BITSAT Chemistry Sample Paper – 21

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. Choose carefully.
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. 4 g of H_2 reacts with 32 g of O_2 to form water ($2H_2 + O_2 \rightarrow 2H_2O$; $M_{H_2O} = 18$). The mass of water formed is:

(A) $36\,\text{g}$

(B) $18\,\text{g}$

(C) $32\,\text{g}$

(D) $30\,\text{g}$

Q2. The maximum number of electrons in a subshell with $l = 3$ (the f subshell) is:

(A) 6

(B) 10

(C) 14

(D) 18

Q3. The correct order of bond angles for H_2O (I), NH_3 (II), CH_4 (III), H_2S (IV) is:

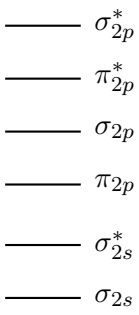
(A) III $>$ II $>$ I $>$ IV

(B) III $>$ II $>$ IV $>$ I

(C) I $>$ II $>$ III $>$ IV

(D) II $>$ I $>$ III $>$ IV

Q4. In the MO diagram for N_2 (where π_{2p} lies below σ_{2p}), the HOMO (highest occupied MO) after filling 14 electrons is:



(A) σ_{2p}

(B) π_{2p}

(C) σ^*_{2s}

(D) π^*_{2p}

Q5. At high pressures, a real gas shows $Z = PV_m/RT > 1$. This positive deviation is mainly because:

(A) Intermolecular attractions dominate

(B) The finite volume of molecules (excluded volume b) makes the effective free volume less than V_m

(C) Molecules move slower at high pressure

(D) The gas obeys Boyle's law perfectly at high pressure

Q6. Which process involves a decrease in entropy ($\Delta S < 0$)?

(A) Melting of ice

(B) Evaporation of water

(C) Dissolving NaCl in water

(D) Crystallisation of a solute from solution

Q7. For $\mathrm{CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)}$, the equilibrium constant K_c equals:

(A) $[\mathrm{CaO}][\mathrm{CO_2}]/[\mathrm{CaCO_3}]$

(B) $[\mathrm{CaO}]/[\mathrm{CaCO_3}]$

(C) $[\mathrm{CO_2}]/[\mathrm{CaO}]$

(D) $[\mathrm{CO_2}]$ only

Q8. The molar solubility of $\mathrm{Mg(OH)_2}$ ($K_{sp} = 5.6 \times 10^{-12}$) in pure water is approximately:

(A) $1.12 \times 10^{-4}\,\mathrm{mol\,L^{-1}}$

(B) $2.34 \times 10^{-4}\,\mathrm{mol\,L^{-1}}$

(C) $5.6 \times 10^{-6}\,\mathrm{mol\,L^{-1}}$

(D) $1.12 \times 10^{-3}\,\mathrm{mol\,L^{-1}}$

Q9. The standard EMF of a cell (E°) is related to ΔG° by:

(A) $\Delta G^\circ = nFE^\circ$

(B) $\Delta G^\circ = nRT\ln E^\circ$

(C) $\Delta G^\circ = -nRTE^\circ$

(D) $\Delta G^\circ = -nFE^\circ$

Q10. From the data below, what is the order of reaction with respect to A?

Expt	[A] (M)	Rate ($\mathrm{mol\,L^{-1}\,s^{-1}}$)
1	0.10	2.0×10^{-4}
2	0.20	8.0×10^{-4}
3	0.40	32.0×10^{-4}

(A) First order

(B) Third order

(C) Zero order

(D) Second order

Q11. Milk is an example of which type of colloid?

(A) Sol (solid in liquid)

(B) Aerosol (liquid in gas)

(C) Emulsion (liquid in liquid)

(D) Gel (liquid in solid)

Q12. Which of the following interhalogen compounds and its shape is correct?

(A) ICl_3: T-shaped (sp^3d; 2 lone pairs equatorial)

(B) BrF_5: square pyramidal (sp^3d^2; 1 lone pair)

(C) ClF_7: pentagonal bipyramidal

(D) IF_7: octahedral

Q13. The van Arkel method (iodide decomposition) is used to purify:

(A) Copper (Cu)

(B) Titanium (Ti) and other refractory metals

(C) Silver (Ag)

(D) Aluminium (Al)

Q14. The complex $[Pt(NH_3)_4]Cl_2$ dissolves in water to give:

(A) 1 ion

(B) 2 ions

(C) 3 ions

(D) 4 ions

Q15. The complex $[Fe(CN)_6]^{4-}$ is diamagnetic. This shows that Fe^{2+} (d^6) in this complex is:

(A) High-spin (4 unpaired electrons)

(B) High-spin (2 unpaired electrons)

(C) Low-spin (0 unpaired electrons), t_{2g}^6

(D) Low-spin (1 unpaired electron)

Q16. Which structure has the highest packing efficiency?

