BITSAT Chemistry Sample Paper – 22

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.

Q1. How many atoms are present in $4\,\text{g}$ of helium? ($M_{\text{He}} = 4\,\text{g}\,\text{mol}^{-1}$; $N_A = 6.022 \times 10^{23}$)

(A) 6.022×10^{23}

(B) 3.011×10^{23}

(C) 1.204×10^{24}

(D) 1.505×10^{23}

Q2. An electron is confined to a box of length $1\,\text{nm}$ ($10^{-9}\,\text{m}$). The minimum uncertainty in its momentum (Δp) is approximately: ($h = 6.626 \times 10^{-34}\,\text{J s}$)

(A) $5.3 \times 10^{-26}\,\text{kg m s}^{-1}$

(B) $5.3 \times 10^{-25}\,\text{kg m s}^{-1}$

(C) $1.05 \times 10^{-25}\,\text{kg m s}^{-1}$

(D) $2.1 \times 10^{-26}\,\text{kg m s}^{-1}$

Q3. In ethylene ($CH_2 = CH_2$), the C=C double bond consists of:

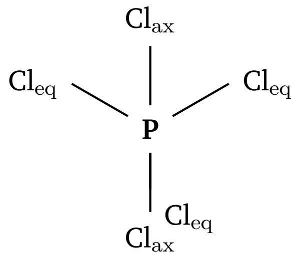
(A) Two σ bonds

(B) Two π bonds

(C) One σ bond and one π bond

(D) One σ bond and two π bonds

Q4. In the trigonal bipyramidal structure of PCl_5:



The axial P–Cl bonds are longer than equatorial P–Cl bonds because:

(A) Axial Cl atoms have more lone pairs

(B) Axial bonds are formed by π-overlap

(C) The equatorial Cl atoms are heavier

(D) Axial bonds involve more p-character (sp^3d hybridisation) and experience greater repulsion from the three equatorial bonds

Q5. A mixture of 2 mol N_2 and 3 mol O_2 exerts a total pressure of $5\,\text{atm}$. The partial pressure of O_2 is:

(A) $2\,\text{atm}$

(B) $1\,\text{atm}$

(C) $5\,\text{atm}$

(D) $3\,\text{atm}$

Q6. Given: $\text{C(s)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$, $\Delta H_1 = -393\,\text{kJ mol}^{-1}$; and $\text{CO(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CO}$ $\Delta H_2 = -283\,\text{kJ mol}^{-1}$. The ΔH for $\text{C(s)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CO(g)}$ is:

(A) $-676\,\text{kJ mol}^{-1}$

(B) $+676\,\text{kJ mol}^{-1}$

(C) $+110\,\text{kJ mol}^{-1}$

(D) $-110\,\text{kJ mol}^{-1}$

Q7. For the reaction $A \rightleftharpoons B$ with $K_c = 4$, if $[A] = 2\,M$ and $[B] = 6\,M$, the reaction will:

(A) Proceed forward (left to right) to reach equilibrium

(B) Proceed backward (right to left) to reach equilibrium

(C) Already be at equilibrium

(D) Stop completely

Q8. At $25°C$, the ionic product of water $K_w = 10^{-14}$. At $60°C$, $K_w > 10^{-14}$. This means that at $60°C$:

(A) Water becomes acidic

(B) Water becomes basic

(C) pH of pure water decreases below 7, but water remains neutral ($[H^+] = [OH^-]$)

(D) The dissociation of water is endothermic

Q9. A concentration cell consists of two hydrogen electrodes at different H^+ concentrations. When the cell reaches equilibrium ($E = 0$), the two concentrations are:

(A) Both equal to 1 M

(B) The EMF becomes 1 V

(C) One becomes zero

(D) Equal to each other (same concentration in both half-cells)

Q10. The rate constant doubles when temperature rises from 300 K to 310 K. The activation energy is approximately: ($R = 8.314\,J\,mol^{-1}K^{-1}$)

(A) $53.6\,kJ\,mol^{-1}$

(B) $106\,kJ\,mol^{-1}$

(C) $26.8\,kJ\,mol^{-1}$

(D) $80\,kJ\,mol^{-1}$

Q11. The Langmuir adsorption isotherm assumes:

(A) Multilayer adsorption on a non-uniform surface

(B) Adsorption follows a power law relationship

(C) Adsorption energy decreases with coverage (Freundlich)

(D) Monolayer adsorption on a uniform surface with no interaction between adsorbed molecules

Q12. Which nitrogen oxide is used as an anaesthetic (laughing gas)?

