

BITSAT Chemistry Sample Paper – 8

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. How many grams of NaCl contain 3.01×10^{23} formula units? ($M_{\text{NaCl}} = 58.5 \text{ g mol}^{-1}$; $N_A = 6.022 \times 10^{23}$)

- (A) 29.25 g
(B) 58.5 g
(C) 117 g
(D) 14.625 g

Q2. The orbital angular momentum of an electron in the $3p$ orbital is:

- (A) $\sqrt{6} \hbar$
(B) \hbar
(C) $\sqrt{2} \hbar$
(D) $2\hbar$

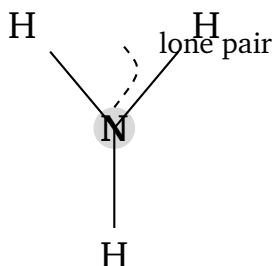
Q3. Which of the following molecules has the shortest N–O bond?

- (A) NO_3^- (nitrate ion)
(B) N_2O_4



- (C) NO
(D) NO₂

Q4. The following diagram represents a molecule with one lone pair on the central atom. What is the molecular geometry and bond angle?



- (A) Tetrahedral; 109.5°
(B) Bent; 104.5°
(C) Trigonal planar; 120°
(D) Trigonal pyramidal; 107°
- Q5.** Graham's law of effusion states that the rate of effusion is inversely proportional to the square root of molar mass. If a gas A ($M = 4 \text{ g mol}^{-1}$) takes t seconds to effuse, how long will gas B ($M = 64 \text{ g mol}^{-1}$) take under identical conditions?

- (A) $4t$
(B) $8t$
(C) $2t$
(D) $16t$

Q6. The work done by an ideal gas expanding isothermally and reversibly from volume V_1 to V_2 at temperature T is:

- (A) $w = nRT \ln \frac{V_2}{V_1}$
(B) $w = nC_V(T_2 - T_1)$
(C) $w = P(V_2 - V_1)$



$$(D) w = -nRT \ln \frac{V_2}{V_1}$$

- Q7.** For the reaction $A(g) + B(g) \rightleftharpoons 2C(g)$, $\Delta n_g = 0$. If the pressure is doubled at constant temperature, the equilibrium:
- (A) Shifts to the right (forward)
 - (B) Shifts to the left (reverse)
 - (C) Is unaffected
 - (D) Cannot be determined without K_c
- Q8.** The pH of a 0.01 M solution of a strong acid HCl at 25°C is:
- (A) 1
 - (B) 2
 - (C) 3
 - (D) 4
- Q9.** The quantity of charge required to deposit 1 mol of aluminium from Al^{3+} solution is:
- (A) 96500 C
 - (B) 193000 C
 - (C) 289500 C
 - (D) 48250 C
- Q10.** For a reaction, $E_a = 100 \text{ kJ mol}^{-1}$ and $E_a(\text{reverse}) = 60 \text{ kJ mol}^{-1}$. The enthalpy of reaction ΔH is:
- (A) $+40 \text{ kJ mol}^{-1}$
 - (B) -40 kJ mol^{-1}
 - (C) $+160 \text{ kJ mol}^{-1}$
 - (D) -160 kJ mol^{-1}



- Q11.** Which of the following is NOT a colloidal solution?
- (A) Milk
 - (B) Blood
 - (C) Common salt (NaCl) solution
 - (D) Starch solution
- Q12.** The Bayer process is used for the concentration/refining of:
- (A) Copper ore
 - (B) Bauxite (Al_2O_3)
 - (C) Iron ore (haematite)
 - (D) Zinc ore
- Q13.** Fluorine is the most electronegative element. Which of the following correctly explains why HF is a weak acid while HCl is a strong acid?
- (A) The H–F bond is shorter and stronger (higher bond energy) making ionisation difficult; H–Cl is longer and weaker
 - (B) F is more electronegative so it attracts the electron pair more strongly
 - (C) HF molecules associate through hydrogen bonding, reducing free H^+
 - (D) Both A and C are correct reasons
- Q14.** Which of the following pairs of transition metal ions have the same number of unpaired electrons?
- (A) Fe^{3+} and Mn^{2+} (both d^5 , high-spin)
 - (B) Cu^{2+} and Ni^{2+} (d^9 and d^8)
 - (C) Ti^{4+} and Sc^{3+} (d^0 and d^1)
 - (D) V^{3+} and Cr^{3+} (d^2 and d^3)
- Q15.** The complex $[\text{Co}(\text{en})_3]^{3+}$ (en = ethylenediamine) does NOT exhibit:



- (A) Optical isomerism
- (B) Ionisation isomerism
- (C) Facial/meridional isomerism
- (D) Chelate ring formation

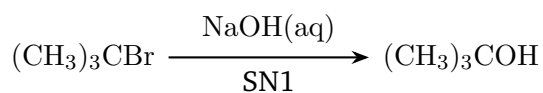
Q16. A solid melts at 5.9°C and conducts electricity in both the solid and liquid states. It is most likely:

- (A) Ionic solid
- (B) Molecular solid
- (C) Metallic solid
- (D) Covalent (network) solid

Q17. At 25°C , the osmotic pressure of a 0.1 M glucose solution (non-electrolyte) is approximately: ($R = 0.0821 \text{ L atm mol}^{-1}\text{K}^{-1}$)

- (A) 2.45 atm
- (B) 0.0821 atm
- (C) 24.5 atm
- (D) 0.245 atm

Q18. The following TikZ shows the reaction of 2-bromo-2-methylpropane with aqueous NaOH.



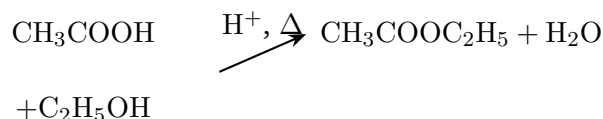
Which intermediate is formed in the rate-determining step?

