# SAAT Chemistry

## Sample Paper – 6

**Duration: 40 Minutes** **Maximum Marks: 40**

### Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry section of the **SAAT** (Siksha 'O' Anusandhan Admission Test).
- Each correct answer carries **+1 mark**. There is **no negative marking** for incorrect or unattempted answers.
- Only **one** option is correct. Attempt every question, since wrong answers are not penalised.
- Use of mobile phones, calculators, or other electronic gadgets is strictly prohibited.

**Q1.** The mass percentage of nitrogen in ammonium nitrate ($NH_4NO_3$, molar mass $80$ g/mol; atomic mass of $N = 14$) is

(A) $35\%$

(B) $17.5\%$

(C) $28\%$

(D) $46\%$

**Q2.** $0.25$ mol of a gas weighs $11$ g. The molar mass of the gas is

(A) $22$ g/mol

(B) $44$ g/mol

(C) $88$ g/mol

(D) $2.75$ g/mol

**Q3.** When $4$ g of hydrogen ($H_2$) reacts with $32$ g of oxygen ($O_2$) to form water ($2H_2 + O_2 \rightarrow 2H_2O$), the maximum mass of water formed is

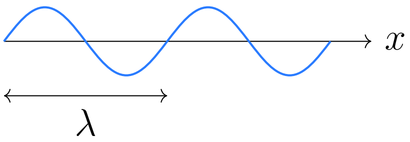
(A) 18 g

(B) 54 g

(C) 36 g

(D) 32 g

**Q4.** A particle of mass $m$ moving with speed $v$ has an associated matter wave, as suggested below. The de Broglie wavelength $\lambda$ of the particle is given by ($h$ = Planck's constant)



(A) $\lambda = mvh$

(B) $\lambda = \dfrac{mv}{h}$

(C) $\lambda = \dfrac{h\,v}{m}$

(D) $\lambda = \dfrac{h}{mv}$

**Q5.** According to the $(n + l)$ rule (Aufbau principle), which of the following orbitals is filled with electrons *immediately after* the $4s$ orbital?

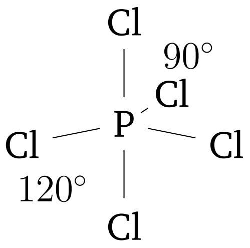
(A) $4p$

(B) $3d$

(C) $4d$

(D) $5s$

**Q6.** The hybridization of the central phosphorus atom in phosphorus pentachloride ($PCl_5$), whose trigonal bipyramidal shape is shown, is



(A) $sp^3d$

(B) $sp^3$

(C) $sp^3d^2$

(D) $sp^2$

**Q7.** Using molecular orbital theory, the species $O_2^+$, $O_2$ and $O_2^-$ have bond orders $2.5$, $2$ and $1.5$ respectively. The correct order of *increasing* O–O bond length is

(A) $O_2^- < O_2 < O_2^+$

(B) $O_2 < O_2^+ < O_2^-$

(C) $O_2^+ < O_2^- < O_2$

(D) $O_2^+ < O_2 < O_2^-$

**Q8.** Which of the following molecules has a net dipole moment of *zero*?

(A) $NH_3$

(B) $H_2O$

(C) $CCl_4$

(D) $CHCl_3$

**Q9.** The enthalpy of combustion of a substance is best described as the enthalpy change when

(A) one mole of the substance is completely burnt in excess oxygen

(B) one mole of the substance is formed from its elements

(C) one mole of water is formed in neutralisation

(D) one mole of a gas expands at constant pressure

**Q10.** For any spontaneous process, the total entropy change of the universe ($\Delta S_{universe} = \Delta S_{system} + \Delta S_{surroundings}$) is always

(A) equal to zero

(B) greater than zero (positive)

(C) less than zero (negative)

(D) equal to $\Delta H/T$

**Q11.** For the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ at equilibrium, $[H_2] = 0.2$ M, $[I_2] = 0.2$ M and $[HI] = 0.8$ M. The value of the equilibrium constant $K_c$ is

(A) 4

(B) 8

(C) 16

(D) 2

**Q12.** The addition of solid sodium acetate ($CH_3COONa$) to an aqueous solution of acetic acid ($CH_3COOH$) causes the ionisation (degree of dissociation) of the acetic acid to

(A) increase sharply

(B) remain exactly the same

(C) first increase then decrease

(D) decrease (common ion effect)

**Q13.** According to Raoult's law, when a non-volatile solute is dissolved in a volatile solvent, the vapour pressure of the solution, compared with that of the pure solvent,

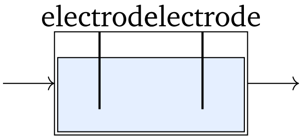
(A) decreases (relative lowering equals the mole fraction of solute)

(B) increases in proportion to the solute

(C) remains unchanged

(D) becomes zero

**Q14.** The conductance of a solution in a cell of cell-constant $G^* = 1.0\ \text{cm}^{-1}$ is measured as shown. The molar conductivity $\Lambda_m$ of an electrolyte solution is related to its conductivity $\kappa$ and molar concentration $c$ by