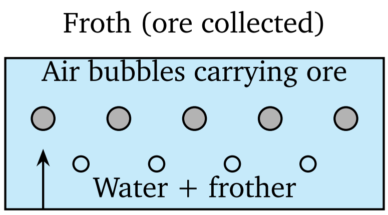
(A) NO (nitric oxide)

(B) NO_2 (nitrogen dioxide)

(C) N_2O (dinitrogen monoxide)

(D) N_2O_5 (dinitrogen pentoxide)

Q13. In froth flotation (shown below), the ore particles are separated because:



(A) Ore particles are denser and sink; gangue floats

(B) Gangue particles react with the frother to form a precipitate

(C) Ore particles are dissolved in the frother liquid

(D) Ore particles (with collector) are wetted by oil (hydrophobic) and attach to air bubbles, rising to the froth; gangue is wetted by water and sinks

Q14. Which of the following M^{2+} ions has the highest magnetic moment?

(A) Cu^{2+} (d^9, 1 unpaired e^-)

(B) Ni^{2+} (d^8, 2 unpaired e^-)

(C) Co^{2+} (d^7, 3 unpaired e^-)

(D) Mn^{2+} (d^5, 5 unpaired e^-)

Q15. Which set of ligands, arranged in order of increasing crystal field splitting (Δ_o), is correct?

(A) $I^- < Br^- < Cl^- < F^- < H_2O < NH_3 < en < CN^-$

(B) $CN^- < H_2O < NH_3 < Cl^- < I^-$

(C) $F^- < H_2O < NH_3 < CN^-$

(D) $H_2O < CN^- < NH_3 < I^-$

Q16. In the NaCl (rock salt) structure, the number of Na^+ and Cl^- ions per unit cell are respectively:

(A) 2 Na^+, 2 Cl^-

(B) 4 Na^+, 4 Cl^-

(C) 1 Na^+, 1 Cl^-

(D) 6 Na^+, 6 Cl^-

Q17. A $0.1\,\text{m}$ aqueous solution of a non-electrolyte freezes at $-0.186°\text{C}$ ($K_f = 1.86\,\text{K kg mol}^{-1}$). This is consistent with:

(A) Complete dissociation into ions (van't Hoff factor $i = 2$)

(B) The solute remaining as discrete molecules ($i = 1$)

(C) Association (dimerisation) of solute molecules ($i = 0.5$)

(D) The solvent associating with solute

Q18. The Wurtz reaction of two moles of CH_3Br with sodium metal gives:

(A) Ethane ($CH_3 - CH_3$)

(B) Methane (CH_4)

(C) Propane ($CH_3CH_2CH_3$)

(D) Ethylene ($CH_2 = CH_2$)

Q19. In the Lucas test ($ZnCl_2$/conc. HCl), a secondary alcohol like 2-butanol gives turbidity (cloudiness):

$$(CH_3)_2CHCH_2OH \xrightarrow{\text{Lucas reagent}} ?$$

Which is correct about the order of reactivity in the Lucas test?

(A) Primary $>$ secondary $>$ tertiary

(B) Tertiary $>$ secondary $>$ primary (immediate $>$ 5 min $>$ no reaction at room temp)

(C) All react at the same rate

(D) Only tertiary alcohols react

Q20. Fehling's solution (deep blue) distinguishes aldehydes from aromatic aldehydes because:

(A) Aliphatic aldehydes give brick-red Cu_2O precipitate; benzaldehyde does not reduce Fehling's solution

(B) Benzaldehyde gives a deeper blue with Fehling's

(C) Both give the same result with Fehling's

(D) Aromatic aldehydes give a green colour

Q21. Formic acid (HCOOH, $pK_a = 3.75$) is a stronger acid than acetic acid (CH_3COOH, $pK_a = 4.76$). This is because:

(A) HCOOH has a higher molecular mass

(B) The H atom in HCOOH (instead of CH_3) is electron-withdrawing by induction, making the O–H bond weaker and the formate ion more stable

(C) HCOOH forms stronger hydrogen bonds

(D) The C–H bond in HCOOH is weaker than C–C in CH_3COOH

Q22. Gabriel synthesis starting from phthalimide and 1-bromobutane gives:

(A) n-Butylamine ($CH_3CH_2CH_2CH_2NH_2$) after hydrolysis

(B) Di-n-butylamine

(C) n-Butanol

(D) Butyl phthalate

Q23. A competitive inhibitor of an enzyme:

(A) Decreases $V_{\max}$ without changing K_m

(B) Increases K_m (apparent) but leaves $V_{\max}$ unchanged; its effect can be overcome by high substrate concentration

(C) Permanently destroys the enzyme's active site

(D) Activates the enzyme at low substrate concentrations

Q24. PHBV (poly-3-hydroxybutyrate-co-3-hydroxyvalerate) is:

(A) A synthetic addition polymer used for packaging

(B) A biodegradable polyester produced by bacteria, used in biodegradable plastics

(C) A thermosetting plastic used in electrical fittings

(D) A polyamide similar to nylon-6

Q25. Sodium benzoate (C_6H_5COONa) is used as a:

(A) Antifungal antibiotic

(B) Food preservative (inhibits mould and yeast in acidic foods)

(C) Analgesic drug

(D) Photographic developer

Q26. Argon is used in welding and in incandescent light bulbs primarily because:

(A) Argon has the highest thermal conductivity of noble gases

(B) Argon is chemically inert, preventing oxidation of the hot metal/tungsten filament

(C) Argon emits blue light when ionised

(D) Argon is less expensive than all other noble gases

Q27. Which of the following pairs shows a diagonal relationship in the periodic table?

(A) Na and Mg

(B) Li and Mg

(C) Be and Al

(D) B and Si

Q28. In the Friedel-Crafts alkylation of benzene:

$$\text{Benzene} + \text{RCl} \xrightarrow{\text{AlCl}_3} \text{Alkylbenzene} + \text{HCl}$$

The electrophile generated is:

(A) Cl^- (chloride ion)

(B) R^+ (carbocation, generated by $RCl + AlCl_3 \rightarrow R^+ + AlCl_4^-$)

(C) $AlCl_3$ itself

(D) HCl

Q29. A high Biological Oxygen Demand (BOD) value of water indicates:

(A) The water is clean and well-oxygenated

(B) The water contains a high level of organic pollutants (sewage, industrial waste), indicating heavy pollution

(C) The water contains dissolved mineral salts

(D) The water has a high pH

Q30. The Diels-Alder reaction between 1,3-butadiene and ethylene gives:

(A) A linear hexadiene

(B) Cyclohexene (a six-membered ring with one double bond)

(C) Benzene (aromatic ring)

(D) 1,2-dibromocyclohexane

Detailed Solutions

Q1.

Solution

Concept — Atoms in a monatomic element: $n(\text{He}) = 4/4 = 1\,\text{mol}$. He is monatomic: each mole contains $N_A = 6.022 \times 10^{23}$ atoms.

$$N = 1 \times 6.022 \times 10^{23} = \mathbf{6.022 \times 10^{23}}\ \text{atoms}$$

Note: For diatomic gases (H_2, O_2), 1 mol of gas contains N_A molecules but $2N_A$ atoms. For monatomic He, atoms = molecules = N_A.

Final Answer: 6.022×10^{23} atoms $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Heisenberg Uncertainty Principle: $\Delta x \cdot \Delta p \geq \dfrac{h}{4\pi}$. Minimum uncertainty: $\Delta p = \dfrac{h}{4\pi\,\Delta x}$.

Step 1: $\Delta p = \frac{6.626\times10^{-34}}{4\pi\times1\times10^{-9}} = \frac{6.626\times10^{-34}}{1.257\times10^{-8}} = 5.27 \times 10^{-26} \approx \mathbf{5.3 \times 10^{-26}}\,\text{kg m s}^{-1}$

Velocity uncertainty: $\Delta v = \Delta p/m_e = 5.3 \times 10^{-26}/9.11 \times 10^{-31} = 5.8 \times 10^4\,\text{m s}^{-1}$ — a huge uncertainty for a 1 nm confinement.

Significance: This is why electrons in atoms cannot be pictured as orbiting in precise paths. For a $1\,\text{Å}$ atomic-scale confinement, Δp would be $\sim 100\times$ larger.

Final Answer: $\Delta p \approx 5.3 \times 10^{-26}\,\text{kg m s}^{-1} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q2

Q3.

Solution

Concept — Double bond composition: one σ + one π: In ethylene (sp^2 hybridised), each C uses 3 sp^2 orbitals for σ bonds (2 C–H and 1 C–C). The remaining unhybridised $2p_z$ orbital on each C overlaps side-on (laterally) to form one π bond.

Summary: C=C double bond $= 1\ \sigma$ (end-on, stronger) $+\ 1\ \pi$ (side-on, weaker, more reactive).

Triple bond: $C \equiv C = 1\sigma + 2\pi$ (two perpendicular π bonds). Hence the pi bond is what reacts in addition reactions (electrophilic addition to alkenes/alkynes).

Final Answer: One σ + one π bond $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Axial vs equatorial bonds in PCl_5 (TBP geometry): In sp^3d hybrid TBP, the equatorial positions use sp^2-like hybrids (more s-character, shorter, stronger bonds), while the axial positions use p and d orbitals (more p-character, longer, weaker bonds).

Experimental data: P–Cl axial $\approx 214\,\text{pm}$; P–Cl equatorial $\approx 202\,\text{pm}$.

