

# PGIMER BSc Nursing Chemistry

## Sample Paper – 3

Duration: 23 Minutes

Maximum Marks: 25

### Instructions

- This paper contains **25** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry portion of the **PGIMER BSc Nursing** entrance exam.
- Each correct answer carries **+1 mark**. **0.25 mark** is deducted for every incorrect answer. Unattempted questions carry **0 marks**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 and 12 (NCERT) Chemistry**.
- The exam is conducted as a computer-based test. Personal calculators, mobile phones, log tables, and other electronic gadgets are strictly prohibited.

**Q1.** An organic compound contains carbon 40%, hydrogen 6.7% and oxygen 53.3% by mass (atomic masses: C = 12, H = 1, O = 16). Its empirical formula is:

- (A) CH<sub>2</sub>O
- (B) CHO
- (C) C<sub>2</sub>H<sub>4</sub>O<sub>2</sub>
- (D) CH<sub>3</sub>O

**Q2.** For the hydrogen atom the energy of the  $n$ th Bohr orbit is  $E_n = -\frac{13.6}{n^2}$  eV. The energy of the electron in the second orbit ( $n = 2$ ) is:

- (A) -13.6 eV
- (B) -3.4 eV
- (C) -1.51 eV



(D)  $-0.85 \text{ eV}$

**Q3.** The correct order of *increasing* electronegativity among the elements boron, carbon, nitrogen and oxygen is:

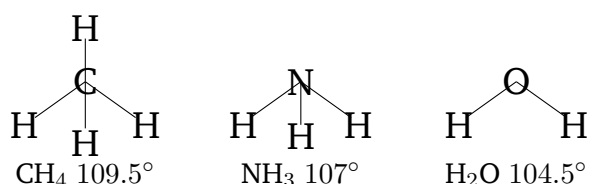
(A)  $\text{N} < \text{C} < \text{B} < \text{O}$

(B)  $\text{B} < \text{C} < \text{N} < \text{O}$

(C)  $\text{O} < \text{N} < \text{C} < \text{B}$

(D)  $\text{C} < \text{B} < \text{N} < \text{O}$

**Q4.** Compare the bond angles of methane, ammonia and water (shown below). The correct order of bond angle is:



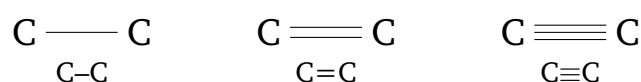
(A)  $\text{H}_2\text{O} > \text{NH}_3 > \text{CH}_4$

(B)  $\text{NH}_3 > \text{CH}_4 > \text{H}_2\text{O}$

(C)  $\text{CH}_4 > \text{NH}_3 > \text{H}_2\text{O}$

(D)  $\text{CH}_4 > \text{H}_2\text{O} > \text{NH}_3$

**Q5.** Considering the carbon-carbon single, double and triple bonds shown below, the correct order of bond *length* is:



(A)  $\text{C}\equiv\text{C} > \text{C}=\text{C} > \text{C}-\text{C}$

(B)  $\text{C}-\text{C} > \text{C}=\text{C} > \text{C}\equiv\text{C}$

(C)  $\text{C}=\text{C} > \text{C}-\text{C} > \text{C}\equiv\text{C}$

(D)  $\text{C}-\text{C} > \text{C}\equiv\text{C} > \text{C}=\text{C}$



- Q6.** A gas absorbs 100 J of heat from its surroundings and does 40 J of work on the surroundings. Using the first law of thermodynamics,  $\Delta U = q + w$ , the change in internal energy of the gas is:
- (A) 140 J  
(B) 60 J  
(C) -60 J  
(D) 40 J
- Q7.** For the gas-phase equilibrium  $\text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g)$ , the correct expression for the equilibrium constant  $K_c$  is:
- (A)  $\frac{[\text{N}_2][\text{H}_2]^3}{[\text{NH}_3]^2}$   
(B)  $\frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]}$   
(C)  $\frac{[\text{NH}_3]}{[\text{N}_2][\text{H}_2]^3}$   
(D)  $\frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$
- Q8.** In acidic medium, the permanganate ion is reduced according to  $\text{MnO}_4^- + 8\text{H}^+ + 5e^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$ . The  $n$ -factor (number of electrons gained per ion) of  $\text{KMnO}_4$  here is:
- (A) 1  
(B) 3  
(C) 5  
(D) 7
- Q9.** Using Kohlrausch's law of independent migration of ions, the limiting molar conductivity of  $\text{NaCl}$ , given  $\lambda_{\text{Na}^+}^\circ = 50.1$  and  $\lambda_{\text{Cl}^-}^\circ = 76.3 \text{ S cm}^2 \text{ mol}^{-1}$ , is:
- (A)  $76.3 \text{ S cm}^2 \text{ mol}^{-1}$