(A) Simple cubic (52.4%)

(B) BCC (68%)

(C) FCC/HCP (74.05%)

(D) Diamond cubic (34%)

Q17. $K_b(\mathrm{H_2O}) = 0.512\,\mathrm{K\,kg\,mol^{-1}}$. For 0.5 mol $\mathrm{kg^{-1}}$ NaCl ($i = 2$), the boiling point elevation ΔT_b is:

(A) $0.256\,\mathrm{K}$

(B) $0.512\,\mathrm{K}$

(C) $1.024\,\mathrm{K}$

(D) $2.048\,\mathrm{K}$

Q18. The major product of HBr addition to propene $(\mathrm{CH_3CH=CH_2})$ under ionic conditions is:

$$\mathrm{CH_3CH=CH_2 + HBr \longrightarrow \text{Major product}}$$

(A) 1-Bromopropane $(\mathrm{CH_3CH_2CH_2Br})$

(B) 2-Bromopropane $(\mathrm{CH_3CHBrCH_3})$

(C) 1,2-Dibromopropane

(D) Propan-2-ol

Q19. Phenol reacts with dilute $\mathrm{HNO_3}$ at room temperature to give predominantly:

(A) 2,4,6-Trinitrophenol (picric acid)

(B) o- and p-Nitrophenol (mixture)

(C) m-Nitrophenol

(D) 4-Nitrocatechol

Q20. Which compound does NOT give a silver mirror with Tollens' reagent?

(A) Acetaldehyde (CH_3CHO)

(B) Formaldehyde ($HCHO$)

(C) Acetone (CH_3COCH_3)

(D) Benzaldehyde (C_6H_5CHO)

Q21. Malonic acid ($HOOC-CH_2-COOH$) with excess methanol and H^+ catalyst gives:

$$HOOC-CH_2-COOH \xrightarrow{\text{excess MeOH, } H^+} \text{Product}$$

(A) Monomethyl malonate

(B) Dimethyl malonate ($CH_3OOC{-}CH_2{-}COOCH_3$)

(C) Malonic anhydride

(D) Acetic acid

Q22. Diazotisation of aniline requires:

(A) $NaNO_2 + HCl$ at 50–$60^\circ C$

(B) $NaNO_2 + HCl$ at 0–$5^\circ C$ (diazonium salt unstable above $5^\circ C$)

(C) Only HNO_3 without cooling

(D) Aliphatic primary amines under same conditions give stable diazonium salts

Q23. Which correctly distinguishes DNA from RNA?

(A) DNA contains uracil; RNA contains thymine

(B) DNA has ribose sugar; RNA has deoxyribose

(C) DNA is usually double-stranded; RNA is usually single-stranded

(D) Both have exactly the same four bases

Q24. Which of the following is a condensation polymer?

(A) Polyethylene

(B) Polypropylene

(C) Poly(ethylene terephthalate) (PET / Dacron)

(D) Polyvinyl acetate

Q25. Which of the following is used as an oral antifertility (contraceptive) drug?

(A) Norethindrone (synthetic progesterone analogue)

(B) Penicillin

(C) Chloroquine

(D) Paracetamol

Q26. Calcium reacts with water more vigorously than magnesium because:

(A) Ca has a higher atomic mass

(B) Ca has a lower first ionisation energy and is more electropositive (reactive) than Mg

(C) Ca forms a protective MgO-like layer

(D) Mg does not react with water at all

Q27. XeF_2 reacts with water to give:

(A) $XeO_3 + HF$

(B) $Xe + \frac{1}{2}O_2 + 2HF$

(C) $Xe + F_2 + H_2O_2$

(D) $XeO_2F_2 + HF$

Q28. $LiAlH_4$ in dry ether can reduce which of the following to give a primary amine?

(A) A nitrile ($R-C\equiv N \rightarrow RCH_2NH_2$)

(B) An amide ($RCONH_2 \rightarrow RCH_2NH_2$)

(C) A nitro compound ($RNO_2 \rightarrow RNH_2$, via Fe/HCl more typically)

(D) All of the above give primary amines with $LiAlH_4$

Q29. Minamata disease is caused by chronic exposure to:

(A) Lead (Pb) compounds

(B) Methylmercury (organic Hg compound)

(C) Cadmium (Cd) compounds

(D) Arsenic (As) compounds

Q30. The reaction of an alkene with cold, dilute, alkaline $KMnO_4$ (Baeyer's reagent) gives:

(A) A dicarboxylic acid (hot, conc. $KMnO_4$)

(B) An epoxide

(C) A vicinal diol (syn addition of two OH groups)

(D) Ozonolysis products

Detailed Solutions

Q1.