(A) $\Lambda_m = \kappa \times c$

(B) $\Lambda_m = \dfrac{\kappa \times 1000}{c}$

(C) $\Lambda_m = \dfrac{c}{\kappa}$

(D) $\Lambda_m = \kappa + c$

**Q15.** Which of the following statements correctly distinguishes molecularity from order of a reaction?

(A) Both molecularity and order can be zero or fractional

(B) Molecularity is determined experimentally; order is theoretical

(C) Molecularity is always a whole number for an elementary step, whereas order can be zero or fractional

(D) Order can never exceed molecularity

**Q16.** The oxidation number of chlorine in perchloric acid ($HClO_4$) is

(A) $+1$

(B) $+3$

(C) $+5$

(D) $+7$

**Q17.** Among the elements $\mathrm{Na}$, $\mathrm{Mg}$, $\mathrm{Al}$ and $\mathrm{Si}$ (all in period 3), which has the *largest* atomic radius?

(A) Na

(B) Mg

(C) Al

(D) Si

**Q18.** Among the elements Li, Be, B and C of period 2, which is the *most metallic* in character?

(A) Carbon

(B) Lithium

(C) Beryllium

(D) Boron

**Q19.** Which of the following is an anomalous property of lithium that distinguishes it from the other alkali metals?

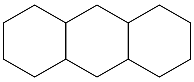
(A) It is the most reactive alkali metal towards water

(B) Its hydroxide is the strongest base in the group

(C) Lithium nitrate decomposes on heating to give $Li_2O$, $NO_2$ and $O_2$, unlike other alkali nitrates

(D) It forms a superoxide on burning in air

**Q20.** Diamond and graphite, two allotropes of carbon (graphite's layered hexagonal sheet is shown), differ mainly because



(A) diamond contains $sp$-hybridized carbon

(B) graphite is harder than diamond

(C) both have identical three-dimensional networks

(D) in diamond each carbon is $sp^3$ (rigid 3-D network) while in graphite each carbon is $sp^2$ (layered sheets)

**Q21.** Sulphur dioxide ($SO_2$) acts as a bleaching agent because it

(A) oxidises the coloured matter permanently

(B) reduces the coloured matter (the bleaching is temporary and reversible in air)

(C) dehydrates the coloured matter

(D) dissolves the coloured matter physically

**Q22.** Which of the following halogens is a *liquid* at room temperature?

(A) Fluorine

(B) Chlorine

(C) Bromine

(D) Iodine

**Q23.** In acidic medium, potassium dichromate ($K_2Cr_2O_7$) acts as a strong oxidising agent; the chromium is reduced from $+6$ to

(A) $+3$

(B) $+2$

(C) $+7$

(D) $0$

**Q24.** As we move from cerium (Ce) to lutetium (Lu) along the lanthanide series, the atomic and ionic ($M^{3+}$) radii

(A) increase steadily

(B) first increase then decrease

(C) remain almost constant

(D) decrease steadily (lanthanide contraction)

**Q25.** In Werner's theory of coordination compounds, the *secondary valence* of a metal corresponds to its

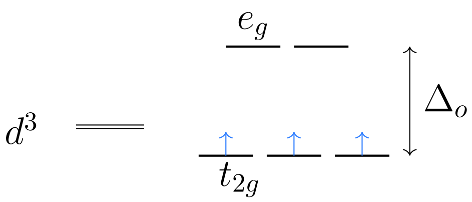
(A) oxidation state (ionisable charge)

(B) coordination number (number of ligands directly bonded)

(C) number of unpaired electrons

(D) atomic number

**Q26.** For an octahedral complex the $d$ orbitals split into a lower $t_{2g}$ set and a higher $e_g$ set, as shown. The crystal field stabilisation energy (CFSE) of a $d^3$ ion (each electron in $t_{2g}$, in $\Delta_o$ units) is



(A) $-1.2\,\Delta_o$

(B) $-0.6\,\Delta_o$

(C) $-0.4\,\Delta_o$

(D) $+1.2\,\Delta_o$

**Q27.** The IUPAC name of the compound $(CH_3)_2CHCH_2Cl$ is

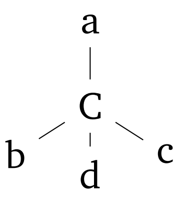
(A) 2-chlorobutane

(B) 1-chlorobutane

(C) 1-chloro-2-methylpropane

(D) 2-chloro-2-methylpropane

**Q28.** Which of the following compounds is chiral (contains an asymmetric carbon bearing four different groups, as illustrated) and therefore shows optical isomerism?