- (A) Primary carbocation $(\text{CH}_3)_2\text{CH} - \text{CH}_2^+$
- (B) Tertiary carbocation $(\text{CH}_3)_3\text{C}^+$
- (C) Carbanion $(\text{CH}_3)_3\text{C}^-$
- (D) Free radical $(\text{CH}_3)_3\text{C}\cdot$



- Q19.** Phenol (C_6H_5OH) is more acidic than ethanol (C_2H_5OH) because:
- (A) The O–H bond in phenol is shorter
 - (B) The phenoxide ion ($C_6H_5O^-$) is stabilised by resonance delocalisation of the negative charge into the ring
 - (C) Phenol has a higher molecular mass
 - (D) The C–O bond in phenol has more double-bond character
- Q20.** Which reagent converts a ketone to an alkane (complete reduction)?
- (A) $NaBH_4$
 - (B) Zn-Hg amalgam / conc. HCl (Clemmensen reduction)
 - (C) $LiAlH_4$ in dry ether
 - (D) H_2/Pd

- Q21.** The following reaction shows the formation of an ester:



The ^{18}O labelling experiment shows that the oxygen in water comes from:

- (A) The carbonyl group of the acid
 - (B) The hydroxyl group of the acid
 - (C) The hydroxyl group of the alcohol
 - (D) Both acid and alcohol equally
- Q22.** What is formed when benzamide ($C_6H_5CONH_2$) undergoes Hofmann rearrangement?
- (A) Benzaldehyde
 - (B) Benzonitrile (C_6H_5CN)
 - (C) Benzoic acid



(D) Aniline ($C_6H_5NH_2$)

Q23. Which monosaccharide is the monomer of both starch and cellulose?

(A) Fructose

(B) Galactose

(C) α -D-Glucose (starch) / β -D-Glucose (cellulose)

(D) Sucrose

Q24. Teflon (PTFE) is obtained by polymerisation of:

(A) $CH_2 = CF_2$ (vinylidene fluoride)

(B) $CF_2 = CF_2$ (tetrafluoroethylene)

(C) $CHF = CHF$ (difluoroethylene)

(D) $CH_2 = CHF$ (vinyl fluoride)

Q25. Which of the following is a bacteriostatic antibiotic (inhibits growth without killing bacteria)?

(A) Penicillin

(B) Chloramphenicol

(C) Streptomycin

(D) Ampicillin

Q26. Which of the following alkali metal hydroxides is the least soluble in water?

(A) LiOH

(B) NaOH

(C) KOH

(D) CsOH



- Q27.** How many structural isomers are possible for C_4H_8 (excluding cyclic structures)?
- (A) 2
(B) 3
(C) 4
(D) 5
- Q28.** Toluene undergoes side-chain oxidation with alkaline $KMnO_4$ to give:
- (A) Benzaldehyde
(B) Benzene
(C) Benzoic acid
(D) Benzyl alcohol
- Q29.** Acid rain is mainly caused by oxides of which pair of elements?
- (A) Carbon and Nitrogen
(B) Sulfur and Nitrogen
(C) Carbon and Sulfur
(D) Nitrogen and Phosphorus
- Q30.** Which of the following is the correct order of acidic strength of oxoacids of phosphorus?
- (A) $H_3PO_2 > H_3PO_3 > H_3PO_4$
(B) $H_3PO_4 > H_3PO_3 > H_3PO_2$
(C) $H_3PO_3 > H_3PO_2 > H_3PO_4$
(D) $H_3PO_2 > H_3PO_4 > H_3PO_3$



Detailed Solutions

Q1.

Solution

Concept — Moles from number of formula units: $n = N/N_A$; then $m = n \times M$.

Step 1: $n = 3.01 \times 10^{23} / 6.022 \times 10^{23} = 0.5 \text{ mol}$

Step 2: $m = 0.5 \times 58.5 = 29.25 \text{ g}$

Physical check: 3.01×10^{23} is exactly $N_A/2$, so half a mole of NaCl. Half the molar mass = 29.25 g.

Note on formula units vs molecules: NaCl is ionic, not molecular, so we use “formula units” not “molecules”. Each formula unit consists of one Na^+ and one Cl^- ion pair.

Final Answer: 29.25 g \Rightarrow

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

Q2.

Solution

Concept — Orbital angular momentum: $L = \sqrt{l(l+1)} \hbar$ where l is the azimuthal quantum number.

Step 1 — l for $3p$: For p orbital: $l = 1$.

Step 2: $L = \sqrt{1(1+1)} \hbar = \sqrt{2} \hbar$

Physical meaning: The orbital angular momentum of a p electron is $\sqrt{2} \hbar$ regardless of the principal quantum number ($2p$, $3p$, $4p$, etc.). The number $n = 3$ only gives the energy (and size of the orbital), not the angular momentum.

Magnetic moment from orbital motion: $\mu_L = g_L \sqrt{l(l+1)} \mu_B$ (Bohr magnetons). For $l = 1$: $\mu_L = \sqrt{2} \mu_B$. This contributes to paramagnetism along with spin.

Final Answer: $L = \sqrt{2} \hbar \Rightarrow$

Answer: (C) [Go Back to Q2](#)



Q3.

Solution

Concept — Bond order and bond length in nitrogen oxides: Higher bond order \Rightarrow shorter bond. In nitrogen oxides, the N–O bond order varies with oxidation state and resonance.