- (B)  $50.1 \text{ S cm}^2 \text{ mol}^{-1}$   
(C)  $126.4 \text{ S cm}^2 \text{ mol}^{-1}$   
(D)  $26.2 \text{ S cm}^2 \text{ mol}^{-1}$

**Q10.** For a first-order reaction the rate constant is  $k = 2.31 \times 10^{-3} \text{ s}^{-1}$ . Using  $t_{1/2} = \frac{0.693}{k}$ , the half-life of the reaction is:

- (A) 150 s  
(B) 300 s  
(C) 600 s  
(D) 30 s

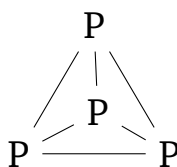
**Q11.** A solution is made by mixing 2 mol of ethanol with 8 mol of water. The mole fraction of ethanol in the solution is:

- (A) 0.8  
(B) 0.5  
(C) 0.2  
(D) 0.1

**Q12.** The coordination number of the central cobalt ion in the complex  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$  is:

- (A) 6  
(B) 3  
(C) 4  
(D) 2

**Q13.** White phosphorus exists as discrete  $\text{P}_4$  molecules whose four atoms are arranged as shown below. The shape of the  $\text{P}_4$  molecule is:



- (A) tetrahedral
- (B) square planar
- (C) linear
- (D) octahedral

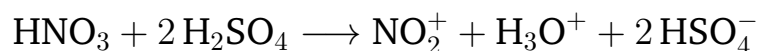
**Q14.** Among the following  $3d$  transition metals, the one that exhibits the maximum number of variable oxidation states is:

- (A) Sc
- (B) Ti
- (C) Cr
- (D) Mn

**Q15.** On account of the diagonal relationship, lithium shows a close resemblance in many of its properties to which of the following elements?

- (A) Mg
- (B) Na
- (C) K
- (D) Ca

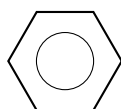
**Q16.** In the nitration of benzene the nitrating mixture generates the attacking species as shown. The electrophile responsible for nitration is:



- (A)  $\text{NO}_2^-$  (nitrite ion)
- (B)  $\text{NO}_3^-$  (nitrate ion)
- (C)  $\text{HNO}_3$  (nitric acid)
- (D)  $\text{NO}_2^+$  (nitronium ion)

**Q17.** According to Huckel's  $(4n + 2)\pi$ -electron rule, which of the following cyclic species is aromatic?





benzene

- (A) cyclobutadiene  
(B) cyclooctatetraene  
(C) cyclopentadienyl cation  
(D) benzene
- Q18.** When bromoethane ( $\text{CH}_3\text{CH}_2\text{Br}$ ) is heated with aqueous potassium hydroxide, the major organic product formed by nucleophilic substitution is:
- (A) ethene  
(B) ethanol  
(C) chloroethane  
(D) diethyl ether
- Q19.** The correct order for the ease of acid-catalysed dehydration of alcohols is:
- (A) primary > secondary > tertiary  
(B) secondary > tertiary > primary  
(C) primary > tertiary > secondary  
(D) tertiary > secondary > primary
- Q20.** The Cannizzaro reaction is given only by aldehydes that have no  $\alpha$ -hydrogen atom. Which of the following undergoes the Cannizzaro reaction?
- (A) acetaldehyde ( $\text{CH}_3\text{CHO}$ )  
(B) propanal ( $\text{CH}_3\text{CH}_2\text{CHO}$ )  
(C) benzaldehyde ( $\text{C}_6\text{H}_5\text{CHO}$ )