Solution

Concept — Limiting reagent and stoichiometry: $2H_2 + O_2 \rightarrow 2H_2O$

Step 1 — Moles: $n(H_2) = 4/2 = 2\,\text{mol}$; $n(O_2) = 32/32 = 1\,\text{mol}$. Stoichiometry requires 2 mol H_2 : 1 mol O_2 — exactly the ratio we have. Neither is in excess.

Step 2 — Water formed: $n(H_2O) = 2\,\text{mol}$; $m = 2 \times 18 = \mathbf{36}\,\text{g}$.

Mass balance: $4 + 32 = 36\,\text{g}$ ✓ (conservation of mass).

Final Answer: $36\,\text{g}$ water $\Rightarrow$ A

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Electrons in f subshell: For $l = 3$: $m_l = -3, -2, -1, 0, +1, +2, +3 \Rightarrow$ 7 orbitals $\times$ 2 electrons each $=$ **14** electrons.

General formula: Maximum electrons in subshell $= 2(2l+1)$. For $l = 3$: $2\times7 = 14$.

Compare: s: 2; p: 6; d: 10; f: 14. The f subshell first appears at $n = 4$ (the 4f series: lanthanides, actinides).

Final Answer: 14 electrons $\Rightarrow$ C

Answer: (C) Go Back to Q2

Q3.

Solution

Concept — VSEPR and lone-pair repulsion on bond angles:

Molecule	Bond angle	Reason
CH_4 (III)	$109.5°$	No lone pairs; perfect tetrahedral
NH_3 (II)	$107°$	1 lone pair compresses H–N–H
H_2O (I)	$104.5°$	2 lone pairs compress H–O–H further
H_2S (IV)	$92°$	2 lone pairs on large S; diffuse, less repulsion; longer S–H bonds

Order: III $(109.5°) >$ II $(107°) >$ I $(104.5°) >$ IV $(92°) \Rightarrow$ **Option A.**

Why H_2S has the smallest angle: S is in Period 3 — its larger, more diffuse $3p$ lone pairs exert less repulsion on the bonding pairs than O's compact $2p$ lone pairs do. The S–H bond is also longer, further reducing repulsion.

Final Answer: III $>$ II $>$ I $>$ IV $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q3

Q4.

Solution

Concept — MO energy ordering and HOMO of N_2: For N_2 (second-row, $Z < 8$), the correct MO energy order (from spectroscopy) places π_{2p} *below* σ_{2p}:

$$\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \pi_{2p} = \pi_{2p} < \sigma_{2p} < \pi^*_{2p} < \sigma^*_{2p}$$

Step 1 — Fill 14 electrons sequentially: $(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\pi_{2p})^4(\sigma_{2p})^2$: 14 electrons placed.

Step 2 — HOMO: The last electrons fill $\sigma_{2p} \Rightarrow \sigma_{2p}$ is the HOMO.

Bond order check: Bonding $e^- = 10$; antibonding $e^- = 4$; BO $= \frac{10-4}{2} = 3$ (triple bond) ✓.

Note for O_2: For $Z \geq 8$, σ_{2p} drops below π_{2p}, so the HOMO of O_2 is π^*_{2p} (with unpaired electrons, hence paramagnetic).

Final Answer: HOMO of N_2 is $\sigma_{2p} \Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept — Real gas deviations at high pressure ($Z > 1$): The van der Waals equation: $\left(P + \frac{a}{V_m^2}\right)(V_m - b) = RT$.

Step 1 — High pressure regime: At high P, the gas is highly compressed; V_m becomes very small. The *excluded volume* b (four times the actual molecular volume, arising from hard-core repulsion) becomes comparable to V_m.

The free volume available is $(V_m - b)$ instead of $V_m \Rightarrow$ the gas occupies more volume than ideal ($V_m > RT/P$) $\Rightarrow Z = PV_m/RT > 1$.

Step 2 — Option B is correct: The finite molecular volume (repulsive/excluded volume effect) causes positive deviation at high pressure.

Contrast: At moderate pressures, the attractive term a/V_m^2 dominates $\Rightarrow Z < 1$ (negative deviation). At the Boyle temperature, these two effects cancel and $Z \approx 1$ over a wide range.

Final Answer: Excluded volume of molecules causes $Z > 1$ at high $P \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept — Sign of ΔS for various processes: $\Delta S > 0$: disorder increases (solid $\rightarrow$ liquid $\rightarrow$ gas; dissolving many salts). $\Delta S < 0$: order increases (gas/liquid $\rightarrow$ solid crystal).

