KEAM Chemistry

Sample Paper – 1

Duration: 36 Minutes **Maximum Marks: 120**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry portion of **KEAM** entrance.
- Each correct answer carries **+4 marks**. There is **a penalty of** -1 **mark** for each incorrect answer. Unattempted questions carry no penalty.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 & 12 (NCERT / Kerala State Board) — Physical, Inorganic and Organic Chemistry.**
- Use of mobile phones, personal calculators, log tables, or any electronic gadgets is strictly prohibited inside the examination hall.

Questions (Q1 – Q30)

Q1. A compound contains 40.0% carbon, 6.67% hydrogen, and 53.33% oxygen by mass. The empirical formula of the compound is: (Atomic masses: C $= 12$, H $= 1$, O $= 16$)

(A) CH_2O_2
(B) CH_2O
(C) C_2H_4O
(D) CHO

Q2. The energy of an electron in the second Bohr orbit of a hydrogen atom is -3.4 eV. The energy of the electron in the fourth Bohr orbit is:

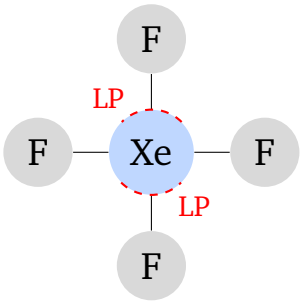
(A) -0.85 eV
(B) -1.70 eV
(C) -6.80 eV

(D) $-0.425\ \text{eV}$

Q3. In the trigonal bipyramidal molecule PCl_5, the bond angle between two equatorial $\text{P}-\text{Cl}$ bonds is:

(A) 90°
(B) 109.5°
(C) 120°
(D) 180°

Q4. The structure of XeF_4 drawn using VSEPR theory is shown below, where dashed arcs represent lone pairs (LP) on the central Xe atom. The molecular shape of XeF_4 is:



(A) Tetrahedral
(B) See-saw
(C) Square pyramidal
(D) Square planar

Q5. The hybridization of the central sulfur atom in SF_6 is:

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

Q6. A gas occupies $4.0\ \text{L}$ at $300\ \text{K}$ and $2\ \text{atm}$ pressure. What volume will the same amount of gas occupy at $600\ \text{K}$ and $1\ \text{atm}$?

(A) $8\ \text{L}$

(B) 16 L
(C) 4 L
(D) 32 L

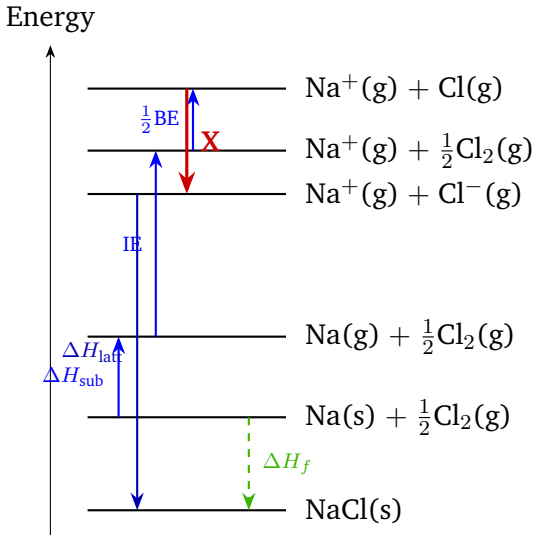
Q7. Given the thermochemical equations:

$$\mathrm{C(s) + O_2(g) \rightarrow CO_2(g)}, \quad \Delta H_1 = -393.5\ \mathrm{kJ\,mol^{-1}}$$
$$\mathrm{C(s) + \tfrac{1}{2}\,O_2(g) \rightarrow CO(g)}, \quad \Delta H_2 = -110.5\ \mathrm{kJ\,mol^{-1}}$$

Using Hess's law, the standard enthalpy for $\mathrm{CO(g) + \frac{1}{2}\,O_2(g) \rightarrow CO_2(g)}$ is:

(A) $+283.0\ \mathrm{kJ\,mol^{-1}}$
(B) $-504.0\ \mathrm{kJ\,mol^{-1}}$
(C) $-283.0\ \mathrm{kJ\,mol^{-1}}$
(D) $-110.5\ \mathrm{kJ\,mol^{-1}}$

Q8. The schematic energy level diagram below shows the Born-Haber cycle for the formation of $\mathrm{NaCl(s)}$. The arrow labelled **X** represents which step?



(A) Sublimation enthalpy of Na
(B) Ionization enthalpy of Na
(C) Bond dissociation enthalpy of $\mathrm{Cl_2}$
(D) Electron gain enthalpy (electron affinity) of Cl

Q9. For the equilibrium $\mathrm{N_2(g) + 3\,H_2(g) \rightleftharpoons 2\,NH_3(g)}$, if the pressure is increased at constant temperature, the equilibrium will:

(A) Shift forward, increasing $[NH_3]$
(B) Shift backward, increasing $[H_2]$
(C) Remain unchanged, since temperature is constant
(D) Shift forward then backward alternately

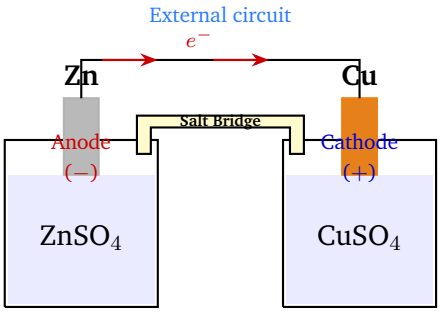
Q10. The K_a of acetic acid is 1.8×10^{-5}. The pH of a 0.1 M aqueous solution of acetic acid is approximately: (use $\log 1.34 = 0.127$)

(A) 5.00
(B) 4.00
(C) 2.87
(D) 3.50

Q11. The standard reduction potentials are: $E^\circ(Zn^{2+}/Zn) = -0.76$ V and $E^\circ(Cu^{2+}/Cu) = +0.34$ V. The standard EMF of the Daniell cell $Zn \,|\, Zn^{2+} \,||\, Cu^{2+} \,|\, Cu$ is:

(A) -0.42 V
(B) 1.10 V
(C) 0.42 V
(D) -1.10 V

Q12. The diagram below shows a Daniell cell. Based on the diagram, which statement is correct?



