AIIMS B.Sc Nursing Chemistry

Sample Paper – 8

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. An empirical formula of a compound represents:

(A) the simplest whole-number ratio of the atoms present

(B) the actual number of atoms in one molecule

(C) the total mass of one mole of the compound

(D) the arrangement of atoms in space

Q2. When 1 mole of sodium chloride (NaCl) dissolves completely in water, it dissociates as $\mathrm{NaCl} \rightarrow \mathrm{Na}^+ + \mathrm{Cl}^-$. The total number of moles of ions produced is:

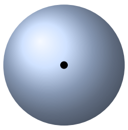
(A) 1

(B) 2

(C) 3

(D) 4

Q3. The boundary surface of an s orbital is drawn below. The shape of an s orbital is:



nucleus at centre

(A) dumb-bell shaped

(B) double dumb-bell shaped

(C) spherical

(D) planar

Q4. According to the aufbau principle, electrons fill orbitals in order of increasing energy. Between the $4s$ and $3d$ orbitals, the one that is filled first is:

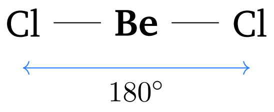
(A) $3d$, because $n = 3$ is lower

(B) both fill at the same time

(C) neither, they remain empty

(D) $4s$, because it has lower energy

Q5. The bonding in beryllium chloride ($BeCl_2$) is shown below, with beryllium having no lone pairs. The shape of the $BeCl_2$ molecule is:



(A) linear

(B) bent

(C) trigonal planar

(D) tetrahedral

Q6. The hybridization of the beryllium atom in beryllium chloride ($BeCl_2$), in which Be forms two σ bonds and has no lone pairs, is:

(A) sp^2

(B) sp

(C) sp^3

(D) sp^3d

Q7. Among the following, hydrogen bonding is strongest in:

(A) HCl

(B) H_2S

(C) HF

(D) PH_3

Q8. The change in the nature of the oxides of the elements of period 3, on moving from sodium to chlorine, is shown below. Across a period, the character of the oxides changes from:

$$\begin{array}{ccc} \text{basic} & \text{amphoteric} & \text{acidic} \\ \multicolumn{3}{c}{\xrightarrow{\hspace{6cm}}} \\ Na_2O & Al_2O_3 & Cl_2O_7 \end{array}$$

(A) acidic to basic

(B) acidic to neutral

(C) neutral to basic

(D) basic to acidic

Q9. Which one of the following elements has the highest first ionization energy?

(A) Helium

(B) Lithium

(C) Oxygen

(D) Fluorine

Q10. According to Hess's law of constant heat summation, the total enthalpy change of a reaction is independent of the:

(A) nature of the reactants
(B) path (number of steps) by which it occurs
(C) temperature at which it is measured
(D) physical states of the substances

Q11. The second law of thermodynamics states that, for any spontaneous (natural) process, the quantity that always increases is the:

(A) enthalpy of the system
(B) internal energy of the system
(C) entropy of the universe
(D) Gibbs free energy of the system

Q12. For a gaseous equilibrium at a fixed temperature, an inert (non-reacting) gas is added while the volume is kept constant. The effect on the position of the equilibrium is:

(A) it shifts towards the products
(B) it shifts towards the reactants
(C) the equilibrium constant changes
(D) there is no shift in the equilibrium

Q13. An aqueous solution of sodium chloride (NaCl), the salt of a strong acid and a strong base, is:

(A) neutral ($\text{pH} = 7$)
(B) acidic ($\text{pH} < 7$)
(C) basic ($\text{pH} > 7$)
(D) strongly acidic ($\text{pH} < 2$)

Q14. According to Lewis theory, a base is a species that:

(A) donates a proton (H^+)

(B) donates a pair of electrons

(C) accepts a pair of electrons

(D) accepts a hydroxide ion

Q15. The oxidation number of phosphorus in phosphoric acid (H_3PO_4), taking H as $+1$ and O as -2, is:

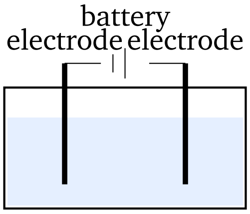
(A) $+3$

(B) $+4$

(C) $+5$

(D) $+6$

Q16. An electrolytic cell connected to an external battery is shown below. Such a cell uses electrical energy to bring about a:



(A) spontaneous reaction

(B) reaction that produces electricity

(C) reaction at equilibrium

(D) non-spontaneous reaction

Q17. In the electrolysis of water, hydrogen is liberated at the cathode by $2H^+ + 2e^- \rightarrow H_2$. The number of faradays of charge required to liberate 1 mole of H_2 gas is:

(A) 2

(B) 1

(C) 3

(D) 4

Q18. A buffer solution is one that:

(A) always has a pH of exactly 7

(B) resists a change in pH on adding small amounts of acid or base

(C) conducts no electric current

(D) contains only a strong acid

Q19. The volume occupied by 1 mole of an ideal gas at standard temperature and pressure (STP) is:

(A) 11.2 L

(B) 44.8 L

(C) 22.4 L

(D) 2.24 L

Q20. The oxidation state of iron in the complex ion $[\text{Fe(CN)}_6]^{4-}$, where each CN ligand carries a charge of -1, is:

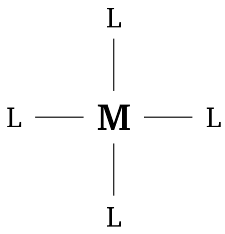
(A) 0

(B) $+3$

(C) $+6$

(D) $+2$

Q21. In the coordination compound shown below, ligands (L) surround a central atom (M) as described by Werner's theory. The central atom of a coordination compound is always a:



(A) metal atom or ion

(B) non-metal atom

(C) noble gas atom

(D) halogen atom

Q22. Which one of the following elements is an inner-transition (lanthanide) element?