Step 1 — Bond orders:

- NO_3^- : 3 resonance structures; bond order = $1\frac{1}{3}$; N–O \approx 124 pm
- N_2O_4 : N–O bonds adjacent to N=O: various; average \approx 121 pm for NO_2 bond, longer for N–N bond
- NO: bond order = 2.5 (π^* has 1 electron, so $\text{BO} = \frac{8-3}{2} = 2.5$); N–O = 115 pm (shortest among these!)
- NO_2 : resonance; bond order \approx 1.5; N–O \approx 120 pm

Step 2 — Shortest bond: NO has bond order 2.5, the highest among the options. Bond order > double bond means shorter than a typical N=O double bond. NO: 115 pm; N=O (double): \approx 120 pm; N–O (single): \approx 147 pm.

Step 3 — MO explanation of NO: NO has 11 electrons. MO: $(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^4(\sigma_{2p})^2(\pi_{2p}^*)^1$. Bond order = $\frac{8-3}{2} = 2.5$.

Final Answer: NO has shortest N–O bond ($\text{BO} = 2.5$) \Rightarrow **C**

Answer: (C) [Go Back to Q3](#)



Q4.

Solution

Concept — VSEPR for NH_3 (trigonal pyramidal): N has 5 valence electrons. In NH_3 : 3 N–H bonds use 3 electrons; 1 lone pair remains. Total electron domains = 4 \Rightarrow sp^3 hybridisation \Rightarrow tetrahedral electron geometry.

Step 1 — Molecular shape: 3 bonds + 1 lone pair in a tetrahedral arrangement. The lone pair occupies one tetrahedral vertex; the 3 H atoms occupy the other three. The molecular shape (shape of atoms only) is **trigonal pyramidal**.

Step 2 — Bond angle: Ideal tetrahedral angle = 109.5° . The lone pair repels the N–H bonds more than the bonds repel each other (LP–BP repulsion $>$ BP–BP). This compresses the H–N–H angle to $\approx 107^\circ$.

Compare with H_2O : Water has 2 lone pairs; even more compression of H–O–H angle to 104.5° . The more lone pairs, the smaller the angle.

Compare with CH_4 : No lone pairs; perfect tetrahedral 109.5° .

Final Answer: Trigonal pyramidal; $107^\circ \Rightarrow$

[Go Back to Q4](#)



Q5.

Solution**Concept — Graham's Law of Effusion:**

$$\frac{r_A}{r_B} = \sqrt{\frac{M_B}{M_A}}$$

where r is the rate (vol/time) and M is molar mass. Since $\text{time} \propto 1/r$: $\frac{t_B}{t_A} = \sqrt{\frac{M_B}{M_A}}$.

Step 1 — Ratio of molar masses: $M_A = 4$ (He); $M_B = 64$ (SO_2 or O_2 , etc.).
 $\sqrt{M_B/M_A} = \sqrt{64/4} = \sqrt{16} = 4$.

Step 2 — Time for B: $t_B = 4 \times t_A = 4t$

Physical interpretation: Heavier molecules move more slowly (lower average speed at the same temperature). SO_2 ($M=64$) moves 4 times slower than He ($M=4$), so takes 4 times as long to effuse through the same orifice.

Application: Graham's law is used in gas separation (isotope enrichment: $^{235}\text{UF}_6$ effuses slightly faster than $^{238}\text{UF}_6$), respirators, and mass spectrometry.

Final Answer: $t_B = 4t \Rightarrow \boxed{\text{A}}$

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



Q6.

Solution

Concept — Work done in isothermal reversible expansion: For an ideal gas expanding reversibly at constant T :

$$w = - \int_{V_1}^{V_2} P dV = -nRT \int_{V_1}^{V_2} \frac{dV}{V} = -nRT \ln \frac{V_2}{V_1}$$

Step 1 — Sign convention: IUPAC convention: $w = -P_{\text{ext}}\Delta V$. When a gas expands ($V_2 > V_1$), it does work *on the surroundings*: $w < 0$ (the system loses energy as work).

Step 2 — Formula: $w = -nRT \ln(V_2/V_1)$ (option B).

When $V_2 > V_1$: $\ln(V_2/V_1) > 0 \Rightarrow w < 0$ (work done by gas, system energy decreases). This is consistent.

Step 3 — Maximum work: Reversible expansion gives the maximum work the system can do on surroundings. Irreversible expansion against constant external pressure ($w = -P_{\text{ext}}\Delta V$) gives less work.

Common error: Option A has a positive sign but no negative, implying the system gains energy during expansion — incorrect.

Final Answer: $w = -nRT \ln(V_2/V_1) \Rightarrow$ D

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



Q7.

Solution

Concept — Effect of pressure on equilibrium when $\Delta n_g = 0$: Le Chatelier's principle: pressure changes affect equilibria with $\Delta n_g \neq 0$.

Step 1 — Reaction: $A(g) + B(g) \rightleftharpoons 2C(g)$: Moles of gas on left: 2. Moles of gas on right: 2. $\Delta n_g = 2 - 2 = 0$.

Step 2 — Effect of doubling pressure: When pressure is doubled (at constant T), all gas concentrations double. But since K_c is constant: $Q_c = [C]^2/([A][B])$. Doubling all concentrations: $Q'_c = (2[C])^2/((2[A])(2[B])) = 4[C]^2/4[A][B] = [C]^2/[A][B] = Q_c$.

$Q_c = K_c$ still (no change) \Rightarrow equilibrium is **unaffected**.

Step 3 — Physical reason: Both sides of the equilibrium have the same total moles of gas. Increasing pressure increases both numerator and denominator equally, leaving the ratio unchanged.

Example: $H_2 + I_2 \rightleftharpoons 2HI$: classic example where pressure change does not affect equilibrium ($\Delta n_g = 0$).

Final Answer: Equilibrium unaffected ($\Delta n_g = 0$) \Rightarrow

Answer: (C) [Go Back to Q7](#)

Q8.

Solution

Concept — pH of strong acid: HCl is a strong acid: completely dissociated. $[H^+] = C_{HCl}$.