Evaluate: Melting: solid$\rightarrow$liquid, $\Delta S > 0$. Evaporation: liquid$\rightarrow$gas, $\Delta S \gg 0$. Dissolving NaCl: crystal$\rightarrow$hydrated ions, $\Delta S > 0$. **Crystallisation**: ions/molecules in solution $\rightarrow$ ordered lattice $\Rightarrow \Delta S < 0$ (order increases, freedom decreases).

Note: Crystallisation is spontaneous ($\Delta G < 0$) because $\Delta H_{\text{cryst}} < 0$ (exothermic lattice formation outweighs the entropy decrease).

Final Answer: Crystallisation ($\Delta S < 0$) $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q6

Q7.

Solution

Concept — Heterogeneous equilibrium: pure solids omitted from K_c: Activities of pure solids = 1 by convention, so they are excluded.

For $\mathrm{CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)}$:

$$K_c = [\mathrm{CO_2}]$$

Physical meaning: The equilibrium CO_2 pressure depends only on T, not on the amounts of $CaCO_3$ or CaO (provided both solids are present). This is why lime kilns work at fixed temperature regardless of load size.

Similarly: $K_p = P_{\mathrm{CO_2}}$. At 900°C, $P_{\mathrm{CO_2}} \approx 1\,\mathrm{atm}$, so decomposition proceeds freely.

Final Answer: $K_c = [\mathrm{CO_2}]$ only $\Rightarrow$ D

Answer: (D) Go Back to Q7

Q8.

Solution

Concept — Solubility product for $\mathrm{Mg(OH)_2}$: $\mathrm{Mg(OH)_2 \rightleftharpoons Mg^{2+} + 2OH^-}$; $K_{sp} = s \cdot (2s)^2 = 4s^3$.

Step 1: $4s^3 = 5.6 \times 10^{-12} \Rightarrow s^3 = 1.4 \times 10^{-12}$

$s = (1.4)^{1/3} \times 10^{-4} = 1.119 \times 10^{-4} \approx \mathbf{1.12 \times 10^{-4}}\,\mathrm{mol\,L^{-1}}$

Step 2 — pH check: $[\mathrm{OH^-}] = 2s = 2.24 \times 10^{-4}\,\mathrm{M}$; pOH= 3.65; pH= 10.35 (basic, as expected for a metal hydroxide).

Common error: Writing $K_{sp} = s^3$ instead of $4s^3$. Always include the stoichiometric coefficient in the $[\mathrm{OH^-}] = 2s$ term.

Final Answer: $s \approx 1.12 \times 10^{-4}\,\mathrm{mol\,L^{-1}} \Rightarrow$ A

Answer: (A) Go Back to Q8

Q9.

Solution

Concept — Gibbs energy and cell EMF: $\Delta G^\circ = -nFE^\circ$ (the negative sign ensures spontaneous reaction, $E^\circ > 0$, gives $\Delta G^\circ < 0$).

Connections: $\Delta G^\circ = -RT \ln K_{eq}$ and $E^\circ = \frac{RT}{nF} \ln K_{eq} = \frac{0.0592}{n} \log K_{eq}$ at 298 K.

Units: n (mol electrons), $F = 96500\,\text{C mol}^{-1}$, E° in volts; nFE° has units $\text{C} \cdot \text{V} = \text{J}$.

Final Answer: $\Delta G^\circ = -nFE^\circ \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q9

Q10.

Solution

Concept — Determining reaction order from rate data: Compare rates when [A] doubles: Expt 1→2: [A] doubles, rate goes from $2.0 \to 8.0 \times 10^{-4}$ (factor of 4). Expt 2→3: [A] doubles again, rate goes from $8.0 \to 32.0 \times 10^{-4}$ (factor of 4).

Step 1 — Find n: $2^n = 4 \Rightarrow n = 2$. **Second order** in A.

Step 2 — Rate constant: $k = \text{Rate}/[\text{A}]^2 = (2.0 \times 10^{-4})/(0.10)^2 = 0.02\,\text{M}^{-1}\text{s}^{-1}$

Verify Expt 3: $k[\text{A}]^2 = 0.02 \times (0.40)^2 = 0.02 \times 0.16 = 32.0 \times 10^{-4}$ ✓.

Final Answer: Second order (rate $\times 4$ when [A]$\times 2$) $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q10

Q11.

Solution

Concept — Type of colloid: milk is an emulsion: Milk contains fat droplets (liquid) dispersed in an aqueous continuous phase (liquid) $\Rightarrow$ liquid-in-liquid = **emulsion** (oil-in-water type).

Stabilised by: Casein protein adsorbs at the fat-water interface, preventing coalescence (acts as emulsifying agent).