(A) Zn is the anode; oxidation occurs at it
(B) Cu is the anode; reduction occurs at it
(C) The salt bridge prevents ion migration between the two solutions
(D) Conventional current flows from the Zn electrode to the Cu electrode in the external circuit

Q13. For the reaction $\mathrm{A} + \mathrm{B} \rightarrow \mathrm{Products}$, the following initial rate data were collected:

Experiment	[A] (M)	[B] (M)	Rate ($\mathrm{M\,s^{-1}}$)
1	0.10	0.10	2.0×10^{-3}
2	0.20	0.10	8.0×10^{-3}
3	0.10	0.20	2.0×10^{-3}

The order of reaction with respect to A is:

(A) Zero order
(B) First order
(C) Third order
(D) Second order

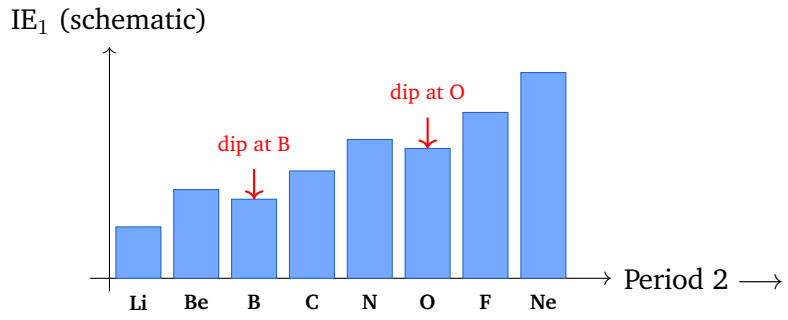
Q14. The vapour pressure of pure water at $25\ ^\circ\mathrm{C}$ is $23.8\ \mathrm{mmHg}$. When $18\ \mathrm{g}$ of glucose ($M = 180\ \mathrm{g\,mol^{-1}}$) is dissolved in $180\ \mathrm{g}$ of water ($M = 18\ \mathrm{g\,mol^{-1}}$), the vapour pressure of the resulting solution is:

(A) $23.80\ \mathrm{mmHg}$
(B) $22.56\ \mathrm{mmHg}$
(C) $23.56\ \mathrm{mmHg}$
(D) $21.60\ \mathrm{mmHg}$

Q15. The osmotic pressure of a $0.10\ \mathrm{M}$ glucose solution at $27\ ^\circ\mathrm{C}$ is: ($R = 0.0821\ \mathrm{L\,atm\,mol^{-1}\,K^{-1}}$)

(A) $2.24\ \mathrm{atm}$
(B) $2.46\ \mathrm{atm}$
(C) $1.23\ \mathrm{atm}$
(D) $4.92\ \mathrm{atm}$

Q16. The bar chart below shows the schematic first ionization enthalpies of elements from Li to Ne (Period 2). Which statement correctly explains the two anomalies in the otherwise increasing trend?



(A) B has lower IE than Be because the $2p^1$ electron in B is easier to remove than the $2s^2$ electron in Be; O has lower IE than N because the extra electron in O's doubly-occupied 2p orbital experiences inter-electronic repulsion

(B) B has lower IE than Be because B has more protons; O has lower IE than N because N is a noble gas

(C) The dip at B is due to lanthanide contraction; the dip at O is due to increased atomic radius

(D) B and O have anomalously high effective nuclear charges compared to their neighbors

Q17. When excess CO_2 gas is passed through an aqueous solution of NaOH, the main product formed is:

(A) Na_2CO_3

(B) A mixture of Na_2CO_3 and $NaHCO_3$

(C) Na_2O

(D) $NaHCO_3$

Q18. The hybridization of nitrogen in NO_2 and the shape of the molecule respectively are:

(A) sp^3, trigonal pyramidal

(B) sp, linear

(C) sp^2, bent (V-shaped)

(D) sp^3d, T-shaped

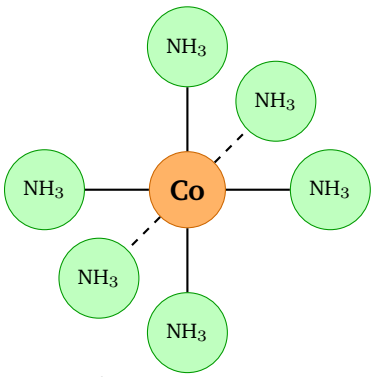
Q19. The hybridizations of the central phosphorus atom in PCl_3 and PCl_5 respectively are:

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

Q20. In which of the following compounds does manganese exhibit its highest oxidation state of $+7$?

(A) $KMnO_4$
(B) MnO_2
(C) $MnSO_4$
(D) $MnCl_2$

Q21. The structure of the complex $[Co(NH_3)_6]^{3+}$ is shown schematically below. Based on the structure, which of the following statements is correct?



$[Co(NH_3)_6]^{3+}$ — *octahedral geometry*

(A) The complex is tetrahedral with coordination number 4
(B) Co has oxidation state $+2$ in this complex
(C) The complex is square planar with 4 NH_3 ligands
(D) The complex is octahedral; Co has oxidation state $+3$ and coordination number 6

Q22. In the **gas phase**, the correct order of basicity of the following amines is:

(A) $CH_3NH_2 < (CH_3)_2NH < (CH_3)_3N$
(B) $(CH_3)_3N > CH_3NH_2 > (CH_3)_2NH$
(C) $(CH_3)_3N > (CH_3)_2NH > CH_3NH_2$
(D) $CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N$

Q23. When HBr is added to propene $(CH_3CH{=}CH_2)$ following Markovnikov's rule, the major product is:

(A) $CH_3CH_2CH_2Br$ (1-bromopropane)
(B) $CH_3CHBrCH_3$ (2-bromopropane)
(C) $CH_3CHBrCH_2Br$ (1,2-dibromopropane)
(D) $CH_2BrCH{=}CH_2$ (allyl bromide)

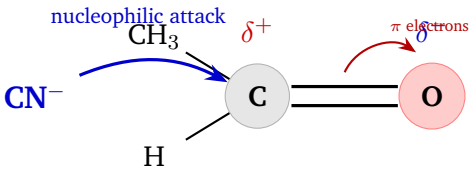
Q24. Which of the following alkyl halides undergoes S_N1 substitution most readily?