(A) Iron (Fe)

(B) Cerium (Ce)

(C) Calcium (Ca)

(D) Copper (Cu)

Q23. Two compounds are said to be isomers of each other if they have:

(A) the same molecular mass but different molecular formulae

(B) the same physical and chemical properties

(C) the same molecular formula but different structural arrangements

(D) different molecular formulae and different structures

Q24. The IUPAC name of the hydrocarbon shown below, which contains a carbon–carbon triple bond, is:

$$\mathrm{H-C\equiv C-H}$$

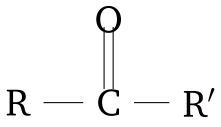
(A) ethane

(B) ethanol

(C) ethene

(D) ethyne

Q25. The functional group shown below, a carbon double-bonded to oxygen and bonded to two carbon atoms, is characteristic of the class of compounds called:



$R-\overset{\overset{\Large O}{\|}}{C}-R'$

(>C=O group)

(A) ketones

(B) alcohols

(C) carboxylic acids

(D) amines

Q26. Which one of the following is an aromatic hydrocarbon?

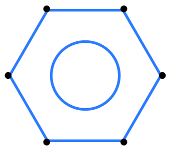
(A) methane (CH_4)

(B) benzene (C_6H_6)

(C) ethene (C_2H_4)

(D) ethyne (C_2H_2)

Q27. The ring skeleton of a benzene molecule is drawn below. The number of carbon atoms forming the benzene ring is:



(A) 4

(B) 5

(C) 6

(D) 7

Q28. The functional group present in a haloalkane (alkyl halide) such as chloromethane (CH_3Cl) is:

(A) –OH (hydroxyl)

(B) $-$CHO (aldehyde)

(C) $-$COOH (carboxyl)

(D) $-$X (halogen, e.g. $-$Cl)

Q29. The biomolecule DNA (deoxyribonucleic acid) is responsible for:

(A) carrying and transmitting the hereditary (genetic) information

(B) providing immediate energy to cells

(C) catalysing all metabolic reactions

(D) forming the structural fat of cell membranes

Q30. When acetic acid (CH_3COOH) reacts with ethanol (C_2H_5OH) in the presence of an acid catalyst, the organic product formed (an ester) is:

(A) ethanal

(B) acetone

(C) ethyl acetate ($CH_3COOC_2H_5$)

(D) sodium acetate

Detailed Solutions

Q1.

Solution

Concept — Empirical formula: The empirical formula of a compound gives the *simplest whole-number ratio* of the atoms of each element present in it. It is found from percentage composition by converting masses to moles and dividing by the smallest number of moles. The molecular formula is a whole-number multiple of the empirical formula: molecular formula $= n\times$ (empirical formula), where $n = \dfrac{\text{molar mass}}{\text{empirical formula mass}}$.

Given: a definition is required, not a calculation; the question asks what an empirical formula represents.

Step 1 — Recall the definition: the empirical formula expresses the relative number of atoms as the smallest set of whole numbers, e.g. the empirical formula of glucose ($C_6H_{12}O_6$) is CH_2O.

Step 2 — Match to the options: only option (A) describes the simplest whole-number ratio of atoms.

Why each other option is wrong:

- (B) The actual number of atoms in one molecule is the *molecular* formula, not the empirical formula.
- (C) The mass of one mole is the molar mass, a different quantity.
- (D) The arrangement of atoms in space is the structural (or stereochemical) formula.

Key point: Empirical = simplest ratio; molecular = actual count; both can be the same (as in H_2O or CO_2) when $n = 1$.

Final Answer: Simplest whole-number ratio of atoms $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Dissociation of an ionic salt: An ionic solid such as NaCl separates into its constituent ions when dissolved in water. The number of moles of ions formed equals the moles of salt multiplied by the number of ions per formula unit. For NaCl $\rightarrow$ Na$^+$ + Cl$^-$, each formula unit gives two ions (one cation and one anion).

Given: 1 mole of NaCl; one Na$^+$ and one Cl$^-$ per formula unit.

Step 1 — Write the dissociation: $\mathrm{NaCl}(s) \xrightarrow{\text{water}} \mathrm{Na}^+(aq) + \mathrm{Cl}^-(aq)$.

Step 2 — Count the ions per mole: 1 mole Na$^+$ $+ 1$ mole Cl$^-$ $= 2$ moles of ions.

Step 3 — Conclusion: 1 mole of NaCl gives 2 moles of ions in total.

Why each other option is wrong:

- (A) 1 counts only one of the two ions.
- (C) 3 would suit a salt giving three ions, e.g. $\mathrm{CaCl_2} \rightarrow \mathrm{Ca^{2+}} + 2\mathrm{Cl^-}$.
- (D) 4 would suit a salt giving four ions, e.g. AlCl$_3$ is four; NaCl gives only two.

Key point: The number of ions depends on the formula. NaCl is a $1:1$ salt, so 1 mole gives exactly 2 moles of ions; this is why its van't Hoff factor is 2.

Final Answer: 2 moles of ions $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — Shape of an s orbital: An orbital is the region around the nucleus where the probability of finding an electron is high. The shape of the boundary surface depends on the azimuthal quantum number l. For an s orbital, $l = 0$, which makes the orbital *spherically symmetric*: the electron-density is the same in all directions at a given distance from the nucleus.