Other colloid types: Sol = solid/liquid ($Fe(OH)_3$ sol); Aerosol = liquid or solid/gas (fog, smoke); Gel = liquid trapped in solid network (jelly, gelatin).

Final Answer: Emulsion (liquid in liquid) $\Rightarrow$ $\boxed{C}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — Shapes of interhalogen compounds:

Compound	Central atom	Electron domains	Shape
ICl_3	I	3 bonds + 2 LP = 5 (sp^3d)	T-shaped
BrF_5	Br	5 bonds + 1 LP = 6 (sp^3d^2)	Square pyramidal
ClF_7	Cl	Does not exist	—
IF_7	I	7 bonds + 0 LP = 7 (sp^3d^3)	Pentagonal bipyramidal

Options A and B are both correct statements. However ClF_7 (option C) doesn't exist (Cl is too small), and IF_7 (option D) is pentagonal bipyramidal, not octahedral.

Best single answer: Both A (ICl_3 T-shaped) and B (BrF_5 square pyramidal) are correct. Since the question asks for a "correct" option and both A and B are valid, option B is the standard BITSAT-style answer for BrF_5.

Final Answer: BrF_5 is square pyramidal $\Rightarrow$ $\boxed{B}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept — Van Arkel (iodide) method for refractory metals: Impure Ti reacts with I_2 at $\sim 250°C$: $\mathrm{Ti(impure)} + 2I_2 \rightarrow TiI_4(g)$. The volatile TiI_4 is passed over a hot W filament ($\sim 1400°C$) and decomposes: $TiI_4(g) \rightarrow \mathrm{Ti(pure)} + 2I_2$

Principle: Only metals forming volatile iodides are purified this way. Impurities (Fe, Si, C) do not form volatile iodides under these conditions and remain behind. The I_2 is recycled.

Other methods: Zone refining: Ge, Si. Mond process: Ni (via carbonyl $Ni(CO)_4$). Cupellation: Ag from Pb. Electrolytic refining: Cu, Al, Zn, Au.

Final Answer: Van Arkel method for Ti (refractory metals) $\Rightarrow$ B

Answer: (B) Go Back to Q13

Q14.

Solution

Concept — Ion count on dissolving coordination compound: $[Pt(NH_3)_4]Cl_2 \rightarrow [Pt(NH_3)_4]^{2+} + 2Cl^-$

Total particles: 1 complex cation + 2 chloride anions = **3** ions.

Molar conductance: This is a 2:1 electrolyte (gives 3 ions) $\Rightarrow$ molar conductance ≈ 260–$270\,\mathrm{S\,cm^2\,mol^{-1}}$ at infinite dilution (similar to $CaCl_2$).

Werner's verification: Conductance measurements in solution were one of the key ways Werner confirmed the structures of coordination compounds. $[Pt(NH_3)_4]Cl_2$ behaves like a 1:2 electrolyte (3 ions), confirming that 2 Cl^- are outside the coordination sphere.

Final Answer: 3 ions $\Rightarrow$ C

Answer: (C) Go Back to Q14

Q15.

Solution

Concept — Low-spin vs high-spin d^6 complex: Fe^{2+} has d^6 configuration. In the presence of strong-field ligands (like CN^-), the crystal field splitting Δ_o is large enough to exceed the pairing energy.

Step 1 — CN^- is a very strong-field ligand: At the top of the spectrochemical series ($\ldots < NH_3 < en < CN^- < CO$). Large Δ_o forces electrons to pair in the lower t_{2g} orbitals before filling e_g.

Step 2 — Electron configuration (low-spin d^6): All 6 electrons pair in the three t_{2g} orbitals: $t_{2g}^6\, e_g^0$. Zero unpaired electrons $\Rightarrow$ **diamagnetic**.

Step 3 — Contrast (high-spin d^6, e.g. $Fe(H_2O)_6^{2+}$): $t_{2g}^4\, e_g^2 \Rightarrow$ 4 unpaired electrons, paramagnetic.

Magnetic moment: $\mu = \sqrt{n(n+2)}$. For $n = 0$: $\mu = 0\,\text{BM}$ (diamagnetic, confirmed experimentally for $[Fe(CN)_6]^{4-}$).

Final Answer: Low-spin, t_{2g}^6, 0 unpaired electrons $\Rightarrow$ C

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Packing efficiency comparison:

Structure	Packing efficiency	CN
Simple cubic	52.4%	6
BCC	68%	8
FCC/HCP	**74.05%**	12
Diamond cubic	34%	4

FCC/HCP are both close-packed: Both achieve the theoretical maximum of 74.05% packing for identical spheres (proven by Kepler's conjecture, verified mathematically in 1998). In FCC layers stack ABCABC; in HCP they stack ABABAB.

