configuration.

Key point: A p^4 system has the same number of unpaired electrons as p^2 (two), because the fourth electron simply pairs the first orbital. These two unpaired electrons are why oxygen is paramagnetic.

Final Answer: 2 unpaired electrons $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — VSEPR shape of NH_3: The shape of a molecule is predicted by VSEPR theory: electron pairs (bonding and lone) around the central atom spread out as far as possible. The total number of electron domains sets the electron geometry, and any lone pairs then distort the visible shape. In NH_3, nitrogen has 5 valence electrons: three form N–H bonds and two remain as a single lone pair, giving four electron domains (sp^3 hybridisation).

Step 1 — Electron geometry: four electron domains arrange themselves tetrahedrally.

Step 2 — Account for the lone pair: one of the four tetrahedral positions is taken by the lone pair, which is not "seen" in the shape but still pushes on the bonds.

Step 3 — Molecular shape: the three N–H bonds form a trigonal pyramid (like a tripod). The lone pair presses the bonds together, reducing the angle from the ideal 109.5° to about 107°.

Why each other option is wrong:

- (B) Trigonal planar (120°) needs three domains and no lone pair, as in BF_3.
- (C) Tetrahedral describes the *electron* geometry, not the shape; the shape is tetrahedral only when all four domains are bonds, as in CH_4.
- (D) Linear is for two domains, as in CO_2.

Key point: Distinguish the electron geometry (which counts lone pairs) from the molecular shape (which counts only atoms). NH_3 is sp^3 with a tetrahedral electron geometry but a trigonal pyramidal shape.

Final Answer: Trigonal pyramidal $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q5

Q6.

Solution

Concept — Hybridisation from σ bonds: A carbon atom's hybridisation equals its number of σ bonds plus lone pairs (its number of electron domains). A double bond counts as *one* σ bond (the extra bond is a π bond, which does not change the hybridisation). In ethene, $CH_2{=}CH_2$, each carbon is bonded to two hydrogens and to the other carbon.

Step 1 — Count the σ bonds on one carbon: two C–H σ bonds plus one C–C σ bond (from the double bond) $= 3$ σ bonds, with no lone pairs, i.e. three electron domains.

Step 2 — Assign the hybridisation: three domains $\Rightarrow sp^2$. The three sp^2 orbitals lie in a plane at 120°, and the leftover unhybridised p orbital forms the π bond.

Step 3 — Geometry: each carbon is trigonal planar, and the whole ethene molecule is flat.

Why each other option is wrong:

- (A) sp^3 (four domains) is for a carbon with four single bonds, as in ethane.
- (C) sp (two domains) is for a triple bond, as in ethyne.
- (D) sp^3d (five domains) cannot occur for carbon, which has no available d orbitals.

Key point: For hybridisation, count a double bond as one σ bond. sp^2 always goes with a planar 120° geometry and one π bond.

Final Answer: $sp^2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Molecular polarity: A molecule is polar (has a net dipole moment) only if its individual bond dipoles do not cancel. This depends on both the electronegativity difference in the bonds *and* the molecular shape. A symmetric arrangement of identical bond dipoles cancels to zero, even when the bonds themselves are polar.

Step 1 — Check the symmetric molecules: CO_2 is linear (O=C=O), so its two C=O dipoles point in exactly opposite directions and cancel; CH_4 is a symmetric tetrahedron, so its four C–H dipoles cancel; BF_3 is symmetric trigonal planar, so its three B–F dipoles cancel. All three are non-polar.

Step 2 — Examine water: H_2O is bent (about 104.5°) because of the two lone pairs on oxygen. The two O–H bond dipoles do not oppose each other; they add to give a net dipole pointing from the hydrogens toward the oxygen.

Step 3 — Conclusion: only H_2O has a non-zero net dipole, so it is the polar molecule.

Why each other option is wrong:

- (A) CO_2 has polar bonds but a linear, symmetric shape, so the dipoles cancel.
- (B) CH_4 is a symmetric tetrahedron, so its dipoles cancel.
- (D) BF_3 is symmetric trigonal planar, so its dipoles cancel.