(D) acetone ( $\text{CH}_3\text{COCH}_3$ )

**Q21.** When sodium acetate ( $\text{CH}_3\text{COONa}$ ) is heated strongly with soda lime, it undergoes decarboxylation to give:

(A) ethane

(B) methane

(C) ethene

(D) acetylene

**Q22.** The carbylamine test, in which a foul-smelling isocyanide is formed on heating with chloroform and alcoholic KOH, is given by:

(A) primary amines

(B) secondary amines

(C) tertiary amines

(D) quaternary ammonium salts

**Q23.** In aqueous solution, near its isoelectric point, an amino acid such as glycine exists predominantly as:

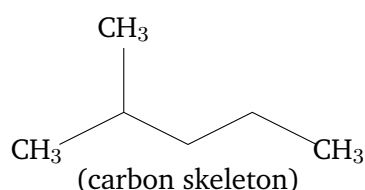
(A) a neutral, uncharged molecule

(B) an anion only

(C) a zwitterion (dipolar ion)

(D) a cation only

**Q24.** Applying the lowest-locant rule, the IUPAC name of the branched alkane whose carbon skeleton is shown below is:



- (A) 3-methylpentane
- (B) hexane
- (C) 4-methylpentane
- (D) 2-methylpentane

**Q25.** The most suitable technique to purify a solid such as camphor, which sublimes on heating, from a small amount of a non-volatile impurity is:

- (A) sublimation
- (B) simple distillation
- (C) column chromatography
- (D) fractional distillation



## Detailed Solutions

Q1.

## Solution

**Concept — Empirical formula:** Divide each element's mass percentage by its atomic mass to get relative moles, then divide by the smallest value to get the simplest whole-number ratio.

**Step 1 — Divide percentage by atomic mass:** Carbon:  $\frac{40}{12} = 3.33$ .

Hydrogen:  $\frac{6.7}{1} = 6.7$ .

Oxygen:  $\frac{53.3}{16} = 3.33$ .

**Step 2 — Divide by the smallest (3.33):** C =  $\frac{3.33}{3.33} = 1$ .

H =  $\frac{6.7}{3.33} = 2$ .

O =  $\frac{3.33}{3.33} = 1$ .

**Step 3 — Write the formula:** The ratio C : H : O is 1 : 2 : 1, so the empirical formula is CH<sub>2</sub>O.

**Why other options are wrong:**

- Option B (CHO): hydrogen ratio is wrong (should be 2, not 1).
- Option C (C<sub>2</sub>H<sub>4</sub>O<sub>2</sub>): this is a molecular formula, not the simplest ratio.
- Option D (CH<sub>3</sub>O): does not match the calculated ratio.

**Final Answer:** The empirical formula is CH<sub>2</sub>O ⇒ A

**Answer: (A)** [Go Back to Q1](#)

Q2.

## Solution

**Concept — Bohr energy levels:** The energy of an electron in the  $n$ th orbit of hydrogen is  $E_n = -\frac{13.6}{n^2}$  eV; the energy becomes less negative as  $n$  increases.

**Step 1 — Substitute  $n = 2$ :**

$$E_2 = -\frac{13.6}{2^2}.$$



**Step 2 — Evaluate the square:**

$$E_2 = -\frac{13.6}{4}.$$

**Step 3 — Divide:**

$$E_2 = -3.4 \text{ eV}.$$

**Why other options are wrong:**

- Option A (−13.6 eV): this is the ground state ( $n = 1$ ).
- Option C (−1.51 eV): this is the third orbit ( $n = 3$ ).
- Option D (−0.85 eV): this is the fourth orbit ( $n = 4$ ).

**Final Answer:**  $E_2 = -3.4 \text{ eV} \Rightarrow$

[Go Back to Q2](#)

**Q3.**

### Solution

**Concept — Electronegativity trend:** Across a period, electronegativity increases as nuclear charge rises and atomic size falls.

**Step 1 — Place the elements:** Boron, carbon, nitrogen and oxygen all lie in period 2, in that left-to-right order.

**Step 2 — Recall the approximate values:** B = 2.0, C = 2.5, N = 3.0, O = 3.5.

**Step 3 — Arrange in increasing order:** Electronegativity increases as  $B < C < N < O$ .

**Why other options are wrong:**

- Option A: places nitrogen below carbon and boron, which is incorrect.
- Option C: this is the decreasing (reverse) order.
- Option D: places boron above carbon, which is wrong.