(A) $CH_3CH_2CH_3$ (propane)

(B) $CH_3CHCl_2$ (1,1-dichloroethane)

(C) $CH_2BrCH_2Br$ (1,2-dibromoethane)

(D) $CH_3CHBrCl$ (1-bromo-1-chloroethane)

**Q29.** The electromeric effect ($E$ effect) is best described as

(A) a permanent polarisation of a sigma bond due to electronegativity difference

(B) a temporary, complete shift of a $\pi$-electron pair to one atom in the presence of an attacking reagent

(C) delocalisation of $\pi$ electrons over the whole molecule in the ground state

(D) overlap of a $\sigma$ bond with an adjacent empty $p$ orbital

**Q30.** The number of structural (chain) isomers possible for the alkane pentane ($C_5H_{12}$) is

(A) $3$

(B) $2$

(C) $4$

(D) $5$

**Q31.** Terminal alkynes such as ethyne ($HC{\equiv}CH$) react with ammoniacal silver nitrate to give a precipitate because the terminal ≡C–H hydrogen is

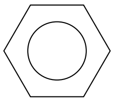
(A) basic

(B) neutral and unreactive

(C) acidic (the $sp$ carbon holds the C–H electrons tightly, so $H$ is replaceable by a metal)

(D) attached by a double bond

**Q32.** According to Hückel's rule, a planar cyclic conjugated ring (such as benzene, shown) is aromatic if the number of delocalised $\pi$ electrons equals



(A) $4n$ (e.g. $4, 8, 12$)

(B) $2n$

(C) $n$

(D) $4n + 2$ (e.g. $2, 6, 10$)

**Q33.** The reaction of an aryl halide and an alkyl halide with sodium metal in dry ether to give an alkylarene is called

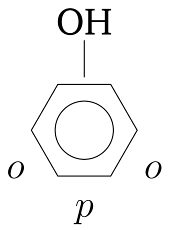
(A) the Wurtz–Fittig reaction

(B) the Wurtz reaction

(C) the Friedel–Crafts reaction

(D) the Sandmeyer reaction

**Q34.** In electrophilic substitution, the $-\mathrm{OH}$ group of phenol (shown) directs the incoming electrophile mainly to the



(A) meta position only

(B) ortho and para positions (it is an activating, o/p-directing group)

(C) ipso position only

(D) it deactivates the ring and is meta-directing

**Q35.** Diethyl ether can be prepared industrially by heating ethanol with concentrated sulphuric acid at about $140\,^\circ\mathrm{C}$. This method works best for

(A) unsymmetrical ethers from two different alcohols

(B) tertiary alcohols

(C) symmetrical ethers from primary alcohols (intermolecular dehydration)

(D) phenols

**Q36.** Which of the following gives a positive iodoform test (yellow precipitate of $CHI_3$) on treatment with $I_2/NaOH$?

(A) HCHO (formaldehyde)

(B) $C_6H_5CHO$ (benzaldehyde)

(C) $CH_3CH_2CHO$ (propanal)

(D) $CH_3COCH_3$ (acetone, a methyl ketone)

**Q37.** When the sodium salt of acetic acid ($CH_3COONa$) is heated with soda lime ($NaOH + CaO$), the product (by decarboxylation) is

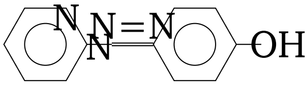
(A) methane ($CH_4$)

(B) ethane ($C_2H_6$)

(C) ethanol ($C_2H_5OH$)

(D) acetaldehyde ($CH_3CHO$)

**Q38.** Benzene diazonium chloride couples with phenol in mildly alkaline medium to form an orange dye. The product, shown below, belongs to which class of compounds?



(A) amides

(B) azo compounds (azo dyes, $-N{=}N-$)

(C) nitro compounds

(D) amines

**Q39.** When an egg is boiled, the soluble globular protein albumin coagulates. This loss of the native three-dimensional structure of a protein (with breaking of hydrogen bonds and unfolding of chains) is called

(A) hydrolysis

(B) peptide-bond formation

(C) polymerisation

(D) denaturation

**Q40.** Teflon (polytetrafluoroethene, PTFE) is an addition polymer of the monomer

(A) vinyl chloride ($CH_2{=}CHCl$)

(B) ethene ($CH_2{=}CH_2$)

(C) tetrafluoroethene ($CF_2{=}CF_2$)

(D) styrene ($C_6H_5CH{=}CH_2$)

# Detailed Solutions

## Q1.

**Solution**

**Concept — Mass percentage:** Mass % of an element $= \dfrac{(\text{number of atoms}) \times (\text{atomic mass})}{\text{molar mass}} \times 100$.

**Step 1 — Mass of N:** $NH_4NO_3$ has 2 nitrogen atoms $\Rightarrow 2 \times 14 = 28$.

**Step 2 — Compute:** $\dfrac{28}{80} \times 100 = 35\%$.

**Why other options are wrong:** $17.5\%$ counts only one N; $28\%$ omits the $\times 100/80$ scaling; $46\%$ corresponds to oxygen.

**Final Answer:** $35\%$ nitrogen $\Rightarrow \boxed{\text{A}}$

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

## Q2.

**Solution**

**Concept — Molar mass from moles:** Molar mass $M = \dfrac{\text{mass}}{\text{number of moles}}$.

**Step 1 — Substitute:** $M = \dfrac{11}{0.25}$.

**Step 2 — Compute:** $M = 44$ g/mol (the gas is $CO_2$).

**Why other options are wrong:** $22$ halves the result; $88$ doubles it; $2.75$ inverts the division $(0.25/11 \times \ldots)$.

