AIIMS B.Sc Nursing Chemistry

Sample Paper – 6

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. Using the atomic masses Ca $= 40$, C $= 12$ and O $= 16$ (all in g mol^{-1}), the molar mass of calcium carbonate ($CaCO_3$) is:

(A) 100 g mol^{-1}

(B) 68 g mol^{-1}

(C) 84 g mol^{-1}

(D) 116 g mol^{-1}

Q2. According to Avogadro's law, the volume occupied by exactly 1 mole of any ideal gas at standard temperature and pressure (STP) is:

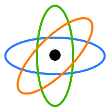
(A) 11.2 L

(B) 22.4 L

(C) 24.0 L

(D) 1.0 L

Q3. The set of orbitals shown below, three dumbbell-shaped orbitals at right angles, makes up a p subshell. The value of the azimuthal (subsidiary) quantum number l for a p subshell is:



$p_x,\ p_y,\ p_z$

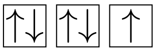
(A) 0

(B) 2

(C) 1

(D) 3

Q4. The filling of the $2p$ subshell of a fluorine atom ($Z = 9$, configuration $1s^2\,2s^2\,2p^5$) is shown. The number of unpaired electrons in a ground-state fluorine atom is:



$2p^5$

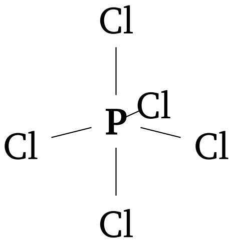
(A) 5

(B) 3

(C) 0

(D) 1

Q5. The structure of a phosphorus pentachloride (PCl_5) molecule, with five P–Cl bonds around the central phosphorus, is shown. The shape of the molecule is:



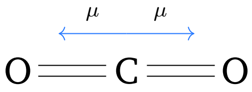
(5 bond pairs)

(A) trigonal bipyramidal
(B) octahedral
(C) square planar
(D) tetrahedral

Q6. In a phosphorus pentachloride (PCl_5) molecule, the phosphorus atom forms five σ bonds with no lone pair. The hybridization of the phosphorus atom is:

(A) sp^3
(B) sp^3d
(C) sp^2
(D) sp^3d^2

Q7. The linear structure of carbon dioxide, O=C=O, is shown with its two bond dipoles. Which of the following molecules is *non-polar* (has a zero net dipole moment)?



(A) H_2O
(B) NH_3
(C) CO_2
(D) HCl

Q8. Among the halogens, which element has the *most negative* (most exothermic) electron gain enthalpy?

(A) Fluorine
(B) Iodine
(C) Bromine
(D) Chlorine

Q9. In the modern (long-form) periodic table, the halogens (F, Cl, Br, I, At) belong to which group?

(A) Group 17

(B) Group 1

(C) Group 18

(D) Group 16

Q10. A state function is a property whose value depends only on the present state of a system, not on the path taken. Which of the following is a state function?

(A) Work (w)

(B) Enthalpy (H)

(C) Heat (q)

(D) Both work and heat

Q11. For a reaction at a certain temperature, $\Delta H = +50$ kJ and $T\Delta S = +30$ kJ. The Gibbs free energy change ΔG $(= \Delta H - T\Delta S)$ for the reaction is:

(A) $+80$ kJ

(B) -20 kJ

(C) $+20$ kJ

(D) -80 kJ

Q12. For the gaseous reaction $a\text{A} + b\text{B} \rightleftharpoons c\text{C} + d\text{D}$ at equilibrium, the correct expression for the equilibrium constant K_c is:

(A) $\dfrac{[\text{A}]^a[\text{B}]^b}{[\text{C}]^c[\text{D}]^d}$

(B) $\dfrac{[\text{A}][\text{B}]}{[\text{C}][\text{D}]}$

(C) $[\text{C}]^c[\text{D}]^d - [\text{A}]^a[\text{B}]^b$

(D) $\dfrac{[\mathrm{C}]^c[\mathrm{D}]^d}{[\mathrm{A}]^a[\mathrm{B}]^b}$

Q13. The pH of a 0.1 M solution of sodium hydroxide (NaOH), a strong base that is fully ionised, at $25°$C is (use pH $+$ pOH $= 14$):

(A) 13

(B) 1

(C) 7

(D) 11

Q14. According to the Bronsted–Lowry concept, a base is a species that:

(A) donates a proton (H^+)

(B) accepts a proton (H^+)

(C) donates an electron pair

(D) accepts an electron pair

Q15. Taking the oxidation number of oxygen as -2, the oxidation number of carbon in carbon dioxide (CO_2) is:

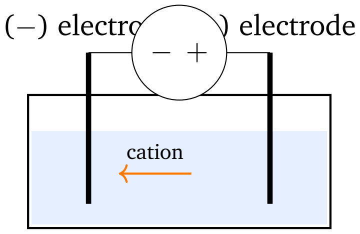
(A) $+2$

(B) -4

(C) $+4$

(D) 0

Q16. In the electrolysis cell shown, a direct current is passed through a molten or aqueous electrolyte. During electrolysis, the positively charged ions (cations) migrate towards the:



(A) anode (positive electrode)

(B) salt bridge

(C) electrolyte surface

(D) cathode (negative electrode)

Q17. The quantity of electric charge (Q) that flows through a conductor is related to the current (I) and the time of flow (t) by the expression:

(A) $Q = I\,t$

(B) $Q = \dfrac{I}{t}$

(C) $Q = \dfrac{t}{I}$

(D) $Q = I + t$

Q18. The concentration unit “parts per million” (ppm) of a solute in a solution is defined as:

(A) moles of solute per litre of solution

(B) parts (by mass) of solute present in one million parts of solution

(C) grams of solute per 100 g of solvent

(D) moles of solute per kilogram of solvent

Q19. The combined gas law, illustrated below as a single relation linking the three boxes, relates the pressure (P), volume (V) and absolute temperature (T) of a fixed mass of an ideal gas as:

$$\boxed{P} \times \boxed{V} \,/\, \boxed{T} \quad = \text{constant}$$

(A) $P\,T = \text{constant}/V$

(B) $\dfrac{P\,T}{V} = \text{constant}$

(C) $\dfrac{P\,V}{T} = \text{constant}$

(D) $P\,V\,T = \text{constant}$

Q20. In the complex ion $[\mathrm{Cr(H_2O)_6}]^{3+}$, the water molecules are neutral ligands. The oxidation state of chromium in this complex is:

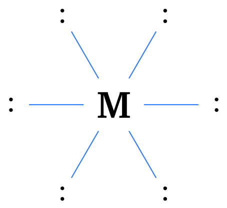
(A) $+6$

(B) 0

(C) $+2$

(D) $+3$

Q21. The ligand EDTA wraps around a central metal ion using several donor sites, as shown schematically below. EDTA acts as a ligand of denticity:



EDTA → 6 donor atoms

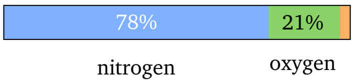
(A) hexadentate (six donor sites)

(B) monodentate (one donor site)

(C) bidentate (two donor sites)

(D) tetradentate (four donor sites)

Q22. The approximate composition (by volume) of dry air is shown below. The most abundant gas in the Earth's atmosphere is:



(A) Oxygen (O_2)

(B) Nitrogen (N_2)

(C) Carbon dioxide (CO_2)

(D) Argon (Ar)

Q23. Dichlorobenzene ($C_6H_4Cl_2$) is formed by replacing two hydrogen atoms of benzene with chlorine atoms. The number of possible positional isomers (ortho, meta, para) of dichlorobenzene is:

(A) 4

(B) 2

(C) 3

(D) 1

Q24. The IUPAC name of the saturated hydrocarbon $CH_3–CH_2–CH_3$ is:

(A) ethane

(B) butane

(C) methane

(D) propane

Q25. The defining feature of a homologous series of organic compounds is that successive members:

(A) differ by a $-CH_2-$ group and share the same general formula

(B) have identical molecular masses

(C) have completely different functional groups

(D) differ by a $-CHO$ group from one another

Q26. When a hydrocarbon undergoes *complete* combustion in an excess supply of oxygen, the products formed are:

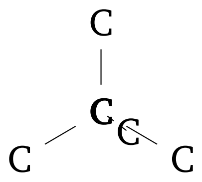
(A) carbon monoxide and water

(B) carbon dioxide and water

(C) carbon (soot) and hydrogen

(D) carbon dioxide and hydrogen gas

Q27. In diamond, each carbon atom is bonded to four other carbon atoms in a rigid three-dimensional tetrahedral network, as shown. The hybridization of each carbon atom in diamond is:



tetrahedral, $109.5°$

(A) sp

(B) sp^2

(C) sp^3

(D) sp^3d

Q28. The functional group shown below, an oxygen atom singly bonded to two carbon-containing groups (R–O–R′), is characteristic of which class of compounds?

$$R - O - R'$$

(–O– between two C groups)

(A) alcohols

(B) aldehydes

(C) ketones

(D) ethers

Q29. Enzymes are the biological catalysts that speed up the reactions of living cells. Chemically, almost all enzymes are:

(A) proteins

(B) carbohydrates

(C) lipids (fats)

(D) nucleic acids

Q30. When a carboxylic acid reacts with an alcohol in the presence of a little concentrated sulphuric acid, the main organic product belongs to which class of compounds?

(A) an aldehyde

(B) an ester

(C) a ketone

(D) an amine

Detailed Solutions

Q1.

Solution

Concept — Molar mass from atomic masses: The molar mass of a compound is the sum of the atomic masses of all the atoms in one formula unit, expressed in grams per mole. To find it, multiply each element's atomic mass by the number of its atoms in the formula and add the results. For calcium carbonate the formula $CaCO_3$ contains one calcium atom, one carbon atom and three oxygen atoms.

Given: atomic masses Ca $= 40$, C $= 12$, O $= 16$ g mol^{-1}; formula $CaCO_3$.

Step 1 — Count the atoms: 1 Ca, 1 C and 3 O atoms per formula unit.

Step 2 — Add the contributions: $M = 40 + 12 + (3 \times 16) = 40 + 12 + 48$.

Step 3 — Evaluate: $M = 100$ g mol^{-1}.

Why each other option is wrong:

- (B) 68 counts only two oxygens $(40 + 12 + 32)$, missing one O atom.
- (C) 84 comes from forgetting the carbonate fully, e.g. $40 + 44$ done wrongly.
- (D) 116 over-counts by adding a fourth oxygen $(40 + 12 + 64)$.

Key point: The carbonate ion CO_3^{2-} contributes $12+48 = 60$, so $CaCO_3 = 40+60 = 100$ g mol^{-1}. Always count the subscript on oxygen carefully.

Final Answer: 100 g mol^{-1} $\Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q1**

Q2.

Solution

Concept — Molar volume at STP: Avogadro's law states that equal volumes of all gases, at the same temperature and pressure, contain equal numbers of molecules. A direct consequence is that one mole of *any* ideal gas occupies the same volume at a given temperature and pressure. At standard temperature and pressure (STP: 273.15 K and 1 bar/1 atm), this molar volume is a fixed standard value.

Given: 1 mole of an ideal gas at STP.

Step 1 — Recall the molar volume: at STP, $V_m = 22.4$ L mol^{-1} (the classic value at 1 atm, 273 K).

Step 2 — Apply to one mole: for $n = 1$ mole, $V = n \times V_m = 1 \times 22.4 = 22.4$ L.

