# BITSAT Chemistry Sample Paper – 4

**Duration: 40 Minutes** **Maximum Marks: 90**

## Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer).
- Each correct answer carries **+3 marks**. Each incorrect answer carries **−1** mark. Unattempted questions carry **0** marks.
- Only **one** option is correct for each question. Choose carefully.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

**Q1.** $100\,\text{mL}$ of $O_2$ and $100\,\text{mL}$ of $CO$ are mixed and ignited at constant temperature and pressure. The residual gas mixture after the reaction $(2CO + O_2 \rightarrow 2C$ is:

(A) $100\,\text{mL}$ $CO_2$ only

(B) $50\,\text{mL}$ $O_2$ + $50\,\text{mL}$ $CO_2$

(C) $100\,\text{mL}$ $CO_2$ + $50\,\text{mL}$ $O_2$ (excess)

(D) $50\,\text{mL}$ $CO_2$ + $75\,\text{mL}$ $O_2$

**Q2.** The de Broglie wavelength of an electron accelerated through $V = 100\,\text{V}$ is given by $\lambda = 12.27/\sqrt{V}\,\text{Å}$. The wavelength is:

(A) $\lambda = 12.27\,\text{Å}$

(B) $\lambda = 0.123\,\text{Å}$

(C) $\lambda = 1.227\,\text{Å}$

(D) $\lambda = 122.7\,\text{Å}$

**Q3.** The shape and hybridisation of $XeF_2$ (xenon difluoride) are:

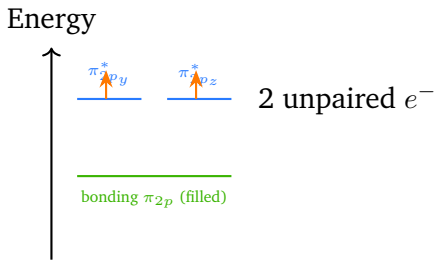
(A) Bent; $sp^3$

(B) V-shaped; $\mathrm{sp^3d^2}$

(C) Trigonal planar; $\mathrm{sp^2}$

(D) Linear; $\mathrm{sp^3d}$ (3 lone pairs occupy equatorial positions)

**Q4.** In the MO diagram of $\mathrm{O_2}$, two electrons singly occupy the degenerate $\pi^*_{2p}$ orbitals with parallel spins. This explains why $\mathrm{O_2}$:




(A) Is diamagnetic and has bond order 3

(B) Is paramagnetic with 2 unpaired electrons and has bond order 2

(C) Forms a triple bond identical to $\mathrm{N_2}$

(D) Is non-polar and has a single bond

**Q5.** At constant volume, $0.5\,\mathrm{mol}$ of an ideal gas is heated from $300\,\mathrm{K}$ to $600\,\mathrm{K}$. Given $C_V = 20\,\mathrm{J\,mol^{-1}K^{-1}}$, the work done $w$ and change in internal energy $\Delta U$ are:

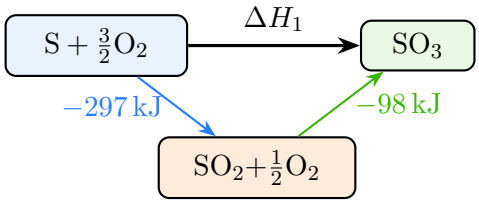
(A) $w = 0;\quad \Delta U = 3000\,\mathrm{J}$

(B) $w = 3000\,\mathrm{J};\quad \Delta U = 0$

(C) $w = -3000\,\mathrm{J};\quad \Delta U = 3000\,\mathrm{J}$

(D) $w = 0;\quad \Delta U = 6000\,\mathrm{J}$

**Q6.** Using the Hess's law cycle below for $\mathrm{SO_3}$ formation, find $\Delta H_1$:



(A) $-199\,\text{kJ mol}^{-1}$

(B) $+199\,\text{kJ mol}^{-1}$

(C) $-395\,\text{kJ mol}^{-1}$

(D) $-493\,\text{kJ mol}^{-1}$

**Q7.** For $\text{A(g)} \rightleftharpoons 2\text{B(g)}$, $K_c = 0.04\,\text{mol L}^{-1}$ at $500\,\text{K}$. Using $R = 0.0821\,\text{L atm mol}^{-1}\text{K}^{-1}$ and $\Delta n_g = +1$, the value of $K_p$ is:

(A) $K_p = 1.66\,\text{atm}$

(B) $K_p = 9.6 \times 10^{-6}\,\text{atm}^{-1}$

(C) $K_p = 0.04$ (same as $K_c$)

(D) $K_p = 1640\,\text{atm}$

**Q8.** $0.02\,\text{mol}$ of $\text{NH}_4\text{Cl}$ is dissolved in $500\,\text{mL}$ of water ($K_b(\text{NH}_3) = 1.8 \times 10^{-5}$; $K_w = 10^{-14}$). The approximate pH is:

(A) pH $= 7.00$

(B) pH $= 8.87$

(C) pH $= 5.13$

(D) pH $= 4.87$

**Q9.** For the cell $\text{Zn}|\text{Zn}^{2+}(1\,\text{M})||\text{Ag}^{+}(1\,\text{M})|\text{Ag}$, $E^\circ_{\text{cell}} = 1.56\,\text{V}$. The equilibrium constant $K_{eq}$ at $298\,\text{K}$ ($n = 2$) is:

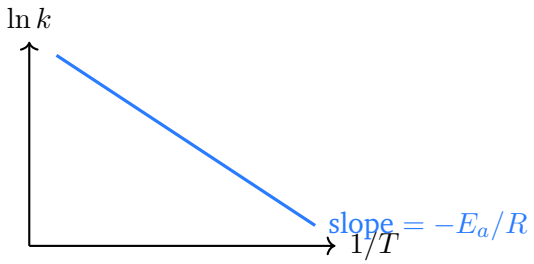
(A) $K_{eq} = 10^{26.4}$

(B) $K_{eq} = 10^{52.8}$

(C) $K_{eq} = 10^{105.6}$

(D) $K_{eq} = e^{52.8}$

**Q10.** From the Arrhenius plot ($\ln k$ vs $1/T$) below, the slope is $-6885\,\text{K}$. The activation energy is ($R = 8.314\,\text{J mol}^{-1}\text{K}^{-1}$):



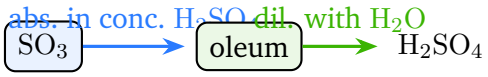

(A) $E_a = 57.3\,\text{kJ mol}^{-1}$

(B) $E_a = 28.6\,\text{kJ mol}^{-1}$

(C) $E_a = 114.6\,\text{kJ mol}^{-1}$

(D) $E_a = 200.0\,\text{kJ mol}^{-1}$

**Q11.** The contact process for $H_2SO_4$ manufacture: $SO_3$ is **not** dissolved directly in water. Instead:




(A) $SO_3$ is absorbed in conc. $H_2SO_4$ forming oleum ($H_2S_2O_7$), then diluted with water