**Final Answer:** The increasing order is  $B < C < N < O \Rightarrow$

[Go Back to Q3](#)



Q4.

**Solution**

**Concept — Bond angle and lone pairs:** All three molecules have an  $sp^3$  central atom, but lone pairs compress the bond angle; more lone pairs mean a smaller angle.

**Step 1 — Count lone pairs:**  $CH_4$  has no lone pair,  $NH_3$  has one lone pair,  $H_2O$  has two lone pairs on the central atom.

**Step 2 — Apply lone-pair repulsion:** Lone pairs repel bonding pairs more strongly, pushing the bonds closer together.

More lone pairs therefore give a smaller bond angle.

**Step 3 — Order the angles:**  $CH_4$  ( $109.5^\circ$ ) >  $NH_3$  ( $107^\circ$ ) >  $H_2O$  ( $104.5^\circ$ ).

**Why other options are wrong:**

- Option A: reverses the order; water cannot have the largest angle.
- Option B: places ammonia above methane, which is incorrect.
- Option D: places water above ammonia, contradicting the lone-pair count.

**Final Answer:**  $CH_4 > NH_3 > H_2O \Rightarrow$   C

**Answer:** (C) [Go Back to Q4](#)

Q5.

**Solution**

**Concept — Bond order and bond length:** As bond order increases, the atoms are pulled closer together, so the bond becomes shorter (and stronger).

**Step 1 — List the bond orders:** C–C is order 1, C=C is order 2, C≡C is order 3.

**Step 2 — Relate to bond length:** Higher bond order  $\Rightarrow$  shorter bond. So the triple bond is shortest and the single bond longest.

**Step 3 — Arrange the lengths:** C–C > C=C > C≡C.

**Why other options are wrong:**

- Option A: this is the order of bond *strength*, the reverse of length.
- Option C: places the double bond above the single bond, which is wrong.
- Option D: places the triple bond above the double bond, which is wrong.

**Final Answer:** C–C > C=C > C≡C  $\Rightarrow$   B



Answer: (B) [Go Back to Q5](#)

Q6.

### Solution

**Concept — First law of thermodynamics:**  $\Delta U = q + w$ , where  $q$  is heat added to the system and  $w$  is work done *on* the system. Work done *by* the system is negative.

**Step 1 — Assign the heat term:** Heat is absorbed by the gas, so  $q = +100$  J.

**Step 2 — Assign the work term:** The gas does 40 J of work on the surroundings, so work done on the gas is  $w = -40$  J.

**Step 3 — Apply the formula:**

$$\Delta U = q + w = (+100) + (-40).$$

$$\Delta U = 60 \text{ J.}$$

**Why other options are wrong:**

- Option A (140 J): adds the work instead of subtracting it.
- Option C (-60 J): uses the wrong signs throughout.
- Option D (40 J): reports only the work term.

**Final Answer:**  $\Delta U = 60 \text{ J} \Rightarrow$

Answer: (B) [Go Back to Q6](#)

Q7.

### Solution

**Concept — Equilibrium constant:** For a balanced reaction,  $K_c$  equals the product of the product concentrations over the reactant concentrations, each raised to the power of its stoichiometric coefficient.

**Step 1 — Identify products and reactants:** Product:  $\text{NH}_3$  with coefficient 2. Reactants:  $\text{N}_2$  (coefficient 1) and  $\text{H}_2$  (coefficient 3).

**Step 2 — Place products in the numerator, reactants in the denominator:**

$$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2]^1 [\text{H}_2]^3}.$$



**Step 3 — Simplify the powers:**

$$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$

**Why other options are wrong:**

- Option A: products and reactants are inverted.
- Option B: the power of  $\text{H}_2$  is missing.
- Option C: the power of  $\text{NH}_3$  is wrong (should be 2).