(A) $(CH_3)_3CBr$ (tert-butyl bromide)
(B) CH_3Br (methyl bromide)
(C) $(CH_3)_2CHBr$ (isopropyl bromide)
(D) CH_3CH_2Br (ethyl bromide)

Q25. In the Lucas test (conc. HCl + anhydrous $ZnCl_2$), which of the following alcohols gives an **immediate** turbidity at room temperature?

(A) Methanol
(B) Ethanol (primary)
(C) 2-Methyl-2-propanol (tert-butyl alcohol)
(D) 1-Propanol (primary)

Q26. The diagram below shows the nucleophilic addition of HCN to acetaldehyde (CH_3CHO). Which species acts as the nucleophile in the **first step** of this mechanism?



(A) H^+ (proton)
(B) HCN molecule as a whole
(C) The carbonyl oxygen (δ^-)
(D) CN^- (cyanide ion)

Q27. Among acetic acid (CH_3COOH, $pK_a = 4.76$) and phenol (C_6H_5OH, $pK_a = 9.95$), the correct statement about relative acidity is:

(A) Phenol is more acidic because the phenoxide ion is resonance-stabilised by the ring
(B) Acetic acid is more acidic; its conjugate base (acetate) is more effectively stabilised by equivalent resonance over two electronegative oxygen atoms
(C) Both are equally acidic since both have an $O-H$ bond
(D) Phenol is more acidic because oxygen is more electronegative than carbon

Q28. In **aqueous solution**, the correct order of basicity of methylamine, dimethylamine, trimethylamine, and ammonia is:

(A) $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$
(B) $(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$
(C) $NH_3 > CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N$
(D) $CH_3NH_2 > (CH_3)_2NH > (CH_3)_3N > NH_3$

Q29. Which of the following is a **non-reducing** sugar?

(A) Glucose
(B) Maltose
(C) Sucrose
(D) Lactose

Q30. Which of the following is an example of **condensation** polymerization?

(A) Polythene (polyethylene)
(B) Nylon-6,6
(C) Polyvinyl chloride (PVC)
(D) Natural rubber (polyisoprene)

Detailed Solutions

Solution

Concept — Empirical Formula: The empirical formula gives the simplest whole-number ratio of atoms. Divide the percentage of each element by its atomic mass to get the mole ratio, then simplify.

Step 1 — Mole ratios:

$$n_C = \frac{40.0}{12} = 3.33, \quad n_H = \frac{6.67}{1} = 6.67, \quad n_O = \frac{53.33}{16} = 3.33$$

Step 2 — Simplify by dividing by the smallest (3.33):

$$C : H : O = \frac{3.33}{3.33} : \frac{6.67}{3.33} : \frac{3.33}{3.33} = 1 : 2 : 1$$

Empirical formula $= \mathrm{CH_2O}$.

Why other options are wrong:

- Option A ($\mathrm{CH_2O_2}$): Ratio C:H:O would be 1:2:2, not the case here.
- Option C ($\mathrm{C_2H_4O}$): This is a multiple (double) of the empirical formula; it is a molecular formula, not the simplest ratio.
- Option D (CHO): Ratio C:H:O = 1:1:1, inconsistent with H being twice C or O.

Final Answer: Empirical formula is $\mathrm{CH_2O} \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q1

Solution

Concept — Bohr Model Energy: The energy of the n-th orbit is $E_n = E_1/n^2$, where $E_1 = -13.6$ eV for hydrogen. Energy scales as $1/n^2$.

Step 1 — Find E_1 from E_2:

$$E_2 = \frac{E_1}{2^2} = \frac{E_1}{4} = -3.4 \text{ eV} \implies E_1 = -13.6 \text{ eV}$$

Step 2 — Calculate E_4:

$$E_4 = \frac{E_1}{4^2} = \frac{-13.6}{16} = -0.85 \text{ eV}$$

Alternatively: $E_4 = E_2 \times \dfrac{2^2}{4^2} = -3.4 \times \dfrac{1}{4} = -0.85$ eV.

Why other options are wrong:

- Option B (-1.70 eV): This would correspond to the third orbit ($E_3 = -13.6/9 \approx -1.51$ eV), not the fourth.
- Option C (-6.80 eV): This equals $E_2 \times 2 = -6.8$ eV; energy does not double when n doubles.
- Option D (-0.425 eV): This corresponds to $E_1/32$, which is not a standard Bohr orbit energy.

Final Answer: $E_4 = -0.85$ eV $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q2

Solution

Concept — Trigonal Bipyramidal Geometry: In PCl_5, P is sp^3d hybridised. The five positions are: three equatorial (in a plane at $120°$ to each other) and two axial (perpendicular to the equatorial plane). Axial–equatorial angle is $90°$; equatorial–equatorial angle is $120°$.

Step 1 — Identify the bond angles:

- Equatorial–equatorial: $120°$
- Axial–equatorial: $90°$
- Axial–axial: $180°$

Step 2 — Answer the question: The question asks for the bond angle between two *equatorial* P–Cl bonds, which is $120°$.

Why other options are wrong:

- Option A ($90°$): This is the axial–equatorial angle, not equatorial–equatorial.
- Option B ($109.5°$): This is the tetrahedral angle (sp^3 geometry).
- Option D ($180°$): This is the axial–axial angle (two axial P–Cl bonds).

Final Answer: Equatorial bond angle in PCl_5 is $120° \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Solution

Concept — VSEPR and XeF_4: XeF_4 has 4 bond pairs and 2 lone pairs around the central Xe atom (total 6 electron pairs $\Rightarrow$ octahedral electron geometry). The two lone pairs occupy the axial positions, leaving the four F atoms in a plane $\Rightarrow$ square planar molecular shape.

Step 1 — Electron pair count for Xe in XeF_4: Xe has 8 valence electrons; 4 are used in bonds to F. Remaining lone pairs: 2. Total electron domains = 6 $\Rightarrow$ octahedral arrangement of electron pairs.