(B) $SO_3$ is directly dissolved in water to give $H_2SO_4$

(C) $SO_2$ is oxidised by water to give $H_2SO_4$ without $SO_3$

(D) $SO_3$ is reduced by $H_2$ in contact with $V_2O_5$

**Q12.** Which statement about Group 15 is **correct**?

(A) Bismuth is a typical non-metal like nitrogen

(B) All Group 15 hydrides are equally strong reducing agents

(C) The stability of $+5$ oxidation state *decreases* down the group due to the inert pair effect

(D) Nitrogen can expand its covalency beyond 4 using $d$-orbitals

**Q13.** The complex $[Co(en)_2Cl_2]^+$ (en = ethylenediamine) exhibits how many geometrical isomers?

(A) 1 (cis only)

(B) 3 (fac, mer, cis)

(C) 4 (two cis + two trans)

(D) 2 (cis and trans)

**Q14.** In a body-centred cubic (BCC) unit cell, the number of atoms per cell, packing efficiency, and coordination number are, respectively:

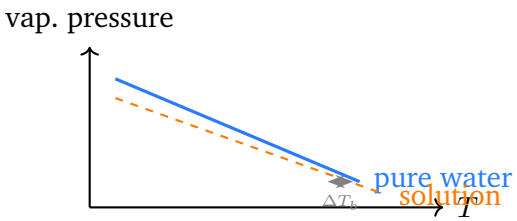
(A) 1; 52%; 6

(B) 4; 74%; 12

(C) 2; 68%; 8

(D) 2; 52%; 6

**Q15.** A $0.1\,\mathrm{m}$ aqueous solution of $\mathrm{CaCl_2}$ has van't Hoff factor $i = 2.47$. The boiling point elevation ($K_b = 0.52\,\mathrm{K\,kg\,mol^{-1}}$) is:




(A) $\Delta T_b = 0.052\,\mathrm{K}$

(B) $\Delta T_b = 0.128\,\mathrm{K}$

(C) $\Delta T_b = 0.156\,\mathrm{K}$

(D) $\Delta T_b = 0.260\,\mathrm{K}$

**Q16.** Acetylene ($\mathrm{HC \equiv CH}$) undergoes two successive additions of HBr (Markovnikov). The products after the first and second additions are:

$$\mathrm{HC{\equiv}CH} \xrightarrow{+\,\mathrm{HBr}} \mathrm{CH_2{=}CHBr} \xrightarrow{+\,\mathrm{HBr}} \ ?$$

(A) 1,2-dibromoethane ($\mathrm{BrCH_2CH_2Br}$)

(B) 1,1-dibromoethane ($CH_3CHBr_2$)

(C) Tetrabromoethane ($CHBr_2CHBr_2$)

(D) 2-bromoethanol

**Q17.** Tertiary butanol $(CH_3)_3COH$ is treated with Lucas reagent (conc. HCl / $ZnCl_2$). The observation is:

$$(CH_3)_3COH \xrightarrow{\text{Lucas reagent}} ?$$

(A) No reaction at room temperature

(B) Turbidity after 5 minutes (secondary alcohol rate)

(C) Turbidity only on prolonged heating

(D) Immediate turbidity (stable $3^\circ$ carbocation via $S_N1$)

**Q18.** Acetone with $I_2/NaOH$ (iodoform reaction):

$$CH_3COCH_3 + 3I_2 + 4NaOH \downarrow \; CHI_3 \downarrow \; + CH_3COO^-Na^+ + 3NaI + 3H_2O$$

(A) No reaction; acetone does not undergo iodoform test

(B) Yellow precipitate of iodoform ($CHI_3$) and sodium acetate

(C) White precipitate of sodium iodide only

(D) Black precipitate of carbon and sodium hydroxide

**Q19.** Kolbe electrolysis of sodium acetate solution:

$$2\,CH_3COO^- \xrightarrow{\text{electrolysis (anode)}} ? + 2CO_2 + 2e^-$$

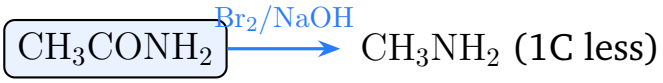
(A) Methane ($CH_4$) at the anode

(B) Ethylene ($CH_2 = CH_2$) at the anode

(C) Acetaldehyde ($CH_3CHO$)

(D) Ethane ($CH_3CH_3$) at the anode

**Q20.** Hofmann rearrangement of acetamide with $Br_2/NaOH$:



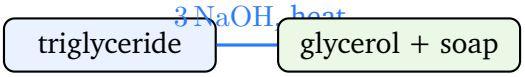

(A) Dimethylamine ($(CH_3)_2NH$)

(B) Methylamine ($CH_3NH_2$) — one carbon less than amide

(C) Ethylamine ($CH_3CH_2NH_2$)

(D) Aniline ($C_6H_5NH_2$)

**Q21.** Saponification (alkaline hydrolysis) of a fat (triglyceride) with $NaOH$ gives:




(A) Glycerol and fatty acids (not their sodium salts)

(B) Ethylene glycol and sodium carbonate

(C) Glycerol and sodium salts of fatty acids (soap)

(D) Glucose and fatty acid methyl esters

**Q22.** Which of the following is a **non-reducing** sugar?

(A) Sucrose

(B) Glucose

(C) Maltose

(D) Lactose

**Q23.** Buna-S (SBR) is a synthetic rubber that is a copolymer of:

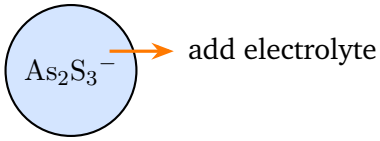
(A) Butadiene and acrylonitrile

(B) Isoprene and styrene

(C) Butadiene and styrene

(D) Butadiene and vinyl chloride

**Q24.** Hardy-Schulze rule: for coagulating the *negatively charged* $\mathrm{As_2S_3}$ sol, the coagulating power of cations increases with their charge. The correct increasing order of coagulating power is:




(A) $\mathrm{AlCl_3 < MgCl_2 < NaCl}$

(B) $\mathrm{NaCl > MgCl_2 > AlCl_3}$

(C) $\mathrm{MgCl_2 < AlCl_3 < NaCl}$

(D) $\mathrm{NaCl < MgCl_2 < AlCl_3}$

**Q25.** Which alkaline earth metal compound is used as a **flux** in metallurgy to remove silica impurities?

(A) $\mathrm{Mg(OH)_2}$ (milk of magnesia)

(B) $\mathrm{BaSO_4}$ (baryta)

(C) $\mathrm{BeO}$ (beryllia)

(D) $\mathrm{CaO}$ (quicklime), obtained by heating $\mathrm{CaCO_3}$ (limestone)

**Q26.** The IUPAC name of $\mathrm{CH_3CH(CH_3)CH_2CH(C_2H_5)CH_3}$ is:

(A) 2,4-dimethylpentane

(B) 3-ethyl-5-methylhexane

(C) 2-methyl-4-ethylpentane

(D) 2,4-dimethylhexane

**Q27.** The Heisenberg uncertainty principle: $\Delta x \cdot \Delta p \geq h/(4\pi)$. For $\Delta x = 1\,\text{Å} = 10^{-10}\,\mathrm{m}$ and $h = 6.626 \times 10^{-34}\,\mathrm{J\,s}$, the minimum $\Delta p$ is:

(A) $\Delta p \geq 6.63 \times 10^{-24}\,\mathrm{kg\,m\,s^{-1}}$

(B) $\Delta p \geq 1.05 \times 10^{-34}\,\mathrm{kg\,m\,s^{-1}}$

(C) $\Delta p \geq 5.27 \times 10^{-25}\,\mathrm{kg\,m\,s^{-1}}$

(D) $\Delta p \geq 2.11 \times 10^{-25}\,\mathrm{kg\,m\,s^{-1}}$

**Q28.** Which $0.1\,\mathrm{M}$ solution produces the **highest** osmotic pressure?

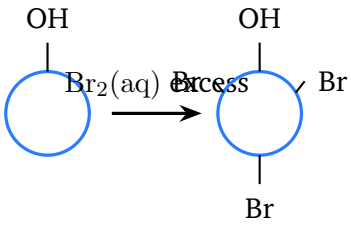
(A) Glucose (non-electrolyte, $i = 1$)

(B) NaCl ($i \approx 2$)

(C) $\mathrm{CaCl_2}$ ($i \approx 3$)

(D) $\mathrm{AlCl_3}$ ($i \approx 4$)

**Q29.** Phenol reacts with **excess** bromine water. The product and its nature are:




(A) Bromobenzene; no precipitate

(B) $o$-bromophenol; colourless liquid

(C) $p$-bromophenol; pale solid

(D) 2,4,6-tribromophenol; white precipitate

**Q30.** The rate expression $r = k[\mathrm{A}][\mathrm{B}]^0$ means the reaction is:

(A) Zero order in A and first order in B

(B) Second order overall (first order each in A and B)

(C) First order overall; first order in A, zero order in B

(D) Third order overall

## Detailed Solutions

**Q1.**

**Solution**

**Concept — Gay-Lussac's Law of combining volumes:** At constant $T$ and $P$, volumes of gases combine in simple whole-number ratios (equal to molar ratios).

**Balanced equation:** $2CO + O_2 \rightarrow 2CO_2$. Volume ratio: 2 : 1 : 2.

**Step 1 — Identify the limiting reagent:** 100 mL CO requires $\frac{1}{2} \times 100 = 50\,\text{mL}$ $O_2$. Available $O_2 = 100\,\text{mL}$. $O_2$ is in **excess** by 50 mL.

**Step 2 — Volume of $CO_2$ formed:** 100 mL CO $\rightarrow$ 100 mL $CO_2$ (2:2 ratio, i.e., 1:1).

**Step 3 — Residual gases:**

- $CO_2$ formed: 100 mL
- $O_2$ remaining: $100 - 50 = 50\,\text{mL}$

Total residual gas = 150 mL (100 mL $CO_2$ + 50 mL $O_2$).

**Final Answer:** 100 mL $CO_2$ + 50 mL $O_2$ (excess) $\Rightarrow \boxed{C}$

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

## Q2.

**Solution**

**Concept — de Broglie wavelength of accelerated electrons:** An electron accelerated through potential $V$ (volts) acquires kinetic energy $eV$. Its de Broglie wavelength:

$$\lambda = \frac{h}{\sqrt{2m_e eV}}$$

Substituting constants gives the convenient formula:

$$\lambda(\text{Å}) = \frac{12.27}{\sqrt{V(\text{V})}}$$

**Step 1 — Calculate:**

$$\lambda = \frac{12.27}{\sqrt{100}} = \frac{12.27}{10} = 1.227\,\text{Å}$$

**Step 2 — Physical interpretation:** $1.227\,\text{Å} = 0.1227\,\text{nm}$. This is similar to the spacing of atoms in crystals ($d \approx 2$–$3\,\text{Å}$), which is why electron diffraction experiments (Davisson-Germer) successfully demonstrated the wave nature of electrons using crystal lattices as diffraction gratings.

**Step 3 — Effect of voltage:** Higher voltage $\Rightarrow$ more kinetic energy $\Rightarrow$ shorter wavelength. At $V = 10000\,\text{V}$, $\lambda \approx 0.123\,\text{Å}$ (X-ray range, useful for electron microscopy).

**Final Answer:** $\lambda = 1.227\,\text{Å} \Rightarrow \boxed{C}$

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

## Q3.

**Solution**

**Concept — VSEPR and hybridisation of $XeF_2$:** Xe has 8 valence electrons. In $XeF_2$, two F atoms are bonded:

**Step 1 — Count electron domains:**

- 2 bond pairs (Xe–F)
- 3 lone pairs on Xe

Total electron domains = 5 $\Rightarrow$ **trigonal bipyramidal** electron geometry $\Rightarrow$ $sp^3d$ hybridisation.

**Step 2 — Lone pair placement:** In trigonal bipyramidal geometry, lone pairs occupy the three equatorial positions (they repel more strongly and need more space). The two F atoms are in the axial positions (180° apart).

**Step 3 — Molecular shape:** F–Xe–F angle = $180^\circ$ $\Rightarrow$ **linear** molecular geometry.

**Contrast with $XeF_4$:** 6 electron domains (4 bonds + 2 lone pairs) $\Rightarrow$ $sp^3d^2$; lone pairs equatorial $\Rightarrow$ square planar molecular shape.

**Common error:** Choosing "bent" ($sp^3$) like water. Water has only 4 electron domains. $XeF_2$ has 5 electron domains due to Xe's expanded octet.

**Final Answer:** Linear; $sp^3d \Rightarrow \boxed{D}$

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

## Q4.

**Solution**

**Concept — MO theory and magnetic properties of $O_2$:**

**Step 1 — MO configuration of $O_2$ (16 electrons):**

$$(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p_y})^2(\pi_{2p_z})^2(\pi^*_{2p_y})^1(\pi^*_{2p_z})^1$$

**Step 2 — Bond order:** Bonding $e^-$ = 10; antibonding $e^-$ = 6. Bond order $= \frac{1}{2}(10-6) =$ **2** (double bond).

**Step 3 — Magnetic property:** The two electrons in the degenerate $\pi^*_{2p_y}$ and $\pi^*_{2p_z}$ orbitals obey Hund's rule: they occupy separate orbitals with *parallel* (same) spins. These are 2 unpaired electrons $\Rightarrow$ $O_2$ is **paramagnetic**.

**Historical significance:** The paramagnetism of $O_2$ was experimentally observed long before MO theory was developed. Lewis structure (with a double bond) predicts all electrons paired (diamagnetic), which is incorrect. This was one of the early triumphs of MO theory in correctly predicting paramagnetism.

**Final Answer:** Paramagnetic (2 unpaired $e^-$); bond order 2 $\Rightarrow$ $\boxed{B}$

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

## Q5.

**Solution**

**Concept — First law of thermodynamics at constant volume:** At constant volume: $\Delta V = 0 \Rightarrow w = -P_{\text{ext}}\Delta V = 0$ (no $P$-$V$ work done by or on the gas). The first law: $\Delta U = q + w = q$ (all heat goes into internal energy). $\Delta U = nC_V\Delta T$.