**Final Answer:**  $K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} \Rightarrow \boxed{\text{D}}$

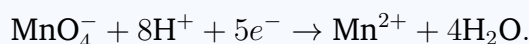
**Answer: (D)** [Go Back to Q7](#)

**Q8.**

### Solution

**Concept —  $n$ -factor in redox:** For an oxidising agent the  $n$ -factor equals the number of electrons gained per formula unit, read directly from the balanced half-reaction.

**Step 1 — Read the half-reaction:**



**Step 2 — Track the oxidation state of Mn:** Manganese goes from +7 in  $\text{MnO}_4^-$  to +2 in  $\text{Mn}^{2+}$ .

**Step 3 — Count the change:** The change is  $7 - 2 = 5$ , so 5 electrons are gained and the  $n$ -factor is 5.

**Why other options are wrong:**

- Option A (1): would mean a one-electron change.
- Option B (3): this is the  $n$ -factor of  $\text{MnO}_4^-$  in neutral/weakly basic medium ( $+7 \rightarrow +4$ ).
- Option D (7): wrongly takes the full oxidation number rather than the change.

**Final Answer:** The  $n$ -factor is 5  $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** [Go Back to Q8](#)



Q9.

**Solution**

**Concept — Kohlrausch's law:** The limiting molar conductivity of an electrolyte is the sum of the limiting molar conductivities of its cation and anion.

**Step 1 — Write the law for NaCl:**

$$\Lambda_m^\circ(\text{NaCl}) = \lambda_{\text{Na}^+}^\circ + \lambda_{\text{Cl}^-}^\circ.$$

**Step 2 — Substitute the values:**

$$\Lambda_m^\circ = 50.1 + 76.3.$$

**Step 3 — Add:**

$$\Lambda_m^\circ = 126.4 \text{ S cm}^2 \text{ mol}^{-1}.$$

**Why other options are wrong:**

- Option A (76.3): uses only the chloride value.
- Option B (50.1): uses only the sodium value.
- Option D (26.2): subtracts the values instead of adding.

**Final Answer:**  $\Lambda_m^\circ = 126.4 \text{ S cm}^2 \text{ mol}^{-1} \Rightarrow \boxed{\text{C}}$

**Answer: (C)** [Go Back to Q9](#)

Q10.

**Solution**

**Concept — First-order half-life:** For a first-order reaction the half-life is independent of concentration and is given by  $t_{1/2} = \frac{0.693}{k}$ .

**Step 1 — Write the formula:**

$$t_{1/2} = \frac{0.693}{k}.$$

**Step 2 — Substitute  $k = 2.31 \times 10^{-3} \text{ s}^{-1}$ :**

$$t_{1/2} = \frac{0.693}{2.31 \times 10^{-3}}.$$



**Step 3 — Divide:**

$$t_{1/2} = 300 \text{ s.}$$

**Why other options are wrong:**

- Option A (150 s): would need  $k$  twice as large.
- Option C (600 s): would need  $k$  half as large.
- Option D (30 s): off by a factor of ten.

**Final Answer:**  $t_{1/2} = 300 \text{ s} \Rightarrow$

**Answer: (B)** [Go Back to Q10](#)

**Q11.**

### Solution

**Concept — Mole fraction:** The mole fraction of a component is its number of moles divided by the total number of moles of all components.

**Step 1 — Find the total moles:**

$$n_{\text{total}} = 2 + 8 = 10 \text{ mol.}$$

**Step 2 — Apply the definition for ethanol:**

$$x_{\text{ethanol}} = \frac{n_{\text{ethanol}}}{n_{\text{total}}} = \frac{2}{10}.$$

**Step 3 — Simplify:**

$$x_{\text{ethanol}} = 0.2.$$

**Why other options are wrong:**

- Option A (0.8): this is the mole fraction of water, not ethanol.
- Option B (0.5): would require equal moles of the two.
- Option D (0.1): divides by 20 instead of 10.

**Final Answer:**  $x_{\text{ethanol}} = 0.2 \Rightarrow$

**Answer: (C)** [Go Back to Q11](#)



Q12.

**Solution**

**Concept — Coordination number:** The coordination number is the number of ligand donor atoms directly bonded to the central metal ion.

**Step 1 — Identify the ligands inside the brackets:** The complex ion is  $[\text{Co}(\text{NH}_3)_6]^{3+}$ , containing six ammonia ligands.