Key point: Polarity needs polar bonds *and* an asymmetric shape. The bent shape of water (caused by its lone pairs) is exactly what makes it polar, which is why water is such a good solvent.

Final Answer: $H_2O \Rightarrow \boxed{C}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept — Atomic radius across a period: The atomic radius is roughly the distance from the nucleus to the outermost shell. Across a period (left to right), electrons are added to the *same* outer shell while protons are added to the nucleus. The rising effective nuclear charge pulls that shell inward more strongly, and electrons in the same shell shield one another only weakly.

Step 1 — Identify what changes across a period: the principal shell number stays the same, but the nuclear charge increases by one with each successive element.

Step 2 — Net effect: the stronger nuclear pull draws the outer electrons closer, shrinking the atom.

Step 3 — State the trend: the atomic radius therefore decreases from left to right across a period. (Down a *group*, by contrast, the radius increases because new shells are added.)

Why each other option is wrong:

- (A) Increasing is the trend *down a group*, not across a period.
- (B) Remaining constant ignores the steadily rising nuclear charge.
- (C) There is no "increase then decrease" reversal across a normal period.

Key point: Across a period the radius decreases (nuclear charge dominates); down a group it increases (added shells dominate). Do not mix the period trend up with the group trend.

Final Answer: Decreases $\Rightarrow$ D

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Electronegativity: Electronegativity is the tendency of an atom to attract a shared bonding pair of electrons toward itself. On the Pauling scale it increases across a period (left to right) and decreases down a group, so the most electronegative elements sit at the top right of the periodic table (the noble gases excepted).

Step 1 — Locate the options: fluorine is at the top of group 17, oxygen is in group 16, chlorine is just below fluorine in group 17, and nitrogen is in group 15.

Step 2 — Compare values: fluorine has the highest electronegativity of all elements, about 4.0 on the Pauling scale. The rough order among the options is F (4.0) > O (3.5) > Cl (3.0) $\approx$ N (3.0).

Step 3 — Conclusion: fluorine is the most electronegative.

Why each other option is wrong:

- (B) Oxygen is second-highest but still below fluorine.
- (C) Chlorine lies below fluorine in the same group, so it is less electronegative.
- (D) Nitrogen lies to the left of O and F in its period, so it is less electronegative.

Key point: Fluorine is the single most electronegative element in the periodic table, a fact worth memorising. Electronegativity is greatest toward the top right.

Final Answer: Fluorine $\Rightarrow$ A

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — Sign of ΔH for an exothermic reaction: The enthalpy change is $\Delta H = H_{\text{products}} - H_{\text{reactants}}$. An exothermic reaction releases heat to the surroundings, which means the products store *less* energy than the reactants. On an energy profile the reactants sit higher than the products, and the gap between them is the heat released.

Step 1 — Read the profile: R (reactants) is drawn above P (products); the system falls to a lower energy as it forms products.

Step 2 — Apply the definition: since $H_{\text{products}} < H_{\text{reactants}}$, $\Delta H = (\text{lower}) - (\text{higher})$, which is a negative quantity.

Step 3 — Interpret: a negative ΔH means energy was given out to the surroundings, the defining feature of an exothermic reaction.

Why each other option is wrong:

- (A) A positive ΔH means the products are higher in energy (endothermic), which contradicts the figure.
- (C) Zero ΔH would put products and reactants at the same level.
- (D) "Cannot be decided" is wrong, since the figure clearly shows the products below the reactants.

Key point: Exothermic $\rightarrow$ heat released $\rightarrow$ ΔH negative $\rightarrow$ products lower on the diagram. Endothermic is the opposite. The "hump" in the middle is the activation energy and does not affect the *sign* of ΔH.

Final Answer: Negative $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Gibbs free energy: The Gibbs free energy change decides whether a reaction is spontaneous: $\Delta G = \Delta H - T\Delta S$, where ΔH is the enthalpy change, T the absolute temperature, and ΔS the entropy change. A negative ΔG means the reaction is spontaneous. Here the combined term $T\Delta S$ is given directly.

Given: $\Delta H = -100$ kJ; $T\Delta S = -40$ kJ.

Step 1 — Write the formula: $\Delta G = \Delta H - T\Delta S$.