Step 2 — Determine molecular geometry: With 4 bonding pairs and 2 lone pairs (LP) at axial positions, the molecule is **square planar**, as shown in the diagram (LP shown as dashed arcs above and below the Xe centre).

Why other options are wrong:

- Option A (Tetrahedral): 4 bond pairs with *no* lone pairs gives tetrahedral geometry (CH_4); Xe has 2 lone pairs.
- Option B (See-saw): 4 bond pairs + 1 lone pair (SF_4); Xe has 2 lone pairs.
- Option C (Square pyramidal): 5 bond pairs + 1 lone pair (BrF_5); not applicable here.

Final Answer: XeF_4 is square planar $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q4

Solution

Concept — Hybridization: The hybridization of the central atom equals the number of electron domains (bonds + lone pairs). SF_6 has S with 6 σ-bonds to F and 0 lone pairs $\Rightarrow$ 6 electron domains.

Step 1 — Electron domains of S in SF_6: S forms 6 bonds with F; no lone pairs. Total electron domains $= 6$.

Step 2 — Assign hybridization:

$$6 \text{ domains} \Rightarrow sp^3d^2 \text{ hybridization (octahedral geometry)}$$

Why other options are wrong:

- Option B (sp^3d): 5 electron domains (e.g., PCl_5, SF_4 with 1 LP).
- Option C (sp^3): 4 electron domains (e.g., CH_4, NH_3).
- Option D (sp^2): 3 electron domains (e.g., BF_3).

Final Answer: S in SF_6 is sp^3d^2 hybridised $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q5

Solution

Concept — Combined Gas Law: For a fixed amount of gas, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$.

Step 1 — Identify the variables: $P_1 = 2$ atm, $V_1 = 4.0$ L, $T_1 = 300$ K; $P_2 = 1$ atm, $T_2 = 600$ K.

Step 2 — Solve for V_2:

$$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{2 \times 4.0 \times 600}{300 \times 1} = \frac{4800}{300} = 16 \text{ L}$$

Why other options are wrong:

- Option A (8 L): Only accounts for the temperature doubling (Charles' law) without including the pressure halving.
- Option C (4 L): Ignores both changes and gives the original volume.
- Option D (32 L): Arises from multiplying instead of dividing pressure effect.

Final Answer: $V_2 = 16$ L $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q6

Solution

Concept — Hess's Law: The enthalpy of a reaction is independent of the pathway. Target reaction = Reaction 1 − Reaction 2.

Step 1 — Identify the target:

$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \quad \Delta H = ?$$

Step 2 — Manipulate given equations: Subtract Equation 2 from Equation 1:

$$[\mathrm{C} + \mathrm{O_2} \rightarrow \mathrm{CO_2}] - [\mathrm{C} + \tfrac{1}{2}\mathrm{O_2} \rightarrow \mathrm{CO}]$$
$$\Rightarrow \mathrm{CO} + \tfrac{1}{2}\mathrm{O_2} \rightarrow \mathrm{CO_2}$$

$$\Delta H = \Delta H_1 - \Delta H_2 = -393.5 - (-110.5) = -393.5 + 110.5 = -283.0\ \mathrm{kJ\,mol^{-1}}$$

Why other options are wrong:

- Option A ($+283.0$): Sign error; CO combustion is exothermic.
- Option B (-504.0): Arises from adding $\Delta H_1 + \Delta H_2$ instead of subtracting.
- Option D (-110.5): This is just ΔH_2 (CO formation from elements), not the CO combustion enthalpy.

Final Answer: $\Delta H = -283.0\ \mathrm{kJ\,mol^{-1}} \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q7

Solution

Concept — Born-Haber Cycle: The Born-Haber cycle for NaCl traces the pathway from elements to ionic solid through: sublimation of Na, ionization of Na, dissociation of $\frac{1}{2}\mathrm{Cl_2}$, electron affinity of Cl, and lattice energy.

Step 1 — Identify the steps in the diagram:

- $\mathrm{Na(s)} \rightarrow \mathrm{Na(g)}$: sublimation ($\Delta H_{\text{sub}}$, endothermic, upward arrow)
- $\mathrm{Na(g)} \rightarrow \mathrm{Na^+(g)} + \mathrm{e^-}$: ionization enthalpy (IE, endothermic, upward)
- $\frac{1}{2}\mathrm{Cl_2(g)} \rightarrow \mathrm{Cl(g)}$: bond enthalpy $\frac{1}{2}$BE, endothermic, upward
- $\mathrm{Na^+(g)} + \mathrm{Cl(g)} \rightarrow \mathrm{Na^+(g)} + \mathrm{Cl^-(g)}$: **step X** (downward, exothermic)
- $\mathrm{Na^+(g)} + \mathrm{Cl^-(g)} \rightarrow \mathrm{NaCl(s)}$: lattice energy ($\Delta H_{\text{latt}}$, exothermic, downward)

Step 2 — Identify step X: The arrow X goes *downward* from $\mathrm{Na^+(g) + Cl(g)}$ to $\mathrm{Na^+(g) + Cl^-(g)}$. This is the process: $\mathrm{Cl(g) + e^- \rightarrow Cl^-(g)}$, which is the **electron gain enthalpy (electron affinity)** of Cl.

Why other options are wrong:

- Option A (Sublimation): This is the step $\mathrm{Na(s) \rightarrow Na(g)}$, an endothermic upward step.
- Option B (IE): Ionisation is the step $\mathrm{Na(g) \rightarrow Na^+(g)}$, endothermic, upward.
- Option C (Bond dissociation): This step converts $\frac{1}{2}\mathrm{Cl_2(g) \rightarrow Cl(g)}$, endothermic.

Final Answer: Step X is the electron gain enthalpy (EA) of Cl $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q8

Solution

Concept — Le Chatelier's Principle: Increasing pressure on a gaseous equilibrium shifts the equilibrium toward the side with *fewer moles of gas*, to reduce the pressure.

Step 1 — Count moles of gas on each side:

$$\mathrm{N_2(g)} + 3\,\mathrm{H_2(g)} \rightleftharpoons 2\,\mathrm{NH_3(g)}$$

Left: $1 + 3 = 4$ mol gas; Right: 2 mol gas.