Reason for longer axial bonds:

(a) Axial bonds have more p-character (less s-character) $\Rightarrow$ less electronegative, weaker, longer.

(b) Each axial bond faces *three* $90°$ repulsions from the equatorial bonds (high-repulsion environment), stretching the axial bond.

(c) Equatorial bonds face only two $90°$ repulsions (from axial) and two $120°$ (from each other, less repulsive).

Option B captures both aspects correctly.

Final Answer: Axial bonds have more p-character and greater repulsion from 3 equatorial bonds $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — Dalton's law of partial pressures: $P_i = x_i \times P_{\text{total}}$ where x_i is the mole fraction.

Step 1: Total moles $= 2 + 3 = 5\,\text{mol}$. Mole fraction of O_2: $x_{O_2} = 3/5 = 0.6$. $P_{O_2} = 0.6 \times 5 = \mathbf{3}\,\text{atm}$.

Step 2 — Partial pressure of N_2: $P_{N_2} = 2/5 \times 5 = 2\,\text{atm}$. Sum: $3 + 2 = 5\,\text{atm}$ ✓.

Final Answer: $P_{O_2} = 3\,\text{atm} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept — Hess's Law applied to a cycle: Target: $C + \frac{1}{2}O_2 \rightarrow CO$, $\Delta H_3 = ?$

Step 1 — Construct the cycle: Reaction 1 (ΔH_1): $C + O_2 \rightarrow CO_2$ Reaction 2 (ΔH_2): $CO + \frac{1}{2}O_2 \rightarrow CO_2$; **reverse**: $CO_2 \rightarrow CO + \frac{1}{2}O_2$, $\Delta H = -\Delta H_2 = +283$.

Step 2 — Add reactions: $C + O_2 \rightarrow CO_2$ (-393) + $CO_2 \rightarrow CO + \frac{1}{2}O_2$ $(+283)$: $C + \frac{1}{2}O_2 \rightarrow CO$; $\Delta H_3 = -393 + 283 = -110\,\text{kJ mol}^{-1}$.

Note: CO is the product of incomplete combustion. $\Delta H_f^\circ(CO) = -110.5\,\text{kJ mol}^{-1}$ (experimental) — exactly matches.

Final Answer: $\Delta H_3 = -110\,\text{kJ mol}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q6

Q7.

Solution

Concept — Reaction quotient Q_c vs K_c: $Q_c = [B]/[A] = 6/2 = 3$. Since $Q_c = 3 < K_c = 4$, the reaction has not yet reached equilibrium.

Direction: When $Q_c < K_c$, the reaction proceeds **forward** (to produce more B and reduce A until $Q_c = K_c = 4$).

Verify equilibrium: At equilibrium, $[B]/[A] = 4$. If reaction shifts forward: $[A]$ decreases, $[B]$ increases until ratio $= 4$.

Final Answer: Forward reaction proceeds ($Q_c < K_c$) $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept — Temperature dependence of K_w and neutrality: $K_w = [H^+][OH^-]$ for pure water. Water self-ionisation is endothermic (bond breaking): $H_2O \rightleftharpoons H^+ + OH^-$, $\Delta H > 0$.

Step 1 — Higher T: By Le Chatelier's, increasing temperature shifts the endothermic equilibrium right $\Rightarrow K_w$ increases. At 60°C, $K_w \approx 9.6 \times 10^{-14}$.

Step 2 — pH of pure water at 60°C: $[H^+] = \sqrt{K_w} = \sqrt{9.6 \times 10^{-14}} \approx 3.1 \times 10^{-7}$ M; pH$= -\log(3.1 \times 10^{-7}) \approx 6.51$.

Step 3 — Is it acidic? No! $[H^+] = [OH^-]$ still (pure water), so it is **neutral**. The pH scale shifts with temperature; neutrality is at pH$= \frac{1}{2}\text{pK}_\text{w} = 6.51$ at 60°C, not at 7.

Conclusion — option C and D are both correct: pH decreases below 7 (C is true) and the ionisation of water is endothermic (D explains why K_w increases). The best single answer is **C** as it addresses both: pH drops and water remains neutral.

Final Answer: pH of pure water < 7 at 60°C but water stays neutral $[H^+] = [OH^-]$ $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q8

Q9.

Solution

Concept — Concentration cell at equilibrium ($E = 0$): A concentration cell: $H_2|H^+(c_1)||H^+(c_2)|H_2$. $E = \frac{0.0592}{1}\log\frac{c_2}{c_1}$. When $E = 0$: $\log(c_2/c_1) = 0 \Rightarrow c_1 = c_2$.