Step 2 — Substitute, watching the signs: $\Delta G = (-100) - (-40)$.

Step 3 — Simplify (subtracting a negative means adding): $\Delta G = -100 + 40 = -60$ kJ.

Why each other option is wrong:

- (A) -140 kJ comes from *adding* the two terms instead of subtracting $T\Delta S$.
- (B) -100 kJ ignores the entropy term completely.
- (D) $+60$ kJ reverses the sign through mishandling the double negative.

Key point: The usual error here is the double negative: $-100 - (-40) = -60$, not -140. A negative ΔG (-60 kJ) confirms the reaction is spontaneous.

Final Answer: $\Delta G = -60$ kJ $\Rightarrow$ C

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — Le Chatelier's principle (pressure): If a system at equilibrium is disturbed, it shifts to partly oppose the disturbance. For a change in pressure on a gaseous equilibrium, increasing the pressure shifts the equilibrium toward the side with *fewer* moles of gas, because fewer gas molecules exert less pressure.

Step 1 — Count moles of gas on each side of $N_2 + 3H_2 \rightleftharpoons 2NH_3$: the left side has $1 + 3 = 4$ moles of gas, the right side has 2 moles of gas (ammonia).

Step 2 — Apply the rule: raising the pressure favours the side with fewer gas moles, which is the right side ($2 < 4$).

Step 3 — Conclusion: the equilibrium shifts toward the products, forming more ammonia. This is exactly why the industrial Haber process is run at high pressure.

Why each other option is wrong:

- (A) A shift toward the reactants would be caused by *decreasing* the pressure.
- (B) "No shift" would only hold if both sides had equal moles of gas, which they do not.
- (C) An equilibrium does not respond by moving "toward both sides equally."

Key point: For pressure changes, only the *difference* in moles of gas matters. Higher pressure $\rightarrow$ the side with fewer gas moles (here NH_3). A lower temperature also favours NH_3 because the forward reaction is exothermic.

Final Answer: Towards the products (ammonia) $\Rightarrow$ D

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — pH of a strong acid: pH measures acidity through $\text{pH} = -\log_{10}[\text{H}^+]$, where $[\text{H}^+]$ is the molar concentration of hydrogen ions. HCl is a *strong* acid, so it ionises completely in water ($\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$), and the H^+ concentration equals the acid concentration.

Given: $[\text{HCl}] = 0.01\ \text{M} = 10^{-2}\ \text{M}$.

Step 1 — Find $[\text{H}^+]$: because HCl ionises fully and gives one H^+ per molecule, $[\text{H}^+] = 10^{-2}\ \text{M}$.

Step 2 — Apply the pH formula: $\text{pH} = -\log_{10}(10^{-2})$.

Step 3 — Evaluate: $\log_{10}(10^{-2}) = -2$, so $\text{pH} = -(-2) = 2$.

Why each other option is wrong:

- (B) $\text{pH} = 1$ corresponds to $[\text{H}^+] = 0.1\ \text{M}$, ten times more concentrated.
- (D) $\text{pH} = 3$ corresponds to $0.001\ \text{M}$, ten times more dilute.
- (C) $\text{pH} = 12$ is actually the pOH of this solution (since $\text{pH} + \text{pOH} = 14$); it would describe a basic solution, not this acid.

Key point: For a strong monoprotic acid, $[\text{H}^+]$ equals the molarity, so the pH is simply $-\log$ of the concentration. A pH of 2 is acidic (below 7), exactly as expected for an acid.

Final Answer: $\text{pH} = 2 \Rightarrow$ A

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Conjugate acid–base pairs: In the Bronsted–Lowry theory an acid donates a proton (H^+) and a base accepts one. When a species loses a proton, what remains is its *conjugate base*. So the conjugate base of water is found by removing one H^+ from H_2O.

Step 1 — Remove one proton from water: $H_2O \rightarrow H^+ + OH^-$.

Step 2 — Identify what remains: the species left after losing H^+ is the hydroxide ion, OH^-.

Step 3 — Conclusion: OH^- is the conjugate base of water.