Step 2 — Predict the shift: Increasing pressure $\Rightarrow$ shift toward fewer gas moles $\Rightarrow$ **forward** direction $\Rightarrow$ $[\mathrm{NH_3}]$ increases.

Why other options are wrong:

- Option B: A backward shift would increase moles of gas, raising pressure further – opposite of Le Chatelier's prediction.
- Option C: Temperature remains constant, but pressure change does cause a shift because moles of gas differ on both sides.
- Option D: No oscillation occurs in equilibrium shifts; the shift is unidirectional until a new equilibrium is reached.

Final Answer: Equilibrium shifts forward, increasing $[\mathrm{NH_3}]$ $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q9

Solution

Concept — pH of Weak Acid: For a weak acid HA with concentration C:

$$[\mathrm{H^+}] = \sqrt{K_a \cdot C} \quad \text{(valid when degree of dissociation is small)}$$

Step 1 — Calculate $[\mathrm{H^+}]$:

$$[\mathrm{H^+}] = \sqrt{1.8 \times 10^{-5} \times 0.1} = \sqrt{1.8 \times 10^{-6}} = 1.342 \times 10^{-3}\ \mathrm{M}$$

Step 2 — Calculate pH:

$$\text{pH} = -\log(1.342 \times 10^{-3}) = 3 - \log(1.342) = 3 - 0.127 = 2.87$$

Why other options are wrong:

- Option A ($\text{pH} = 5$): This would require $[\text{H}^+] = 10^{-5}$ M, which is far too low for a 0.1 M weak acid.
- Option B ($\text{pH} = 4$): Would imply $K_a \approx 10^{-7}$, not 1.8×10^{-5}.
- Option D ($\text{pH} = 3.5$): Overestimates the pH by about 0.6 units.

Final Answer: $\text{pH} \approx 2.87 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q10

Solution

Concept — Standard EMF of Electrochemical Cell:

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$$

In a Daniell cell, Cu^{2+}/Cu is the cathode (higher reduction potential) and Zn^{2+}/Zn is the anode.

Step 1 — Identify cathode and anode: $E^\circ(\text{Cu}^{2+}/\text{Cu}) = +0.34$ V (more positive $\Rightarrow$ cathode). $E^\circ(\text{Zn}^{2+}/\text{Zn}) = -0.76$ V (less positive $\Rightarrow$ anode).

Step 2 — Calculate E°_{cell}:

$$E^\circ_{\text{cell}} = 0.34 - (-0.76) = 0.34 + 0.76 = 1.10 \text{ V}$$

Why other options are wrong:

- Option A (-0.42 V): Calculated as $0.34 - 0.76 = -0.42$ V (wrong: both taken as reduction potentials without sign correction).
- Option C ($+0.42$ V): This is $|E^\circ(\text{Cu}) - |E^\circ(\text{Zn})||$, an incorrect subtraction.
- Option D (-1.10 V): Anode and cathode were interchanged, giving a negative cell potential.

Final Answer: $E^\circ_{\text{cell}} = 1.10 \text{ V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q11

Solution

Concept — Daniell Cell: In a galvanic cell, oxidation occurs at the anode (negative terminal) and reduction occurs at the cathode (positive terminal). In the Daniell cell: Zn is oxidised at the anode; Cu^{2+} is reduced at the cathode.

Step 1 — Half-reactions:

$$\text{Anode (Zn): } \mathrm{Zn(s)} \rightarrow \mathrm{Zn}^{2+}\mathrm{(aq)} + 2\,\mathrm{e}^- \quad \text{(oxidation)}$$
$$\text{Cathode (Cu): } \mathrm{Cu}^{2+}\mathrm{(aq)} + 2\,\mathrm{e}^- \rightarrow \mathrm{Cu(s)} \quad \text{(reduction)}$$

Step 2 — Match with the diagram: From the diagram, the left electrode (Zn) labelled Anode$(-)$ releases electrons that flow through the external circuit to the right Cu electrode (Cathode, $+$). This confirms that **Zn is the anode and oxidation occurs at it**.

Why other options are wrong:

- Option B: Cu is the cathode (reduction occurs there), not the anode.
- Option C: The salt bridge *allows* ion migration (maintains electrical neutrality), it does not prevent it.
- Option D: Conventional current flows from $+$ to $-$ in the external circuit, i.e., from Cu to Zn – opposite of the statement.

Final Answer: Zn is the anode; oxidation occurs at it $\Rightarrow \boxed{\mathrm{A}}$

Answer: (A) Go Back to Q12

Solution

Concept — Rate Law and Reaction Order: Rate $= k[\mathrm{A}]^m[\mathrm{B}]^n$. To find the order with respect to A, compare experiments where only $[\mathrm{A}]$ changes.

Step 1 — Compare Experiments 1 and 2 ($[\mathrm{B}]$ constant):

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \left(\frac{[\mathrm{A}]_2}{[\mathrm{A}]_1}\right)^m \implies \frac{8.0\times10^{-3}}{2.0\times10^{-3}} = \left(\frac{0.20}{0.10}\right)^m$$

$$4 = 2^m \implies m = 2$$

Step 2 — Verify with Experiments 1 and 3: $[\mathrm{A}]$ is constant and $[\mathrm{B}]$ doubles, yet rate is unchanged $\Rightarrow$ order w.r.t. B $= 0$.

Why other options are wrong:

- Option A (zero order): Rate would be independent of $[\mathrm{A}]$; but rate quadruples when $[\mathrm{A}]$ doubles.
- Option B (first order): Rate would double when $[\mathrm{A}]$ doubles; observed increase is fourfold.
- Option C (third order): Rate would increase 8-fold when $[\mathrm{A}]$ doubles.

Final Answer: Order w.r.t. A is 2 (second order) $\Rightarrow \boxed{\mathrm{D}}$

Answer: (D) Go Back to Q13

Solution

Concept — Raoult's Law: $P_{\text{solution}} = P^{\circ}_{\text{solvent}} \times \chi_{\text{solvent}}$, where χ_{solvent} is the mole fraction of the solvent (water).