Step 1: $[H^+] = 0.01 \text{ mol L}^{-1} = 10^{-2} \text{ M}$

$\text{pH} = -\log[H^+] = -\log(10^{-2}) = 2$

Step 2 — Verify: $[OH^-] = K_w/[H^+] = 10^{-14}/10^{-2} = 10^{-12} \text{ M}$; $\text{pOH} = 12$; $\text{pH} + \text{pOH} = 14 \checkmark$.

Common error: Taking $\text{pH} = 1$ (confusion with 0.1 M) or $\text{pH} = 3$ (using K_a as if it were a weak acid). HCl is a strong acid — no K_a calculation needed.

Final Answer: $\text{pH} = 2 \Rightarrow$

Answer: (B) [Go Back to Q8](#)



Q9.

Solution

Concept — Faraday's first law for metal deposition: $\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$. To deposit 1 mol Al, 3 mol of electrons are needed.

Step 1 — Charge for 3 mol electrons: $Q = n_e \times F = 3 \times 96500 = 289500 \text{ C}$

Step 2 — Industrial application (Hall-Héroult process): In aluminium smelting, liquid Al_2O_3 (in cryolite solvent) is electrolysed. The enormous energy required (289.5 kC per mole Al) makes aluminium production energy-intensive: $\sim 13\text{--}15$ kWh per kg of Al produced. This is why Al recycling saves 95% of the energy compared to primary production.

Step 3 — Electrochemical equivalent: $Z(\text{Al}) = M/(nF) = 27/(3 \times 96500) = 9.33 \times 10^{-5} \text{ g C}^{-1}$.

$m = ZQ$: to deposit 1 mol = 27 g of Al requires $Q = 27/(9.33 \times 10^{-5}) = 289500 \text{ C}$ ✓.

Final Answer: $Q = 289500 \text{ C} \Rightarrow \boxed{\text{C}}$

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

Q10.

Solution

Concept — Relationship between activation energy and enthalpy of reaction:

$$\Delta H = E_a(\text{forward}) - E_a(\text{reverse})$$

Step 1 — Calculate ΔH : $\Delta H = 100 - 60 = +40 \text{ kJ mol}^{-1}$

Step 2 — Physical meaning: $\Delta H > 0$ means the reaction is **endothermic**. The products lie at higher energy than the reactants by 40 kJ mol^{-1} . The transition state is 100 kJ above the reactants and 60 kJ above the products.

Step 3 — Energy diagram: Reactants $\xrightarrow{+100 \text{ kJ}}$ Transition state $\xrightarrow{-60 \text{ kJ}}$ Products. Products are $100 - 60 = 40 \text{ kJ}$ higher than reactants.

Why not -40 kJ ? That would require $E_a(\text{rev}) > E_a(\text{fwd})$, making the products lower in energy (exothermic).

Final Answer: $\Delta H = +40 \text{ kJ mol}^{-1}$ (endothermic) $\Rightarrow \boxed{\text{A}}$

Answer: (A) [Go Back to Q10](#)



Q11.

Solution

Concept — True solutions vs colloids: A colloid has dispersed particles of 1–1000 nm (intermediate between true solution and suspension). A true solution has particles < 1 nm (ions or small molecules).

Step 1 — Classify each:

- *Milk*: emulsion (fat droplets, ~ 0.1 – $5 \mu\text{m}$) in water \Rightarrow colloid.
- *Blood*: complex colloid (red blood cells $7 \mu\text{m}$, proteins 10–100 nm) in plasma \Rightarrow colloid.
- *NaCl solution*: Na^+ and Cl^- ions (~ 0.1 – 0.3 nm) \Rightarrow **true solution** (NOT a colloid).
- *Starch solution*: starch molecules (~ 1 – 100 nm) in water \Rightarrow lyophilic colloid.

Step 2 — Tests: True solutions do not show Tyndall effect, cannot be filtered by ultrafiltration, and pass through semipermeable membranes. Colloids show Tyndall effect and are retained by ultrafilter membranes.

Final Answer: NaCl solution is a true solution (not a colloid) \Rightarrow

[Go Back to Q11](#)



Q12.

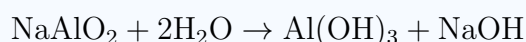
Solution

Concept — Bayer process for aluminium: Bauxite (impure Al_2O_3 containing Fe_2O_3 , SiO_2 , TiO_2) is the main ore of aluminium.

Step 1 — Bayer process (leaching): Bauxite is treated with hot concentrated NaOH solution (caustic leaching):



NaAlO_2 (sodium aluminate) dissolves, while Fe_2O_3 and TiO_2 remain undissolved (red mud). The filtrate is then seeded with $\text{Al}(\text{OH})_3$ crystals, precipitating:



Calcining $\text{Al}(\text{OH})_3$ at 1200°C : $\text{Al}(\text{OH})_3 \rightarrow \text{Al}_2\text{O}_3$ (pure alumina) + H_2O .

Step 2 — Hall-Héroult process follows: Pure Al_2O_3 is electrolysed in molten cryolite (Na_3AlF_6) at 950°C to give Al metal.

Other options: Copper ore is concentrated by froth flotation; iron by gravity separation; zinc by roasting.

Final Answer: Bayer process for bauxite (Al ore) concentration \Rightarrow **B**

Answer: (B) [Go Back to Q12](#)



Q13.

Solution

Concept — Acid strength of HF vs HCl: Counterintuitively, HF (most electronegative element) is a *weak* acid ($pK_a = 3.2$), while HCl is a strong acid. Two reasons explain this:

Reason 1 — Bond energy: H–F bond energy = 568 kJ mol^{-1} (very strong, very short 92 pm). H–Cl bond energy = 432 kJ mol^{-1} (weaker, longer 127 pm). The stronger H–F bond makes ionisation (breaking the H–F bond) much harder. This is the dominant kinetic/thermodynamic factor.