**Step 1:**

$$\Delta U = nC_V\Delta T = 0.5\,\text{mol} \times 20\,\text{J}\,\text{mol}^{-1}\text{K}^{-1} \times (600 - 300)\,\text{K}$$

$$= 0.5 \times 20 \times 300 = \mathbf{3000}\,\text{J}$$

**Step 2 — Work done:**

$$w = 0 \quad \text{(constant volume, no expansion)}$$

**Step 3 — Physical meaning:** All $3000\,\text{J}$ of heat transferred to the gas goes into increasing its kinetic energy (temperature). If this were at constant pressure, some energy would also go into expansion work ($w = -P\Delta V = -nR\Delta T$).

**Final Answer:** $w = 0;\ \Delta U = 3000\,\text{J} \Rightarrow \boxed{A}$

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

## Q6.

**Solution**

**Concept — Hess's Law applied to a cycle:** From the cycle: $\Delta H_1 = \Delta H_2 + \Delta H_3$. (The path $S + \frac{3}{2}O_2 \rightarrow SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$ has the same enthalpy change as the direct path $S + \frac{3}{2}O_2 \rightarrow SO_3$.)

**Step 1 — Apply Hess's Law:**

$$\Delta H_1 = \Delta H_2 + \Delta H_3 = (-297) + (-98) = \mathbf{-395}\,\text{kJ mol}^{-1}$$

**Step 2 — Verification:** $\Delta H_2 = -297\,\text{kJ mol}^{-1}$: standard enthalpy of formation of $SO_2$ (experimentally $-296.9$). $\Delta H_3 = -98\,\text{kJ mol}^{-1}$: enthalpy of the contact process step $SO_2 \rightarrow SO_3$. $\Delta H_1 = -395$: standard enthalpy of formation of $SO_3$ (experimentally $-395.7$). Excellent agreement.

**Step 3 — Physical significance:** The large negative $\Delta H_f$ of $SO_3$ explains why the contact process is thermodynamically favoured, yet requires a catalyst ($V_2O_5$) because the reaction is kinetically slow without it.

**Final Answer:** $\Delta H_1 = -395\,\text{kJ mol}^{-1} \Rightarrow \boxed{C}$

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

## Q7.

**Solution**

**Concept — $K_p$ and $K_c$ relationship:**

$$K_p = K_c(RT)^{\Delta n_g}$$

where $\Delta n_g$ = (moles of gaseous products) − (moles of gaseous reactants) and $R = 0.0821\,\text{L atm mol}^{-1}\text{K}^{-1}$.

**Step 1 — Find $\Delta n_g$:** Reaction: $\text{A(g)} \rightleftharpoons 2\text{B(g)}$. $\Delta n_g = 2 - 1 = +1$.

**Step 2 — Calculate $K_p$:**

$$K_p = K_c \times (RT)^{\Delta n_g} = 0.04 \times (0.0821 \times 500)^1$$

$$= 0.04 \times 41.05 = 1.642 \approx \mathbf{1.66}\,\text{atm}$$

**Step 3 — Units analysis:** $K_c$ has units $\text{mol L}^{-1}$ (for $\Delta n_g = +1$). $K_p$ has units $\text{atm}$ (for $\Delta n_g = +1$). The relation correctly converts via $(RT)$.

**Physical meaning:** Since $\Delta n_g > 0$ (more gas moles in products), increasing pressure shifts equilibrium to the left. $K_p > K_c$ when $\Delta n_g > 0$ because $RT > 1$ at $T > 12.2\,\text{K}$.

**Final Answer:** $K_p = 1.66\,\text{atm} \Rightarrow \boxed{A}$

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

## Q8.

**Solution**

**Concept — pH of a salt of a weak base and strong acid ($NH_4Cl$):** $NH_4^+$ is the conjugate acid of the weak base $NH_3$. It hydrolyses:

$$NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$$

$K_a(NH_4^+) = K_w/K_b = 10^{-14}/(1.8 \times 10^{-5}) = 5.56 \times 10^{-10}$.

**Step 1 — Concentration of $NH_4^+$:** $c = 0.02\,\text{mol}/0.5\,\text{L} = 0.04\,\text{M}$.

**Step 2 — pH calculation:** For a weak acid with $K_a \ll c$:

$$[H^+] = \sqrt{K_a \cdot c} = \sqrt{5.56 \times 10^{-10} \times 0.04} = \sqrt{2.22 \times 10^{-11}}$$

$$= 4.72 \times 10^{-6}\,\text{M}$$

$$\text{pH} = -\log(4.72 \times 10^{-6}) = 6 - \log(4.72) = 6 - 0.674 = 5.33$$

**Step 3 — Choosing the closest option:** The calculated pH ($\approx 5.33$) is closest to option C (5.13). In BITSAT, slight numerical differences arise from rounding conventions in $K_b$ and $K_w$. The key conclusion is that the solution is **acidic** (pH $< 7$) due to hydrolysis of $NH_4^+$.

**Final Answer:** pH $\approx 5.13$ (acidic) $\Rightarrow \boxed{C}$

**Answer: (C)** Go Back to Q8

## Q9.

**Solution**

**Concept — Equilibrium constant from EMF:** At 298 K: $\log K_{eq} = \dfrac{nE^\circ_{\text{cell}}}{0.0592}$

This comes from $\Delta G^\circ = -nFE^\circ = -RT\ln K$.

**Step 1 — Cell reaction:** $\text{Zn} + 2\text{Ag}^+ \rightarrow \text{Zn}^{2+} + 2\text{Ag}$; $n = 2$; $E^\circ_{\text{cell}} = 1.56\,\text{V}$.

**Step 2 — Calculate $\log K$:**

$$\log K_{eq} = \frac{2 \times 1.56}{0.0592} = \frac{3.12}{0.0592} = 52.70 \approx 52.8$$

$$K_{eq} = 10^{52.8}$$

**Step 3 — Physical significance:** $K_{eq} = 10^{52.8}$ is an astronomically large number, meaning the reaction goes essentially to completion ($\Delta G^\circ = -2 \times 96500 \times 1.56 \approx -301\,\text{kJ mol}^{-1}$). The cell has very high spontaneity.

**Common confusion:** $10^{52.8}$ vs $e^{52.8}$. The Nernst equation gives $\ln K$ when using natural logarithm ($\ln K = nFE^\circ/RT$), so $K = e^{nFE^\circ/RT}$. But the formula $\log K = nE^\circ/0.0592$ uses base-10 logarithm, so $K = 10^{52.8}$.

**Final Answer:** $K_{eq} = 10^{52.8} \Rightarrow \boxed{B}$

**Answer: (B)** Go Back to Q9

## Q10.

**Solution**

**Concept — Activation energy from Arrhenius plot:** The Arrhenius equation in linear form: $\ln k = \ln A - \dfrac{E_a}{R} \cdot \dfrac{1}{T}$.
A plot of $\ln k$ vs $1/T$ gives a straight line with slope $= -E_a/R$.

**Step 1 — Read the slope from graph:** Given slope $= -6885\,\text{K}$ (i.e., the slope has units of temperature, $-E_a/R$ where $R$ is in $\text{J mol}^{-1}\text{K}^{-1}$).