Step 3 — Note the independence of identity: this volume is the same whether the gas is H_2, O_2, CO_2 or any other ideal gas.

Why each other option is wrong:

- (A) 11.2 L is the volume of *half* a mole (0.5 mol) at STP.
- (C) 24.0 L is the molar volume at room temperature ($25°$C), not at STP.
- (D) 1.0 L has no physical basis for one mole of gas.

Key point: Remember 22.4 L per mole at STP. This lets you convert quickly between moles of a gas and its volume: $n = V/22.4$ at STP.

Final Answer: 22.4 L $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — Azimuthal (subsidiary) quantum number l: The azimuthal quantum number l defines the shape of a subshell and can take integer values from 0 up to $(n-1)$. Each value of l corresponds to a particular type of subshell: $l = 0$ is an s subshell, $l = 1$ is a p subshell, $l = 2$ is a d subshell, and $l = 3$ is an f subshell.

Step 1 — Match the subshell to l: the labels s, p, d, f correspond to $l = 0, 1, 2, 3$ respectively.

Step 2 — Read off the p subshell: a p subshell has $l = 1$.

Step 3 — Cross-check with orbitals: a subshell with quantum number l contains $(2l + 1)$ orbitals; for $l = 1$ this gives $2(1) + 1 = 3$ orbitals (p_x, p_y, p_z), exactly the three shown.

Why each other option is wrong:

- (A) $l = 0$ is the s subshell (one spherical orbital).
- (B) $l = 2$ is the d subshell (five orbitals).
- (D) $l = 3$ is the f subshell (seven orbitals).

Key point: $s\,p\,d\,f \leftrightarrow l = 0\,1\,2\,3$. The three dumbbell orbitals are the hallmark of p ($l = 1$), since the number of orbitals is $2l + 1 = 3$.

Final Answer: $l = 1 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Unpaired electrons (Hund's rule and Pauli): Electrons fill degenerate orbitals singly first, with parallel spins (Hund's rule of maximum multiplicity), and only pair up once each orbital has one electron. Pauli's exclusion principle limits each orbital to two electrons of opposite spin. Fluorine has $Z = 9$, so its ground-state configuration is $1s^2\,2s^2\,2p^5$.

Step 1 — Write the configuration: $1s^2\,2s^2\,2p^5$; the $1s$ and $2s$ subshells are completely paired, so the unpaired electron must be in the $2p^5$.

Step 2 — Distribute the five $2p$ electrons among the three $2p$ orbitals: first one each (↑↑↑), then pairing fills two orbitals, leaving the pattern ↑↓|↑↓|↑.

Step 3 — Count the unpaired electrons: two orbitals are full (paired) and one orbital holds a single electron, so there is exactly 1 unpaired electron.

Why each other option is wrong:

- (A) 5 would mean all five $2p$ electrons stay unpaired, impossible in only three orbitals.
- (B) 3 describes a half-filled $2p^3$ (as in nitrogen), not $2p^5$.
- (C) 0 would require a completely filled $2p^6$ (as in neon).

Key point: A p^5 configuration always has one unpaired electron (one short of the full p^6). This single unpaired electron is why fluorine is so reactive, readily gaining one electron to complete its octet.

Final Answer: 1 unpaired electron $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — VSEPR shape of PCl_5: VSEPR theory predicts molecular shape from the number of electron domains (bonding pairs plus lone pairs) around the central atom. Phosphorus in PCl_5 has five valence electrons, all used to form five P–Cl bonds, with no lone pair. Five bonding domains and zero lone pairs give a specific, well-defined geometry.

Step 1 — Count the electron domains on phosphorus: five P–Cl bond pairs and no lone pair $= 5$ domains.

Step 2 — Assign the geometry: five domains arrange themselves in a trigonal bipyramidal shape: three chlorines in an equatorial plane at 120° and two chlorines axial (above and below) at 90° to that plane.

Step 3 — Conclusion: since there is no lone pair to distort it, the molecular shape is exactly trigonal bipyramidal.

Why each other option is wrong:

- (B) Octahedral needs six bonding domains, as in SF_6.
- (C) Square planar arises from six domains with two lone pairs, as in XeF_4.
- (D) Tetrahedral is for four domains, as in CH_4.

Key point: Five bond pairs with no lone pair $\Rightarrow$ trigonal bipyramidal. The two axial bonds in PCl_5 are slightly longer than the three equatorial bonds.

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

Answer: (A) **Go Back to Q5**

Q6.

Solution

Concept — Hybridisation from electron domains: The hybridisation of a central atom equals its number of electron domains (sigma bonds plus lone pairs). The standard mapping is: two domains $\to sp$, three $\to sp^2$, four $\to sp^3$, five $\to sp^3d$, six $\to sp^3d^2$. Phosphorus in PCl_5 forms five σ bonds with no lone pair.

Step 1 — Count the domains: five P–Cl σ bonds $+0$ lone pairs $= 5$ electron domains.

Step 2 — Map domains to hybridisation: five domains correspond to sp^3d hybridisation (one s, three p and one d orbital mixing to give five equivalent hybrid orbitals).

Step 3 — Link to geometry: the five sp^3d hybrid orbitals point toward the corners of a trigonal bipyramid, matching the shape of PCl_5.

Why each other option is wrong:

- (A) sp^3 (four domains) suits a tetrahedral atom such as carbon in CH_4.
- (C) sp^2 (three domains) suits a trigonal planar atom such as boron in BF_3.
- (D) sp^3d^2 (six domains) suits an octahedral atom such as sulphur in SF_6.

Key point: Five σ bonds (no lone pair) $\Rightarrow sp^3d \Rightarrow$ trigonal bipyramidal. Phosphorus can do this because it has accessible $3d$ orbitals (an expanded octet).