Physical meaning: At equilibrium, both half-cells have the same H^+ concentration. The driving force (concentration gradient) has been eliminated by the cell process (ions migrate until concentrations equalise). This is analogous to entropy maximisation.

Final Answer: Concentrations equalise ($c_1 = c_2$) when $E = 0 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q9

Q10.

Solution

Concept — Activation energy from two-temperature Arrhenius data: $\ln\frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

Step 1 — Substitute: $k_2/k_1 = 2$ (rate doubles); $T_1 = 300\,\text{K}$; $T_2 = 310\,\text{K}$.

$\ln 2 = \frac{E_a}{8.314}\left(\frac{1}{300} - \frac{1}{310}\right) = \frac{E_a}{8.314} \times \frac{10}{300\times310} = \frac{E_a}{8.314} \times \frac{10}{93000}$

Step 2 — Solve: $0.6931 = \frac{E_a\times10}{8.314\times93000} = \frac{E_a}{77316}$

$E_a = 0.6931 \times 77316 = 53600\,\text{J mol}^{-1} \approx \mathbf{53.6}\,\text{kJ mol}^{-1}$

Rule of thumb: A rate doubling per $10\,\text{K}$ near $300\,\text{K}$ corresponds to $E_a \approx 50$–$55\,\text{kJ mol}^{-1}$, consistent with many biochemical reactions.

Final Answer: $E_a \approx 53.6\,\text{kJ mol}^{-1} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

Q11.

Solution

Concept — Langmuir adsorption model assumptions:

(a) **Monolayer adsorption:** Only a single layer of adsorbate forms (no multi-layer).
(b) **Uniform surface:** All adsorption sites are identical (same energy).
(c) **No interaction between adsorbed molecules:** Neighbouring adsorbed molecules do not affect each other.
(d) **Dynamic equilibrium:** Rate of adsorption = rate of desorption at equilibrium.

Contrast with BET isotherm: BET (Brunauer-Emmett-Teller) extends Langmuir to allow multilayer adsorption and is used for surface area measurement (N_2 gas adsorption at 77 K).

Final Answer: Monolayer on uniform surface, no interaction between adsorbed molecules $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q11

Q12.

Solution

Concept — Nitrogen oxides and their uses:

- N_2O (nitrous oxide, dinitrogen monoxide): colourless, sweet-smelling gas; used as an anaesthetic ("laughing gas", N_2O + oxygen in surgery) and as a food aerosol propellant (whipped cream canisters).
- NO: radical; signalling molecule; relaxes blood vessels (basis of nitroglycerin as heart medication).
- NO_2: toxic brown gas; component of photochemical smog.
- N_2O_5: anhydride of nitric acid; unstable solid.

Final Answer: N_2O is used as anaesthetic (laughing gas) $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q12

Q13.

Solution

Concept — Froth flotation for sulfide ore concentration: The process exploits the difference in surface properties between ore and gangue:

Step 1 — Reagents:

- **Collector** (e.g. xanthate): adsorbs selectively onto ore particle surfaces, making them hydrophobic (water-repellent, oil-loving).
- **Frother** (e.g. pine oil, terpene): stabilises air bubbles, creating persistent foam.
- **Depressant** (e.g. NaCN): selectively keeps some ore particles hydrophilic to separate mixed ores.

Step 2 — Mechanism: Hydrophobic ore particles (coated by collector) attach to air bubbles $\Rightarrow$ rise to the froth. Hydrophilic gangue (wetted by water) sinks to the bottom of the tank and is removed as tailings.

Applications: Particularly effective for sulfide ores (ZnS, PbS, $CuFeS_2$, MoS_2) — the basis of global copper, lead, zinc, and molybdenum production.

Final Answer: Ore (hydrophobic) attaches to bubbles and floats; gangue (hydrophilic) sinks $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q13

Q14.

Solution

Concept — Spin-only magnetic moment: $\mu = \sqrt{n(n+2)}$ **BM:**

Ion	Config	Unpaired e^- (n)	μ (BM)
Cu^{2+}	d^9	1	$\sqrt{3} = 1.73$
Ni^{2+}	d^8	2	$\sqrt{8} = 2.83$
Co^{2+}	d^7	3	$\sqrt{15} = 3.87$
Mn^{2+}	d^5	5	$\sqrt{35} = \mathbf{5.92}$

Mn^{2+} has 5 unpaired electrons (half-filled d^5, maximum number for d^n, $n \leq 5$) $\Rightarrow$ highest magnetic moment.

Final Answer: Mn^{2+} (d^5, $\mu = 5.92\,\text{BM}$) $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q14

Q15.