**Final Answer:** $M = 44$ g/mol $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q2

## Q3.

**Solution**

**Concept — Limiting reagent:** The reactant that runs out first fixes the amount of product.

**Step 1 — Moles available:** $H_2 : \dfrac{4}{2} = 2$ mol; $O_2 : \dfrac{32}{32} = 1$ mol.

**Step 2 — Check ratio:** $2H_2 + O_2 \rightarrow 2H_2O$ needs $H_2{:}O_2 = 2{:}1$. Here it is exactly 2:1, so both are fully used; 2 mol $H_2$ gives 2 mol water.

**Step 3 — Mass:** $2 \times 18 = 36$ g.

**Why other options are wrong:** $18$ g is $1$ mol water; $54$ g assumes $3$ mol; $32$ g is the oxygen mass.

**Final Answer:** $36$ g of water $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q3

## Q4.

**Solution**

**Concept — de Broglie relation:** Every moving particle has a matter wave of wavelength $\lambda = \dfrac{h}{p} = \dfrac{h}{mv}$.

**Step 1 — Momentum:** $p = mv$.

**Step 2 — Wavelength:** $\lambda = \dfrac{h}{mv}$, so $\lambda$ is inversely proportional to mass and speed.

**Why other options are wrong:** $mvh$ and $\dfrac{mv}{h}$ invert the relation; $\dfrac{hv}{m}$ misplaces $v$ in the numerator.

**Final Answer:** $\lambda = \dfrac{h}{mv} \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q4

## Q5.

**Solution**

**Concept — $(n+l)$ rule:** Orbitals fill in order of increasing $(n+l)$; for equal $(n+l)$, the lower $n$ fills first.

**Step 1 — Compare values:** $4s$ has $n + l = 4 + 0 = 4$; $3d$ has $n + l = 3 + 2 = 5$; $4p$ has $4 + 1 = 5$.

**Step 2 — Choose:** For $(n + l) = 5$, $3d$ (lower $n = 3$) fills before $4p$ ($n = 4$). Hence the orbital filled right after $4s$ is $3d$.

**Why other options are wrong:** $4p$ fills after $3d$; $4d$ and $5s$ come much later.

**Final Answer:** $3d$ fills immediately after $4s \Rightarrow \boxed{\text{B}}$

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

## Q6.

### Solution

**Concept — Hybridization and shape:** Five sigma bonds with no lone pair give a trigonal bipyramidal geometry.

**Step 1 — Count domains:** P in $\mathrm{PCl_5}$ has $5$ bonding pairs and no lone pair.

**Step 2 — Assign:** Five electron domains $\Rightarrow$ $sp^3d$ (three equatorial at $120^\circ$, two axial at $90^\circ$).

**Why other options are wrong:** $sp^3$ is tetrahedral; $sp^3d^2$ is octahedral ($\mathrm{SF_6}$); $sp^2$ is trigonal planar.

**Final Answer:** Phosphorus is $sp^3d$ hybridized $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q6

## Q7.

### Solution

**Concept — Bond order vs bond length:** Bond length decreases as bond order increases.

**Step 1 — Order of bond orders:** $\mathrm{O_2^+}\ (2.5) > \mathrm{O_2}\ (2) > \mathrm{O_2^-}\ (1.5)$.

**Step 2 — Reverse for length:** Higher bond order $\Rightarrow$ shorter bond. So increasing bond length: $\mathrm{O_2^+} < \mathrm{O_2} < \mathrm{O_2^-}$.

**Why other options are wrong:** They place the species in the wrong order; the highest bond order ($\mathrm{O_2^+}$) must have the shortest bond.

**Final Answer:** $\mathrm{O_2^+} < \mathrm{O_2} < \mathrm{O_2^-} \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q7

## Q8.

### Solution

**Concept — Net dipole moment:** A molecule has zero dipole moment if its bond dipoles cancel by symmetry.

**Step 1 — Examine $\mathrm{CCl_4}$:** Regular tetrahedral; the four C–Cl dipoles point symmetrically and cancel, giving $\mu = 0$.

**Why other options are wrong:** $\mathrm{NH_3}$ (pyramidal) and $\mathrm{H_2O}$ (bent) have net dipoles; $\mathrm{CHCl_3}$ is unsymmetrical, so dipoles do not cancel.

**Final Answer:** $CCl_4$ has zero dipole moment $\Rightarrow \boxed{C}$

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

## Q9.

### Solution

**Concept — Enthalpy of combustion:** It is the heat change when one mole of a substance is completely burnt in excess (sufficient) oxygen.

**Step 1 — Definition:** $\Delta_c H$ refers to complete oxidation of $1$ mol of the substance under standard conditions.

**Why other options are wrong:** Formation from elements is $\Delta_f H$; one mole of water in neutralisation is $\Delta_{neut} H$; gas expansion at constant $P$ is unrelated to combustion.

**Final Answer:** Complete burning of one mole in excess oxygen $\Rightarrow \boxed{A}$

$\boxed{\textbf{Answer: (A)}}$ Go Back to Q9

## Q10.

### Solution

**Concept — Second law of thermodynamics:** For a spontaneous (irreversible) change the total entropy of the universe increases.