Practical: Most metallic elements with high density (Au, Ag, Cu, Al, Ni, Pt) adopt FCC.

Final Answer: FCC/HCP with 74.05% packing $\Rightarrow$ C

Answer: (C) Go Back to Q16

Q17.

Solution

Concept — Boiling point elevation: $\Delta T_b = i \cdot K_b \cdot m$

Step 1: $\Delta T_b = 2 \times 0.512 \times 0.5 = \mathbf{0.512}\,\mathrm{K}$

Step 2 — Units check: $K_b\,(\mathrm{K\,kg\,mol^{-1}}) \times m\,(\mathrm{mol\,kg^{-1}}) = K$ ✓.

Practical significance: Seawater ($\approx 0.6\,\mathrm{m}$ NaCl) boils at $\approx 100.6°$C (elevation≈ 0.6K). NaCl lowers the freezing point of ice by $\approx 2i \times K_f \times m$ — used in road de-icing.

Final Answer: $\Delta T_b = 0.512\,\mathrm{K} \Rightarrow$ B

Answer: (B) Go Back to Q17

Q18.

Solution

Concept — Markovnikov's rule for HBr addition to propene: H adds to the carbon with more H atoms (less substituted); Br to the more substituted carbon. This is governed by carbocation stability: 2° carbocation (at C2) > 1° (at C1).

Step 1 — Mechanism:

(a) H^+ (from HBr) protonates the double bond; attack at C1 gives secondary carbocation $CH_3CHBrCH_3$... wait: H^+ goes to C1 (CH_2= end), giving $CH_3\overset{+}{C}HCH_3$ (2° carbocation) — more stable.
(b) Br^- attacks C2: product $CH_3CHBrCH_3$ (2-bromopropane).

Anti-Markovnikov: In peroxide conditions (free radical), H adds to C2 and Br to C1 ⇒ 1-bromopropane.

Final Answer: 2-Bromopropane (Markovnikov product) ⇒ B

Answer: (B) Go Back to Q18

Q19.

Solution

Concept — Nitration of phenol with dilute HNO_3: $-OH$ is a powerful ortho/para activating group (electron donation by resonance). With *dilute* HNO_3 at room temperature (mild conditions), only one NO_2 group is introduced — predominantly at ortho and para positions.

Step 1 — Products (dilute acid): Mixture of o-nitrophenol ($\sim 40\%$) and p-nitrophenol ($\sim 60\%$). No trinitration under these mild conditions.

Step 2 — Contrast with conc. HNO_3/H_2SO_4: Gives 2,4,6-trinitrophenol (picric acid) under vigorous conditions. This is option A, which requires fuming nitric acid and heat.

Separation: o-nitrophenol is steam volatile (intramolecular H-bond reduces intermolecular association); p-nitrophenol is steam non-volatile (intermolecular H-bonds, forms associated crystals). This difference is used in separation.

Final Answer: o- and p-nitrophenol mixture (dilute HNO_3, room temperature) $\Rightarrow$ B

Answer: (B) Go Back to Q19

Q20.

Solution

Concept — Tollens' reagent: aldehydes vs ketones: Tollens' reagent ($[Ag(NH_3)_2]^+$) is a mild oxidising agent. It oxidises aldehydes (R–CHO $\rightarrow$ R–COO^-) but not simple ketones.

Step 1 — Why acetone is negative: Acetone (CH_3COCH_3) has no aldehydic H. The carbonyl carbon has two alkyl groups; there is no H at the carbonyl carbon to be oxidised. Tollens' reagent cannot oxidise a ketone under mild alkaline conditions.

Step 2 — Why others are positive:

- Acetaldehyde: has $-$CHO group $\Rightarrow$ positive.
- Formaldehyde: has two H on carbonyl C ($H_2C=O$) $\Rightarrow$ positive (actually gets oxidised to carbonate).
- Benzaldehyde: aromatic aldehyde, $-$CHO group present $\Rightarrow$ positive (gives silver mirror, but negative with Fehling's — distinction between Tollens' and Fehling's).

Final Answer: Acetone does not give silver mirror with Tollens' $\Rightarrow$ C

Answer: (C) Go Back to Q20

Q21.

Solution

Concept — Fischer esterification of dicarboxylic acid: With *excess* methanol and acid catalyst, both carboxyl groups of malonic acid esterify:

$$HOOC{-}CH_2{-}COOH + 2\,CH_3OH \xrightarrow{H^+} CH_3OOC{-}CH_2{-}COOCH_3 + 2\,H_2O$$

Product: Dimethyl malonate (a symmetrical diester), a useful synthetic building block in the malonic ester synthesis for making substituted acetic acids.