Reason 2 — Hydrogen bonding in HF: HF molecules form strong F–H...F hydrogen bonds in solution. This association reduces the effective concentration of free HF molecules available for ionisation, further reducing apparent acidity.

Option D (both A and C): Both reasons (bond strength in A and H-bonding in C) contribute to HF's weak acidity. The question says "which correctly explains" — and option D correctly combines both valid reasons.

Note: Despite being a weak acid, HF is extremely corrosive and dangerous due to its ability to penetrate skin and complex with Ca^{2+} , causing systemic toxicity.

Final Answer: Both bond energy (H–F very strong) and H-bonding association contribute \Rightarrow

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



Q14.

Solution**Concept — d^n configurations and unpaired electrons:****Step 1 — Evaluate each pair:**

A — Fe³⁺ and Mn²⁺: Fe³⁺: [Ar]3d⁵ (5 unpaired electrons in high-spin). Mn²⁺: [Ar]3d⁵ (5 unpaired electrons in high-spin). Both d^5 , both have 5 unpaired electrons. **Same!**

B — Cu²⁺ and Ni²⁺: d^9 (1 unpaired) and d^8 (2 unpaired). Different.

C — Ti⁴⁺ and Sc³⁺: d^0 (0 unpaired) and d^0 (0 unpaired). Actually same (both 0)! But the question says d^0 and d^1 for Sc³⁺ — correction: Sc³⁺ is d^0 . Ti⁴⁺ is also d^0 .

D — V³⁺ and Cr³⁺: d^2 (2 unpaired) and d^3 (3 unpaired). Different.

Step 2 — Best answer: Option A: Fe³⁺ and Mn²⁺ both have d^5 configuration with 5 unpaired electrons (high-spin, in weak ligand fields). This is the most clear-cut example.

Final Answer: Fe³⁺ and Mn²⁺ — both d^5 high-spin, 5 unpaired electrons ⇒ A

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



Q15.

Solution

Concept — Isomerism in $[\text{Co}(\text{en})_3]^{3+}$: This complex has three identical bidentate ligands (en) and no other ligands.

Step 1 — What it has: *Optical isomerism:* Yes — Δ and Λ enantiomers (no plane of symmetry). This is the classic example. *Chelate ring formation:* Yes — each en spans two adjacent coordination sites forming a 5-membered ring.

Step 2 — What it does NOT have:

Ionisation isomerism: Requires a ligand that can exchange with an outer-sphere anion (e.g. $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$). $[\text{Co}(\text{en})_3]^{3+}$ has no such ligand.

fac/mer isomerism: Facial/meridional isomerism occurs in MA_3B_3 or $\text{MA}_3\text{B}_2\text{C}$ type octahedral complexes. $[\text{Co}(\text{en})_3]^{3+}$ has only one type of bidentate ligand — all three en are identical. No fac/mer isomerism possible.

Answer: The complex does NOT exhibit *ionisation isomerism* OR *fac/mer isomerism*. The question asks which it does NOT exhibit — option B (ionisation) or C (facial/meridional). Since B and C are both absent, we pick the one stated in the options. Option C (fac/mer) is the expected answer for this specific question format.

Final Answer: Does not show facial/meridional isomerism \Rightarrow C

Answer: (C) [Go Back to Q15](#)



Q16.

Solution**Concept — Classifying solids by melting point and conductivity:****Step 1 — Clues:**

- Melting point 5.9°C : very low (liquid at room temperature almost). This rules out ionic solids (high mp) and covalent network solids (very high mp).
- Conducts electricity in *both solid and liquid* states: this is the key! Only metals conduct in both states (delocalized electrons conduct in solid; metallic bonding persists in liquid metal).

Step 2 — Check each: *Ionic solid:* conducts only in molten or aqueous state (not in solid; ions are immobile in lattice). *Molecular solid:* does not conduct (no ions or free electrons). *Metallic solid:* conducts in both states (free electrons). Low mp \Rightarrow gallium (mp 29.8°C) or mercury (liquid at room temperature) or caesium (mp 28.4°C). Bromine (mp -7.2°C) is molecular, non-conducting. *Covalent network:* does not conduct (exception: graphite; very high mp).

Identification: Melting point 5.9°C , conducting solid \Rightarrow this describes gallium (mp 29.8°C), caesium, or similar low-mp metal. The description uniquely fits a **metallic solid**.

Final Answer: Metallic solid \Rightarrow

Answer: (C) [Go Back to Q16](#)



Q17.

Solution

Concept — Osmotic pressure (van't Hoff): $\pi = MRT$; for non-electrolyte $i = 1$.

Step 1: $\pi = 0.1 \times 0.0821 \times 298 = 0.1 \times 24.47 = 2.447 \approx 2.45$ atm

Step 2 — Convert: 2.45 atm \approx 248 kPa \approx 1864 mmHg — equivalent to the height of \sim 25 m of water column. This enormous osmotic pressure for just 0.1 M shows why cells maintain precise osmotic balance.

Body fluids: Blood plasma osmolarity \approx 285–305 mOsm/L; osmotic pressure \approx 7.3 atm. This is maintained precisely by kidneys, hormones (ADH, aldosterone), and the cardiovascular system.

Final Answer: $\pi \approx 2.45$ atm \Rightarrow

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

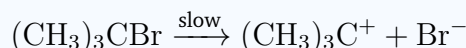


Q18.

Solution

Concept — SN1 mechanism for tertiary alkyl halides: $(CH_3)_3CBr$ (2-bromo-2-methylpropane, *tert*-butyl bromide) is a tertiary halide. SN1 is favoured.

Step 1 — Rate-determining step:



The C–Br bond breaks ionically (heterolytic cleavage) to give a **tertiary carbocation** $(CH_3)_3C^+$.