**Step 1 — Criterion:** $\Delta S_{universe} = \Delta S_{system} + \Delta S_{surroundings} > 0$ for any spontaneous process.

**Why other options are wrong:** $\Delta S_{universe} = 0$ holds only for a reversible (equilibrium) process; a negative value means the process is non-spontaneous; $\Delta H/T$ is only the surroundings' term.

**Final Answer:** $\Delta S_{universe} > 0 \Rightarrow \boxed{B}$

$\boxed{\textbf{Answer: (B)}}$ Go Back to Q10

## Q11.

### Solution

**Concept — Equilibrium constant:** $K_c = \dfrac{[HI]^2}{[H_2][I_2]}$.

**Step 1 — Substitute:** $K_c = \dfrac{(0.8)^2}{(0.2)(0.2)} = \dfrac{0.64}{0.04}$.

**Step 2 — Compute:** $K_c = 16$.

**Why other options are wrong:** $4$ forgets to square $[\mathrm{HI}]$; $8$ and $2$ mishandle the denominator.

**Final Answer:** $K_c = 16 \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q11

## Q12.

### Solution

**Concept — Common ion effect:** Adding a salt that supplies a common ion suppresses the ionisation of a weak electrolyte.

**Step 1 — Identify the common ion:** $\mathrm{CH_3COONa}$ supplies $\mathrm{CH_3COO^-}$, the same ion produced by acetic acid.

**Step 2 — Apply Le Chatelier:** The extra $\mathrm{CH_3COO^-}$ shifts $\mathrm{CH_3COOH} \rightleftharpoons \mathrm{CH_3COO^-} + \mathrm{H^+}$ to the left, decreasing the degree of dissociation.

**Why other options are wrong:** Ionisation does not increase or stay the same; it falls steadily.

**Final Answer:** Dissociation decreases (common ion effect) $\Rightarrow \boxed{\mathrm{D}}$

Answer: (D) Go Back to Q12

## Q13.

### Solution

**Concept — Raoult's law:** For a solution of a non-volatile solute, $p_{solution} = x_{solvent}\, p^\circ_{solvent}$, so vapour pressure is lowered.

**Step 1 — Relative lowering:** $\dfrac{p^\circ - p}{p^\circ} = x_{solute}$, the mole fraction of solute.

**Step 2 — Conclusion:** Since $x_{solvent} < 1$, the solution's vapour pressure is always lower than that of the pure solvent.

**Why other options are wrong:** A non-volatile solute cannot raise vapour pressure; it does change it, and it does not drop to zero for a dilute solution.

**Final Answer:** Vapour pressure decreases $\Rightarrow \boxed{\mathrm{A}}$

Answer: (A) Go Back to Q13

## Q14.

### Solution

**Concept — Molar conductivity:** $\Lambda_m = \dfrac{\kappa \times 1000}{c}$, where $\kappa$ is in $\mathrm{S\,cm^{-1}}$ and $c$ in $\mathrm{mol\,L^{-1}}$.

**Step 1 — Definition:** Molar conductivity is the conducting power of all the ions from one mole of electrolyte.

**Step 2 — Units:** The factor 1000 converts $\mathrm{cm^3}$ to litres, giving $\mathrm{S\,cm^2\,mol^{-1}}$.

**Why other options are wrong:** $\kappa \times c$ and $c/\kappa$ have the wrong dependence; $\kappa + c$ is dimensionally meaningless.

**Final Answer:** $\Lambda_m = \dfrac{\kappa \times 1000}{c} \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) **Go Back to Q14**

## Q15.

### Solution

**Concept — Molecularity vs order:** Molecularity is the number of species in an elementary step (always a positive whole number); order is found from the experimental rate law and may be zero, fractional or negative.

**Step 1 — Compare:** For an elementary reaction molecularity equals order, but for a complex (multistep) reaction the overall order can differ and may be fractional.

**Why other options are wrong:** Molecularity cannot be zero or fractional; molecularity is theoretical (from mechanism) while order is experimental; order can exceed molecularity is not the defining distinction.

**Final Answer:** Molecularity is a whole number; order may be zero/fractional $\Rightarrow \boxed{\mathrm{C}}$

Answer: (C) **Go Back to Q15**

## Q16.

### Solution

**Concept — Oxidation number:** The sum of oxidation numbers in a neutral molecule is zero.

**Step 1 — Assign known values:** $\mathrm{H} = +1$, $\mathrm{O} = -2$ $(\times 4 = -8)$.

**Step 2 — Solve for Cl:** $+1 + x - 8 = 0 \Rightarrow x = +7$.

**Why other options are wrong:** $+1$, $+3$ and $+5$ are the Cl states in HOCl, $HClO_2$ and $HClO_3$ respectively.

**Final Answer:** Cl is $+7$ in $HClO_4 \Rightarrow \boxed{D}$

**Answer: (D)** Go Back to Q16

## Q17.

**Solution**

**Concept — Atomic radius across a period:** Radius decreases left to right as nuclear charge increases within the same shell.