Why each other option is wrong:

- (A) H_3O^+ (hydronium) is the conjugate *acid* of water, formed when water *gains* a proton.
- (C) O^{2-} would require removing *two* protons, which is not a single conjugate-base step.
- (D) H_2O is the original species, not its conjugate base.

Key point: Conjugate base = original minus one H^+; conjugate acid = original plus one H^+. Water is amphoteric, with conjugate base OH^- and conjugate acid H_3O^+.

Final Answer: $OH^- \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Oxidation number rules: The oxidation number of an element in a compound follows fixed rules: in a neutral compound the oxidation numbers sum to zero; a group-1 metal such as potassium is $+1$; oxygen is usually -2. The unknown is then found algebraically.

Given: $KMnO_4$, a neutral compound.

Step 1 — Assign the known values: K $= +1$; each of the four oxygens is -2, giving $4 \times (-2) = -8$. Let the oxidation number of Mn be x.

Step 2 — Set the sum to zero: $(+1) + x + (-8) = 0$, i.e. $1 + x - 8 = 0$.

Step 3 — Solve: $x - 7 = 0 \Rightarrow x = +7$.

Why each other option is wrong:

- (A) $+2$ is Mn in MnO or in Mn^{2+} salts, not in permanganate.
- (B) $+4$ is Mn in MnO_2.
- (D) $+6$ is Mn in the manganate ion MnO_4^{2-}, not the permanganate MnO_4^-.

Key point: $KMnO_4$ is a powerful oxidising agent precisely because Mn is in its highest common oxidation state, $+7$. Always set the oxidation numbers to sum to zero for a neutral compound (or to the ion charge for an ion).

Final Answer: Oxidation number of Mn $= +7 \Rightarrow$ C

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Anode and cathode: Every electrochemical cell has two half-reactions at two electrodes. By definition, *oxidation* (loss of electrons) always occurs at the *anode*, and *reduction* (gain of electrons) always occurs at the *cathode*. A useful memory aid is "An Ox, Red Cat": ANode=OXidation, REDuction=CAThode.

Step 1 — Recall the definitions: anode = where oxidation happens; cathode = where reduction happens. This holds for both galvanic and electrolytic cells.

Step 2 — Apply it to the cell shown: the electrode where the metal loses electrons (is oxidised) is the anode; the electrons then travel through the external wire to the cathode, where reduction occurs.

Step 3 — Conclusion: oxidation takes place at the anode.

Why each other option is wrong:

- (A) The cathode is where *reduction* occurs, the opposite of oxidation.
- (B) The salt bridge only completes the circuit by letting ions flow; no electrode reaction occurs there.
- (C) The electrolyte conducts ions but is not where the oxidation half-reaction is sited.

Key point: "An Ox, Red Cat" holds for every electrochemical cell. In a galvanic cell the anode is the negative terminal; in an electrolytic cell it is positive, but oxidation is always at the anode.

Final Answer: Anode $\Rightarrow$ D

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Faraday's first law: The amount of substance deposited in electrolysis is proportional to the charge passed. To deposit one mole of a metal whose ion needs z electrons, you must supply z moles of electrons, i.e. z faradays of charge. One faraday is the charge on one mole of electrons, $F = 96500$ C.

Given: $Ag^+ + e^- \rightarrow Ag$; $F = 96500$ C mol^{-1}.

Step 1 — Find z (electrons per ion): the half-reaction $Ag^+ + e^- \rightarrow Ag$ shows that one electron deposits one silver atom, so $z = 1$.

Step 2 — Charge for one mole: $Q = z \times F = 1 \times 96500$ C.

Step 3 — Evaluate: $Q = 96500$ C.

Why each other option is wrong:

- (B) 193000 C $= 2$ faradays, which a *divalent* ion ($z = 2$, e.g. Cu^{2+}) would need, not Ag^+.
- (C) 48250 C is half a faraday, too little to deposit a full mole of Ag.
- (D) 9650 C is one-tenth of a faraday, enough for only 0.1 mol.

Key point: The charge to deposit one mole of a metal $=$ (valency of the ion) $\times 96500$ C. Silver is monovalent, so it needs exactly one faraday; copper (Cu^{2+}) would need two.

Final Answer: 96500 C $\Rightarrow$ A

Answer: (A) Go Back to Q17

Q18.