Step 1 — Identify the orbital type: the s orbital corresponds to $l = 0$.

Step 2 — Relate l to shape: $l = 0 \Rightarrow$ spherical; $l = 1$ $(p) \Rightarrow$ dumb-bell; $l = 2$ (d) $\Rightarrow$ mostly double dumb-bell (cloverleaf).

Step 3 — Conclusion: the s orbital is spherical, as shown by the ball-shaped boundary surface in the figure.

Why each other option is wrong:

- (A) Dumb-bell shaped describes a p orbital ($l = 1$).
- (B) Double dumb-bell (cloverleaf) describes most d orbitals ($l = 2$).
- (D) Planar is not the shape of any single atomic orbital boundary surface.

Key point: All s orbitals ($1s, 2s, 3s, \dots$) are spherical; only the size and the number of radial nodes increase with n. The spherical symmetry is the defining feature of s orbitals.

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

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Aufbau principle and the $(n + l)$ rule: The aufbau principle states that electrons occupy the lowest-energy orbital available before filling higher ones. The relative energy of orbitals is decided by the $(n + l)$ rule: the orbital with the lower $(n + l)$ value fills first, and for equal $(n + l)$ the one with the lower n fills first.

Step 1 — Compute $(n+l)$ for each: for $4s$, $n+l = 4+0 = 4$; for $3d$, $n+l = 3+2 = 5$.

Step 2 — Compare: $4 < 5$, so $4s$ has the lower energy and is filled before $3d$.

Step 3 — Conclusion: the $4s$ orbital fills first, which is why potassium and calcium fill $4s$ before the $3d$ block begins at scandium.

Why each other option is wrong:

- (A) Although $3d$ has the smaller principal quantum number, energy ordering uses $(n + l)$, not n alone, so $3d$ is actually higher in energy than $4s$.
- (B) The two orbitals do not have equal energy, so they do not fill simultaneously.
- (C) Electrons certainly fill these orbitals in multi-electron atoms.

Key point: Energy order: $4s$ (lower) then $3d$ (higher), by the $(n + l)$ rule. This is why the $4s$ orbital is filled first and, interestingly, is also emptied first during ionisation.

Final Answer: $4s$ fills first $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — VSEPR shape of $BeCl_2$: The shape of a molecule is set by the number of electron domains (bonding pairs plus lone pairs) around the central atom. Beryllium has only 2 valence electrons; in $BeCl_2$ both are used to form two Be–Cl bonds, leaving *no* lone pairs. Two bonding domains and no lone pairs give two electron domains.

Step 1 — Count electron domains on Be: two Be–Cl bonds $+ 0$ lone pairs $= 2$ domains.

Step 2 — Apply VSEPR: two domains repel each other to lie as far apart as possible, i.e. at 180°.

Step 3 — State the shape: the molecule is linear, Cl–Be–Cl, with a bond angle of 180° as shown.

Why each other option is wrong:

- (B) Bent needs two bonds plus one or more lone pairs (as in H_2O); Be has no lone pair.
- (C) Trigonal planar needs three domains (BF_3).
- (D) Tetrahedral needs four domains (CH_4).

Key point: $BeCl_2$ is a classic electron-deficient molecule: only two domains, no lone pairs $\Rightarrow$ linear, 180°. (In the solid state it polymerises, but the isolated gaseous molecule is linear.)

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

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 (number of σ bonds plus lone pairs). Two domains give sp, three give sp^2, four give sp^3. In $BeCl_2$, beryllium forms two σ bonds to chlorine and has no lone pairs.

Step 1 — Count domains on Be: 2 σ bonds $+$ 0 lone pairs $=$ 2 electron domains.

Step 2 — Assign the hybridisation: two domains $\Rightarrow$ sp hybridisation. One s and one p orbital of beryllium mix to form two equivalent sp hybrid orbitals.

Step 3 — Geometry check: the two sp orbitals point in opposite directions ($180°$), consistent with the linear shape of $BeCl_2$.

Why each other option is wrong:

- (A) sp^2 (three domains) is for trigonal planar molecules like BF_3.
- (C) sp^3 (four domains) is for tetrahedral molecules like CH_4.
- (D) sp^3d (five domains) is for trigonal bipyramidal molecules like PCl_5.

Key point: Hybridisation matches the number of electron domains: $sp \to 2 \to$ linear. Be in $BeCl_2$ is sp, just like C in CO_2 and in ethyne.

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

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q6**

Q7.

Solution

Concept — Hydrogen bonding: A hydrogen bond forms when an H atom bonded to a small, highly electronegative atom (F, O, or N) is attracted to a lone pair on another such atom. The strength of hydrogen bonding rises with the electronegativity and small size of that atom. Since fluorine is the most electronegative element, the H–F bond is the most polar and forms the *strongest* hydrogen bonds.

Step 1 — Identify candidates capable of hydrogen bonding: only molecules with H bonded directly to F, O, or N qualify. Among the options, HF has H bonded to fluorine.

Step 2 — Compare the options: HCl (Cl is much less electronegative), H_2S (S is large, low electronegativity), and PH_3 (P, low electronegativity) form, at best, only very weak hydrogen bonds.

Step 3 — Conclusion: HF has the strongest hydrogen bonding, which is why HF has an abnormally high boiling point for its molar mass.

Why each other option is wrong:

- (A) In HCl, chlorine is too large and not electronegative enough for strong H-bonding.
- (B) In H_2S, sulphur cannot form effective hydrogen bonds (hence H_2S is a gas while H_2O is a liquid).
- (D) In PH_3, phosphorus is not electronegative enough; PH_3 shows essentially no hydrogen bonding.