Final Answer: $sp^3d \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Molecular polarity: A molecule is non-polar when its bond dipoles cancel out, leaving zero net dipole moment. This happens when the molecule is symmetric so that equal bond dipoles point in opposing directions. Both the bond polarity *and* the molecular shape decide the overall result.

Step 1 — Examine CO_2: it is linear, O=C=O. The two C=O bond dipoles are equal in size but point in exactly opposite directions, so they cancel, giving a net dipole moment of zero. CO_2 is non-polar.

Step 2 — Examine the other choices: H_2O is bent (two lone pairs), so its O–H dipoles add to a net dipole; NH_3 is trigonal pyramidal (one lone pair), so its N–H dipoles add up; HCl is a single polar bond with an obvious dipole. All three are polar.

Step 3 — Conclusion: only CO_2 has a zero net dipole, so it is the non-polar molecule.

Why each other option is wrong:

- (A) H_2O is bent, so its bond dipoles do not cancel; it is strongly polar.
- (B) NH_3 is pyramidal (lone pair), so it has a net dipole.
- (D) HCl is a single polar bond and is therefore polar.

Key point: Polar bonds do not always make a polar molecule. A symmetric linear shape (like CO_2) cancels the dipoles, so it is non-polar despite having two polar bonds.

Final Answer: $CO_2 \Rightarrow \boxed{\text{C}}$

$\boxed{\textbf{Answer: (C)}}$ **Go Back to Q7**

Q8.

Solution

Concept — Electron gain enthalpy of halogens: Electron gain enthalpy is the energy change when an atom gains an electron. A more negative value means more energy is released and the atom accepts an electron more readily. Halogens have the most negative electron gain enthalpies of any group because they are one electron short of a stable noble-gas configuration.

Step 1 — Note the expected trend: normally electron gain enthalpy becomes less negative down a group, which would make fluorine the most negative.

Step 2 — Apply the exception: fluorine is anomalous. Its very small size packs electrons tightly, so the incoming electron feels strong electron–electron repulsion. This makes chlorine, not fluorine, the halogen with the most negative electron gain enthalpy.

Step 3 — State the order: Cl $>$ F $>$ Br $>$ I in terms of how negative (exothermic) the electron gain enthalpy is.

Why each other option is wrong:

- (A) Fluorine's small size causes high repulsion in the compact $2p$ subshell, so it is slightly less negative than chlorine.
- (B) Iodine is largest, so the added electron is least tightly held; least negative.
- (C) Bromine lies between chlorine and iodine, less negative than chlorine.

Key point: Chlorine has the most negative (most exothermic) electron gain enthalpy among the halogens, an important exception caused by the unusually small size of fluorine.

Final Answer: Chlorine $\Rightarrow \boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q8**

Q9.

Solution

Concept — Position of the halogens: The modern periodic table is divided into 18 groups. Elements in the same group share the same number of valence electrons and similar chemistry. The halogens all have seven electrons in their outermost shell ($ns^2\,np^5$), one short of a complete octet, which places them together in a single group.

Step 1 — Identify the valence configuration: F, Cl, Br, I and At all end in $ns^2\,np^5$ (seven valence electrons).

Step 2 — Locate the group: elements with seven valence electrons occupy the second-from-last column, which is group 17.

Step 3 — Conclusion: the halogens belong to group 17 of the periodic table.

Why each other option is wrong:

- (B) Group 1 holds the alkali metals (one valence electron), not the halogens.
- (C) Group 18 holds the noble gases (eight valence electrons, full octet).
- (D) Group 16 holds the chalcogens such as oxygen and sulphur (six valence electrons).

Key point: Halogens = group 17, with the general valence shell $ns^2\,np^5$. They are highly reactive non-metals because they need only one electron to reach a stable octet.

Final Answer: Group 17 $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — State functions versus path functions: A state function depends only on the initial and final states of a system, not on the route taken between them. Examples are internal energy (U), enthalpy (H), entropy (S), pressure, volume and temperature. In contrast, heat (q) and work (w) are path functions: their values depend on *how* the change is carried out.

Step 1 — Classify each option: enthalpy H is defined as $H = U + PV$, built entirely from state functions, so H is itself a state function.

Step 2 — Classify the rest: heat q and work w both depend on the path (for example, reversible versus irreversible), so they are path functions, not state functions.

Step 3 — Conclusion: of the choices given, only enthalpy (H) is a state function.

Why each other option is wrong:

- (A) Work (w) is a path function; it depends on how the process is performed.
- (C) Heat (q) is a path function for the same reason.
- (D) Since both w and q are path functions, this choice is incorrect.

Key point: State functions (U, H, S, P, V, T) depend only on the current state; path functions (q, w) depend on the route. A handy memory aid: "state" functions describe where you *are*, path functions describe how you *got there*.

Final Answer: Enthalpy (H) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Gibbs free energy: The Gibbs free energy change tells us 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 process is spontaneous; a positive ΔG means it is non-spontaneous. Here the combined term $T\Delta S$ is supplied directly.

Given: $\Delta H = +50$ kJ; $T\Delta S = +30$ kJ.

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

Step 2 — Substitute the values: $\Delta G = (+50) - (+30)$.

Step 3 — Evaluate: $\Delta G = 50 - 30 = +20$ kJ.

Why each other option is wrong:

- (A) $+80$ kJ comes from *adding* the two terms instead of subtracting.
- (B) -20 kJ reverses the order of subtraction ($T\Delta S - \Delta H$).
- (D) -80 kJ both adds and flips the sign incorrectly.

Key point: $\Delta G = +20$ kJ is positive, so this reaction is non-spontaneous at this temperature. Raising T (and hence $T\Delta S$) above 50 kJ would eventually make ΔG negative and the reaction spontaneous.