**Step 1 — Order in period 3:** Na $>$ Mg $>$ Al $>$ Si.

**Step 2 — Largest:** Sodium, being furthest left, has the largest atomic radius.

**Why other options are wrong:** Mg, Al and Si all have higher effective nuclear charge and therefore smaller radii.

**Final Answer:** Na has the largest radius $\Rightarrow \boxed{A}$

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

## Q18.

**Solution**

**Concept — Metallic character:** Metallic character decreases left to right across a period (elements lose the tendency to release electrons).

**Step 1 — Order in period 2:** Li (metal) $>$ Be $>$ B (metalloid) $>$ C (non-metal).

**Step 2 — Most metallic:** Lithium, on the far left, is the most metallic.

**Why other options are wrong:** Carbon is non-metallic; boron is a metalloid; beryllium is less metallic than lithium.

**Final Answer:** Lithium is the most metallic $\Rightarrow \boxed{B}$

**Answer: (B)** Go Back to Q18

## Q19.

### Solution

**Concept — Anomalous behaviour of lithium:** Because of its very small size and high polarising power, lithium differs from the rest of group 1.

**Step 1 — Nitrate test:** $4LiNO_3 \xrightarrow{\Delta} 2Li_2O + 4NO_2 + O_2$, whereas other alkali nitrates give only the nitrite and oxygen ($2NaNO_3 \rightarrow 2NaNO_2 + O_2$).

**Why other options are wrong:** Lithium is the *least* reactive alkali metal towards water; LiOH is the *weakest* base in the group; lithium forms only the normal oxide ($Li_2O$), not a superoxide.

**Final Answer:** $LiNO_3$ gives $Li_2O + NO_2 + O_2 \Rightarrow \boxed{C}$

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

## Q20.

### Solution

**Concept — Allotropes of carbon:** The properties of diamond and graphite follow from their bonding and structure.

**Step 1 — Diamond:** Each carbon is $sp^3$ hybridized, bonded tetrahedrally to four others in a rigid 3-D covalent network (hard, non-conducting).

**Step 2 — Graphite:** Each carbon is $sp^2$ hybridized, forming planar hexagonal layers with delocalised electrons (soft, conducting).

**Why other options are wrong:** Diamond carbon is $sp^3$ not $sp$; graphite is softer, not harder; their networks are not identical.

**Final Answer:** Diamond is $sp^3$ (3-D) and graphite $sp^2$ (layered) $\Rightarrow \boxed{D}$

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

## Q21.

### Solution

**Concept — $SO_2$ as a bleaching agent:** $SO_2$ bleaches by reduction, using nascent hydrogen in the presence of moisture.

**Step 1 — Mechanism:** $SO_2 + 2H_2O \rightarrow H_2SO_4 + 2[H]$; the nascent hydrogen reduces the coloured substance to a colourless form.

**Step 2 — Temporary nature:** On standing in air the bleached material is reoxidised, so the colour returns. The bleaching is therefore temporary.

**Why other options are wrong:** $SO_2$ does not oxidise or dehydrate the colour, nor merely dissolve it.

**Final Answer:** $SO_2$ bleaches by reduction (temporary) $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q21

## Q22.

### Solution

**Concept — Physical states of the halogens:** At room temperature, $F_2$ and $Cl_2$ are gases, $Br_2$ is a liquid, and $I_2$ is a solid.

**Step 1 — Identify:** Bromine is the only halogen that is liquid at ordinary temperature.

**Why other options are wrong:** Fluorine and chlorine are gases; iodine is a shiny solid that sublimes.

**Final Answer:** Bromine is liquid at room temperature $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q22

## Q23.

### Solution

**Concept — Dichromate as oxidant:** In acidic medium $Cr_2O_7^{2-}$ is reduced, with chromium going from $+6$ to $+3$.

**Step 1 — Half reaction:** $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$.

**Step 2 — Identify the product state:** Each Cr is reduced from $+6$ to $+3$.

**Why other options are wrong:** $+2$ and $0$ are too low (not formed in this reduction); $+7$ is higher than the starting $+6$.

**Final Answer:** Cr is reduced to $+3 \Rightarrow \boxed{\text{A}}$

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

## Q24.

**Solution**

**Concept — Lanthanide contraction:** Across the $4f$ series the poor shielding by $4f$ electrons lets the effective nuclear charge rise steadily.

**Step 1 — Effect:** From Ce to Lu both atomic and $\mathrm{M^{3+}}$ ionic radii decrease gradually.

**Why other options are wrong:** The radii do not increase or stay constant; the decrease is steady, not up-then-down.

**Final Answer:** Radii decrease steadily (lanthanide contraction) $\Rightarrow \boxed{\text{D}}$

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

## Q25.

**Solution**

**Concept — Werner's theory:** Each metal has a primary valence (oxidation state, satisfied by anions) and a secondary valence (coordination number, satisfied by ligands).

**Step 1 — Identify:** The secondary valence is the number of ligand atoms directly bonded to the metal, i.e. the coordination number.

**Why other options are wrong:** The oxidation state is the *primary* valence; unpaired electrons and atomic number are unrelated to Werner's valences.