**Step 2 — Count the donor atoms:** Each  $\text{NH}_3$  is monodentate and donates one nitrogen lone pair, so six ligands give six bonds.

**Step 3 — State the coordination number:** The coordination number of cobalt is 6.

**Why other options are wrong:**

- Option B (3): this is the charge of the complex, not the coordination number.
- Option C (4): would require only four ligands.
- Option D (2): would require only two ligands.

**Final Answer:** The coordination number is 6  $\Rightarrow$

**Answer: (A)** [Go Back to Q12](#)

Q13.

**Solution**

**Concept — Structure of white phosphorus:** White phosphorus is made of discrete  $\text{P}_4$  units in which the four phosphorus atoms sit at the corners of a tetrahedron, each bonded to the other three.

**Step 1 — Examine the bonding:** In  $\text{P}_4$  there are six P–P single bonds, one along each edge of the figure shown.

**Step 2 — Identify the shape:** Four atoms each joined to the other three describe a regular tetrahedron, with a P–P–P angle of  $60^\circ$ .

**Why other options are wrong:**

- Option B (square planar): would place all four atoms in one plane, which  $\text{P}_4$  is not.
- Option C (linear): impossible for four mutually bonded atoms.
- Option D (octahedral): needs six vertices, not four.

**Final Answer:**  $\text{P}_4$  is tetrahedral  $\Rightarrow$



Answer: (A) [Go Back to Q13](#)

Q14.

### Solution

**Concept — Variable oxidation states:** A transition metal shows the most oxidation states when it has the largest number of unpaired  $3d$  and  $4s$  electrons available for bonding, which peaks near the middle of the series.

**Step 1 — Write the valence configurations:** Sc is  $3d^14s^2$ , Ti is  $3d^24s^2$ , Cr is  $3d^54s^1$ , Mn is  $3d^54s^2$ .

**Step 2 — Compare available electrons:** Manganese has seven electrons ( $3d^54s^2$ ) that can take part in bonding, the most of these four.

**Step 3 — Conclude:** Manganese therefore shows the widest range of oxidation states, from +2 up to +7.

**Why other options are wrong:**

- Option A (Sc): shows essentially only +3.
- Option B (Ti): shows mainly +3 and +4.
- Option C (Cr): shows a wide range but fewer states than Mn (commonly up to +6).

**Final Answer:** Manganese shows the maximum oxidation states  $\Rightarrow$

Answer: (D) [Go Back to Q14](#)

Q15.

### Solution

**Concept — Diagonal relationship:** The first element of a group often resembles the second element of the next group (diagonally placed) because the two have similar size-to-charge ratios.

**Step 1 — Locate lithium's diagonal partner:** Lithium (group 1) is diagonally related to magnesium (group 2).

**Step 2 — Recall shared properties:** Both form covalent, slightly soluble compounds; both nitrides ( $\text{Li}_3\text{N}$ ,  $\text{Mg}_3\text{N}_2$ ) form directly with nitrogen, and both carbonates decompose on heating.

**Why other options are wrong:**



- Option B (Na) and Option C (K): these are group-1 neighbours, related by group trends, not the diagonal relationship.
- Option D (Ca): magnesium, not calcium, is lithium's diagonal partner.

**Final Answer:** Lithium resembles magnesium  $\Rightarrow$  A

**Answer: (A)** [Go Back to Q15](#)

Q16.

### Solution

**Concept — Electrophilic aromatic substitution:** Nitration proceeds through an electron-deficient species (an electrophile) generated when nitric acid is protonated by sulphuric acid.

**Step 1 — Read the generating reaction:**



**Step 2 — Identify the attacking species:** The nitronium ion  $\text{NO}_2^+$  is positively charged and electron-deficient, so it acts as the electrophile that attacks the benzene ring.

**Why other options are wrong:**

- Option A ( $\text{NO}_2^-$ ): an anion, electron-rich, cannot be an electrophile.
- Option B ( $\text{NO}_3^-$ ): also an anion and not the attacking species.
- Option C ( $\text{HNO}_3$ ): the source, but it must first form  $\text{NO}_2^+$  to react.