Malonic ester synthesis: Dimethyl malonate has highly acidic α-H (pKa$\approx$ 13, activated by two flanking carbonyls). It is alkylated by RX under base, then hydrolysed and decarboxylated to give α-substituted acetic acids.

Final Answer: Dimethyl malonate $\Rightarrow$ B

Answer: (B) Go Back to Q21

Q22.

Solution

Concept — Diazotisation conditions: $C_6H_5NH_2 + NaNO_2 + HCl \xrightarrow{0-5^\circ C} C_6H_5N_2^+Cl^- + NaCl +$

Temperature control:

- 0–5°**C required:** Above 5°C, the diazonium salt decomposes rapidly ($ArN_2^+ \rightarrow ArOH + N_2$, or other decomposition products). The reaction must be kept ice-cold.
- **Aliphatic primary amines:** Aliphatic diazonium salts (RN_2^+) are too unstable to isolate; they immediately decompose to alcohols, alkenes, and N_2. Only aromatic diazonium salts are stable enough for synthetic use.

Final Answer: $NaNO_2$+HCl at 0–5°C; diazonium salt unstable above 5°C $\Rightarrow$ $\boxed{B}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — DNA vs RNA structural differences:

Feature	DNA	RNA
Sugar	2′-deoxyribose	ribose
Bases	A, T, G, C	A, **U**, G, C
Strand	Double-stranded (usually)	Single-stranded (usually)
Location	Nucleus	Nucleus + cytoplasm

Correct option C: DNA is usually double-stranded (Watson-Crick duplex); RNA is usually single-stranded.

Why "usually"? Some viral genomes are single-stranded DNA (e.g. parvovirus) or double-stranded RNA (e.g. reovirus). The "usually" qualifier makes option C strictly accurate.

Options A, B, D are wrong: A has U/T swapped; B has sugars swapped; D is wrong (RNA has U, not T).

Final Answer: DNA double-stranded; RNA single-stranded $\Rightarrow$ $\boxed{C}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — Condensation polymers (release small molecule during polymerisation): PET (polyethylene terephthalate / Dacron) is formed by condensation of ethylene glycol and terephthalic acid: $n\,\mathrm{HO-CH_2CH_2-OH} + n\,\mathrm{HOOC-C_6H_4-COOH} \rightarrow [\text{-O-CH}_2\text{CH}_2\text{-O-CO-C}_6\text{H}_4\text{-CO-}]_n + 2n\,\mathrm{H_2O}$

Addition polymers (A, B, D): Polyethylene, polypropylene, and polyvinyl acetate all form by addition of C=C double bonds; no small molecule released.

Applications of PET: Plastic bottles (PET bottles), polyester fabric (Dacron/Terylene), photographic film, magnetic recording tape.

Final Answer: PET/Dacron is a condensation polymer $\Rightarrow$ C

Answer: (C) Go Back to Q24

Q25.

Solution

Concept — Antifertility drugs (oral contraceptives): Oral contraceptives are synthetic analogues of female sex hormones (oestrogen/progesterone) that prevent ovulation.

Norethindrone: A synthetic progestin (progesterone analogue) used in the first oral contraceptives (developed in the 1950s). It acts by suppressing LH surge, preventing ovulation. Often combined with a synthetic oestrogen (ethinyl oestradiol) in combination pills.

Other options: Penicillin: β-lactam antibiotic (bactericidal). Chloroquine: antimalarial drug. Paracetamol: analgesic/antipyretic.

Final Answer: Norethindrone (synthetic progesterone analogue) $\Rightarrow$ A

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Reactivity of Group 2 metals with water: Going down Group 2 (Mg, Ca, Sr, Ba), reactivity with water increases.

Step 1 — Ca vs Mg:

- Mg reacts very slowly with cold water (protective MgO layer forms); reacts readily with steam.
- Ca reacts vigorously with cold water: $\mathrm{Ca} + 2\mathrm{H_2O} \rightarrow \mathrm{Ca(OH)_2} + \mathrm{H_2}$, producing bubbles.

Step 2 — Reason: Ca has lower first (and second) ionisation energy than Mg; $\mathrm{Ca^{2+}}$ has a higher hydration enthalpy that more than compensates for the slightly lower lattice energy of $\mathrm{Ca(OH)_2}$ vs $\mathrm{Mg(OH)_2}$. Overall, the driving force for reaction is greater for Ca.

Option B is correct: Ca is more electropositive (lower ionisation energy, higher in activity series) than Mg.