Solution

Concept — Spectrochemical series (increasing Δ_o): $I^- < Br^- < S^{2-} < SCN^- < Cl^- < NO_3^- < F^- < OH^- < H_2O < NCS^- < py < NH_3 < en < NO_2^-$

Option A is correct: $I^- < Br^- < Cl^- < F^- < H_2O < NH_3 < en < CN^-$ matches the spectrochemical series trend.

Why? σ-only donors (halides): weak field (low Δ_o). σ-donor + weak π donor (H_2O): intermediate. σ-donor + π-back-acceptor (CN^-, CO): very strong field (high Δ_o). The π-acceptor ligands pull electron density from metal d orbitals into their own π^*, increasing the apparent Δ_o.

Final Answer: $I^- < Br^- < Cl^- < F^- < H_2O < NH_3 < en < CN^- \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q15

Q16.

Solution

Concept — NaCl (rock salt) unit cell: Structure: Cl^- forms FCC sublattice; Na^+ occupies all octahedral holes (which are also FCC-like).

Step 1 — Count Cl^-: 8 corners $\times\frac{1}{8}$ + 6 faces $\times\frac{1}{2} = 1 + 3 = 4\,Cl^-$.

Step 2 — Count Na^+: 12 edge-centre positions $\times\frac{1}{4}$ + 1 body-centre $\times 1 = 3 + 1 = 4\,Na^+$.

Total: $4\,Na^+$ and $4\,Cl^-$ per unit cell $\Rightarrow$ 4 formula units of NaCl. CN(Na^+)=6; CN(Cl^-)=6 (each surrounded by 6 of the other ion at the corners of an octahedron).

Final Answer: 4 Na^+ and 4 Cl^- per unit cell $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept — Freezing point depression and van't Hoff factor: $\Delta T_f = i \cdot K_f \cdot m$; $i = \Delta T_f/(K_f \cdot m) = 0.186/(1.86 \times 0.1) = 0.186/0.186 = 1$.

Interpretation: $i = 1$ means the solute behaves as undissociated molecules in solution (no dissociation or association). The solute remains as discrete molecules $\Rightarrow$ non-electrolyte.

If $i = 2$: $\Delta T_f = 2 \times 1.86 \times 0.1 = 0.372\,\text{K}$ (for a 1:1 electrolyte). Our value is only $0.186\,\text{K} \Rightarrow$ consistent with $i = 1$.

Final Answer: Solute stays as molecules ($i = 1$, non-electrolyte behaviour) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q17

Q18.

Solution

Concept — Wurtz reaction: $2\,\text{RX} + 2\text{Na} \rightarrow \text{R{-}R} + 2\text{NaX}$ (coupling of two alkyl halides via sodium metal).

Step 1: $2\,\text{CH}_3\text{Br} + 2\,\text{Na} \rightarrow \text{CH}_3{-}\text{CH}_3 + 2\,\text{NaBr}$

Product: **ethane**.

Mechanism: Na reduces RX to form organosodium species (RNa), which then reacts with another RX via SN2: $\text{RNa} + \text{R}'\text{X} \rightarrow \text{R{-}R}' + \text{NaX}$.

Limitation: Symmetric Wurtz gives one product (both Rs same). Mixed Wurtz ($\text{R{-}R} + \text{R{-}R}' + \text{R}'{-}\text{R}'$) gives three products (poor selectivity, used only when $R = R'$).

Final Answer: Ethane ($\text{CH}_3{-}\text{CH}_3$) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept — Lucas test reactivity order: Lucas reagent ($ZnCl_2$/conc. HCl) reacts via SN1 with alcohols. Reactivity $\propto$ carbocation stability.

Order: Tertiary $>$ secondary $>$ primary.

- Tertiary alcohol: immediate turbidity (within seconds; stable 3° carbocation)
- Secondary alcohol: turbidity in $\sim 5\,\text{min}$ (less stable 2° carbocation)
- Primary alcohol: no turbidity at room temperature (unstable 1° carbocation; would need heat or reflux)

This is the basis of the Lucas test to classify alcohols as 1°, 2°, or 3°.

Final Answer: Tertiary $>$ secondary $>$ primary (immediate $>$ 5 min $>$ no reaction at RT) $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q19

Q20.

Solution

Concept — Fehling's test: aliphatic aldehydes vs aromatic aldehydes: Fehling's solution (Cu^{2+} tartrate complex, alkaline) is selectively reduced by *aliphatic* aldehydes to give brick-red Cu_2O precipitate.

Key distinction:

- Aliphatic aldehydes (RCHO where R = alkyl or H): **positive** Fehling's (brick-red Cu_2O)
- Aromatic aldehydes (C_6H_5CHO, benzaldehyde): **negative** Fehling's (no reduction)
- Both give positive Tollens' (silver mirror)

Reason: Aromatic aldehydes are weaker reducing agents (the ring stabilises the carbonyl; the rate of oxidation is too slow to reduce the Cu^{2+} complex under mild conditions).