Final Answer: $\Delta G = +20 \text{ kJ} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — The equilibrium constant K_c: For a reversible reaction at equilibrium, the law of mass action gives the equilibrium constant as the ratio of the product of the molar concentrations of the *products* to that of the *reactants*, each raised to the power of its stoichiometric coefficient. For $a\text{A} + b\text{B} \rightleftharpoons c\text{C} + d\text{D}$, the products go on top and reactants on the bottom.

Step 1 — Place the products in the numerator: $[\text{C}]^c[\text{D}]^d$, with each concentration raised to its coefficient.

Step 2 — Place the reactants in the denominator: $[\text{A}]^a[\text{B}]^b$, again raised to their coefficients.

Step 3 — Write the full expression: $K_c = \dfrac{[\text{C}]^c[\text{D}]^d}{[\text{A}]^a[\text{B}]^b}$.

Why each other option is wrong:

- (A) This inverts the ratio, putting reactants on top; it is actually $1/K_c$.
- (B) This drops the stoichiometric powers, which must equal the coefficients.
- (C) K_c is defined as a *ratio*, not a difference of concentration terms.

Key point: "Products over reactants, each raised to its coefficient." A large K_c means the equilibrium lies toward the products; a small K_c means it lies toward the reactants.

Final Answer: $K_c = \dfrac{[\text{C}]^c[\text{D}]^d}{[\text{A}]^a[\text{B}]^b} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — pH of a strong base: For a strong base such as NaOH, ionisation is complete: $NaOH \rightarrow Na^+ + OH^-$. The hydroxide concentration equals the base concentration. We first find $pOH = -\log_{10}[OH^-]$, then use the relation $pH+pOH = 14$ (at 25°C) to obtain the pH.

Given: $[NaOH] = 0.1$ M $= 10^{-1}$ M.

Step 1 — Find $[OH^-]$: since NaOH gives one OH^- per formula unit, $[OH^-] = 10^{-1}$ M.

Step 2 — Compute pOH: $pOH = -\log_{10}(10^{-1}) = 1$.

Step 3 — Convert to pH: $pH = 14 - pOH = 14 - 1 = 13$.

Why each other option is wrong:

- (B) 1 is the pOH of the solution, not the pH.
- (C) 7 is the pH of pure neutral water, not of a 0.1 M base.
- (D) 11 would correspond to $[OH^-] = 10^{-3}$ M, a far more dilute base.

Key point: For a strong base, find pOH first from $[OH^-]$, then use $pH = 14 - pOH$. A pH of 13 is strongly basic (well above 7), exactly as expected.

Final Answer: $pH = 13 \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Bronsted–Lowry acids and bases: In the Bronsted–Lowry theory, an acid is a proton (H^+) *donor* and a base is a proton *acceptor*. This focuses on the transfer of a single hydrogen ion between species. It is a broader idea than the Arrhenius definition because it applies to reactions even without water.

Step 1 — State the definition of a base: a Bronsted–Lowry base is any species that accepts a proton.

Step 2 — Illustrate: ammonia acts as a base, $NH_3 + H^+ \rightarrow NH_4^+$, by accepting a proton; hydroxide does the same, $OH^- + H^+ \rightarrow H_2O$.

Step 3 — Conclusion: the correct description of a Bronsted base is “a species that accepts a proton.”

Why each other option is wrong:

- (A) Donating a proton is the definition of a Bronsted *acid*, not a base.
- (C) Donating an electron pair defines a *Lewis* base, a different (broader) theory.
- (D) Accepting an electron pair defines a *Lewis* acid, not a Bronsted base.

Key point: Bronsted base = proton acceptor; Bronsted acid = proton donor. Do not confuse this with the Lewis picture, which is built around electron-pair donation and acceptance.

Final Answer: Accepts a proton $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Oxidation number rules: In a neutral molecule, the oxidation numbers of all atoms add up to zero. Oxygen is normally assigned -2 (except in peroxides and with fluorine). The oxidation number of the remaining element is then found algebraically by setting the total to zero.

Given: the molecule CO_2 is neutral; each O is -2.

Step 1 — Assign the known values: two oxygen atoms contribute $2 \times (-2) = -4$. Let the oxidation number of carbon be x.

Step 2 — Set the sum to zero: $x + (-4) = 0$.

Step 3 — Solve: $x = +4$, so carbon is in the $+4$ oxidation state.

Why each other option is wrong:

- (A) $+2$ is carbon in carbon monoxide (CO), not in CO_2.
- (B) -4 is carbon in methane (CH_4), where hydrogen is $+1$.
- (D) 0 is the oxidation number of carbon in its free elemental form, such as graphite.

Key point: For a neutral compound, set the oxidation numbers to sum to zero. In CO_2 carbon is at its highest common state, $+4$, which is why CO_2 is a fully oxidised product of combustion.

Final Answer: Oxidation number of C $= +4 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Ion movement during electrolysis: In an electrolytic cell, an external supply drives a current through the electrolyte. The cathode is the negative electrode and the anode is the positive electrode. Oppositely charged species are attracted to each electrode: positive ions (cations) move toward the negative cathode, while negative ions (anions) move toward the positive anode.

Step 1 — Identify the charge on the electrodes: in electrolysis the cathode is negative and the anode is positive.

Step 2 — Apply electrostatic attraction: a cation carries a positive charge, so it is attracted to the oppositely charged (negative) electrode.

Step 3 — Conclusion: cations migrate toward the cathode (the negative electrode), where they are reduced by gaining electrons.

Why each other option is wrong:

- (A) The anode is positive, so it attracts the negative anions, not the positive cations.
- (B) A salt bridge belongs to a galvanic cell and does not feature here.
- (C) The electrolyte surface is not an electrode and does not attract ions by charge.