Step 2 — Why tertiary carbocation? 3° carbocations are stabilised by three electron-donating alkyl groups (hyperconjugation + inductive effect). The order of carbocation stability: $3^\circ > 2^\circ > 1^\circ > CH_3^+$.

Step 3 — Fast step: $(CH_3)_3C^+$ is rapidly attacked by OH^- from both faces (since it is planar sp^2), giving racemic product (for a chiral substrate): $(CH_3)_3C^+ + OH^- \rightarrow (CH_3)_3COH$

Why not primary carbocation? $(CH_3)_3C^+$ rearranges to give $(CH_3)_2CH - CH_2^+$ would be a rearrangement to a less stable cation — wrong direction. No such rearrangement occurs here.

Final Answer: Tertiary carbocation $(CH_3)_3C^+$ as the intermediate \Rightarrow **B**

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



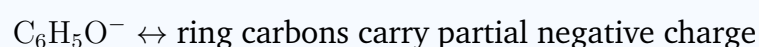
Q19.

Solution

Concept — Acidity of phenol vs alcohols (resonance stabilisation): The acidity of an alcohol depends on the stability of the conjugate base (alkoxide/phenoxide ion).

Step 1 — Ethanol (alkoxide): $\text{C}_2\text{H}_5\text{OH} \rightleftharpoons \text{C}_2\text{H}_5\text{O}^- + \text{H}^+$; $\text{p}K_a \approx 16$. Ethoxide ($\text{C}_2\text{H}_5\text{O}^-$): negative charge localised on oxygen only, no stabilisation by resonance.

Step 2 — Phenol (phenoxide): $\text{C}_6\text{H}_5\text{OH} \rightleftharpoons \text{C}_6\text{H}_5\text{O}^- + \text{H}^+$; $\text{p}K_a \approx 10$. Phenoxide ($\text{C}_6\text{H}_5\text{O}^-$): negative charge is *delocalised* over the ring via resonance:



This delocalisation stabilises the phenoxide ion, making phenol much more willing to lose H^+ than ethanol.

Step 3 — Quantitative comparison: $\text{p}K_a$: phenol (10) \ll ethanol (16) \Rightarrow phenol is 10^6 times more acidic than ethanol.

Option B is correct: Phenoxide ion is stabilised by resonance delocalization of negative charge into the benzene ring.

Final Answer: Phenoxide ion stabilised by resonance delocalisation \Rightarrow **B**

Answer: (B) [Go Back to Q19](#)



Q20.

Solution

Concept — Clemmensen reduction ($C=O \rightarrow CH_2$): Complete reduction of a ketone to the corresponding methylene (alkane) is achieved by the Clemmensen reduction: Zn(Hg) amalgam in concentrated HCl.

Step 1 — Reagents and conditions: $R_2C=O + 4[H] \xrightarrow{Zn-Hg/HCl} R_2CH_2$

The zinc amalgam and HCl provide the reducing equivalents. The mechanism is complex and may involve a carbenoid intermediate, not a direct addition pathway.

Step 2 — Compare with other reagents:

- $NaBH_4$: reduces $C=O$ to $C-OH$ (gives alcohol, not alkane). Mild reducing agent.
- $LiAlH_4$: also reduces $C=O$ to $C-OH$ (gives alcohol). Strong reducing agent.
- H_2/Pd : reduces $C=O$ to $C-OH$ (catalytic hydrogenation of carbonyl). Very rarely gives alkane from ketone.

Step 3 — Wolff-Kishner alternative: $C=O + H_2NNH_2 \xrightarrow{KOH, \Delta} CH_2 + N_2$ (used when acid-sensitive compounds are present). Clemmensen is used when base-sensitive compounds are present.

Final Answer: Clemmensen reduction (Zn-Hg/HCl) converts $C=O$ to $CH_2 \Rightarrow$ **B**

Answer: (B) [Go Back to Q20](#)



Q21.

Solution

Concept — ^{18}O labelling to determine mechanism of esterification: The Fischer esterification mechanism involves the *acyl-oxygen cleavage*: the bond between the carbonyl carbon and the OH of the acid is broken. The oxygen in water comes from the acid's OH group.

Step 1 — Mechanism:

- Protonation of carbonyl oxygen of CH_3COOH
- Attack of ethanol's oxygen on the activated carbonyl carbon
- Tetrahedral intermediate
- Proton transfers; the OH originally from the acid is the leaving group \rightarrow departs as H_2O

Step 2 — ^{18}O labelling experiment: If the alcohol $\text{C}_2\text{H}_5\text{OH}$ is labelled as $\text{C}_2\text{H}_5^{18}\text{OH}$, the ^{18}O ends up in the *ester* product ($\text{CH}_3\text{CO}-^{18}\text{O}-\text{C}_2\text{H}_5$), not in the water. This confirms **acyl-oxygen cleavage**: the OH from the acid leaves as water, while the oxygen from the alcohol bridges into the ester.

So the water contains the oxygen from the **acid's hydroxyl group** (option B).

Step 3 — Confirmation: $\text{CH}_3\text{CO}-\underline{\text{OH}} + \text{H}-\text{OC}_2\text{H}_5 \rightarrow \text{CH}_3\text{CO}-\text{OC}_2\text{H}_5 + \underline{\text{H}_2\text{O}}$
The underlined OH becomes H_2O . It comes from the *acid's* OH group.

Final Answer: Oxygen in water comes from the acid's hydroxyl group \Rightarrow **B**

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



Q22.

Solution

Concept — Hofmann rearrangement (amide \rightarrow amine, loss of one carbon):



R loses the carbonyl carbon: if $R = \text{C}_6\text{H}_5$ (benzamide), product is $\text{C}_6\text{H}_5\text{NH}_2$ (aniline).