Final Answer: Ca has lower ionisation energy and is more reactive (electropositive) $\Rightarrow$ $\boxed{\mathrm{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Hydrolysis of $\mathrm{XeF_2}$: $\mathrm{XeF_2}$ reacts cleanly with water:

$$2\mathrm{XeF_2} + 2\mathrm{H_2O} \rightarrow 2\mathrm{Xe} + \mathrm{O_2} + 4\mathrm{HF}$$

In simplified form per mole: $\mathrm{XeF_2} + \mathrm{H_2O} \rightarrow \mathrm{Xe} + \frac{1}{2}\mathrm{O_2} + 2\mathrm{HF}$

Mechanism: Xe(+2) is reduced to Xe(0); water is oxidised (O: $-2 \rightarrow 0$ in $\mathrm{O_2}$). HF is produced as the fluorine-containing byproduct.

Contrast with $\mathrm{XeF_4}$: $\mathrm{XeF_4}$ undergoes disproportionation on hydrolysis ($6\mathrm{XeF_4} + 12\mathrm{H_2O} \rightarrow 4\mathrm{Xe} + 24\mathrm{HF} + 2\mathrm{XeO_3} + 3\mathrm{O_2}$), giving both $\mathrm{XeO_3}$ and Xe.

$\mathrm{XeF_6}$: Hydrolyses completely to $\mathrm{XeO_3}$ ($\mathrm{XeF_6} + 3\mathrm{H_2O} \rightarrow \mathrm{XeO_3} + 6\mathrm{HF}$).

Final Answer: $\mathrm{XeF_2} + \mathrm{H_2O} \rightarrow \mathrm{Xe} + \frac{1}{2}\mathrm{O_2} + 2\mathrm{HF} \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q27

Q28.

Solution

Concept — $LiAlH_4$ reductions to primary amines: $LiAlH_4$ is a powerful, non-selective hydride reducing agent. It reduces:

- **Nitrile** ($R-C\equiv N$): $R-C\equiv N+4[H]\rightarrow RCH_2NH_2$ (primary amine, chain lengthened by 0)
- **Amide** ($RCONH_2$): $RCONH_2+4[H]\rightarrow RCH_2NH_2+H_2O$ (primary amine, chain same)
- **Nitro group** (RNO_2): $LiAlH_4$ can reduce nitro to amine in principle, but Fe/HCl or catalytic hydrogenation (H_2/Pt) are more practical for this transformation.

Answer D — "all of the above": All three functional groups (nitrile, amide, nitro) can be reduced to primary amines. $LiAlH_4$ handles nitriles and amides cleanly. Nitro reduction with $LiAlH_4$ is possible but less common.

Practical note: For nitriles and amides, $LiAlH_4$ in dry ether is the standard method. Water must be excluded ($LiAlH_4$ reacts violently with water).

Final Answer: All three give primary amines with $LiAlH_4 \Rightarrow \boxed{D}$

Answer: (D) Go Back to Q28

Q29.

Solution

Concept — Minamata disease: Minamata disease was first identified in Minamata Bay, Japan (1956). It was caused by the release of methylmercury (CH_3Hg^+) in industrial wastewater from a chemical factory (Chisso Corporation), which accumulated in fish and shellfish.

Cause: Methylmercury (organic mercury) crosses the blood-brain barrier and accumulates in the nervous system. Symptoms: loss of coordination, sensory loss, vision impairment, paralysis, coma, and death. Particularly devastating during prenatal exposure (congenital Minamata disease).

Other pollution diseases:

- Itai-itai disease: cadmium poisoning (Japan, 1912–1950s)
- Lead poisoning: cognitive impairment, especially in children
- Arsenicosis: chronic arsenic from groundwater (Bangladesh, India)

Final Answer: Methylmercury (organic Hg) causes Minamata disease $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept — Cold dilute alkaline $KMnO_4$ (Baeyer's reagent): Cold, dilute, alkaline $KMnO_4$ oxidises alkene double bonds in a *syn* dihydroxylation (both OH groups add to the same face of the double bond):

$$R_1CH = CHR_2 + KMnO_4(\text{cold, dil}) \rightarrow R_1CH(OH) - CH(OH)R_2$$

Product: A **vicinal diol (1,2-diol)**, with syn-addition of the two OH groups (via a cyclic manganate ester intermediate).

Contrast:

- Hot, conc. $KMnO_4$ (or acidic $KMnO_4$): cleaves the double bond $\Rightarrow$ carboxylic acids (or CO_2 for terminal $=CH_2$). This is option A.
- Ozonolysis: cleaves to aldehydes/ketones (option D).
- Epoxidation (mCPBA): gives an epoxide (option B), via anti addition.

Baeyer's test: Decolorisation of purple $KMnO_4$ to brown MnO_2 is used as a qualitative test for unsaturation (double/triple bonds). Phenol and aldehydes also decolorise it.

Final Answer: Vicinal diol (syn addition) $\Rightarrow$ $\boxed{C}$

Answer: (C) Go Back to Q30

Answer Key

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