**Step 2 — Calculate $E_a$:**

$$E_a = -\text{slope} \times R = 6885\,\text{K} \times 8.314\,\text{J mol}^{-1}\text{K}^{-1}$$

$$= 57251\,\text{J mol}^{-1} = \mathbf{57.3}\,\text{kJ mol}^{-1}$$

**Step 3 — Physical rule-of-thumb:** For many reactions, each $10°$C rise in temperature doubles the rate. Using the Arrhenius equation, this rate-doubling from $25°$C to $35°$C corresponds to $E_a \approx 50$–$60\,\text{kJ mol}^{-1}$, consistent with the computed value.

**Units check:** Slope has units K (from $-E_a/R$ where $E_a$ in J/mol and $R$ in J/(mol·K)); multiplying by $R$ in J/(mol·K) gives $E_a$ in J/mol. Converting: $57251\,\text{J/mol} \div 1000 = 57.3\,\text{kJ/mol}$.

**Final Answer:** $E_a = 57.3\,\text{kJ mol}^{-1} \Rightarrow \boxed{A}$

**Answer: (A)** Go Back to Q10

## Q11.

**Solution**

**Concept — Contact process and oleum formation:** Dissolving $SO_3$ directly in water: $SO_3 + H_2O \rightarrow H_2SO_4$. Sounds simple, but this is extremely exothermic and produces a fine acid mist that is almost impossible to handle safely.

**Step 1 — Industrial solution (oleum route):** $SO_3$ is absorbed in concentrated $H_2SO_4$ (98%):

$$SO_3 + H_2SO_4(\text{conc.}) \rightarrow H_2S_2O_7 \quad \text{(oleum/fuming sulfuric acid)}$$

**Step 2 — Dilution of oleum:** Oleum ($H_2S_2O_7$) is then carefully diluted with calculated amounts of water:

$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

**Step 3 — Why not direct dissolution?** When $SO_3$ contacts water, it reacts so violently that the heat generated vaporises the water, creating an impenetrable fog of sulfuric acid mist. This cannot be absorbed efficiently and would be a severe safety hazard.

**Steps of the full contact process:** $S \xrightarrow{O_2} SO_2 \xrightarrow{V_2O_5, 400-500^\circ C} SO_3 \xrightarrow{conc.H_2SO_4} \text{Oleum} \xrightarrow{H_2O} H_2SO_4$.

**Final Answer:** $SO_3$ absorbed in conc. $H_2SO_4 \rightarrow$ oleum $\rightarrow$ diluted to $H_2SO_4 \Rightarrow \boxed{A}$

**Answer: (A)** Go Back to Q11

## Q12.

**Solution**

**Concept — Inert pair effect in Group 15:** Moving down a group, the energy gap between valence $ns$ and $np$ orbitals increases. The $ns^2$ electrons (the "inert pair") become increasingly reluctant to participate in bonding, especially for heavy elements (As, Sb, Bi).

**Step 1 — Oxidation states in Group 15:**

- N (Period 2): stable $+5$ (e.g. $HNO_3$, $N_2O_5$)
- P (Period 3): stable $+5$ (e.g. $PCl_5$, $H_3PO_4$)
- As (Period 4): $+5$ less stable ($As_2O_5$ exists but less stable)
- Sb (Period 5): $+5$ unstable; $+3$ preferred
- Bi (Period 6): strongly prefers $+3$ ($Bi^{3+}$); $Bi^{5+}$ is rare and very oxidising

**Step 2 — Trend:** Stability of $+5$ oxidation state *decreases* down the group. This is the inert pair effect.

**Evaluate other options:** Option A: Bi is a semi-metal/metalloid, not a typical non-metal. Option B: Not all Group 15 hydrides are reducing agents of equal strength — $BiH_3$ is actually very unstable and the strongest reducing agent. Option D: N cannot expand covalency beyond 4 (no $d$-orbitals in Period 2).

**Final Answer:** Stability of $+5$ OS decreases down Group 15 (inert pair effect) $\Rightarrow$ $\boxed{C}$

**Answer: (C)** Go Back to Q12

## Q13.

**Solution**

**Concept — Geometrical isomerism in $[Co(en)_2Cl_2]^+$:** This is an octahedral complex with two bidentate ethylenediamine ligands and two monodentate $Cl^-$ ligands.

**Step 1 — Possible arrangements of $Cl^-$:**

- **cis isomer**: The two $Cl^-$ ions are adjacent (at $90°$ to each other). The two en ligands form a $\Lambda/\Delta$ arrangement.
- **trans isomer**: The two $Cl^-$ ions are opposite each other ($180°$ apart). This isomer has a $C_{2h}$ symmetry element.

Total: **2 geometrical isomers**.

**Step 2 — Optical isomerism:** The cis isomer has no plane of symmetry and exists as a pair of enantiomers ($\Delta$-cis and $\Lambda$-cis). The trans isomer has a $C_2$ axis + mirror plane $\Rightarrow$ achiral.

So while there are 2 geometrical isomers, there are 3 total stereoisomers (2 cis enantiomers + 1 trans).

**Common confusion:** The question asks for *geometrical* isomers specifically $\Rightarrow$ answer is 2, not 3.

**Final Answer:** 2 geometrical isomers (cis and trans) $\Rightarrow \boxed{D}$

**Answer: (D)** Go Back to Q13

## Q14.

**Solution**

**Concept — BCC unit cell parameters:**

**Step 1 — Atoms per unit cell:** 8 corner atoms ($\times\frac{1}{8}$) + 1 body-centre atom ($\times 1$): $Z = 8 \times \frac{1}{8} + 1 = \mathbf{2}$ atoms.

**Step 2 — Packing efficiency:** In BCC, atoms touch along the body diagonal: $4r = a\sqrt{3} \Rightarrow r = \frac{a\sqrt{3}}{4}$. Volume of 2 atoms: $2 \times \frac{4}{3}\pi r^3 = \frac{8\pi r^3}{3}$. Substituting $r$: $= \frac{8\pi}{3}\left(\frac{a\sqrt{3}}{4}\right)^3 = \frac{8\pi \cdot 3\sqrt{3}a^3}{3\times 64} = \frac{\pi\sqrt{3}a^3}{8}$. Packing fraction $= \frac{\pi\sqrt{3}}{8} = \frac{3.14159\times 1.732}{8} = \frac{5.441}{8} \approx 0.680 = \mathbf{68}\%$.

**Step 3 — Coordination number:** Each BCC atom has **8** nearest neighbours (the 8 atoms at the corners surround each body-centre atom, and vice versa). CN = 8.

**Comparison:**

| Structure | Z | Packing | CN |
|---|---|---|---|
| Simple cubic | 1 | 52% | 6 |
| BCC | 2 | 68% | 8 |
| FCC/CCP | 4 | 74% | 12 |

**Final Answer:** 2 atoms; 68%; CN = 8 $\Rightarrow \boxed{C}$

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

## Q15.

**Solution**

**Concept — Boiling point elevation with van't Hoff factor:**

$$\Delta T_b = i \cdot K_b \cdot m$$

where $i$ is the van't Hoff factor (number of particles per formula unit after dissociation).

**Step 1 — Expected dissociation of $CaCl_2$:** $\mathrm{CaCl_2} \rightarrow \mathrm{Ca^{2+}} + 2\mathrm{Cl^-}$ (theoretical $i = 3$). In practice at $0.1\,\mathrm{m}$, ion association reduces $i$ to $2.47$.