Step 1 — Calculate moles:

$$n_{\text{glucose}} = \frac{18}{180} = 0.10 \text{ mol}, \quad n_{\text{water}} = \frac{180}{18} = 10.0 \text{ mol}$$

Step 2 — Mole fraction of water and vapour pressure:

$$\chi_{\text{water}} = \frac{10.0}{10.0 + 0.10} = \frac{10.0}{10.1} = 0.9901$$

$$P_{\text{solution}} = 23.8 \times 0.9901 = 23.56 \text{ mmHg}$$

Why other options are wrong:

- Option A (23.80 mmHg): Equals pure water; ignores the effect of solute on lowering vapour pressure.
- Option B (22.56 mmHg): Calculates vapour pressure lowering as $\chi_{\text{glucose}} \times P^{\circ}$ but uses wrong mole fraction.
- Option D (21.60 mmHg): Corresponds to a much higher solute concentration.

Final Answer: $P_{\text{solution}} = 23.56$ mmHg $\Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q14

Solution

Concept — Osmotic Pressure: $\pi = CRT$, where C is the molar concentration of solute, R is the gas constant, and T is the temperature in Kelvin.

Step 1 — Convert temperature: $T = 27 + 273 = 300$ K

Step 2 — Apply the formula:

$$\pi = CRT = 0.10 \times 0.0821 \times 300 = 2.463 \text{ atm} \approx 2.46 \text{ atm}$$

Why other options are wrong:

- Option A (2.24 atm): Corresponds to $T = 273$ K (0°C); the question specifies 27°C.
- Option C (1.23 atm): Half the correct answer; may result from using $C = 0.05$ M in error.
- Option D (4.92 atm): Twice the correct value; uses $C = 0.20$ M.

Final Answer: $\pi = 2.46$ atm $\Rightarrow$ B

Answer: (B) Go Back to Q15

Solution

Concept — Ionization Enthalpy Trend: Across a period, IE_1 generally increases due to increasing nuclear charge. However, two well-known exceptions exist: Be→B (dip) and N→O (dip).

Step 1 — Explain the dip at B: Be has configuration $[He]\,2s^2$; B has $[He]\,2s^2\,2p^1$. The 2p electron in B is in a higher-energy subshell and is more shielded than the $2s^2$ electrons in Be. Hence, B has a *lower* IE than Be.

Step 2 — Explain the dip at O: N has configuration $2s^2\,2p^3$ (half-filled 2p, extra stability due to exchange energy). O has $2s^2\,2p^4$, where one 2p orbital is doubly occupied. The two electrons in the same orbital repel each other, making one easier to remove. Hence, O has a *lower* IE than N.

Why other options are wrong:

- Option B: Both statements are factually incorrect (B does *not* have higher IE than Be; N is not a noble gas).
- Option C: Lanthanide contraction applies to 4f elements; it has nothing to do with Period 2 anomalies.

- Option D: The anomalies show *dips*, not peaks, at B and O.

Final Answer: The dips arise from subshell/exchange-energy effects $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q16

Solution

Concept — Reaction of NaOH with CO_2: The product depends on the relative amounts of NaOH and CO_2. With limited CO_2 (excess NaOH): Na_2CO_3 is formed. With excess CO_2: $NaHCO_3$ is formed.

Step 1 — Reactions:

$$\text{Excess NaOH: } 2\,NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$$
$$\text{Excess } CO_2 : NaOH + CO_2 \rightarrow NaHCO_3$$

Step 2 — Apply to the question: When *excess* CO_2 is passed, all the NaOH reacts according to the second equation. The NaOH is the limiting reagent and $NaHCO_3$ is the sole product.

Why other options are wrong:

- Option A (Na_2CO_3): Formed when CO_2 is *limited* (excess NaOH), not when CO_2 is excess.
- Option B (mixture): Occurs only at intermediate CO_2/NaOH ratios.
- Option C (Na_2O): Na_2O is produced by heating NaOH with Na metal, not by CO_2 reaction.

Final Answer: Excess CO_2 gives $NaHCO_3$ $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q17

Solution

Concept — Hybridization and Shape of NO_2: Electron domain geometry determines hybridization. In NO_2, nitrogen has two N=O bonds (or one single and one double in resonance) and one unpaired electron (radical). The three electron regions (2 bonds + 1 unpaired electron region) give sp^2 hybridization.

Step 1 — Electron domains around N in NO_2:

- Two bond pairs to O (one single, one double in resonance form)
- One unpaired electron (radical, occupies one sp^2 orbital)

Total $= 3$ electron domains $\Rightarrow$ sp^2 hybridization.

Step 2 — Molecular shape: With 3 regions but only 2 bonded atoms (plus one odd electron), the molecular shape is **bent (V-shaped)**, with a bond angle slightly less than 120° ($\approx 134^\circ$ due to double bond repulsion being greater than a lone pair).

Why other options are wrong:

- Option A (sp^3, trigonal pyramidal): sp^3 requires 4 electron domains; NO_2 has only 3.
- Option B (sp, linear): sp requires 2 electron domains; NO_2 has 3.
- Option D (sp^3d, T-shaped): sp^3d requires 5 domains; NO_2 is a much lighter molecule.

Final Answer: N in NO_2 is sp^2; shape is bent $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q18

Solution

Concept — Hybridization of P in PCl_3 and PCl_5: Count electron domains (bonds + lone pairs) around P.

Step 1 — PCl_3: P forms 3 bonds with Cl and has 1 lone pair. Total electron domains $= 4 \Rightarrow sp^3$ hybridization. Shape: trigonal pyramidal.

Step 2 — PCl_5: P forms 5 bonds with Cl and has 0 lone pairs. Total electron domains $= 5 \Rightarrow sp^3d$ hybridization. Shape: trigonal bipyramidal.

Why other options are wrong:

- Option A (sp^2 and sp^3d): sp^2 (3 domains) is wrong for PCl_3 which has 4 domains.
- Option C (sp^3 and sp^3d^2): sp^3d^2 (6 domains) is for PCl_5? No, PCl_5 has only 5 domains.
- Option D (sp^2 and sp^2): Both assignments are incorrect.

Final Answer: PCl_3: sp^3; PCl_5: $sp^3d \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q19

Solution

Concept — Oxidation States of Mn: Mn exhibits multiple oxidation states ($+2$ to $+7$). In oxo-compounds and oxyanions, use the oxidation state algebra with known values of other elements.