Key point: “Cations to the cathode, anions to the anode.” The names even help: *cat*ions go to the *cat*hode. At the cathode cations gain electrons (reduction).

Final Answer: Cathode (negative electrode) $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Charge, current and time: Electric current is the rate of flow of charge. If a steady current I (in amperes) flows for a time t (in seconds), the total charge Q (in coulombs) that passes is the product of the two. This relation, $Q = I\,t$, is the basis of Faraday’s quantitative laws of electrolysis.

Step 1 — Recall the definition of current: $I = \dfrac{Q}{t}$ (charge per unit time).

Step 2 — Rearrange for charge: multiplying both sides by t gives $Q = I\,t$.

Step 3 — Check the units: amperes $\times$ seconds $=$ coulombs ($1\ \text{A} \cdot 1\ \text{s} = 1\ \text{C}$), which is consistent.

Why each other option is wrong:

- (B) $Q = I/t$ has the wrong units (ampere per second) and is not charge.
- (C) $Q = t/I$ is also dimensionally incorrect.
- (D) $Q = I + t$ adds quantities with different units, which is meaningless.

Key point: $Q = I\,t$ links charge, current and time. Combined with the Faraday constant ($F = 96500$ C mol^{-1}), it lets you calculate how much substance is deposited in electrolysis.

Final Answer: $Q = I\,t \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q17**

Q18.

Solution

Concept — Parts per million (ppm): Parts per million is a concentration unit used for very dilute solutions, such as trace impurities in water or air. It expresses the amount of solute present in one million equal parts of the solution. By mass, 1 ppm means 1 part of solute (e.g. 1 g) in 10^6 parts of solution (e.g. 10^6 g, that is one tonne).

Step 1 — State the definition: $\text{ppm} = \dfrac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$.

Step 2 — Interpret in words: this is the number of parts (by mass) of solute present in one million parts of the solution.

Step 3 — Conclusion: the matching description is “parts of solute in one million parts of solution.”

Why each other option is wrong:

- (A) Moles of solute per litre of solution defines *molarity*, not ppm.
- (C) Grams of solute per 100 g of solvent is *mass percentage* (multiplied to per 100, not per million).
- (D) Moles of solute per kilogram of solvent defines *molality*, not ppm.

Key point: ppm is for extremely dilute solutions and is based on a ratio per million. It is independent of temperature (unlike molarity) because it is a mass-based ratio.

Final Answer: Parts of solute in one million parts of solution $\Rightarrow \boxed{\text{B}}$

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q18**

Q19.

Solution

Concept — The combined gas law: The combined gas law brings together Boyle's law ($P \propto 1/V$ at constant T), Charles's law ($V \propto T$ at constant P) and Gay-Lussac's law ($P \propto T$ at constant V). For a fixed mass of an ideal gas, the product of pressure and volume divided by the absolute temperature stays constant.

Step 1 — Combine the individual laws: merging the three proportionalities gives $\frac{PV}{T}$ = constant for a fixed amount of gas.

Step 2 — Read the figure: the diagram shows P multiplied by V, then divided by T, equalling a constant, exactly $\frac{PV}{T}$.

Step 3 — Conclusion: the correct combined gas law is $\frac{PV}{T}$ = constant, equivalently $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$.

Why each other option is wrong:

- (A) Rearranges the terms wrongly and breaks the V in the denominator relationship.
- (B) Puts T in the numerator with P, which inverts the temperature dependence.
- (D) The product PVT is not constant; only PV/T is.

Key point: $\frac{PV}{T}$ = constant for a fixed mass of gas. Including the number of moles n turns it into the ideal gas equation $PV = nRT$.

Final Answer: $\frac{PV}{T} = \text{constant} \Rightarrow \boxed{\text{C}}$

$\boxed{\textbf{Answer: (C)}}$ **Go Back to Q19**

Q20.

Solution

Concept — Oxidation state in a complex ion: In a coordination complex, the sum of the oxidation state of the central metal and the charges of all the ligands equals the overall charge of the complex ion. Neutral ligands (such as H_2O and NH_3) contribute zero charge, so only charged ligands change the balance.

Given: the complex ion $[\mathrm{Cr(H_2O)_6}]^{3+}$; water is a neutral ligand.

Step 1 — Sum the ligand charges: six neutral H_2O ligands contribute $6 \times 0 = 0$.

Step 2 — Apply the charge balance: let chromium's oxidation state be x. Then $x + 0 = +3$ (the overall charge of the complex).

Step 3 — Solve: $x = +3$, so chromium is in the $+3$ oxidation state.

Why each other option is wrong:

- (A) $+6$ would require the ligands to carry an extra -3 in total, but water is neutral.
- (B) 0 ignores the overall $+3$ charge of the complex ion.
- (C) $+2$ would give an overall charge of only $+2$, not the stated $+3$.

Key point: Neutral ligands do not affect the metal's oxidation state, so for $[\mathrm{Cr(H_2O)_6}]^{3+}$ the chromium charge simply equals the ion charge, $+3$.

Final Answer: Oxidation state of Cr $= +3 \Rightarrow \boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q20**

Q21.

Solution

Concept — Denticity of a ligand: Denticity is the number of donor atoms through which a single ligand attaches to a central metal ion. A monodentate ligand binds through one atom, a bidentate through two, and so on. EDTA (ethylenediaminetetraacetate) is a famous chelating ligand that can grip a metal ion through six donor atoms.

Step 1 — Identify EDTA's donor atoms: EDTA has two nitrogen atoms (from the amine groups) and four oxygen atoms (from the four carboxylate groups), giving six donor sites in all.

Step 2 — Count the points of attachment: all six of these atoms can simultaneously coordinate to a single metal ion, wrapping around it (chelation), as the figure shows.