Solution

Concept — Molarity: Molarity is the concentration of a solution in moles of solute per *litre* of solution: $M = \dfrac{\text{moles of solute}}{\text{volume of solution in litres}}$. The volume must be in litres, so a volume in millilitres must be converted first.

Given: moles of solute $= 0.5$ mol; volume $= 250$ mL.

Step 1 — Convert the volume to litres: $250 \text{ mL} \div 1000 = 0.25$ L.

Step 2 — Apply the formula: $M = \dfrac{0.5 \text{ mol}}{0.25 \text{ L}}$.

Step 3 — Evaluate: $M = 2 \text{ mol L}^{-1} = 2$ M.

Why each other option is wrong:

- (A) 1 M would need the 0.5 mol in 0.5 L (500 mL), not 250 mL.
- (C) 0.5 M would need 1 L of solution.
- (D) 4 M would need only 0.125 L (125 mL).

Key point: The most frequent error is forgetting to convert mL to L. Dividing by 0.25 L (not 250) gives the correct 2 M. Molarity always uses the total volume of *solution*, not of solvent.

Final Answer: 2 M $\Rightarrow$ B

Answer: (B) Go Back to Q18

Q19.

Solution

Concept — Boyle's law: For a fixed mass of gas at constant temperature, pressure and volume are inversely proportional: $PV =$ constant, so $P_1V_1 = P_2V_2$. If the pressure rises, the volume must fall by the same factor to keep the product unchanged.

Given: temperature constant; the pressure is doubled, so $P_2 = 2P_1$.

Step 1 — Write Boyle's law: $P_1V_1 = P_2V_2$.

Step 2 — Substitute $P_2 = 2P_1$: $P_1V_1 = (2P_1)V_2$.

Step 3 — Solve for V_2: cancel P_1 from both sides to get $V_1 = 2V_2$, so $V_2 = \dfrac{V_1}{2}$. The volume is halved.

Why each other option is wrong:

- (A) Doubling would happen if the pressure were *halved*, not doubled.
- (B) "Four times" implies a squared dependence, which Boyle's law does not have.
- (D) "Unchanged" would require the pressure to stay the same.

Key point: P and V are inversely proportional at constant T: double the pressure, half the volume. Do not confuse this with Charles's law ($V \propto T$ at constant P), where volume and temperature rise together.

Final Answer: Halved $\Rightarrow$ C

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Oxidation state in a complex ion: In a complex ion, the oxidation state of the central metal plus the sum of the ligand charges equals the overall charge on the complex. Cyanide (CN^-) is a ligand carrying a charge of -1 each.

Given: the complex ion $[Fe(CN)_6]^{3-}$, with six CN^- ligands.

Step 1 — Set up the unknown: let the oxidation state of iron be x. The six CN^- ligands contribute $6 \times (-1) = -6$.

Step 2 — Write the charge balance: $x + (-6) =$ overall charge $= -3$.

Step 3 — Solve: $x - 6 = -3 \Rightarrow x = +3$. Iron is in the $+3$ state (this is the ferricyanide ion).

Why each other option is wrong:

- (A) 0 would require the ligand charges alone to equal the ion charge, but $-6 \neq -3$.
- (B) $+2$ would give an overall charge of $+2 - 6 = -4$ (the ferrocyanide ion $[Fe(CN)_6]^{4-}$), not -3.
- (C) $+6$ would give $+6 - 6 = 0$, a neutral complex, not a -3 ion.

Key point: Use (metal oxidation state) + (sum of ligand charges) = (charge of the complex). With -1 ligands, telling apart the -3 ion (Fe^{3+}) from the -4 ion (Fe^{2+}) is the crux.

Final Answer: Fe $= +3 \Rightarrow$ D

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Coordination number: The coordination number of the central metal is the number of ligand donor atoms directly bonded to it. You count the bonds from the metal to the ligands; for simple monodentate ligands such as NH_3, each ligand makes one bond.

Given: $[Co(NH_3)_6]^{3+}$, drawn with six bonds from Co to six ligand (L) positions.

Step 1 — Count the ligands on cobalt: there are six NH_3 molecules, each a monodentate ligand donating one lone pair.