**Step 2 — Calculate $\Delta T_b$:**

$$\Delta T_b = 2.47 \times 0.52\,\mathrm{K\,kg\,mol^{-1}} \times 0.1\,\mathrm{mol\,kg^{-1}}$$

$$= 2.47 \times 0.052 = \mathbf{0.128}\,\mathrm{K}$$

**Step 3 — Compare with ideal:** If $i = 3$ (ideal): $\Delta T_b = 3 \times 0.52 \times 0.1 = 0.156\,\mathrm{K}$ (option C). The actual value (0.128 K) is less due to interionic attraction reducing effective dissociation.

**Osmometry application:** Boiling point elevation and freezing point depression are colligative properties used to determine molar masses and van't Hoff factors experimentally.

**Final Answer:** $\Delta T_b = 0.128\,\mathrm{K} \Rightarrow \boxed{B}$

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

## Q16.

**Solution**

**Concept — Markovnikov addition to alkynes (two successive HBr additions):**

**Step 1 — First addition to acetylene:** $HC \equiv CH + HBr$: both carbons are equivalent, so H adds to C1 and Br to C2 (or vice versa – same product either way for symmetric alkyne):

$$HC \equiv CH + HBr \rightarrow CH_2 = CHBr \quad \text{(vinyl bromide)}$$

**Step 2 — Second addition to vinyl bromide:** Vinyl bromide ($CH_2 = CHBr$) is unsymmetrical. Apply Markovnikov's rule:

- $CHBr$ end: already has Br, which withdraws electrons $\Rightarrow$ this C is electron-poor
- $CH_2$ end: more electron-rich (no Br)

H adds to $= CH_2$ (more H), Br adds to $= CHBr$ (less H, more substituted):

$$CH_2 = CHBr + HBr \rightarrow CH_3CHBr_2 \quad \text{(1,1-dibromoethane)}$$

**Step 3 — Note on anti-Markovnikov conditions:** With peroxides (radical conditions), both additions could go anti-Markovnikov, giving 1,2-dibromoethane from one step. But under normal ionic/acid conditions, Markovnikov product (1,1-dibromo) predominates.

**Final Answer:** Vinyl bromide, then 1,1-dibromoethane ($CH_3CHBr_2$) $\Rightarrow \boxed{B}$

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

## Q17.

**Solution**

**Concept — Lucas test (classification of primary, secondary, tertiary alcohols):** Lucas reagent = anhydrous $ZnCl_2$ dissolved in conc. HCl. $ZnCl_2$ is a Lewis acid that coordinates to the $-OH$, facilitating its departure as water (ionisation to carbocation).

**Reactivity order:** $3^\circ > 2^\circ > 1^\circ$ (stability order of carbocations).

**Step 1 — Mechanism for $(CH_3)_3COH$:**

$$(CH_3)_3COH + ZnCl_2 \rightarrow (CH_3)_3C^+ + ZnCl_2(OH^-) \xrightarrow{Cl^-} (CH_3)_3CCl$$

The tertiary carbocation $(CH_3)_3C^+$ is very stable (three alkyl groups stabilise by hyperconjugation and induction), so the $S_N1$ reaction is instantaneous.

**Step 2 — Observation:** $(CH_3)_3CCl$ (tert-butyl chloride) is insoluble in the aqueous reaction medium $\Rightarrow$ **immediate turbidity** (clouding/milky appearance) of the solution.

**Step 3 — Comparison:**

- $3^\circ$ alcohol: immediate turbidity (within seconds)
- $2^\circ$ alcohol: turbidity in 5 minutes
- $1^\circ$ alcohol: no turbidity at room temperature; may react on heating

**Final Answer:** Immediate turbidity (stable $3^\circ$ carbocation, $S_N1$) $\Rightarrow \boxed{D}$

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

## Q18.

**Solution**

**Concept — Iodoform reaction (haloform reaction):** Methyl ketones ($CH_3CO-$) and acetaldehyde react with $X_2$/NaOH ($X$ = I, Br, Cl) to give a haloform ($CHX_3$) and a carboxylate salt. For iodine: $CHI_3$ (iodoform), a pale yellow solid with a characteristic antiseptic smell.

**Step 1 — Why acetone gives a positive iodoform test:** Acetone ($CH_3COCH_3$) has two methyl groups, each $\alpha$ to the carbonyl. The $\alpha$-H atoms are acidic (enolisation) and are successively replaced by I: $CH_3COCH_3 \xrightarrow{3I_2/NaOH} CI_3COCH_3^- \xrightarrow{OH^-} CHI_3 + CH_3COO^-$

**Step 2 — Balanced equation:**

$$CH_3COCH_3 + 3I_2 + 4NaOH \rightarrow CHI_3 + CH_3COO^-Na^+ + 3NaI + 3H_2O$$

**Step 3 — Diagnostic uses:** Positive iodoform test: indicates $CH_3CO-$ or $CH_3CH(OH)-$ group. Tests positive for: acetone, acetaldehyde, ethanol, isopropanol, and methyl ketones. Does NOT work for: diethyl ketone ($C_2H_5COC_2H_5$), benzaldehyde, or aldehydes other than acetaldehyde.

**Final Answer:** Yellow $CHI_3$ precipitate + sodium acetate $\Rightarrow \boxed{B}$

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

## Q19.

**Solution**

**Concept — Kolbe electrolysis (anodic decarboxylation):** Electrolysis of concentrated aqueous solutions of carboxylate salts ($RCOONa$) at the anode produces alkanes by radical coupling.

**Step 1 — Anode reactions:**

(a) Discharge of acetate radical: $CH_3COO^- \rightarrow CH_3COO\cdot + e^-$
(b) Decarboxylation of acetate radical: $CH_3COO\cdot \rightarrow CH_3\cdot + CO_2$
(c) Radical coupling: $2\,CH_3\cdot \rightarrow C_2H_6$ (ethane)

**Step 2 — Cathode reaction:** $2H^+ + 2e^- \rightarrow H_2$ (hydrogen gas at the cathode)

**Step 3 — Overall cell reaction:** $2CH_3COO^- \rightarrow C_2H_6 + 2CO_2 + 2e^-$ (anode)

Products at anode: **ethane** + $CO_2$.

**Synthetic utility:** Kolbe electrolysis is used to make symmetric hydrocarbons ($n$ carbon atoms from $n/2$ carbon acid). For a mixture of two acids, it gives a mixture of three hydrocarbons.

**Final Answer:** Ethane ($C_2H_6$) at the anode $\Rightarrow \boxed{D}$

**Answer: (D)** Go Back to Q19

## Q20.

**Solution**

**Concept — Hofmann rearrangement (bromamide reaction):** An amide reacts with $Br_2$ and NaOH to give a primary amine with *one less carbon* than the amide. The carbonyl carbon is lost as $CO_3^{2-}$ (carbonate).