Step 3 — Conclusion: EDTA is a hexadentate ligand (six donor sites).

Why each other option is wrong:

- (B) Monodentate (one site) describes ligands such as Cl^- or NH_3.
- (C) Bidentate (two sites) describes ligands such as ethylenediamine (en) or the oxalate ion.
- (D) Tetradentate (four sites) is fewer than EDTA's six donor atoms.

Key point: EDTA is hexadentate (2 N + 4 O donors). Because it forms very stable chelate complexes, EDTA is widely used in titrations and to soften hard water by trapping Ca^{2+} and Mg^{2+}.

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

$\boxed{\textbf{Answer: (A)}}$ **Go Back to Q21**

Q22.

Solution

Concept — Composition of the atmosphere: Dry air is a mixture of gases in fairly fixed proportions. By volume, nitrogen makes up about 78%, oxygen about 21%, argon about 0.9%, and carbon dioxide only about 0.04%. The single largest component is therefore nitrogen.

Step 1 — List the major fractions: $N_2 \approx 78\%$, $O_2 \approx 21\%$, $Ar \approx 0.9\%$, $CO_2 \approx 0.04\%$ by volume.

Step 2 — Compare: nitrogen at 78% is clearly the largest fraction, far ahead of oxygen at 21%.

Step 3 — Conclusion: the most abundant gas in the Earth's atmosphere is nitrogen (N_2).

Why each other option is wrong:

- (A) Oxygen, at about 21%, is the second most abundant, not the first.
- (C) Carbon dioxide is a trace gas (about 0.04%).
- (D) Argon is only about 0.9%, the most abundant of the noble gases but still minor.

Key point: Nitrogen ($\approx 78\%$) is the most abundant atmospheric gas; oxygen

($\approx 21\%$) is second. The relatively inert nitrogen dilutes the reactive oxygen, which is important for life.

Final Answer: Nitrogen (N_2) $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Positional isomerism in disubstituted benzene: When two identical substituents are placed on a benzene ring, the number of distinct positional isomers depends on the relative positions of the two groups. The three possible arrangements are ortho (1,2 – adjacent), meta (1,3 – one carbon apart) and para (1,4 – directly opposite).

Step 1 — Fix the first chlorine: place one Cl at position 1 of the ring.

Step 2 — Place the second chlorine: the second Cl can go to position 2 (ortho), position 3 (meta) or position 4 (para). Positions 5 and 6 are equivalent to 3 and 2 by symmetry, so they give no new isomers.

Step 3 — Count: three distinct isomers result, namely ortho-, meta- and para-dichlorobenzene.

Why each other option is wrong:

- (A) 4 over-counts; positions 5 and 6 duplicate ortho and meta by the ring's symmetry.
- (B) 2 omits one of the three valid arrangements.
- (D) 1 ignores positional isomerism altogether.

Key point: A benzene ring with two identical substituents always gives exactly three positional isomers: ortho (1,2), meta (1,3) and para (1,4).

Final Answer: 3 isomers $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — IUPAC naming of alkanes: Straight-chain saturated hydrocarbons (alkanes) are named by a root that indicates the number of carbon atoms, followed by the suffix "-ane." The roots are meth- (1 C), eth- (2 C), prop- (3 C), but- (4 C), and so on. Counting the carbon atoms in the chain gives the name directly.

Step 1 — Count the carbon atoms: CH_3–CH_2–CH_3 has three carbon atoms in an unbranched chain.

Step 2 — Choose the root and suffix: three carbons gives the root "prop-"; since it is a saturated alkane, the suffix is "-ane."

Step 3 — Combine: prop- $+$ -ane $=$ propane.

Why each other option is wrong:

- (A) Ethane has two carbons (CH_3–CH_3), one fewer than the molecule shown.
- (B) Butane has four carbons, one more than shown.
- (C) Methane has just one carbon (CH_4).

Key point: Count the carbons, pick the matching root (meth/eth/prop/but...), and add "-ane" for a saturated chain. Three carbons $\Rightarrow$ propane.

Final Answer: Propane $\Rightarrow \boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q24**

Q25.

Solution

Concept — Homologous series: A homologous series is a family of organic compounds with the same functional group and the same general molecular formula, in which each successive member differs from the previous one by a constant unit of $-CH_2-$ (a methylene group, mass 14). Members of a series show a gradual, predictable change in physical properties and very similar chemical behaviour.

Step 1 — State the defining feature: consecutive members differ by a $-CH_2-$ group and obey one common general formula (for example, C_nH_{2n+2} for alkanes).

Step 2 — Note the consequences: because the functional group is the same throughout, all members undergo similar reactions; only the chain length, and hence properties such as boiling point, change steadily.

Step 3 — Conclusion: the correct defining feature is "differ by a $-CH_2-$ group and share the same general formula."

Why each other option is wrong:

- (B) Members have *different* molecular masses, increasing by 14 each step, not identical ones.
- (C) Members share the *same* functional group; they do not have completely different ones.
- (D) The difference between members is a $-CH_2-$ unit, not a $-CHO$ group.

Key point: A homologous series = same general formula + same functional group + successive members differing by CH_2. This is why properties grade smoothly down a series.

Final Answer: Differ by $-CH_2-$, same general formula $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Complete combustion of a hydrocarbon: A hydrocarbon contains only carbon and hydrogen. When it burns in a plentiful (excess) supply of oxygen, every carbon atom is fully oxidised to carbon dioxide and every hydrogen atom to water. This is complete combustion, and it releases the maximum energy. A general example is $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$.

Step 1 — Track the carbon: with enough oxygen, carbon is oxidised all the way to CO_2 (not the partially oxidised CO).

Step 2 — Track the hydrogen: hydrogen combines with oxygen to form water, H_2O.