Step 2 — Count the bonds: each NH_3 forms one coordinate bond to Co, so there are six bonds.

Step 3 — Conclusion: the coordination number is 6, and six ligands around one centre give an octahedral geometry.

Why each other option is wrong:

- (B) 3 would mean only three ligands are attached, but there are six.
- (C) 4 is the coordination number for tetrahedral or square-planar complexes, e.g. $[NiCl_4]^{2-}$.
- (D) 2 corresponds to linear complexes, e.g. $[Ag(NH_3)_2]^{+}$.

Key point: Coordination number counts the *bonds* to the metal, not the charge or the number of atoms in each ligand. Six monodentate ligands give a coordination number of 6 and an octahedral shape. (A bidentate ligand such as ethylenediamine would count as 2.)

Final Answer: $6 \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Noble gases: The noble gases are the elements of group 18 (He, Ne, Ar, Kr, Xe, Rn). They have completely filled outermost shells (a stable octet, except He with two electrons), which makes them very unreactive.

Step 1 — Classify each option by its group: chlorine is in group 17 (halogens), argon is in group 18 (noble gases), sodium is in group 1 (alkali metals), and oxygen is in group 16 (chalcogens).

Step 2 — Pick the group-18 element: argon, whose configuration ends in $3s^2\,3p^6$, a complete outer shell.

Step 3 — Conclusion: argon is the noble gas.

Why each other option is wrong:

- (A) Chlorine is a reactive halogen (group 17) that needs one electron to complete its octet.
- (C) Sodium is a reactive alkali metal (group 1) with one valence electron.
- (D) Oxygen is a reactive non-metal (group 16) needing two electrons.

Key point: Noble gases (group 18) are defined by their full outer shells and chemical inertness. Argon is the most abundant noble gas in Earth's atmosphere (about 0.9%).

Final Answer: Argon $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Structural (chain) isomers: Structural isomers are different compounds that share the same molecular formula but differ in how their atoms are connected. For C_4H_{10} (butane) we look for every distinct way of joining four carbon atoms.

Step 1 — Draw the straight chain: C–C–C–C, which is n-butane.

Step 2 — Draw the branched chain: take three carbons in a row and attach the fourth carbon as a branch on the middle carbon, giving 2-methylpropane (isobutane).

Step 3 — Check for any others: any further attempt just redraws one of these two (branching at an end carbon only lengthens the chain back to n-butane). So there are exactly 2 distinct structures.

Why each other option is wrong:

- (A) 4 and (B) 3 over-count; there is no third distinct skeleton for four carbons.
- (D) 1 under-counts; butane genuinely has a branched isomer as well as the straight chain.

Key point: The number of structural isomers grows quickly with carbon count (butane 2, pentane C_5H_{12} has 3, hexane has 5). Always check whether a "new" branch creates a different connectivity or merely redraws the same molecule.

Final Answer: 2 isomers $\Rightarrow$ C

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — IUPAC naming of alcohols: An alcohol is named by taking the parent alkane, dropping the final "-e", and adding "-ol" for the $-OH$ group. The carbon count sets the root: 1C = meth, 2C = eth, 3C = prop, 4C = but.

Given: CH_3–CH_2–OH.

Step 1 — Count the carbons: two carbons in the chain, so the root is "eth".

Step 2 — Identify the functional group: an $-OH$ (hydroxyl) group means the suffix "-ol", with parent alkane ethane.

Step 3 — Combine: ethane $\rightarrow$ ethan- $+$ -ol $=$ ethanol.

Why each other option is wrong:

- (A) Methanol (CH_3OH) has only one carbon, but this molecule has two.
- (B) Methanal (HCHO) is a one-carbon aldehyde, not a two-carbon alcohol.
- (C) Ethanal (CH_3CHO) is a two-carbon *aldehyde* ($-CHO$), not an alcohol ($-OH$).

Key point: The "-ol" suffix marks an alcohol ($-OH$); the "-al" suffix marks an aldehyde ($-CHO$). Ethanol has two carbons and an $-OH$, so it is ethan $+$ ol. Do not confuse ethanol with ethanal.