Key point: Hydrogen bonding needs H attached to F, O, or N. Strength order F > O > N, so among these choices HF wins.

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

Answer: (C) Go Back to Q7

Q8.

Solution

Concept — Acid–base nature of oxides across a period: Metals form basic oxides, non-metals form acidic oxides, and elements near the metal/non-metal border form amphoteric oxides. Across a period (left to right), the elements change from metallic to non-metallic, so their oxides change from *basic* through amphoteric to *acidic*.

Step 1 — Look at the start of period 3: sodium and magnesium are metals; Na_2O and MgO are basic oxides (they react with water to give alkalis).

Step 2 — Look at the middle and end: aluminium oxide (Al_2O_3) is amphoteric; the oxides of the non-metals at the right, such as SO_3 and Cl_2O_7, are acidic (they give acids with water).

Step 3 — State the trend: the nature of the oxides changes from basic (left) to acidic (right), as drawn in the figure.

Why each other option is wrong:

- (A) Acidic to basic is the reverse of the actual trend.
- (B) Acidic to neutral does not describe the metal oxides at the left, which are basic.
- (C) Neutral to basic ignores the strongly acidic non-metal oxides on the right.

Key point: Left = metals = basic oxides; right = non-metals = acidic oxides; the border (Al) is amphoteric. So the trend is basic → acidic across a period.

Final Answer: Basic to acidic $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — First ionization energy: The first ionization energy is the minimum energy needed to remove the most loosely held electron from a neutral gaseous atom. It increases across a period (electrons are held more tightly by the rising nuclear charge) and decreases down a group. Noble gases, with their completely filled, very stable electron shells, have the highest ionization energies in their periods, and helium has the highest of all elements.

Step 1 — Compare the options: helium ($1s^2$, a noble gas with a full first shell), lithium (a group-1 metal, very low), oxygen, and fluorine (high but less than the noble gas).

Step 2 — Identify the most stable, tightly held configuration: helium's filled $1s^2$ shell and small size make its electron extremely hard to remove.

Step 3 — Conclusion: helium has the highest first ionization energy of these elements (and indeed of all elements).

Why each other option is wrong:

- (B) Lithium loses its single $2s$ electron very easily, giving a low ionization energy.
- (C) Oxygen's ionization energy is high but lower than fluorine's and far below helium's.
- (D) Fluorine is high, but a noble gas (He) is higher because of its filled, stable shell.

Key point: Noble gases sit at the top of ionization-energy charts; helium, being the smallest with a complete $1s^2$ shell, has the single highest first ionization energy.

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

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — Hess's law of constant heat summation: Hess's law states that the total enthalpy change of a reaction depends only on the initial and final states, not on the route taken. This follows because enthalpy (H) is a state function: ΔH depends only on the start and end points, so it is the same whether the reaction happens in one step or in several.

Step 1 — Recall the basis: enthalpy is a state function, so $\Delta H = H_{\text{final}} - H_{\text{initial}}$ is fixed by the states alone.

Step 2 — Apply to a multi-step path: if a reaction can occur by different sequences of steps, the sum of the step enthalpies equals the overall ΔH, regardless of the path chosen.

Step 3 — Conclusion: the enthalpy change is independent of the path (the number of steps) by which the reaction takes place.

Why each other option is wrong:

- (A) The enthalpy change certainly depends on what the reactants are.
- (C) ΔH does vary with temperature (through heat capacities); Hess's law concerns the path, not temperature.
- (D) The physical states of the substances (solid, liquid, gas) do affect ΔH, so it is not independent of them.

Key point: Hess's law lets us add reactions like algebraic equations to find an unknown ΔH, precisely because enthalpy is path-independent (a state function).

Final Answer: Independent of the path $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — The second law of thermodynamics: The second law states that in any spontaneous (natural) process, the total entropy of the universe (system + surroundings) always increases: $\Delta S_{\text{universe}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}} > 0$. Entropy ($S$) is a measure of the disorder or the number of accessible microstates of a system.

Step 1 — State the criterion: for a spontaneous change, $\Delta S_{\text{universe}} > 0$.

Step 2 — Identify the increasing quantity: the quantity that must always increase is the entropy of the universe, not any property of the system alone.

Step 3 — Conclusion: the second law concerns the entropy of the universe.

Why each other option is wrong:

- (A) The enthalpy of the system can increase or decrease in a spontaneous process (endothermic processes can be spontaneous).
- (B) The internal energy of the system is not the quantity referred to by the second law.
- (D) The Gibbs free energy of the system *decreases* (not increases) in a spontaneous process at constant T and P.

Key point: Spontaneity is governed by $\Delta S_{\text{universe}} > 0$. Equivalently, at constant T and P, $\Delta G_{\text{system}} < 0$; the second law in its entropy form always refers to the universe.

Final Answer: Entropy of the universe increases $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — Adding an inert gas at constant volume: An equilibrium responds only to changes in the concentrations (or partial pressures) of the *reacting* species. Adding an inert gas at constant volume does not change the partial pressure or molar concentration of any reactant or product, so the reaction quotient Q is unchanged and the system stays at equilibrium.

Step 1 — Consider the volume: the volume is held constant, so the concentrations $\left(\frac{n}{V}\right)$ of all reacting species stay the same.

Step 2 — Effect on Q: since none of the reacting concentrations change, Q stays equal to K, and there is no driving force to shift.

Step 3 — Conclusion: adding an inert gas at constant volume causes no shift in the equilibrium position.