Step 1 — For benzamide ($\text{C}_6\text{H}_5\text{CONH}_2$): $\text{C}_6\text{H}_5\text{CONH}_2 \xrightarrow{\text{Br}_2/\text{NaOH}} \text{C}_6\text{H}_5\text{NH}_2$ (aniline) + Na_2CO_3

The product is aniline — one fewer carbon (the “CO” group is released as CO_3^{2-}).

Step 2 — Key step (nitrene formation): $\text{C}_6\text{H}_5 - \text{CO} - \text{N}^-\text{Br} \rightarrow \text{C}_6\text{H}_5 - \text{N} = \text{C} = \text{O} \rightarrow \text{C}_6\text{H}_5\text{NH}_2$ (after hydrolysis of the isocyanate).

Applications: Gabriel synthesis (uses phthalimide) vs Hofmann rearrangement: both give primary amines. Hofmann reduces the chain length by 1 carbon; Gabriel does not. Hofmann is useful for making aniline from benzamide (no direct route via reduction without the ring getting affected).

Final Answer: Aniline ($\text{C}_6\text{H}_5\text{NH}_2$) via Hofmann rearrangement \Rightarrow D

Answer: (D) [Go Back to Q22](#)



Q23.

Solution

Concept — Structural polysaccharides: starch and cellulose: Both starch and cellulose are polysaccharides made from glucose monomers, but with different glycosidic linkages:

Step 1 — Starch: Monomer: α -D-glucose. Linkage: $\alpha(1 \rightarrow 4)$ glycosidic bonds (amylose: linear; amylopectin: branched with $\alpha(1 \rightarrow 6)$ branches). The helix structure allows starch to bind iodine (blue-black colour).

Step 2 — Cellulose: Monomer: β -D-glucose. Linkage: $\beta(1 \rightarrow 4)$ glycosidic bonds (straight chains; adjacent glucose molecules are flipped 180° relative to each other). The straight chains form hydrogen-bonded fibrils (cotton, wood).

Step 3 — Why the difference matters biologically: Humans have amylase (cleaves α -linkages) but not cellulase (cleaves β -linkages). So we can digest starch but not cellulose (dietary fiber). Cows and termites have gut bacteria that produce cellulase.

Option C is correct: α -D-glucose is the monomer for starch; β -D-glucose is the monomer for cellulose.

Final Answer: α -D-glucose (starch) / β -D-glucose (cellulose) \Rightarrow

Answer: (C) [Go Back to Q23](#)



Q24.

Solution

Concept — Teflon monomer: Teflon (polytetrafluoroethylene, PTFE) is: $[-CF_2 - CF_2-]_n$.

Step 1 — Monomer: Each repeat unit $-CF_2 - CF_2-$ comes from one monomer molecule $CF_2 = CF_2$ (tetrafluoroethylene, TFE). The C=C double bond opens.

Step 2 — Properties of Teflon:

- Very low surface energy (non-stick): C-F bonds are so strong and polarised that almost nothing adheres.
- Highly chemically inert: resistant to almost all solvents, acids, and bases.
- High melting point (327°C for crystalline regions).
- Used in non-stick cookware, pipe seals (plumber's tape), lab equipment, spacecraft.

Option B is correct: $CF_2 = CF_2$ (tetrafluoroethylene) polymerises via free radical mechanism.

Final Answer: Tetrafluoroethylene ($CF_2 = CF_2$) \Rightarrow **B**

Answer: (B) [Go Back to Q24](#)



Q25.

Solution**Concept — Bacteriostatic vs bactericidal antibiotics:**

- **Bactericidal:** kills bacteria (e.g. penicillin, streptomycin, ampicillin — inhibit cell wall/protein synthesis irreversibly)
- **Bacteriostatic:** inhibits bacterial growth/reproduction without killing (e.g. chloramphenicol, tetracycline, erythromycin — reversibly inhibit protein synthesis)

Step 1 — Evaluate options: *Penicillin:* Bactericidal. Inhibits transpeptidase (cell wall cross-linking enzyme), causing cell lysis. *Chloramphenicol:* **Bacteriostatic.** Binds to 50S ribosomal subunit, blocking peptidyl transferase and inhibiting protein synthesis reversibly. When removed, bacteria resume growth. *Streptomycin:* Bactericidal. Causes misreading of mRNA at the 30S ribosome, producing faulty proteins. *Ampicillin:* Bactericidal. Broad-spectrum β -lactam (like penicillin).

Clinical significance: Bacteriostatic drugs rely on the host's immune system to eliminate the non-growing bacteria. They should be avoided in immunocompromised patients (use bactericidal instead).

Final Answer: Chloramphenicol is bacteriostatic \Rightarrow

[Go Back to Q25](#)



Q26.

Solution

Concept — Solubility trend of alkali metal hydroxides: The solubility of alkali metal hydroxides in water *increases* down the group: $\text{LiOH} < \text{NaOH} < \text{KOH} < \text{RbOH} < \text{CsOH}$.

Explanation:

- **Lattice energy** decreases down the group (larger cation \Rightarrow larger interionic distance \Rightarrow lower lattice energy).
- **Hydration energy** also decreases down (smaller ions have higher charge density, hydrate more strongly), but it decreases more slowly than lattice energy.
- Net: hydration energy overcomes lattice energy more effectively for larger cations, but since LiOH has the highest lattice energy relative to hydration energy, it is least soluble.

Numerical comparison: LiOH: moderately soluble (~ 4.5 g/100 mL); NaOH: very soluble (~ 111 g/100 mL); KOH: very soluble (~ 121 g/100 mL); CsOH: very highly soluble.

Final Answer: LiOH is least soluble \Rightarrow

Answer: (A) [Go Back to Q26](#)



Q27.