Final Answer: Aliphatic RCHO gives Cu_2O (brick-red); benzaldehyde does not $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept — Inductive effect on carboxylic acid strength: Acid strength depends on the stability of the conjugate base (carboxylate ion).

Formic acid vs acetic acid: In HCOOH, the carbonyl C is bonded directly to H (not an alkyl group). H has very little electron-donating ability by induction ($+I$ effect of H ≈ 0). In contrast, CH_3 has a slight $+I$ effect (electron-donating), which *destabilises* the acetate anion slightly (makes it a weaker acid).

Step 1 — Compare conjugate bases: $HCOO^-$ (formate): less electron density on O $\Rightarrow$ more stable. CH_3COO^- (acetate): slightly more electron density on O (from $+I$ of CH_3) $\Rightarrow$ less stable.

Step 2 — Conclusion: HCOOH is more acidic (lower pKa) because the formate ion is better stabilised (less electron-donating group adjacent to the carboxylate).

Option B correctly states that H (in place of CH_3) is electron-withdrawing compared to methyl, stabilising the formate anion.

Final Answer: HCOOH more acidic; formate more stable due to no $+I$ alkyl group $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept — Gabriel synthesis gives primary amine: Phthalimide $\xrightarrow{KOH}$ K-phthalimide $\xrightarrow{\text{RX=1-bromobutane}}$ N-butylphthalimide $\xrightarrow{KOH/H_2O}$ n-butylamine + phthalic acid.

Step 1 — Alkyl group transferred: 1-bromobutane has the n-butyl group ($CH_3CH_2CH_2CH_2-$). This group is N-alkylated onto the phthalimide nitrogen.

Step 2 — Hydrolysis product: N-butylphthalimide + KOH/H_2O $\rightarrow$ $CH_3CH_2CH_2CH_2NH_2$ (n-butylamine) + phthalate salt.

Why only primary amine? The nitrogen can be alkylated only once (only one N–H in phthalimide). No secondary or tertiary amine forms.

Final Answer: n-butylamine ($CH_3CH_2CH_2CH_2NH_2$) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

Q23.

Solution

Concept — Competitive enzyme inhibition (Michaelis-Menten kinetics): A competitive inhibitor (I) binds reversibly to the enzyme's *active site* (competes with substrate S for the same site). Effects:

- K_m **(apparent) increases:** The inhibitor makes it harder for substrate to bind, so a higher $[\text{S}]$ is needed to achieve half-maximal rate.
- V_{max} **unchanged:** At very high $[\text{S}]$, substrate can outcompete the inhibitor; the enzyme still reaches the same maximum velocity.

Example: Malonate (competitive inhibitor of succinate dehydrogenase); sulfonamide drugs (competitive inhibitors of dihydropteroate synthase in bacteria, resembling PABA).

Option B is the correct definition.

Final Answer: Increases K_m; V_{max} unchanged; overcome by high $[\text{S}] \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept — PHBV: a biodegradable bacterial polyester: PHBV (poly-3-hydroxybutyrate-co-3-hydroxyvalerate) is a naturally occurring polyester produced by bacteria (e.g. *Ralstonia eutropha*) as an intracellular carbon/energy reserve.

Properties:

- Biodegradable: hydrolysed by microorganisms in soil and water $\Rightarrow$ used in biodegradable packaging, sutures, drug delivery.
- Thermoplastic: can be moulded and processed like conventional plastics.
- Biocompatible: can be implanted in the body.

Distinction: PHBV is an option in exam questions as an example of a *biodegradable* polymer, contrasting with non-biodegradable polyethylene, polypropylene, PVC.

Final Answer: Biodegradable bacterial polyester $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q24

Q25.

Solution

Concept — Sodium benzoate as food preservative: Sodium benzoate (C_6H_5COONa) is the sodium salt of benzoic acid. In acidic foods (pH< 4.5), it converts to benzoic acid, which inhibits the growth of moulds, yeasts, and some bacteria.

Mechanism: Benzoic acid disrupts enzyme function in microorganisms by lowering intracellular pH. Effective against fermenting yeasts and mould.

Uses: Carbonated drinks, fruit juices, pickles, soy sauce (E211 in Europe). FDA-approved at concentrations up to 0.1%.

Final Answer: Food preservative in acidic foods $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q25

Q26.

Solution

Concept — Use of argon (inert noble gas): Argon is the most abundant noble gas in the atmosphere ($\approx 0.93\%$ by volume). Its key property: **complete chemical inertness** (stable $3s^2 3p^6$ configuration, no tendency to form compounds).