Why each other option is wrong:

- (A) and (B) A shift would require a change in a reacting concentration, which does not happen at constant volume.

- (C) The equilibrium constant K depends only on temperature, so it is unaffected by an inert gas.

Key point: Inert gas at constant *volume* $\Rightarrow$ no effect. (If instead it were added at constant *pressure*, the volume would expand and the equilibrium could shift toward the side with more gas moles.)

Final Answer: No shift in the equilibrium $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — Salt hydrolysis and the nature of a salt solution: The acidity or basicity of a salt solution depends on the strengths of the parent acid and base. A salt of a strong acid and a strong base does not hydrolyse appreciably, so its aqueous solution is *neutral* ($\text{pH} = 7$). NaCl comes from the strong acid HCl and the strong base NaOH.

Step 1 — Identify the parents of NaCl: acid = HCl (strong), base = NaOH (strong).

Step 2 — Test for hydrolysis: neither Na^+ nor Cl^- reacts with water to release H^+ or OH^-, so no hydrolysis occurs.

Step 3 — Conclusion: the solution stays neutral, $\text{pH} = 7$.

Why each other option is wrong:

- (B) An acidic solution ($\text{pH} < 7$) results from a salt of a strong acid and a *weak* base, e.g. NH_4Cl.
- (C) A basic solution ($\text{pH} > 7$) results from a salt of a *weak* acid and a strong base, e.g. CH_3COONa.
- (D) There is nothing to make the solution strongly acidic; both ions are neutral toward water.

Key point: Strong acid + strong base $\Rightarrow$ neutral salt (pH 7). The pH is decided by whichever parent is weaker; here both are strong, so the solution is neutral.

Final Answer: Neutral, $\text{pH} = 7 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Lewis acids and bases: The Lewis theory defines an acid as an electron-pair *acceptor* and a base as an electron-pair *donor*. A Lewis base must have at least one lone pair of electrons available to donate into an empty orbital of a Lewis acid, forming a coordinate (dative) bond.

Step 1 — Recall the definition: Lewis base = electron-pair donor; Lewis acid = electron-pair acceptor.

Step 2 — Match to the options: the description "donates a pair of electrons" corresponds exactly to a Lewis base. For example, NH_3 donates the lone pair on nitrogen.

Step 3 — Conclusion: a Lewis base is a species that donates a pair of electrons.

Why each other option is wrong:

- (A) Donating a proton (H^+) is the Bronsted–Lowry definition of an *acid*, not the Lewis definition of a base.
- (C) Accepting a pair of electrons defines a Lewis *acid* (e.g. BF_3).
- (D) Accepting a hydroxide ion is not how a Lewis base is defined.

Key point: Lewis base = electron-pair donor (has a lone pair); Lewis acid = electron-pair acceptor (has an empty orbital). This broader definition covers reactions with no H^+ transfer at all.

Final Answer: Donates a pair of electrons $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Oxidation number rules: In a neutral compound the oxidation numbers of all atoms add up to zero. Standard assignments: hydrogen is $+1$ (with non-metals) and oxygen is -2. The oxidation number of the remaining element is then found algebraically.

Given: H_3PO_4, a neutral molecule; H $= +1$, O $= -2$. Let the oxidation number of P be x.

Step 1 — Write the totals: three H contribute $3 \times (+1) = +3$; four O contribute $4 \times (-2) = -8$.

Step 2 — Set the sum to zero: $(+3) + x + (-8) = 0$, i.e. $3 + x - 8 = 0$.

Step 3 — Solve for x: $x - 5 = 0 \Rightarrow x = +5$.

Why each other option is wrong:

- (A) $+3$ is the oxidation state of P in phosphorous acid (H_3PO_3), not phosphoric acid.
- (B) $+4$ does not balance the charges in H_3PO_4.
- (D) $+6$ would require the totals to sum to $+1$, not zero, so it is incorrect.

Key point: For a neutral compound, set the oxidation numbers to sum to zero. In H_3PO_4 phosphorus is in its highest oxidation state, $+5$.

Final Answer: Oxidation number of P $= +5 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Electrolytic cell: An electrolytic cell is a device in which an external source of electrical energy (a battery) is used to drive a chemical reaction that would not occur on its own. The supplied energy pushes a *non-spontaneous* reaction ($\Delta G > 0$) to proceed, converting electrical energy into chemical energy.

Step 1 — Identify the energy flow: a battery feeds electrical energy into the cell.

Step 2 — Identify the type of reaction driven: because the reaction has $\Delta G > 0$, it cannot happen by itself; the electrical energy forces it forward (e.g. electrolysis of water or molten NaCl).

Step 3 — Conclusion: an electrolytic cell uses electrical energy to drive a non-spontaneous reaction.

Why each other option is wrong:

- (A) A spontaneous reaction would not need an external battery; that describes a galvanic cell, which *produces* electricity.
- (B) Producing electricity from a reaction is what a galvanic (voltaic) cell does, the opposite of an electrolytic cell.
- (C) A reaction at equilibrium has $\Delta G = 0$ and produces no net change; the electrolytic cell deliberately pushes the system away from equilibrium.

Key point: Electrolytic cell: electrical energy in → non-spontaneous reaction

($\Delta G > 0$). Galvanic cell: spontaneous reaction ($\Delta G < 0$) → electrical energy out. They are exact opposites.

Final Answer: Non-spontaneous reaction $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Faraday's first law of electrolysis: One faraday ($1\,\text{F} = 96500$ C) is the charge carried by one mole of electrons. The amount of substance liberated at an electrode is proportional to the charge passed, and is found from the electrode half-reaction, which tells how many moles of electrons are needed per mole of product.