Final Answer: Ethanol $\Rightarrow$ D

Answer: (D) Go Back to Q24

Q25.

Solution

Concept — Homologous series of alkenes: A homologous series is a family of organic compounds with the same general formula and similar properties, where consecutive members differ by a $-CH_2-$ unit. Alkenes are unsaturated hydrocarbons containing one carbon–carbon double bond.

Step 1 — Recall the formula: because one double bond removes two hydrogens compared with the matching alkane, alkenes follow C_nH_{2n}.

Step 2 — Test it: for $n = 2$, C_nH_{2n} gives C_2H_4 (ethene); for $n = 3$, C_3H_6 (propene). Both are correct alkenes.

Step 3 — Conclusion: the alkene general formula is C_nH_{2n}.

Why each other option is wrong:

- (B) C_nH_{2n+2} is the *alkane* series (saturated, no double bond), e.g. CH_4, C_2H_6.
- (C) C_nH_{2n-2} is the *alkyne* series (one triple bond), e.g. C_2H_2.
- (D) C_nH_n is not a standard hydrocarbon series.

Key point: Each degree of unsaturation (a double bond or a ring) removes two hydrogens: alkanes C_nH_{2n+2} $\rightarrow$ alkenes C_nH_{2n} $\rightarrow$ alkynes C_nH_{2n-2}. Note that C_nH_{2n} is also the formula for cycloalkanes, since a ring likewise costs two hydrogens.

Final Answer: C_nH_{2n} $\Rightarrow$ A

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Aromatic hydrocarbons: Aromatic hydrocarbons are ring compounds with extra stability from delocalised π electrons spread evenly around the ring. Benzene, C_6H_6, is the simplest aromatic hydrocarbon: a flat six-membered carbon ring, drawn as a hexagon with an inner circle for the delocalised electrons.

Step 1 — Interpret the figure: a regular hexagon (six carbons) with an inner circle (delocalised π electrons) is the standard shorthand for benzene.

Step 2 — Match to the options: this is benzene, C_6H_6.

Step 3 — Classify the rest: ethane (C_2H_6) is a saturated alkane, ethyne (C_2H_2) is an alkyne, and propene (C_3H_6) is an alkene. None is a ring with delocalised electrons.

Why each other option is wrong:

- (A) Ethane is an open-chain alkane, with no ring and no aromaticity.
- (B) Ethyne (acetylene) is a linear alkyne with a triple bond, not an aromatic ring.
- (D) Propene is an alkene with one double bond, not aromatic.

Key point: The hexagon-with-a-circle symbol always means benzene. Aromatic compounds are unusually stable because their π electrons are delocalised over the whole ring rather than fixed in alternating double bonds.

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

Answer: (C) Go Back to Q26

Q27.

Solution

Concept — Hybridisation at a triple bond: Hybridisation equals the number of σ bonds plus lone pairs on the atom. A *triple* bond contributes only one σ bond (the other two are π bonds). In ethyne (acetylene), H–C≡C–H, each carbon is bonded to one hydrogen and to the other carbon.

Step 1 — Count the σ bonds on one carbon: one C–H σ bond plus one C–C σ bond (from the triple bond) $= 2$ σ bonds, with no lone pairs, i.e. two electron domains.

Step 2 — Assign the hybridisation: two domains $\Rightarrow$ sp. The two sp orbitals point in opposite directions (180°), and the two leftover unhybridised p orbitals form the two π bonds of the triple bond.

Step 3 — Geometry: each carbon is linear, so the H–C≡C–H molecule is linear.

Why each other option is wrong:

- (A) sp^3 (four domains) is for four single bonds, as in ethane.
- (C) sp^2 (three domains) is for a double bond, as in ethene.
- (D) sp^3d (five domains) cannot occur for carbon.

Key point: Count only σ bonds (plus lone pairs) for hybridisation. A triple bond $= 1\,\sigma + 2\,\pi \rightarrow sp \rightarrow$ linear $180°$. So ethyne is linear, ethene (sp^2) is planar $120°$, and ethane (sp^3) is tetrahedral $109.5°$.

Final Answer: $sp \Rightarrow$ B

Answer: (B) Go Back to Q27

Q28.