**Final Answer:** The electrophile is the nitronium ion  $\text{NO}_2^+ \Rightarrow$  D

**Answer: (D)** [Go Back to Q16](#)

Q17.

### Solution

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

**Step 1 — Count  $\pi$  electrons in benzene:** Benzene has three C=C double bonds in the ring, giving  $6 \pi$  electrons.

**Step 2 — Test the rule:** With  $n = 1$ ,  $4n + 2 = 6$ , which matches; benzene is planar and fully conjugated, so it is aromatic.



Why other options are wrong:

- Option A (cyclobutadiene):  $4\pi$  electrons ( $4n$ ), antiaromatic.
- Option B (cyclooctatetraene):  $8\pi$  electrons and non-planar (tub shape), non-aromatic.
- Option C (cyclopentadienyl cation):  $4\pi$  electrons, not  $4n+2$ , so not aromatic.

Final Answer: Benzene is aromatic  $\Rightarrow$

Answer: (D) [Go Back to Q17](#)

Q18.

### Solution

**Concept — Nucleophilic substitution of haloalkanes:** Aqueous KOH supplies hydroxide ion, which replaces the halogen to give an alcohol (substitution). Alcoholic KOH would instead cause elimination.

**Step 1 — Identify the nucleophile:** In aqueous KOH the hydroxide ion  $\text{OH}^-$  is the attacking nucleophile.

**Step 2 — Write the substitution:**



**Step 3 — Name the product:** The product is ethanol.

Why other options are wrong:

- Option A (ethene): this is the elimination product, formed with *alcoholic* KOH.
- Option C (chloroethane): no chlorine source is present.
- Option D (diethyl ether): would need a Williamson synthesis with an alkoxide, not aqueous KOH.

Final Answer: The product is ethanol  $\Rightarrow$

Answer: (B) [Go Back to Q18](#)



Q19.

**Solution**

**Concept — Dehydration of alcohols:** Acid-catalysed dehydration goes through a carbocation; the more stable the carbocation, the easier the dehydration.

**Step 1 — Relate alcohol type to carbocation:** A tertiary alcohol forms a tertiary carbocation, a secondary alcohol a secondary carbocation, and a primary alcohol a primary carbocation.

**Step 2 — Order carbocation stability:** Tertiary > secondary > primary, because more alkyl groups stabilise the positive charge.

**Step 3 — Conclude the ease of dehydration:** Ease of dehydration follows the same order: tertiary > secondary > primary.

**Why other options are wrong:**

- Option A: this is the reverse (incorrect) order.
- Option B: misplaces the primary alcohol and the order.
- Option C: places tertiary above secondary but primary at the top, which is wrong.

**Final Answer:** tertiary > secondary > primary ⇒

**Answer: (D)** [Go Back to Q19](#)

Q20.

**Solution**

**Concept — Cannizzaro reaction:** This is a base-induced disproportionation of aldehydes that lack an  $\alpha$ -hydrogen; one molecule is oxidised to an acid salt and another reduced to an alcohol.

**Step 1 — Check for  $\alpha$ -hydrogens:** Benzaldehyde,  $C_6H_5CHO$ , has no hydrogen on the carbon next to the carbonyl, so it has no  $\alpha$ -hydrogen.

**Step 2 — Apply the requirement:** Only aldehydes without an  $\alpha$ -hydrogen undergo the Cannizzaro reaction, so benzaldehyde qualifies.

**Why other options are wrong:**

- Option A (acetaldehyde) and Option B (propanal): both have  $\alpha$ -hydrogens, so they undergo aldol reactions instead.
- Option D (acetone): a ketone with  $\alpha$ -hydrogens; it does not give the Cannizzaro reaction.



**Final Answer:** Benzaldehyde undergoes the Cannizzaro reaction  $\Rightarrow$

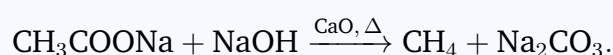
**Answer:** (C) [Go Back to Q20](#)

Q21.

### Solution

**Concept — Decarboxylation:** Heating the sodium salt of a carboxylic acid with soda lime (NaOH + CaO) removes the carboxyl group as  $\text{Na}_2\text{CO}_3$ , leaving a hydrocarbon with one fewer carbon.