Given: cathode reaction $2\text{H}^+ + 2e^- \rightarrow \text{H}_2$; required product $= 1$ mole of H_2.

Step 1 — Read the electrons per mole of product: the half-reaction shows that 2 moles of electrons are needed to form 1 mole of H_2.

Step 2 — Convert to faradays: 2 moles of electrons $=$ 2 faradays of charge.

Step 3 — Conclusion: 2 faradays ($= 2 \times 96500 = 193000$ C) liberate 1 mole of H_2 at the cathode.

Why each other option is wrong:

- (B) 1 faraday would deposit only $\frac{1}{2}$ mole of H_2.
- (C) 3 faradays correspond to 1.5 moles of H_2, more than asked.
- (D) 4 faradays correspond to 2 moles of H_2, twice the required amount.

Key point: Faradays needed $=$ (electrons in the half-reaction) per mole of product. H_2 needs $2e^-$, so 2 faradays per mole; contrast $\text{Ag}^+ + e^- \rightarrow \text{Ag}$, which needs only 1 faraday per mole.

Final Answer: 2 faradays $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept — Buffer solution: A buffer is a solution that resists a change in pH when a small amount of acid or base is added to it. It is usually made from a weak acid and its conjugate base (acidic buffer, e.g. CH_3COOH/CH_3COONa) or a weak base and its conjugate acid (basic buffer, e.g. NH_4OH/NH_4Cl). Its components neutralise added H^+ or OH^-.

Step 1 — Recall the function: a buffer keeps the pH nearly constant against small additions of acid or alkali.

Step 2 — Match to the options: only "resists a change in pH" describes a buffer.

Step 3 — Conclusion: a buffer solution resists a change in pH.

Why each other option is wrong:

- (A) A buffer's pH need not be 7; an acetate buffer, for instance, is acidic.
- (C) Buffers contain ions and do conduct electricity, so this is false.
- (D) A buffer needs a weak acid (or base) *with* its conjugate, not a strong acid alone.

Key point: Buffer $=$ weak acid/base $+$ its conjugate $=$ pH stays nearly constant on adding small amounts of acid or base. This is vital in biological systems (e.g. blood is buffered near pH 7.4).

Final Answer: Resists a change in pH $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept — Molar volume at STP: The molar volume is the volume occupied by one mole of a gas. Avogadro's law states that equal volumes of all gases at the same temperature and pressure contain equal numbers of molecules. Consequently, one mole of any ideal gas occupies the same volume at a given temperature and pressure; at STP this molar volume is 22.4 L mol^{-1}.

Given: 1 mole of an ideal gas at STP ($0\ ^\circ$C, 1 atm, by the older convention).

Step 1 — Recall the standard value: at STP, molar volume $V_m = 22.4$ L mol^{-1}.

Step 2 — Apply to 1 mole: volume $= 1$ mol $\times$ 22.4 L mol^{-1} $= 22.4$ L.

Step 3 — Conclusion: one mole occupies 22.4 L at STP.

Why each other option is wrong:

- (A) 11.2 L is the volume of 0.5 mole, not 1 mole.
- (B) 44.8 L is the volume of 2 moles.
- (D) 2.24 L corresponds to only 0.1 mole.

Key point: At STP, 1 mole of any ideal gas $= 22.4$ L. Use this to convert between moles and gas volume directly (e.g. 11.2 L $= 0.5$ mol).

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

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Oxidation state of a metal in a complex ion: In a coordination complex, the overall charge of the ion equals the sum of the oxidation state of the central metal and the total charge of all the ligands. Rearranging: (metal oxidation state) $=$ (charge on complex) $-$ (total ligand charge).

Given: complex $[\text{Fe(CN)}_6]^{4-}$; each CN^- has a charge of -1, and there are six of them. Let the oxidation state of Fe be x.

Step 1 — Total ligand charge: six CN^- ligands $\times(-1) = -6$.

Step 2 — Set up the charge balance: $x + (-6) = -4$ (the overall charge of the ion).

Step 3 — Solve for x: $x = -4 + 6 = +2$.

Why each other option is wrong:

- (A) 0 would make the complex charge -6, not -4.
- (B) $+3$ is the iron oxidation state in $[\text{Fe(CN)}_6]^{3-}$ (the ferricyanide ion), not in this $4-$ ion.
- (C) $+6$ would make the complex charge 0, which is incorrect.

Key point: Metal oxidation state $=$ (ion charge) $-$ (sum of ligand charges). Here Fe is $+2$ in $[\text{Fe(CN)}_6]^{4-}$ (ferrocyanide), compared with $+3$ in the $3-$ ferricyanide ion.

Final Answer: Oxidation state of Fe $= +2 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Werner's coordination theory: Werner's theory describes coordination compounds in terms of a central metal atom or ion surrounded by a fixed number of ligands. The central atom shows two kinds of valency: a primary valency (ionisable, satisfied by negative ions) and a secondary valency (non-ionisable, satisfied by ligands and equal to the coordination number). The central species is always a metal (usually a transition metal) atom or ion.

Step 1 — Identify the role of the central atom: it accepts lone pairs from the surrounding ligands, forming coordinate bonds.

Step 2 — Recall which kind of element this is: metals (especially transition metals) have empty orbitals to accept these lone pairs, so the central atom is a metal atom or ion.

Step 3 — Conclusion: the central atom of a coordination compound is a metal atom or ion.