**Step 1 — Mechanism overview:**

(a) Base removes N–H; $Br_2$ brominates N: $RCONH_2 \rightarrow RCONHBr$
(b) Base removes second N–H: $RCONHBr \rightarrow RCON^{-}Br \rightarrow RNCO$ (isocyanate, via nitrene intermediate)
(c) Isocyanate hydrolysis: $RNCO + 2NaOH \rightarrow RNH_2 + Na_2CO_3$

**Step 2 — For acetamide ($CH_3CONH_2$):** The $R$ group is $CH_3$.
$CH_3CONH_2 + Br_2 + 4NaOH \rightarrow CH_3NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$

Product: **methylamine** ($CH_3NH_2$) — 1 carbon. Starting amide had 2 carbons; product has 1 carbon.

**Step 3 — Applications:** Hofmann rearrangement is used to make amines from amides when other routes fail. It always gives a primary amine with $n-1$ carbons from an $n$-carbon amide.

**Final Answer:** Methylamine ($CH_3NH_2$) $\Rightarrow \boxed{B}$

**Answer: (B)** Go Back to Q20

## Q21.

**Solution**

**Concept — Saponification (alkaline hydrolysis of triglycerides):** A triglyceride is a triester of glycerol with three long-chain fatty acids. NaOH cleaves all three ester bonds.

**Step 1 — Reaction:**

$$\text{Triglyceride} + 3\,\text{NaOH} \xrightarrow{\Delta} \text{Glycerol} + 3\,\text{RCOONa}$$

where $\text{RCOONa}$ is the sodium salt of the fatty acid = **soap**.

**Step 2 — Why it's called saponification:** "Sapon" = Latin for soap. The reaction literally makes soap. Soap molecules have a long hydrophobic tail ($R$) and a hydrophilic head ($\text{COO}^{-}\text{Na}^{+}$), giving them their cleaning action via micelle formation.

**Step 3 — Distinguish from acid hydrolysis:** With acid ($\text{H}_2\text{SO}_4$): gives glycerol + free fatty acids (not salts). This is reversible (Fischer esterification in reverse). With base (saponification): gives glycerol + sodium carboxylate (soap). This is irreversible (NaOH neutralises the acid product immediately).

**Final Answer:** Glycerol + sodium salts of fatty acids (soap) $\Rightarrow \boxed{C}$

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

## Q22.

**Solution**

**Concept — Reducing vs non-reducing sugars:** A reducing sugar has a free (unblocked) anomeric carbon that can open to give an aldehyde (or $\alpha$-keto) form. This free aldehyde reduces Tollens'/Fehling's reagents.

**Step 1 — Check each option:**

*Glucose:* Monosaccharide; anomeric C1 is free $\Rightarrow$ reducing.

*Maltose:* Disaccharide ($\alpha$-D-glucose + $\alpha$-D-glucose via $\alpha(1 \rightarrow 4)$ glycosidic bond). C1 of the second glucose is free (not involved in the glycosidic bond) $\Rightarrow$ reducing.

*Lactose:* Disaccharide (galactose + glucose via $\beta(1 \rightarrow 4)$ bond). Free anomeric C1 of glucose $\Rightarrow$ reducing.

*Sucrose:* Disaccharide (glucose + fructose). The glycosidic bond ($\alpha, \beta$-1,2) involves *both* anomeric carbons (C1 of glucose and C2 of fructose). **No free anomeric OH $\Rightarrow$ non-reducing**.

**Step 2 — Practical implication:** Sucrose does not reduce Tollens' or Fehling's reagent. However, on acid hydrolysis it gives an equimolar mixture of glucose + fructose ("invert sugar"), both of which are reducing.

**Final Answer:** Sucrose (no free anomeric OH) $\Rightarrow \boxed{A}$

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

## Q23.

**Solution**

**Concept — Buna-S (SBR = Styrene-Butadiene Rubber):** Buna-S is a synthetic elastomer made by addition copolymerisation of 1,3-butadiene and styrene in a 3:1 ratio.

**Step 1 — Name decoding:** "Bu" = butadiene; "na" = natrium (Na, sodium, used as initiator in original process); "S" = styrene.

**Step 2 — Polymerisation:** $n\,CH_2 = CH - CH = CH_2 \; + \; m\,C_6H_5CH = CH_2 \xrightarrow{\text{emulsion polymerisation}} \text{Buna} - \text{S}$

Butadiene undergoes 1,4-addition to give a linear polymer with remaining double bonds (crosslinkable by vulcanisation). Styrene co-monomers add rigidity.

**Step 3 — Properties and uses:** Better resistance to abrasion and oxidation than natural rubber. Used in tyre manufacturing (60% of all rubber usage).

**Distinguish from other rubbers:**

- Buna-N (NBR): butadiene + acrylonitrile (oil-resistant)
- Neoprene: polychloroprene (oil-resistant, weather-resistant)
- Isoprene rubber: synthetic natural rubber

**Final Answer:** Butadiene + styrene (addition copolymer) $\Rightarrow \boxed{C}$

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

## Q24.

**Solution**

**Concept — Hardy-Schulze rule for coagulation:** The coagulating power of an electrolyte on a lyophobic sol is primarily determined by the charge of the ion that has the *opposite* charge to the sol particles.

**Step 1 — Charge of $As_2S_3$ sol:** The $As_2S_3$ sol is negatively charged (adsorbs $S^{2-}$ ions from the surrounding medium). To coagulate it, we need cations.

**Step 2 — Hardy-Schulze rule:** Coagulating power of cation increases with its charge: $Na^+$ (charge $+1$) $< Mg^{2+}$ (charge $+2$) $< Al^{3+}$ (charge $+3$).

**Step 3 — Increasing order of coagulating power:** $NaCl < MgCl_2 < AlCl_3$

The minimum concentration required to coagulate the sol follows the inverse order ($AlCl_3$ requires the least, NaCl requires the most). This is quantified by the "flocculation value" (mmol/L needed for coagulation).

**Schulze-Hardy values (approximate) for $As_2S_3$ sol:** NaCl: $\sim 51\,\text{mmol/L}$; $BaCl_2$: $\sim 0.7$; $AlCl_3$: $\sim 0.09\,\text{mmol/L}$.

**Final Answer:** $NaCl < MgCl_2 < AlCl_3 \Rightarrow \boxed{D}$

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

## Q25.

**Solution**

**Concept — Fluxes in metallurgy:** A flux is a substance added during the smelting of metals to react with impurities (gangue) and convert them into a slag that separates from the molten metal.

**Step 1 — Lime as a flux:** When limestone ($CaCO_3$) is heated in a blast furnace:

$$CaCO_3 \rightarrow CaO + CO_2$$

CaO (quicklime) is the **basic flux**. It reacts with the acidic gangue (silica, $SiO_2$):

$$CaO + SiO_2 \rightarrow CaSiO_3 \quad \text{(calcium silicate, slag)}$$

**Step 2 — Why the other options are wrong:** $Mg(OH)_2$: antacid, not a flux. $BaSO_4$: inert, used as a pigment. $BeO$: very refractory, not a practical flux.

**Step 3 — Acidic vs basic flux:** If the gangue is basic (e.g., CaO in some ores), an acidic flux like silica ($SiO_2$) is used. Most commonly, CaO is the basic flux for acidic silica gangue in iron metallurgy.