**Step 1 — Write the reaction:**



**Step 2 — Identify the hydrocarbon:** The two-carbon acetate loses  $\text{CO}_2$  (as carbonate) and gives the one-carbon hydrocarbon, methane.

**Why other options are wrong:**

- Option A (ethane): would need a two-carbon product, but decarboxylation removes a carbon.
- Option C (ethene): an alkene is not formed in this reaction.
- Option D (acetylene): requires a different preparation entirely.

**Final Answer:** Sodium acetate gives methane  $\Rightarrow$

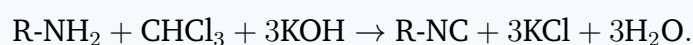
**Answer:** (B) [Go Back to Q21](#)

Q22.

### Solution

**Concept — Carbylamine test:** A primary amine, when warmed with chloroform and alcoholic KOH, forms an isocyanide (carbylamine) with an offensive smell; this is a test specific to primary amines.

**Step 1 — Write the reaction type:**



**Step 2 — Note the requirement:** The reaction needs two N-H bonds on the same nitrogen, which only primary amines possess.



**Why other options are wrong:**

- Option B (secondary amines): have only one N–H bond and do not give the test.
- Option C (tertiary amines): have no N–H bond, so no reaction.
- Option D (quaternary ammonium salts): have no N–H bond and no lone pair available.

**Final Answer:** Primary amines give the carbylamine test  $\Rightarrow$

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**Q23.****Solution**

**Concept — Zwitterion:** An amino acid has both an acidic -COOH group and a basic  $-\text{NH}_2$  group; near the isoelectric point a proton transfers internally to give a dipolar ion with no net charge.

**Step 1 — Show the internal proton transfer:** The carboxyl group loses a proton ( $-\text{COO}^-$ ) and the amino group gains it ( $-\text{NH}_3^+$ ).

**Step 2 — Describe the species:** The molecule then carries both a positive and a negative charge but is overall neutral; this is the zwitterion.

**Why other options are wrong:**

- Option A (neutral, uncharged): ignores the separated + and - charges that actually exist.
- Option B (anion only): occurs in basic solution, not at the isoelectric point.
- Option D (cation only): occurs in acidic solution, not at the isoelectric point.

**Final Answer:** An amino acid exists as a zwitterion  $\Rightarrow$

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Q24.

**Solution**

**Concept — Lowest-locant rule:** Choose the longest chain as the parent and number it from the end that gives the substituents the lowest set of locants.

**Step 1 — Find the longest chain:** The skeleton is a five-carbon chain,  $\text{CH}_3\text{-CH}(\text{CH}_3)\text{-CH}_2\text{-CH}_2\text{-CH}_3$ , with one methyl branch, so the parent is pentane.

**Step 2 — Number from each end:** From the left, the methyl group is on C-2; from the right, it would be on C-4.

**Step 3 — Apply the lowest-locant rule:** The locant 2 is lower than 4, so the methyl group is at position 2, giving 2-methylpentane.

**Why other options are wrong:**

- Option A (3-methylpentane): wrong locant; the branch is not at C-3.
- Option B (hexane): ignores the branch and miscounts the chain.
- Option C (4-methylpentane): numbers from the wrong end, against the lowest-locant rule.

**Final Answer:** The compound is 2-methylpentane  $\Rightarrow$

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Q25.

**Solution**

**Concept — Sublimation:** A solid that passes directly from solid to vapour on heating (and back on cooling) can be separated from a non-volatile impurity by sublimation.

**Step 1 — Match the property to the method:** Camphor sublimes readily, while a non-volatile impurity does not, so heating lets the camphor vaporise and recondense on a cool surface, leaving the impurity behind.

**Step 2 — Select the technique:** This selective vaporisation and recondensation is exactly sublimation.

**Why other options are wrong:**

- Option B (simple distillation): used to separate a liquid from non-volatile impurities, not a subliming solid.
- Option C (column chromatography): used to separate components with different adsorption, an unnecessarily elaborate method here.



- Option D (fractional distillation): separates two miscible liquids of close boiling points.

**Final Answer:** Camphor is purified by sublimation ⇒

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## Answer Key

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