Step 1 — Find Mn oxidation state in $KMnO_4$: Let Mn $= x$.

$$(+1) + x + 4(-2) = 0 \implies x = 8 - 1 = +7$$

Step 2 — Verify other options:

- MnO_2: $x + 2(-2) = 0 \Rightarrow x = +4$
- $MnSO_4$: $x + (-2) = 0 \Rightarrow x = +2$ (since SO_4^{2-} carries -2)
- $MnCl_2$: $x + 2(-1) = 0 \Rightarrow x = +2$

Final Answer: Mn shows $+7$ in $KMnO_4 \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q20

Solution

Concept — Coordination Compounds: In $[Co(NH_3)_6]^{3+}$, the central metal Co is surrounded by 6 neutral NH_3 ligands (monodentate). The coordination number is 6, and the geometry is octahedral.

Step 1 — Determine oxidation state of Co: The complex ion has charge $+3$. Each NH_3 is neutral. Therefore:

$$\text{Oxidation state of Co} = +3$$

Step 2 — Coordination number and geometry: 6 monodentate ligands $\Rightarrow$ CN $= 6$

$\Rightarrow$ **octahedral geometry**, as depicted in the diagram (dashed bonds indicate the bonds going behind the plane).

Why other options are wrong:

- Option A (tetrahedral, CN 4): Incorrect; there are 6 ligands shown in the diagram.
- Option B (Co^{2+}): The charge on the complex ion is $+3$; with 6 neutral NH_3 ligands, Co must be $+3$.
- Option C (square planar, 4 ligands): Square planar has CN $= 4$; the complex clearly has CN $= 6$.

Final Answer: Octahedral complex; Co is $+3$, CN is 6 $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q21

Solution

Concept — Basicity of Amines in Gas Phase: In the gas phase, there is no solvation effect. Basicity depends purely on electron density on N. More alkyl groups $\Rightarrow$ greater +I (inductive) effect $\Rightarrow$ higher electron density on N $\Rightarrow$ stronger base.

Step 1 — Rank by inductive electron donation: Each methyl group donates electrons to N through the +I effect. More methyl groups $\Rightarrow$ more electron density on N.

Step 2 — Gas-phase basicity order:

$$(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$$

Why other options are wrong:

- Option A: This is the same order written as an inequality chain $<$; though the chain shows the same trend, option C correctly writes it as $>$ and answers the question explicitly.
- Option B: The middle two are swapped; in gas phase, dimethylamine is less basic than trimethylamine.
- Option D: This reverses the correct order; methylamine is NOT the most basic in gas phase.

Final Answer: Gas-phase order: $(CH_3)_3N > (CH_3)_2NH > CH_3NH_2$ $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q22

Solution

Concept — Markovnikov's Rule: In the addition of HX to an unsymmetrical alkene, H adds to the carbon bearing more H atoms (less substituted C), and X adds to the more substituted carbon (more stable carbocation intermediate).

Step 1 — Identify the alkene carbons: $CH_3 - CH{=}CH_2$: C1 (terminal, CH_2, 2 H's) is less substituted; C2 (CH, 1 H) is more substituted.

Step 2 — Apply Markovnikov's rule: H adds to C1 (terminal CH_2) $\Rightarrow$ forms secondary carbocation at C2 $\Rightarrow$ Br^- attacks C2.

$$CH_3 - \underset{\displaystyle Br}{\underset{|}{CH}} - CH_3 \quad \text{(2-bromopropane)}$$

Why other options are wrong:

- Option A (1-bromopropane): Anti-Markovnikov product; would form a less stable primary carbocation. Not the major product under normal (non-peroxide) conditions.
- Option C (1,2-dibromopropane): This is the product of Br_2 addition, not HBr.
- Option D (allyl bromide): This would require free-radical conditions with NBS, not HBr addition.

Final Answer: Major product is 2-bromopropane $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q23

Solution

Concept — SN1 vs SN2: S_N1 is favoured by substrates that form stable carbocations (tertiary > secondary > primary > methyl). The rate-determining step in S_N1 is ionisation to form a carbocation.

Step 1 — Classify each substrate:

- $(CH_3)_3CBr$: tertiary (3°) – forms a highly stable tertiary carbocation
- $(CH_3)_2CHBr$: secondary (2°)
- CH_3CH_2Br: primary (1°)
- CH_3Br: methyl (0°)

Step 2 — Identify the best SN1 substrate: Tertiary substrates form the most stable

(most substituted) carbocations $\Rightarrow (CH_3)_3CBr$ undergoes S_N1 most readily.

Why other options are wrong:

- Option B (CH_3Br): Methyl substrates form the least stable carbocations; they react almost exclusively via S_N2.
- Option C (isopropyl bromide): Secondary; S_N1 is possible but slower than tertiary.
- Option D (ethyl bromide): Primary; strongly favours S_N2 over S_N1.

Final Answer: tert-Butyl bromide undergoes S_N1 most readily $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q24

Solution

Concept — Lucas Test: Lucas reagent (anhydrous $ZnCl_2$ + conc. HCl) converts $R-OH$ to $R-Cl$, which is insoluble (turbid). The speed depends on the order of alcohol:

- 3° alcohol: *immediate* turbidity (fast S_N1, stable carbocation)
- 2° alcohol: turbidity after 5 minutes
- 1° alcohol: no turbidity at room temperature (or very slow)

Step 1 — Classify each alcohol: 2-Methyl-2-propanol $= (CH_3)_3COH$ is a **tertiary** alcohol. Methanol, ethanol, and 1-propanol are primary (or simplest) alcohols.

Step 2 — Predict Lucas test result: $(CH_3)_3COH$ forms a stable tertiary carbocation $\Rightarrow$ S_N1 reaction is immediate $\Rightarrow$ immediate turbidity.

Why other options are wrong:

- Option A (methanol): primary; reacts only under heating, no turbidity at room temperature.
- Option B (ethanol): primary; no immediate turbidity at room temperature.
- Option D (1-propanol): primary; no turbidity at room temperature.

Final Answer: 2-Methyl-2-propanol gives immediate turbidity $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q25

Solution

Concept — Nucleophilic Addition to Carbonyl: The carbonyl carbon (C=O) is electrophilic (δ^+ on C due to electronegativity of O). In the first step, a nucleophile attacks this electrophilic carbon.