**Final Answer:** Secondary valence $=$ coordination number $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q25

## Q26.

**Solution**

**Concept — CFSE (octahedral):** Each $t_{2g}$ electron lowers energy by $0.4\,\Delta_o$, each $e_g$ electron raises it by $0.6\,\Delta_o$. CFSE $= (-0.4\,n_{t_{2g}} + 0.6\,n_{e_g})\Delta_o$.

**Step 1 — $d^3$ configuration:** All three electrons occupy $t_{2g}$ ($t_{2g}^3 e_g^0$).

**Step 2 — Compute:** CFSE $= 3 \times (-0.4\,\Delta_o) = -1.2\,\Delta_o$.

**Why other options are wrong:** $-0.6$ and $-0.4$ count too few $t_{2g}$ electrons; $+1.2$ has the wrong sign.

**Final Answer:** CFSE $= -1.2\,\Delta_o \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q26

## Q27.

### Solution

**Concept — IUPAC naming of haloalkanes:** Choose the longest chain, number to give the lowest locant to the substituents, and name halogen and alkyl groups as prefixes.

**Step 1 — Structure:** $(CH_3)_2CHCH_2Cl$ has a three-carbon (propane) chain with a methyl branch on C-2 and Cl on C-1.

**Step 2 — Name:** 1-chloro-2-methylpropane.

**Why other options are wrong:** 2-chlorobutane and 1-chlorobutane assume a four-carbon main chain; 2-chloro-2-methylpropane is the tertiary isomer $(CH_3)_3CCl$.

**Final Answer:** 1-chloro-2-methylpropane $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q27

## Q28.

### Solution

**Concept — Chirality:** A molecule is optically active if it has a carbon bonded to four different groups (an asymmetric/chiral centre).

**Step 1 — Test the options:** In $CH_3CHBrCl$ the central carbon carries $CH_3$, H, Br and Cl — four different groups — so it is chiral.

**Why other options are wrong:** Propane has no asymmetric carbon; in $CH_3CHCl_2$ and $CH_2BrCH_2Br$ every carbon has at least two identical groups, so none is chiral.

**Final Answer:** $CH_3CHBrCl$ is chiral $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q28

## Q29.

### Solution

**Concept — Electromeric effect:** It is a temporary effect in which a complete pair of $\pi$ electrons shifts to one of the doubly bonded atoms only at the moment an attacking reagent approaches.

**Step 1 — Key features:** It is reversible (disappears when the reagent is removed) and involves the full transfer of a $\pi$ pair.

**Why other options are wrong:** Permanent $\sigma$-bond polarisation is the inductive effect; ground-state $\pi$ delocalisation is resonance; $\sigma$–empty-$p$ overlap is hyperconjugation.

**Final Answer:** Temporary complete $\pi$-pair shift on reagent approach $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** **Go Back to Q29**

## Q30.

### Solution

**Concept — Chain isomers:** These differ in the branching of the carbon skeleton.

**Step 1 — Enumerate** $C_5H_{12}$**:** (i) $n$-pentane, (ii) isopentane (2-methylbutane), (iii) neopentane (2,2-dimethylpropane).

**Step 2 — Count:** There are $3$ structural isomers.

**Why other options are wrong:** $2$ misses neopentane; $4$ and $5$ overcount (the rest are duplicates).

**Final Answer:** $3$ isomers $\Rightarrow \boxed{\text{A}}$

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

## Q31.

### Solution

**Concept — Acidity of terminal alkynes:** The terminal ≡C–H hydrogen of an alkyne is weakly acidic because the carbon is $sp$ hybridized (high s-character holds the bonding electrons close to carbon).

**Step 1 — Reaction:** $HC{\equiv}CH + 2[Ag(NH_3)_2]^+ \rightarrow Ag{-}C{\equiv}C{-}Ag\downarrow + \ldots$, the acidic H being replaced by silver.

**Why other options are wrong:** The hydrogen is acidic, not basic or neutral; it is on an $sp$ carbon of a triple bond, not a double bond.

**Final Answer:** The terminal C–H is acidic $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** **Go Back to Q31**

## Q32.

### Solution

**Concept — Hückel's rule:** A planar, cyclic, fully conjugated ring is aromatic if it contains $(4n+2)$ delocalised $\pi$ electrons ($n = 0, 1, 2, \dots$).

**Step 1 — Apply to benzene:** Benzene has $6$ $\pi$ electrons $= 4(1)+2$, so it is aromatic.

**Why other options are wrong:** $4n$ electrons ($4, 8, \dots$) is the anti-aromatic count; $2n$ and $n$ are not Hückel numbers.

**Final Answer:** Aromatic when $\pi$ electrons $= 4n+2 \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q32**

## Q33.

### Solution

**Concept — Wurtz–Fittig reaction:** A mixture of an aryl halide and an alkyl halide treated with sodium in dry ether gives an alkyl-substituted arene.

**Step 1 — Example:** $C_6H_5Br + CH_3Br + 2Na \rightarrow C_6H_5CH_3 + 2NaBr$ (toluene).

**Why other options are wrong:** The Wurtz reaction couples two alkyl halides; Friedel–Crafts uses $AlCl_3$; the Sandmeyer reaction converts diazonium salts to halides.