Why each other option is wrong:

- (B) Non-metal atoms generally act as ligands or donor atoms, not as the central acceptor.
- (C) Noble gases are unreactive and do not form ordinary coordination centres.
- (D) Halogen atoms typically serve as ligands (e.g. Cl^-), not as the central atom.

Key point: In a complex such as $[Co(NH_3)_6]^{3+}$, cobalt (a metal) is the central atom and the ammonia molecules are the ligands. Werner's central atom is always a metal.

Final Answer: Metal atom or ion $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Inner-transition elements: The inner-transition elements are the two rows placed below the main body of the periodic table: the lanthanides (also called lanthanoids, Ce to Lu, filling the $4f$ subshell) and the actinides (filling the $5f$ subshell). They are characterised by the filling of f orbitals.

Step 1 — Recall what defines a lanthanide: the $4f$ subshell is being progressively filled; cerium (Ce, $Z = 58$) is the first lanthanide.

Step 2 — Examine the options: Fe and Cu are d-block (transition) metals, Ca is an s-block (group-2) metal, while Ce is a $4f$ inner-transition element.

Step 3 — Conclusion: cerium (Ce) is the lanthanide (inner-transition) element.

Why each other option is wrong:

- (A) Iron (Fe) is a $3d$ transition metal, not an inner-transition element.
- (C) Calcium (Ca) is an s-block alkaline-earth metal.
- (D) Copper (Cu) is a $3d$ transition metal.

Key point: Inner-transition $=$ f-block $=$ lanthanides ($4f$) and actinides ($5f$). Among the options, only cerium belongs to the f-block.

Final Answer: Cerium (Ce) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Isomerism: Isomers are two or more compounds that have the *same molecular formula* but *different structural arrangements* (different connectivity or spatial arrangement of atoms). Because the arrangement differs, isomers usually have different physical and chemical properties even though their molecular formulae are identical.

Step 1 — Recall the definition: same molecular formula, different structure.

Step 2 — Illustrate: both n-butane and isobutane have the formula C_4H_{10} but differ in the way the carbon atoms are linked, so they are isomers.

Step 3 — Conclusion: isomers share a molecular formula but differ in structure.

Why each other option is wrong:

- (A) Isomers must have the same molecular formula (and hence the same molecular mass); equal mass alone is not enough.
- (B) Isomers usually have *different* properties; identical properties would mean they are the same compound.
- (D) Different molecular formulae cannot be isomers; isomers must share the molecular formula.

Key point: Isomers = same molecular formula + different arrangement. This gives rise to structural isomers (different connectivity) and stereoisomers (same connectivity, different spatial arrangement).

Final Answer: Same molecular formula, different structure $\Rightarrow \boxed{C}$

Answer: (C) **Go Back to Q23**

Q24.

Solution

Concept — IUPAC naming of alkynes: In IUPAC nomenclature, the suffix tells the family: *-ane* for a single bond (alkane), *-ene* for a double bond (alkene), and *-yne* for a triple bond (alkyne). The prefix gives the number of carbon atoms (meth-, eth-, prop-, . . .). The molecule shown, H–C≡C–H, has two carbons joined by a triple bond.

Step 1 — Count the carbons: two carbon atoms ⇒ root "eth".

Step 2 — Identify the bond: a carbon–carbon triple bond ⇒ suffix "-yne".

Step 3 — Combine: eth + yne = ethyne (the common name is acetylene).

Why each other option is wrong:

- (A) Ethane (C_2H_6) has a single C–C bond, not a triple bond.
- (B) Ethanol (C_2H_5OH) is an alcohol, containing an $-OH$ group, not shown here.
- (C) Ethene (C_2H_4) has a C=C double bond, not a triple bond.

Key point: Triple bond ⇒ "-yne"; two carbons ⇒ "eth-"; so H–C≡C–H is ethyne. Match the suffix to the bond and the prefix to the carbon count.

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

Answer: (D) **Go Back to Q24**

Q25.

Solution

Concept — The carbonyl group in ketones: A functional group is the reactive part that defines a class of compounds. The carbonyl group (>C=O) is a carbon double-bonded to oxygen. When this carbonyl carbon is bonded to *two* other carbon atoms (two alkyl or aryl groups), the compound is a *ketone*, written R–CO–R′.

Step 1 — Read the structure: the central carbon is double-bonded to O and singly bonded to two carbon groups (R and R′).

Step 2 — Match to the class: a carbonyl flanked by two carbons is the defining feature of a ketone, e.g. propanone (acetone), CH_3COCH_3.

Step 3 — Conclusion: the >C=O group between two carbons is characteristic of ketones.

Why each other option is wrong:

- (B) Alcohols contain the $-$OH group, not a carbonyl.
- (C) Carboxylic acids have $-$COOH, a carbonyl *plus* a hydroxyl on the same carbon.
- (D) Amines contain the $-NH_2$ (or substituted nitrogen) group, not a carbonyl.

Key point: Carbonyl between two carbons = ketone; carbonyl with at least one H = aldehyde; carbonyl plus $-$OH = carboxylic acid. The position of the carbonyl decides the class.

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

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Aromatic hydrocarbons: Aromatic hydrocarbons are cyclic, planar compounds containing delocalised π electrons that obey Hückel's rule ($4n + 2$ π electrons). Benzene (C_6H_6), a flat six-membered ring with 6 delocalised π electrons, is the simplest and most representative aromatic hydrocarbon.

Step 1 — Recall the requirement: aromatic compounds are cyclic, planar, fully conjugated, and have $4n + 2$ delocalised π electrons.