Step 3 — Conclusion: the products of complete combustion are carbon dioxide and water.

Why each other option is wrong:

- (A) Carbon monoxide and water are products of *incomplete* combustion (limited oxygen), not complete combustion.
- (C) Carbon (soot) and hydrogen appear only with a severe shortage of oxygen, again incomplete.
- (D) Hydrogen gas is not a product; hydrogen ends up as water, not as H_2.

Key point: Complete combustion (excess O_2) $\rightarrow CO_2 + H_2O$. A shortage of oxygen gives the toxic CO or sooty carbon instead, which is incomplete combustion.

Final Answer: Carbon dioxide and water $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Hybridisation of carbon in diamond: The hybridisation of a carbon atom equals its number of σ bonds plus lone pairs. In diamond, every carbon atom is covalently bonded to four other carbon atoms by single (σ) bonds, with no lone pairs, forming a giant tetrahedral covalent network.

Step 1 — Count the σ bonds: each carbon forms four single C–C bonds, giving four σ bonds and no lone pairs, i.e. four electron domains.

Step 2 — Assign the hybridisation: four electron domains correspond to sp^3 hybridisation, with the four hybrid orbitals pointing to the corners of a tetrahedron at $109.5°$.

Step 3 — Link to structure: this sp^3 tetrahedral bonding, repeated throughout the crystal, makes diamond extremely hard and gives it a very high melting point.

Why each other option is wrong:

- (A) sp (two domains, linear) describes carbon in a triple bond, as in ethyne.
- (B) sp^2 (three domains, planar) describes carbon in graphite or a double bond.
- (D) sp^3d would require five domains, impossible for carbon (no available d orbitals).

Key point: Diamond carbon is sp^3 (four single bonds, tetrahedral). Contrast this with graphite, where each carbon is sp^2 and forms flat sheets, explaining their very different properties.

Final Answer: $sp^3 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept — The ether functional group: A functional group is the part of a molecule that determines its chemical class. An ether contains an oxygen atom singly bonded between two carbon-containing groups, written R–O–R′. The two groups may be alkyl or aryl, for example dimethyl ether (CH_3–O–CH_3) or diethyl ether (C_2H_5–O–C_2H_5).

Step 1 — Read the structure: the figure shows an oxygen bonded by single bonds to two carbon groups, R–O–R′, with no hydrogen on the oxygen.

Step 2 — Match the group to its class: an oxygen bridging two carbon groups is the characteristic linkage of an ether.

Step 3 — Conclusion: the R–O–R′ arrangement is the functional group of ethers.

Why each other option is wrong:

- (A) Alcohols have an $-$OH group (oxygen bonded to one carbon *and* one hydrogen), not two carbons.
- (B) Aldehydes have a $-$CHO group (a carbonyl with a terminal H), which is a C=O, not a single-bonded bridging O.
- (C) Ketones have a carbonyl (>C=O) between two carbons, a double bond to oxygen rather than the single bonds of an ether.

Key point: Ether = R–O–R′ (oxygen singly bonded to two carbon groups). The absence of an O–H bond is why ethers are relatively unreactive and make good solvents.

Final Answer: Ethers $\Rightarrow \boxed{\text{D}}$

$\boxed{\textbf{Answer: (D)}}$ **Go Back to Q28**

Q29.

Solution

Concept — Chemical nature of enzymes: Enzymes are biological catalysts that greatly speed up the chemical reactions occurring in living organisms, while themselves remaining unchanged. Chemically, almost all enzymes are globular proteins, that is, large molecules built from chains of amino acids folded into precise three-dimensional shapes.

Step 1 — Identify the chemical class: enzymes are made of one or more polypeptide chains, so they are proteins.

Step 2 — Connect structure to function: the folded protein creates an active site whose specific shape binds the substrate, which is why each enzyme is highly selective for its reaction.

Step 3 — Conclusion: enzymes are chemically proteins.

Why each other option is wrong:

- (B) Carbohydrates are energy-storage and structural molecules (sugars, starch, cellulose), not catalysts.
- (C) Lipids (fats) form membranes and store energy; they are not enzymes.
- (D) Nucleic acids (DNA, RNA) store and transmit genetic information; ordinary metabolic enzymes are proteins.

Key point: Enzymes are proteins (built from amino acids) and act as highly specific biological catalysts. Their precise folded shape, and hence their active site, is what gives them their catalytic power.

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

Answer: (A)

Go Back to Q29

Q30.

Solution

Concept — Esterification: When a carboxylic acid reacts with an alcohol in the presence of a small amount of concentrated sulphuric acid (which acts as a catalyst and dehydrating agent), the product is an ester and a molecule of water. This reaction is called esterification: $RCOOH + R'OH \xrightarrow{H_2SO_4} RCOOR' + H_2O$.

Step 1 — Identify the reactants: a carboxylic acid ($-COOH$) and an alcohol ($-OH$).

Step 2 — Form the product: the $-OH$ of the acid and the H of the alcohol leave together as water, joining the two parts through an ester linkage ($-COO-$).

Step 3 — Conclusion: the main organic product is an ester. For example, acetic acid + ethanol gives ethyl acetate (an ester), which has a pleasant fruity smell.

Why each other option is wrong:

- (A) An aldehyde would form from controlled oxidation of a primary alcohol, not from this acid–alcohol reaction.

- (C) A ketone forms from oxidation of a secondary alcohol, not by esterification.
- (D) An amine forms from reactions involving nitrogen, not from an acid plus an alcohol.

Key point: Carboxylic acid $+$ alcohol $\xrightarrow{\text{conc. } H_2SO_4}$ ester $+$ water. This is esterification, and the fruity-smelling esters it produces are widely used as flavourings and fragrances.

Final Answer: An ester $\Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q30**

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	B	27	C	28	D	29	A	30	B