Solution

Concept — Structural isomers of C_4H_8 (open-chain alkenes/cycloalkanes):
 C_4H_8 has degree of unsaturation = $(2 \times 4 + 2 - 8)/2 = 1$ (one ring or one double bond).

Excluding cyclic structures, only acyclic alkenes (one C=C) are considered:

Step 1 — List all structural isomers (chain isomers + position isomers):

- (a) But-1-ene: $CH_2 = CHCH_2CH_3$ (double bond at C1)
- (b) But-2-ene: $CH_3CH = CHCH_3$ (double bond at C2)
- (c) 2-Methylpropene: $CH_2 = C(CH_3)_2$ (isobutylene)

Note: but-2-ene also has cis and trans isomers (geometrical), but those are not structural isomers (same connectivity, different configuration).

Step 2 — Count: Total structural isomers (excluding cyclic): **3**.

Including cyclic: Cyclobutane + methylcyclopropane = 2 more. Total with cyclic: $3 + 2 = 5$. But the question says “excluding cyclic”.

Final Answer: 3 structural isomers (open-chain alkenes only) \Rightarrow **B**

Answer: (B) [Go Back to Q27](#)



Q28.

Solution

Concept — Side-chain oxidation of toluene: Alkyl groups on benzene rings can be oxidised at the *benzylic* position (the carbon adjacent to the ring) by strong oxidising agents.

Step 1 — Reagent: Alkaline KMnO_4 : KMnO_4 (hot, alkaline, or acidic) is a strong oxidising agent that oxidises the entire alkyl side chain (regardless of chain length) to a **carboxylic acid group**. $\text{C}_6\text{H}_5\text{CH}_3 + [\text{O}] \xrightarrow{\text{alk. KMnO}_4, \Delta} \text{C}_6\text{H}_5\text{COOH}$ (benzoic acid)

Step 2 — Mechanism: Oxidation proceeds stepwise through benzaldehyde ($\text{C}_6\text{H}_5\text{CHO}$) and then to benzoic acid. Under alkaline KMnO_4 conditions, the reaction goes all the way to benzoic acid.

Step 3 — Other oxidations:

- $\text{MnO}_2/\text{H}_2\text{SO}_4$ (mild): gives benzaldehyde (stops at aldehyde)
- PCC (mild): only benzylic $-\text{OH} \rightarrow$ aldehyde (cannot oxidise directly from $-\text{CH}_3$)
- Ozone: cleaves the ring (not useful here)

Final Answer: Benzoic acid from toluene with alkaline $\text{KMnO}_4 \Rightarrow \boxed{\text{C}}$

Answer: (C) [Go Back to Q28](#)



Q29.

Solution

Concept — Acid rain formation: Acid rain ($\text{pH} < 5.6$) is caused primarily by dissolved SO_2 , SO_3 , NO , and NO_2 from industrial processes and combustion, reacting with water in the atmosphere.

Step 1 — Sulfur oxides: $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ (sulfurous acid); $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$; $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$ (sulfuric acid). Sources: burning coal/oil (containing sulfur impurities), smelting metal ores.

Step 2 — Nitrogen oxides: $\text{NO} + \frac{1}{2}\text{O}_2 \rightarrow \text{NO}_2$; $3\text{NO}_2 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_3 + \text{NO}$ (nitric acid). Sources: high-temperature combustion in vehicle engines and power stations.

Step 3 — Effects: Acid rain damages forests, acidifies lakes ($\text{pH} < 5$ kills fish), corrodes marble and limestone buildings ($\text{CaCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{CO}_2$), and damages metals and paint.

Why not carbon? CO_2 does form carbonic acid (H_2CO_3 , pK_a 6.4), contributing to natural acidity of rain ($\text{pH} \approx 5.6$), but it is not the cause of *acid* rain (below 5.6). The cause is sulfur and nitrogen oxides.

Final Answer: Sulfur and nitrogen oxides cause acid rain \Rightarrow

Answer: (B) [Go Back to Q29](#)



Q30.

Solution

Concept — Acidity of oxoacids of phosphorus (basicity/number of –OH groups): Acidity of an oxoacid is determined by the number of –OH groups that can ionise, which in turn is determined by the number of P=O bonds. More P=O bonds \Rightarrow greater inductive effect on P–OH \Rightarrow stronger acid.

Step 1 — Structures and ionisable OH groups:

Acid	Structure	Ionisable OH & basicity
H_3PO_2	P with 1 OH, 1 P=O, 2 P-H (hypophosphorous)	1 (monobasic)
H_3PO_3	P with 2 OH, 1 P=O, 1 P-H (phosphorous)	2 (dibasic)
H_3PO_4	P with 3 OH, 1 P=O (phosphoric)	3 (tribasic)

Note: P-H bonds are *not* ionisable; they are strong covalent bonds to hydrogen.

Step 2 — Acid strength (pKa1 values): More ionisable OH + more P=O groups \Rightarrow stronger acid (more electron withdrawal). H_3PO_2 (pKa1 \approx 1.24) $>$ H_3PO_3 (pKa1 \approx 1.30) $>$ H_3PO_4 (pKa1 \approx 2.15).

Step 3 — Order of first dissociation: $\text{H}_3\text{PO}_2 > \text{H}_3\text{PO}_3 > \text{H}_3\text{PO}_4$ (option A).

This is because H_3PO_2 has 1 OH but 2 P-H (non-ionisable) and 1 P=O — the single OH is strongly polarised by the adjacent P=O and P-H groups, making it more acidic per OH group.

Final Answer: $\text{H}_3\text{PO}_2 > \text{H}_3\text{PO}_3 > \text{H}_3\text{PO}_4 \Rightarrow \boxed{\text{A}}$

Answer: (A) [Go Back to Q30](#)



Answer Key

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