Step 2 — Test benzene: it is a planar six-carbon ring with 6 delocalised π electrons ($n = 1$, $4n + 2 = 6$), so it is aromatic.

Step 3 — Conclusion: benzene is the aromatic hydrocarbon among the options.

Why each other option is wrong:

- (A) Methane is a saturated (aliphatic) alkane, not cyclic or aromatic.
- (C) Ethene is an open-chain alkene; it is unsaturated but not aromatic.
- (D) Ethyne is an open-chain alkyne; it is unsaturated but not aromatic.

Key point: Aromatic $=$ cyclic $+$ planar $+$ conjugated $+$ $(4n + 2)$ π electrons. Benzene is the textbook example; the open-chain compounds (methane, ethene, ethyne) are aliphatic.

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

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Structure of benzene: Benzene has the molecular formula C_6H_6. Its skeleton is a regular hexagon of six carbon atoms, each carbon bonded to one hydrogen and to two neighbouring carbons, with the six π electrons delocalised over the whole ring (shown by the inner circle).

Step 1 — Read the molecular formula: C_6H_6 tells us there are six carbon atoms.

Step 2 — Relate to the figure: a hexagon has six corners, and each corner is one carbon atom of the ring.

Step 3 — Conclusion: the benzene ring is made of 6 carbon atoms.

Why each other option is wrong:

- (A) 4 carbons would form a four-membered ring (cyclobutadiene skeleton), not benzene.
- (B) 5 carbons would form a five-membered ring (e.g. cyclopentadiene), not benzene.
- (D) 7 carbons would form a seven-membered ring (e.g. cycloheptatriene), not benzene.

Key point: Benzene $=$ a six-membered carbon ring (C_6H_6) with delocalised π electrons. The hexagonal shape directly shows the six ring carbons.

Final Answer: 6 carbon atoms ⇒ $\boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept — Functional group of haloalkanes: A haloalkane (alkyl halide) is formed when one or more hydrogen atoms of an alkane are replaced by a halogen atom (F, Cl, Br, or I). The characteristic functional group is therefore the carbon–halogen bond, $-X$ (where $X = F, Cl, Br, I$), as in chloromethane CH_3Cl.

Step 1 — Identify the defining atom: a haloalkane contains a halogen atom bonded to a saturated carbon.

Step 2 — Write the functional group: the C–X bond, written as $-X$ (e.g. $-Cl$ in CH_3Cl).

Step 3 — Conclusion: the functional group present in a haloalkane is the halogen, $-X$.

Why each other option is wrong:

- (A) $-OH$ (hydroxyl) is the functional group of alcohols.
- (B) $-CHO$ (aldehyde) belongs to aldehydes.
- (C) $-COOH$ (carboxyl) belongs to carboxylic acids.

Key point: Haloalkane = C–X bond ($-F$, $-Cl$, $-Br$, $-I$). The halogen is the functional group, and the polar C–X bond makes these compounds reactive in substitution and elimination reactions.

Final Answer: $-X$ (halogen, e.g. $-Cl$) ⇒ $\boxed{\text{D}}$

Answer: (D) Go Back to Q28

Q29.

Solution

Concept — Function of DNA: DNA (deoxyribonucleic acid) is a nucleic acid, a polymer of nucleotides, that stores the hereditary information of a living organism. The sequence of its four bases (A, T, G, C) encodes the genetic instructions, which are passed on from one generation to the next and direct the synthesis of proteins.

Step 1 — Recall the biological role: DNA is the molecule of heredity; its base sequence is the genetic code.

Step 2 — Match to the options: only "carrying and transmitting hereditary (genetic) information" describes the role of DNA.

Step 3 — Conclusion: DNA carries the genetic (hereditary) information.

Why each other option is wrong:

- (B) Immediate energy for cells is supplied by ATP and by carbohydrates such as glucose, not by DNA.
- (C) Catalysing metabolic reactions is the role of enzymes (proteins), not DNA.
- (D) The structural fat of membranes is provided by phospholipids, not DNA.

Key point: DNA = store of genetic information; RNA helps express it; proteins do most of the cell's work; carbohydrates and fats provide energy and structure. DNA's job is heredity.

Final Answer: Carries hereditary (genetic) information $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept — Esterification: Esterification is the reaction of a carboxylic acid with an alcohol, in the presence of an acid catalyst (such as concentrated H_2SO_4), to form an ester and water. The general reaction is acid + alcohol $\rightleftharpoons$ ester + water; the $-$OH of the acid and the $-$H of the alcohol combine to leave as water.

Given: acetic acid CH_3COOH + ethanol C_2H_5OH, with an acid catalyst.

Step 1 — Write the reaction: $CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$.

Step 2 — Identify the organic product: the ester formed is ethyl acetate (ethyl ethanoate), $CH_3COOC_2H_5$.

Step 3 — Conclusion: the product of esterification is ethyl acetate.

Why each other option is wrong:

- (A) Ethanal (CH_3CHO) is an aldehyde, formed by oxidation of ethanol, not by esterification.
- (B) Acetone (CH_3COCH_3) is a ketone and is not produced here.

- (D) Sodium acetate would form if acetic acid reacted with sodium hydroxide (a base), not with ethanol.

Key point: Carboxylic acid + alcohol $\xrightarrow{H^+}$ ester + water. Acetic acid + ethanol gives ethyl acetate, a sweet-smelling ester, releasing water in a reversible condensation.

Final Answer: Ethyl acetate $\Rightarrow \boxed{\text{C}}$

$\boxed{\textbf{Answer: (C)}}$ **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	C