Applications of inertness:

- **Welding (TIG/MIG):** Ar shields the hot weld pool and tungsten electrode from atmospheric O_2 and N_2, preventing oxidation and porosity.
- **Incandescent/halogen bulbs:** Ar fill prevents filament oxidation and slows evaporation of W.
- **Semiconductor manufacturing:** Inert atmosphere prevents oxidation during doping.
- **Cryogenic laser gain medium:** Ar^+ lasers emit at $488\,\text{nm}$ (blue-green).

Final Answer: Chemically inert — prevents oxidation of hot metal $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Diagonal relationships in the periodic table: Elements diagonally adjacent (upper-left/lower-right, e.g. Li-Mg, Be-Al, B-Si) often show similar properties because their charge/radius ratios (z/r) are comparable, giving similar polarising power.

Classic diagonal pairs:

- **Li and Mg**: both form nitrides (Li_3N, Mg_3N_2); both form normal oxides (not peroxides); both salts similar in solubility.
- **Be and Al**: both form amphoteric oxides (BeO, Al_2O_3); both form polymeric chlorides; both dissolve in excess NaOH.
- **B and Si**: both form acidic oxides (B_2O_3, SiO_2); both are semiconductors; polymeric hydrides.

Options C and D are both valid diagonal pairs. The most commonly tested in BITSAT are Li-Mg and Be-Al. Option C (Be and Al) is a classic example.

Final Answer: Be and Al (diagonal relationship) $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept — Friedel-Crafts alkylation electrophile: $\mathrm{RCl} + \mathrm{AlCl_3} \rightarrow \mathrm{R^+} + \mathrm{AlCl_4^-}$ (Lewis acid $AlCl_3$ abstracts Cl^- from RCl, generating a carbocation electrophile R^+).

Mechanism:

(a) R^+ attacks benzene's π system $\rightarrow$ arenium (Wheland) ion intermediate.
(b) $AlCl_4^-$ removes H^+ from arenium ion $\rightarrow$ restores aromaticity.
(c) Products: PhR (alkylbenzene) + HCl; $AlCl_3$ regenerated (catalyst).

Limitations of Friedel-Crafts alkylation:

- Carbocation rearrangement (e.g. 1-chloropropane gives isopropylbenzene, not n-propylbenzene).
- Polyalkylation (product is more reactive than starting material).
- Does not work on deactivated rings (e.g. nitrobenzene, $-NO_2$ deactivates).

Final Answer: R^+ (carbocation from RCl + $AlCl_3$) $\Rightarrow$ $\boxed{\mathrm{B}}$

Answer: (B) Go Back to Q28

Q29.

Solution

Concept — BOD (Biological Oxygen Demand): BOD measures the amount of dissolved O_2 consumed by biological organisms (mainly bacteria) when decomposing organic matter in water at $20°C$ over 5 days (BOD_5).

Interpretation:

- **High BOD:** Large organic load $\Rightarrow$ bacteria proliferate, consuming dissolved O_2 $\Rightarrow$ fish and aquatic organisms suffocate. Indicates **heavily polluted** water (sewage, agricultural runoff, industrial effluent).
- **Low BOD ($< 2\,\mathrm{mg\,L^{-1}}$):** Clean water.
- **BOD** $> 10\,\mathrm{mg\,L^{-1}}$**:** Heavily polluted.

Related parameter: COD (Chemical Oxygen Demand) measures total oxidisable material (biological + chemical); COD $>$ BOD always.

Final Answer: High BOD $=$ high organic pollution $\Rightarrow$ $\boxed{B}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept — Diels-Alder reaction (4+2 cycloaddition): The Diels-Alder reaction is a [4+2] cycloaddition between a diene (4 π electrons) and a dienophile (2 π electrons). It forms a six-membered ring with one double bond.

Step 1 — Components: Diene: 1,3-butadiene ($CH_2 = CH - CH = CH_2$, in s-cis conformation). Dienophile: ethylene ($CH_2 = CH_2$).

Step 2 — Product: $CH_2 = CH - CH = CH_2 + CH_2 = CH_2 \rightarrow$ cyclohexene (a 6-membered ring with one C=C double bond).

Step 3 — Stereochemistry: The reaction is a *concerted* pericyclic process (no intermediates): syn addition of both new σ bonds. The reaction proceeds with retention of dienophile stereochemistry (endo/exo rule for substituted dienophiles).

Applications: Diels-Alder is one of the most powerful reactions in organic synthesis, used to build six-membered rings with controlled stereochemistry (total synthesis of steroids, terpenoids, natural products).

Final Answer: Cyclohexene (6-membered ring with one double bond) $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q30

Answer Key

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