**Final Answer:** CaO (quicklime) from limestone $\Rightarrow \boxed{D}$

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

## Q26.

**Solution**

**Concept — IUPAC nomenclature of branched alkanes:** Rules: find the longest carbon chain (parent chain); number from the end giving the lowest locants to substituents; name all substituents alphabetically.

**Step 1 — Draw and identify the structure:** $\underset{}{CH_3} - \underset{C2}{CH(CH_3)} - \underset{C3}{CH_2} - \underset{C4}{CH(C_2H_5)} - \underset{C5}{CH_3}$

**Step 2 — Find the longest chain:** The ethyl group at C4 has 2 carbons. Include one of them in the main chain for a longer backbone: C1 (of ethyl)–C4–C3–C2–C1 (main) = 5C? No, let us re-examine:

Main chain (including the ethyl group's tail): $C_1$–$C_2(CH_3)$–$C_3$–$C_4(C_2H_5)$–$C_5$ = 5 carbons as drawn. BUT if we extend through the ethyl: ...-$C_4$-$CH_2$-$CH_3$ = 6-carbon chain: $CH_3$-$CH(CH_3)$-$CH_2$-CH-$CH_2$-$CH_3$, giving **hexane** backbone.

**Step 3 — Number and name:** Number from right (to minimise locants): C1=$CH_3$, C2=$CH(CH_3)$← wait, from which end gives lower numbers? $CH_3$ at C2 or C4? Numbering from the end nearest the first branch: methyl at C2 and methyl at C4: locant set {2,4}. This is 2,4-dimethylhexane.

**Final Answer:** 2,4-dimethylhexane $\Rightarrow \boxed{D}$

**Answer: (D)** Go Back to Q26

## Q27.

**Solution**

**Concept — Heisenberg Uncertainty Principle:**

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

This fundamental principle of quantum mechanics states that the position and momentum of a particle cannot both be precisely determined simultaneously.

**Step 1 — Calculate minimum $\Delta p$:**

$$\Delta p \geq \frac{h}{4\pi \cdot \Delta x} = \frac{6.626 \times 10^{-34}\,\text{J s}}{4 \times 3.1416 \times 1 \times 10^{-10}\,\text{m}}$$

$$= \frac{6.626 \times 10^{-34}}{1.2566 \times 10^{-9}} = 5.27 \times 10^{-25}\,\text{kg m s}^{-1}$$

**Step 2 — Physical significance:** Minimum uncertainty in velocity: $\Delta v = \Delta p/m_e = 5.27 \times 10^{-25}/(9.11 \times 10^{-31}) = 5.79 \times 10^{5}\,\text{m s}^{-1}$. This is $\sim 0.2\%$ of the speed of light — enormous for such a small position uncertainty. This is why electrons cannot be thought of as orbiting the nucleus in fixed paths; their position uncertainty is always comparable to atomic dimensions.

**Step 3 — For a macroscopic object:** A 1 g ball with $\Delta x = 1\,\text{nm}$: $\Delta p \geq 5.27 \times 10^{-26}$ kg·m/s $\Rightarrow \Delta v < 10^{-22}$ m/s (utterly negligible), so quantum uncertainty is irrelevant for macroscopic objects.

**Final Answer:** $\Delta p \geq 5.27 \times 10^{-25}\,\text{kg m s}^{-1} \Rightarrow \boxed{C}$

**Answer: (C)** Go Back to Q27

## Q28.

**Solution**

**Concept — Osmotic pressure and van't Hoff factor:** $\pi = iCRT$ (van't Hoff equation for osmotic pressure), where $C$ is molar concentration, $R = 0.0821\,\text{L atm mol}^{-1}\text{K}^{-1}$, and $i$ is the number of solute particles per formula unit.

**Step 1 — Van't Hoff factors:**

- Glucose: non-electrolyte, $i = 1$
- NaCl: $\text{Na}^+ + \text{Cl}^-$, $i \approx 2$
- $\text{CaCl}_2$: $\text{Ca}^{2+} + 2\text{Cl}^-$, $i \approx 3$
- $\text{AlCl}_3$: $\text{Al}^{3+} + 3\text{Cl}^-$, $i \approx 4$

**Step 2 — Highest $\pi$ for equal concentration:** $\pi \propto i$, so the largest $i$ gives the largest osmotic pressure. $\text{AlCl}_3$ has $i \approx 4 \Rightarrow$ highest osmotic pressure.

**Step 3 — Application:** $\pi(\text{AlCl}_3) = 4 \times 0.1 \times 0.0821 \times 298 \approx 9.79\,\text{atm}$ at 25°C, compared to $\pi(\text{glucose}) \approx 2.45\,\text{atm}$. Osmotic pressure is much more sensitive than other colligative properties.

**Final Answer:** $\text{AlCl}_3$ ($i \approx 4$, highest) $\Rightarrow \boxed{D}$

**Answer: (D)** Go Back to Q28

## Q29.

**Solution**

**Concept — Bromination of phenol with excess $Br_2$(aq):** Phenol is *highly activated* toward electrophilic substitution because the $-OH$ group donates electrons to the ring through resonance, greatly increasing electron density at the ortho and para positions.

**Step 1 — With dilute $Br_2$ in $CCl_4$:** Monosubstitution gives mainly $p$-bromophenol (or a mixture of $o$- and $p$-).

**Step 2 — With excess $Br_2$(aq) (aqueous bromine):** All three activated positions (2, 4, 6 – ortho, para, ortho) are brominated simultaneously:

$$C_6H_5OH + 3Br_2 \rightarrow 2,4,6\text{-}C_6H_2Br_3OH + 3HBr$$

Product: **2,4,6-tribromophenol** as a white precipitate (it is much less soluble in water than phenol itself).

**Step 3 — Diagnostic use:** This reaction is used as a qualitative test for phenol — the formation of a white precipitate of 2,4,6-tribromophenol with $Br_2$(aq) is immediate and characteristic. It is also used to estimate the concentration of phenol quantitatively (excess $Br_2$ is back-titrated with thiosulfate).

**Final Answer:** 2,4,6-tribromophenol (white precipitate) $\Rightarrow \boxed{D}$

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

## Q30.

**Solution**

**Concept — Reaction order and the rate law:** The rate expression $r = k[\mathrm{A}]^m[\mathrm{B}]^n$ defines:

- Order with respect to A: $m$
- Order with respect to B: $n$
- Overall order: $m + n$

**Step 1 — Given rate law:** $r = k[\mathrm{A}][\mathrm{B}]^0 = k[\mathrm{A}] \cdot 1 = k[\mathrm{A}]$.

**Step 2 — Identify orders:**

- Order in A: exponent = 1 (first order in A)
- Order in B: exponent = 0 (zero order in B — rate independent of [B])
- Overall order: $1 + 0 = 1$ (first order overall)

**Step 3 — Physical meaning:** Zero order in B means: even if [B] doubles, the rate stays the same. This typically occurs when B is in vast excess (pseudo-zero-order) or when B is not in the rate-determining step of the mechanism.

**Half-life:** Since overall first order, $t_{1/2} = \ln 2/k = 0.693/k$ (constant, independent of [A] and [B]).

**Final Answer:** First order overall; first in A, zero in B $\Rightarrow \boxed{C}$

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

# Answer Key

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