BITSAT Chemistry Sample Paper – 3

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. $1.0\,\text{g}$ of magnesium is burned in excess oxygen. The mass of magnesium oxide formed and the number of Mg^{2+} ions produced are: ($M_{\text{Mg}} = 24$, $M_{\text{O}} = 16$)

(A) $1.67\,\text{g}$ MgO; 2.51×10^{22} ions

(B) $1.0\,\text{g}$ MgO; 6.02×10^{23} ions

(C) $2.0\,\text{g}$ MgO; 5.02×10^{22} ions

(D) $0.5\,\text{g}$ MgO; 1.26×10^{22} ions

Q2. The ionisation energy of hydrogen is $13.6\,\text{eV}$. The energy required to excite the electron in hydrogen from $n = 1$ to $n = 2$ is:

(A) $13.6\,\text{eV}$

(B) $3.4\,\text{eV}$

(C) $10.2\,\text{eV}$

(D) $1.5\,\text{eV}$

Q3. Which electronic configuration represents the ground state of Fe^{3+}? (At. no. of Fe = 26)

(A) $[\mathrm{Ar}]\,3d^5\,4s^2$

(B) $[\mathrm{Ar}]\,3d^6\,4s^0$

(C) $[\mathrm{Ar}]\,3d^5\,4s^0$

(D) $[\mathrm{Ar}]\,3d^4\,4s^1$

Q4. Which of the following has the highest lattice energy?

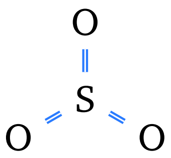
(A) NaF

(B) MgO

(C) NaCl

(D) KCl

Q5. The Lewis structure of $\mathrm{SO_3}$ (sulfur trioxide) with formal charges minimised. Sulfur uses expanded octet. Which structure best represents $\mathrm{SO_3}$?



(I) three S=O

all bond angles 120°

(A) S has two S–O single bonds and one S=O double bond; S bears $+2$ formal charge

(B) S has three S=O double bonds; S has formal charge 0; bond angles 120°; $\mathrm{sp^2}$ hybridised

(C) S has three S–O single bonds; all oxygens have formal charge -1; S has $+3$

(D) S has one S=O and two S–O bonds; molecule is pyramidal

Q6. The enthalpy of neutralisation of a strong acid by a strong base is always $-57.3\,\mathrm{kJ\,mol^{-1}}$. However, the neutralisation of acetic acid by NaOH gives $\Delta H = -55.2\,\mathrm{kJ\,mol^{-1}}$. The enthalpy of ionisation of acetic acid is:

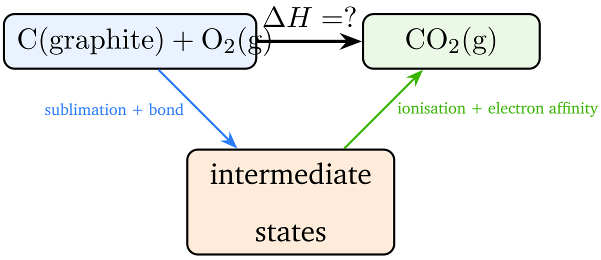
(A) $+112.5\,\mathrm{kJ\,mol^{-1}}$

(B) $-2.1\,\mathrm{kJ\,mol^{-1}}$

(C) $+2.1\,\mathrm{kJ\,mol^{-1}}$

(D) $+57.3\,\mathrm{kJ\,mol^{-1}}$

Q7. For the reaction $\mathrm{C(graphite) + O_2(g) \rightarrow CO_2(g)}$, the enthalpy change can be obtained from a Born-Haber-type cycle using the following data:



The enthalpy of sublimation of C is $+715\,\mathrm{kJ\,mol^{-1}}$, bond dissociation of $\mathrm{O_2}$ is $+498\,\mathrm{kJ\,mol^{-1}}$, and formation of $\mathrm{CO_2}$ from atoms releases $1608\,\mathrm{kJ\,mol^{-1}}$. The $\Delta H_f^\circ(\mathrm{CO_2})$ is:

(A) $-395\,\mathrm{kJ\,mol^{-1}}$

(B) $+605\,\mathrm{kJ\,mol^{-1}}$

(C) $-1608\,\mathrm{kJ\,mol^{-1}}$

(D) $-821\,\mathrm{kJ\,mol^{-1}}$

Q8. At $700\,\mathrm{K}$, $K_p = 1.8\times10^{-3}\,\mathrm{atm}$ for the reaction $\mathrm{SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)}$. For the reverse reaction $\mathrm{SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)}$, the value of K_p is:

(A) $K_p = 1.8 \times 10^{-3}\,\mathrm{atm^{-1}}$

(B) $K_p = (1.8 \times 10^{-3})^2$

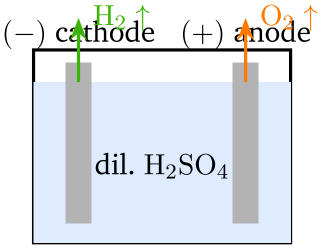
(C) $K_p = \sqrt{1.8 \times 10^{-3}}$

(D) $K_p = 556\,\mathrm{atm^{0.5}}$

Q9. $20\,\mathrm{mL}$ of $0.1\,\mathrm{M}$ $\mathrm{CH_3COOH}$ is titrated with $0.1\,\mathrm{M}$ NaOH. At the half-equivalence point (10 mL NaOH added), the pH equals $\mathrm{p}K_a = 4.74$. At the equivalence point (20 mL NaOH added), the solution is:

- (A) Acidic ($pH < 7$) because CH_3COO^- is a conjugate acid
- (B) Neutral ($pH = 7$) because the acid is fully neutralised
- (C) Basic ($pH > 7$) because CH_3COO^- undergoes hydrolysis
- (D) Acidic ($pH < 7$) because CH_3COOH is still present

Q10. The electrolysis of dilute H_2SO_4 with inert platinum electrodes. The products at the cathode and anode, and the electrode reaction at the anode are:



- (A) Cathode: O_2; anode: H_2; anode reaction: $4H^+ + 4e^- \rightarrow 2H_2$
- (B) Cathode: H_2; anode: O_2; anode reaction: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$
- (C) Cathode: SO_4^{2-} is reduced; anode: H_2 is released
- (D) Cathode: H_2; anode: SO_3; anode reaction: $SO_4^{2-} \rightarrow SO_3 + O^{2-}$

Q11. For the reaction $2A + B \rightarrow C$, the rate is $r = k[A]^2[B]$. When $[A]$ is doubled and $[B]$ is halved, the rate changes by a factor of:

- (A) Doubles (factor of 2)
- (B) Halves (factor of $1/2$)
- (C) Quadruples (factor of 4)
- (D) Remains the same (factor of 1)

Q12. The reaction of P_4 with excess $NaOH$ solution (disproportionation) gives phosphine and sodium hypophosphite:

$$\boxed{P_4 + NaOH(aq) + H_2O}$$

$$\Big\downarrow \text{balance}$$

$$a\,PH_3 + b\,NaH_2PO_2$$

(A) $P_4 + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$

(B) $P_4 + 4NaOH \rightarrow 4PH_3 + 4NaO$

(C) $2P_4 + 3NaOH + 3H_2O \rightarrow 3PH_3 + 5NaH_2PO_2$ (incorrect)

(D) $P_4 + 2NaOH + 2H_2O \rightarrow 2PH_3 + 2NaH_2PO_2$

Q13. Arrange the following in **increasing** order of boiling points: HF, HCl, HBr, HI

(A) HF < HCl < HBr < HI

(B) HCl < HBr < HI < HF

(C) HI < HBr < HCl < HF

(D) HCl < HI < HBr < HF

Q14. The complex $[Ni(CO)_4]$ has which of the following properties?

(A) Ni is +2; tetrahedral geometry; paramagnetic

(B) Ni is 0; tetrahedral geometry; diamagnetic (sp^3 hybridised)

(C) Ni is 0; square planar geometry; diamagnetic (dsp^2 hybridised)

(D) Ni is +1; octahedral geometry; paramagnetic

Q15. At high temperatures, FeO often has the non-stoichiometric formula $Fe_{0.93}O$. The percentage of Fe^{3+} ions present and the type of defect responsible are:

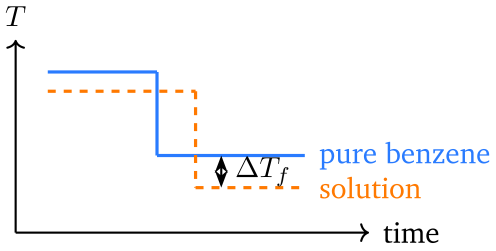
(A) 5% Fe^{3+}; interstitial defect

(B) 15% Fe^{3+}; metal excess defect

(C) 15% Fe^{3+}; metal deficiency defect (cation vacancies)

(D) 7% Fe^{3+}; Schottky defect

Q16. When $6\,g$ of a non-volatile solute is dissolved in $100\,g$ of benzene (molar mass $78\,g\,mol^{-1}$; $K_f = 5.12\,K\,kg\,mol^{-1}$), the freezing point depression is $\Delta T_f = 0.512\,K$. The molar mass of the solute is:



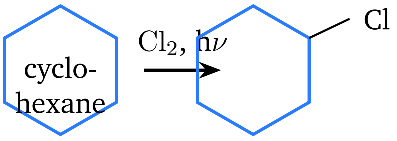
(A) $M = 120\,\text{g mol}^{-1}$

(B) $M = 600\,\text{g mol}^{-1}$

(C) $M = 60\,\text{g mol}^{-1}$

(D) $M = 240\,\text{g mol}^{-1}$

Q17. Cyclohexane reacts with Cl_2 under UV light (free radical halogenation). The mechanism involves:



chlorocyclohexane

(A) Electrophilic addition: Cl^+ adds across C–C bond

(B) Nucleophilic substitution S_N2: Cl^- displaces H

(C) Free radical substitution: $Cl\cdot$ abstracts H from the ring, then Cl_2 donates Cl to the cyclohexyl radical

(D) Ionic elimination: HCl is lost and a double bond forms

Q18. Toluene undergoes nitration (electrophilic substitution) with HNO_3/H_2SO_4 to give predominantly:

(A) m-nitrotoluene (meta isomer)

(B) Benzaldehyde (oxidation product)

(C) o- and p-nitrotoluene (mixture of ortho and para)

(D) p-nitrotoluene only

Q19. The dehydration of 2-methylbutan-2-ol with conc. H_2SO_4 at $170°C$ proceeds via an E1 mechanism. The major product (Zaitsev rule: more substituted alkene) is:

$$\begin{array}{l}\boxed{(CH_3)_2C(OH)CH_2CH_3} \\ \quad\quad\big\downarrow \text{ conc. } H_2SO_4,\ 170°C \\ \quad\quad ?\end{array}$$

(A) 2-methylbut-1-ene ($CH_2 = C(CH_3)CH_2CH_3$)

(B) 3-methylbut-1-ene ($CH_2 = CHCH(CH_3)_2$)

(C) 2-methylbut-2-ene ($CH_3C(CH_3) = CHCH_3$) — most substituted

(D) But-1-ene ($CH_2 = CHCH_2CH_3$)

Q20. Benzaldehyde undergoes Cannizzaro reaction (no α-H) with conc. NaOH:

$$\begin{array}{l}\boxed{2\,C_6H_5CHO} \\ \quad\quad\big\downarrow \text{ conc. NaOH} \\ \quad\quad ?\end{array}$$

(A) $C_6H_5COOH + C_6H_5CH_3$ (benzoic acid + toluene)

(B) $C_6H_5CH_2OH + C_6H_5COO^-Na^+$ (benzyl alcohol + sodium benzoate)

(C) $2\,C_6H_5COOH$ (disproportionation to acid only)

(D) $C_6H_5CH_2CH_2C_6H_5$ (pinacol coupling)

Q21. Which of the following reagents can distinguish between an aldehyde and a ketone?

(A) 2,4-Dinitrophenylhydrazine (Brady's reagent)

(B) Tollens' reagent ($[Ag(NH_3)_2]^+$)

(C) Sodium bisulfite ($NaHSO_3$)

(D) Concentrated H_2SO_4

Q22. Fischer esterification: acetic acid reacts with ethanol in the presence of conc. H_2SO_4 (catalyst). The mechanism involves nucleophilic acyl substitution. The product and by-product are:

$$CH_3COOH + C_2H_5OH \xrightarrow{H^+,\ \text{heat}} CH_3COOC_2H_5 + H_2O$$

reversible equilibrium

(A) Ethyl acetate (ethyl ethanoate) and water; reaction is reversible

(B) Acetaldehyde and water; reaction is irreversible

(C) Ethyl acetate; H_2SO_4 is consumed

(D) Acetic anhydride and ethanol

Q23. Gabriel synthesis is used to prepare primary amines. The sequence is:

(A) Phthalimide $\xrightarrow{RX}$ N-alkylphthalimide $\xrightarrow{KOH/H_2O}$ primary amine + phthalic acid

(B) Phthalimide $\xrightarrow{HNO_3}$ N-nitrophthalimide $\xrightarrow{\text{reduce}}$ amine

(C) Benzamide $\xrightarrow{Br_2/NaOH}$ aniline (Hofmann rearrangement)

(D) Nitrobenzene $\xrightarrow{Fe/HCl}$ aniline $\xrightarrow{RX}$ N-alkylaniline

Q24. The linkage between two monosaccharide units in a disaccharide (e.g. maltose) is called a:

(A) Peptide bond (amide linkage)

(B) Glycosidic bond (acetal/ketal linkage between anomeric C and -OH of another sugar)

(C) Ester bond (between -COOH and -OH)

(D) Phosphodiester bond

Q25. Vitamin C (ascorbic acid) is water-soluble and acts as an antioxidant. Which of the following is a fat-soluble vitamin?