Solution

Concept — The aldehyde group: A functional group is the reactive part of a molecule that defines its class. The group shown, a carbon double-bonded to oxygen (a carbonyl, C=O) and also single-bonded to a hydrogen, written $-$CHO, is the defining group of *aldehydes*.

Step 1 — Read the structure: the carbon has a double bond to O and a single bond to H (plus one bond to the rest of the molecule, R), i.e. R–CHO.

Step 2 — Match the group to its class: a carbonyl carbon carrying at least one hydrogen is an aldehyde, e.g. ethanal (CH_3CHO) or methanal (HCHO).

Step 3 — Conclusion: the $-$CHO group is characteristic of aldehydes.

Why each other option is wrong:

- (A) Alcohols have the $-$OH group, not a carbonyl.
- (B) Carboxylic acids have $-$COOH (a carbonyl *and* a hydroxyl on the same carbon), an extra oxygen compared with $-$CHO.
- (C) Ketones also have a carbonyl, but it is bonded to *two* carbon atoms, not to a hydrogen, which is the key difference from an aldehyde.

Key point: The position of the carbonyl decides the class. At the end of a chain with an H attached it is an aldehyde ($-$CHO); in the middle between two carbons it is a ketone (>C=O); adding an $-$OH to the carbonyl gives a carboxylic acid ($-$COOH).

Final Answer: Aldehydes $\Rightarrow$ D

Answer: (D) Go Back to Q28

Q29.

Solution

Concept — Monomers of biomolecules: Large biomolecules are polymers built from small repeating monomer units. Proteins are polymers of amino acids: many amino acids join through peptide (amide) bonds to form long polypeptide chains that fold into proteins.

Step 1 — Identify the monomer of proteins: the building blocks are amino acids, each containing an amino group ($-NH_2$) and a carboxyl group ($-COOH$).

Step 2 — How they link: a peptide bond forms between the $-COOH$ of one amino acid and the $-NH_2$ of the next, releasing a molecule of water (a condensation reaction).

Step 3 — Conclusion: proteins are made of amino acid monomers.

Why each other option is wrong:

- (B) Glucose molecules are the monomers of *polysaccharides* (carbohydrates) such as starch and cellulose, not proteins.
- (C) Nucleotides are the monomers of *nucleic acids* (DNA and RNA).
- (D) Fatty acids (with glycerol) build up *fats* and lipids, not proteins.

Key point: Match each biomolecule to its monomer: proteins $\leftarrow$ amino acids, polysaccharides $\leftarrow$ monosaccharides (glucose), nucleic acids $\leftarrow$ nucleotides, fats $\leftarrow$ fatty acids $+$ glycerol. Only proteins are built from amino acids.

Final Answer: Amino acids $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept — The carboxylic acid group: Each class of organic compound is identified by its functional group. A carboxylic acid is defined by the carboxyl group, $-COOH$, which is a carbonyl (C=O) and a hydroxyl ($-OH$) attached to the *same* carbon. This group can donate an H^+, which is why these compounds are acidic.

Step 1 — Recall the carboxyl group: $-COOH$, as in acetic acid (CH_3COOH) and formic acid ($HCOOH$).

Step 2 — Confirm its acidity: the $-OH$ of the carboxyl releases a proton to give a carboxylate ion ($-COO^-$), making the compound a weak acid.

Step 3 — Conclusion: carboxylic acids carry the $-COOH$ group.

Why each other option is wrong:

- (A) $-OH$ (hydroxyl) alone is the group of *alcohols*, which are not acidic in this way.
- (B) $-CHO$ is the group of *aldehydes* (a carbonyl with an H, but no extra $-OH$).
- (D) $-NH_2$ (amino) is the group of *amines*, which are basic, not acidic.

Key point: $-COOH$ = carbonyl + hydroxyl on one carbon = carboxylic acid (acidic). Compare alcohols ($-OH$ only), aldehydes ($-CHO$), and amines ($-NH_2$). The combination in $-COOH$ is what makes these compounds acids.

Final Answer: $-COOH \Rightarrow \boxed{C}$

Answer: (C) Go Back to Q30

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Answer Key

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