Step 1 — Identify the nucleophile: HCN generates CN^- (cyanide ion) in the presence of base. CN^- has a lone pair on carbon and is the **nucleophile** that attacks the carbonyl carbon.

Step 2 — Mechanism:

(a) CN^- attacks the δ^+ carbonyl carbon $\Rightarrow$ the π electrons of C=O shift onto O $\Rightarrow$ forms an alkoxide intermediate.
(b) Protonation of the alkoxide by H^+ (from HCN) gives the cyanohydrin product.

As shown in the diagram, the curved arrow from CN^- points to the carbonyl C.

Why other options are wrong:

- Option A (H^+): H^+ is an electrophile, not a nucleophile; it attacks the oxygen (in the second step).
- Option B (HCN molecule): HCN acts as a source of CN^- but HCN itself is not the nucleophile in the first step.
- Option C (carbonyl oxygen): The oxygen is part of the substrate (electrophile system), not the nucleophile.

Final Answer: The nucleophile in the first step is $CN^- \Rightarrow \boxed{D}$

Answer: (D) Go Back to Q26

Solution

Concept — Acidity of Carboxylic Acids vs Phenol: A lower pK_a means a stronger acid. Acetic acid ($pK_a = 4.76$) is a much stronger acid than phenol ($pK_a = 9.95$).

Step 1 — Compare pK_a values:

$$pK_a(CH_3COOH) = 4.76 \ll pK_a(C_6H_5OH) = 9.95$$

Lower $pK_a \Rightarrow$ acetic acid is approximately $10^{9.95-4.76} \approx 10^{5.2}$ times more acidic than phenol.

Step 2 — Reason for greater acidity of acetic acid: The acetate ion (CH_3COO^-) has both C=O and C–O bonds equivalent due to resonance, with the negative charge symmetrically distributed over *two* equivalent electronegative oxygen atoms. This provides more effective charge stabilisation than the phenoxide ion, where resonance delocalises charge into the ring (less electronegative C atoms share the charge).

Why other options are wrong:

- Option A: Phenol IS less acidic than acetic acid, and while phenoxide IS resonance-stabilised, the stabilisation is less effective than in acetate.
- Option C: Same O–H bond exists in both; the key is conjugate-base stability, not bond type.
- Option D: Though O is electronegative, the direct attachment to the ring in phenol does not make it more acidic; the data shows phenol is much less acidic.

Final Answer: Acetic acid is more acidic due to better acetate stabilisation $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q27

Solution

Concept — Basicity of Amines in Water: In aqueous solution, basicity is affected by both (i) inductive electron donation (+I effect, increases with more alkyl groups) and (ii) solvation of the ammonium cation (decreases with bulkier groups). The combined effect gives: $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$.

Step 1 — Factors at play in water:

- Inductive effect alone (gas phase): $(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$
- Solvation of R_3NH^+: less effective for bulkier amines (trimethylammonium ion is poorly solvated)

Step 2 — Net aqueous basicity order: Dimethylamine benefits strongly from both moderate induction and good solvation. Trimethylamine, despite three methyl groups, is weakly solvated due to steric crowding $\Rightarrow$ drops below methylamine.

$$(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$$

Why other options are wrong:

- Option B: This is the gas-phase order; ignores the solvation effect that makes trimethylamine less basic in water.

- Option C: This is the inverse of the inductive order; NH_3 is not the strongest base.
- Option D: Places methylamine first; though methylamine is more basic than NH_3, it is less basic than dimethylamine in water.

Final Answer: Aqueous basicity order: $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3 \Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q28

Solution

Concept — Reducing and Non-Reducing Sugars: A *reducing* sugar has a free anomeric hydroxyl group (free aldehyde or ketone in open-chain form) that can reduce Fehling's or Tollens' reagent. A *non-reducing* sugar has no such free group.

Step 1 — Analyse each option:

- Glucose: Has a free aldehyde group (C1 anomeric OH free) $\Rightarrow$ reducing sugar.
- Maltose: Disaccharide (α-1,4 glycosidic bond); C1 of one glucose unit is free $\Rightarrow$ reducing sugar.
- **Sucrose**: Disaccharide formed by the α, β-1,2-glycosidic linkage between C1 of glucose and C2 of fructose. *Both* anomeric carbons are involved in the bond $\Rightarrow$ no free anomeric OH $\Rightarrow$ **non-reducing sugar**.
- Lactose: Has a free anomeric OH on the glucose unit $\Rightarrow$ reducing sugar.

Why other options are wrong:

- Option A (Glucose): The classic reducing sugar; reduces Tollens' and Fehling's reagents.
- Option B (Maltose): Reducing; gives positive Tollens' test.
- Option D (Lactose): Reducing; contains free anomeric carbon on its galactose moiety.

Final Answer: Sucrose is the non-reducing sugar $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q29

Solution

Concept — Addition vs Condensation Polymerization: *Addition polymerization*: monomers add directly with no by-product (e.g., alkenes). *Condensation polymerization*: monomers join with elimination of a small molecule (usually H_2O, HCl, etc.); requires bifunctional monomers.

Step 1 — Identify Nylon-6,6: Nylon-6,6 is formed by the condensation of hexamethylenediamine $[H_2N(CH_2)_6NH_2]$ and adipic acid $[HOOC(CH_2)_4COOH]$ with elimination of water at each step:

$$-NH(CH_2)_6NH - CO(CH_2)_4CO- + n\,H_2O$$

This is a polyamide and a classic example of **condensation polymerization**.

Step 2 — Classify the other options:

- Polythene: $CH_2 = CH_2$ addition polymerisation, no by-product.
- PVC: $CH_2 = CHCl$ addition polymerisation.
- Natural rubber: isoprene ($CH_2 = C(CH_3) - CH = CH_2$) addition polymerisation.

Why other options are wrong:

- Option A (Polythene): Chain-growth addition polymer; no condensate expelled.
- Option C (PVC): Vinyl polymer; addition type.
- Option D (Natural rubber): Addition polymer of isoprene units.

Final Answer: Nylon-6,6 is formed by condensation polymerization $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q30

Answer Key

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