**Final Answer:** It is the Wurtz–Fittig reaction $\Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q33**

## Q34.

### Solution

**Concept — Directing effect of $-$OH:** The $-$OH group donates electron density into the ring by resonance, activating it and directing electrophiles to the ortho and para positions.

**Step 1 — Resonance:** The oxygen lone pair builds up negative charge at the ortho and para carbons.

**Why other options are wrong:** $-$OH is activating and o/p-directing, not meta-directing or deactivating; it does not give ipso-only substitution.

**Final Answer:** Substitution occurs at ortho and para positions $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q34

## Q35.

**Solution**

**Concept — Ether by dehydration of alcohol:** Heating a primary alcohol with conc. $H_2SO_4$ at $\sim 140\,^\circ\mathrm{C}$ gives a symmetrical ether by intermolecular dehydration.

**Step 1 — Reaction:** $2C_2H_5OH \xrightarrow[140\,^\circ\mathrm{C}]{\text{conc. } H_2SO_4} C_2H_5OC_2H_5 + H_2O.$

**Why other options are wrong:** The method gives *symmetrical* ethers from one primary alcohol (not mixed ethers cleanly); tertiary alcohols dehydrate to alkenes; phenols do not form ethers this way.

**Final Answer:** Symmetrical ethers from primary alcohols $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q35

## Q36.

**Solution**

**Concept — Iodoform test:** A positive iodoform test is given by compounds containing a $CH_3CO-$ (methyl ketone) group or a $CH_3CH(OH)-$ group, plus ethanol and acetaldehyde.

**Step 1 — Examine acetone:** $CH_3COCH_3$ has the $CH_3CO-$ group, so it gives the yellow $CHI_3$ precipitate.

**Why other options are wrong:** Formaldehyde, benzaldehyde and propanal lack the $CH_3CO-$ (or $CH_3CHOH-$) unit, so they fail the test.

**Final Answer:** Acetone gives a positive iodoform test $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q36

## Q37.

**Solution**

**Concept — Decarboxylation:** Heating the sodium salt of a carboxylic acid with soda lime removes $CO_2$ and gives an alkane with one fewer carbon.

**Step 1 — Reaction:** $CH_3COONa + NaOH \xrightarrow{\text{CaO, }\Delta} CH_4 + Na_2CO_3.$

**Why other options are wrong:** Ethane would need a two-carbon residue (e.g. from propanoate); ethanol and acetaldehyde are not decarboxylation products.

**Final Answer:** The product is methane $\Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q37

## Q38.

**Solution**

**Concept — Diazo coupling:** A diazonium salt couples with an electron-rich arene (phenol or aniline) to give a coloured $-\text{N}{=}\text{N}-$ linked product.

**Step 1 — Reaction:** $C_6H_5N_2^+Cl^- + C_6H_5OH \rightarrow$ $p$-hydroxyazobenzene (an orange azo dye) $+HCl$.

**Step 2 — Class:** The $-\text{N}{=}\text{N}-$ group makes it an azo compound (azo dye).

**Why other options are wrong:** It is not an amide, nitro compound or simple amine; the defining feature is the azo $-\text{N}{=}\text{N}-$ bridge.

**Final Answer:** The product is an azo compound (dye) $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q38

## Q39.

**Solution**

**Concept — Denaturation:** Physical or chemical agents (heat, acid, etc.) can disrupt the hydrogen bonds and disulphide/secondary structure of a protein, unfolding it and destroying its biological activity, while the peptide (primary) bonds stay intact.

**Step 1 — Coagulation of albumin:** On boiling an egg, soluble albumin loses its native folded structure and becomes an insoluble solid — this is denaturation.

**Why other options are wrong:** Hydrolysis breaks peptide bonds into amino acids; peptide-bond formation and polymerisation build the protein, the opposite of what happens here.

**Final Answer:** The process is denaturation $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q39

## Q40.

### Solution

**Concept — Addition polymers:** Teflon (PTFE) forms by addition polymerisation of a fluorinated ethene.

**Step 1 — Identify the monomer:** Repeated $\mathrm{CF_2{=}CF_2}$ (tetrafluoroethene) units link to give $-(\mathrm{CF_2}-\mathrm{CF_2})_n-$.

**Why other options are wrong:** Vinyl chloride gives PVC; ethene gives polythene; styrene gives polystyrene.

**Final Answer:** The monomer is tetrafluoroethene $\Rightarrow \boxed{\mathrm{C}}$

Answer: (C) **Go Back to Q40**

## Answer Key

| Q | Ans | Q | Ans | Q | Ans | Q | Ans | Q | Ans |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | 2 | B | 3 | C | 4 | D | 5 | B |
| 6 | A | 7 | D | 8 | C | 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 | B | 22 | C | 23 | A | 24 | D | 25 | B |
| 26 | A | 27 | C | 28 | D | 29 | B | 30 | A |
| 31 | C | 32 | D | 33 | A | 34 | B | 35 | C |
| 36 | D | 37 | A | 38 | B | 39 | D | 40 | C |