(A) Vitamin B complex

(B) Vitamin C

(C) Vitamin A

(D) Folic acid

Q26. The addition polymer of styrene ($C_6H_5CH = CH_2$) is polystyrene. The repeating unit is:

$$n\ C_6H_5CH{=}CH_2 \xrightarrow{\text{initiator}} [-CH_2 - CH(C_6H_5)-]_n$$

(A) $[-CH_2 - CH(C_6H_5)-]_n$; addition polymer; no by-product

(B) $[-CH(C_6H_5) - CH_2 - O-]_n$; condensation polymer; water lost

(C) $[-C_6H_5 - CH_2-]_n$; cross-linked

(D) $[-CH_2 - CH_2 - C_6H_5-]_n$; copolymer with ethylene

Q27. Tyndall effect is observed in colloids but not in true solutions. The reason is:

(A) Colloidal particles are too small to scatter light; true solutions scatter it strongly

(B) Colloidal particles (1–1000 nm) scatter a beam of light; particles in true solutions ($<$1 nm) are too small to scatter visible light

(C) Tyndall effect is due to absorption of light, not scattering

(D) Both colloids and true solutions show Tyndall effect equally

Q28. The effective atomic number (EAN) rule predicts that metal complexes achieve a noble gas configuration. For $[Fe(CO)_5]$, the EAN is:

(A) 36 (Kr configuration)

(B) 54 (Xe configuration)

(C) 18 (Ar configuration)

(D) 86 (Rn configuration)

Q29. The conductivity of a $0.01\,\mathrm{M}$ solution of KCl is $1.41 \times 10^{-3}\,\mathrm{S\,cm^{-1}}$. The molar conductivity Λ_m is:

(A) $\Lambda_m = 141\,\mathrm{S\,cm^2\,mol^{-1}}$

(B) $\Lambda_m = 14.1\,\mathrm{S\,cm^2\,mol^{-1}}$

(C) $\Lambda_m = 1410\,\mathrm{S\,cm^2\,mol^{-1}}$

(D) $\Lambda_m = 1.41\,\mathrm{S\,cm^2\,mol^{-1}}$

Q30. A zero-order reaction has rate constant $k = 2.5 \times 10^{-3}\,\mathrm{mol\,L^{-1}\,s^{-1}}$. Starting with $[\mathrm{A}]_0 = 0.1\,\mathrm{mol\,L^{-1}}$, the time for the concentration to fall to $0.05\,\mathrm{mol\,L^{-1}}$ is:

(A) $t = 40\,\mathrm{s}$

(B) $t = 100\,\mathrm{s}$

(C) $t = 277\,\mathrm{s}$

(D) $t = 20\,\mathrm{s}$

Detailed Solutions

Q1.

Solution

Concept — Stoichiometry of combustion and Avogadro's number:

$$2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$$

Every mole of Mg burnt produces exactly one mole of MgO and yields one mole of Mg^{2+} ions in the ionic lattice.

Step 1 — Moles of Mg:

$$n(\text{Mg}) = \frac{1.0\,\text{g}}{24\,\text{g mol}^{-1}} = \frac{1}{24}\,\text{mol} \approx 0.0417\,\text{mol}$$

Step 2 — Mass of MgO: $M(\text{MgO}) = 24 + 16 = 40\,\text{g mol}^{-1}$.

$$m(\text{MgO}) = \frac{1}{24} \times 40 = \frac{40}{24} = 1.667 \approx \mathbf{1.67}\,\text{g}$$

Step 3 — Number of Mg^{2+} ions: Each mole of MgO contains N_A Mg^{2+} ions.

$$N(\text{Mg}^{2+}) = \frac{1}{24} \times 6.022 \times 10^{23} = \frac{6.022 \times 10^{23}}{24} = 2.509 \times 10^{22} \approx \mathbf{2.51 \times 10^{22}}\,\text{ions}$$

Common error: Using $M(\text{Mg}) = 24$ but then computing $m(\text{MgO})$ by adding only the O mass without multiplying by number of moles. Always track moles throughout.

Final Answer: $1.67\,\text{g}$ MgO; 2.51×10^{22} Mg^{2+} ions $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Bohr model energy levels: Energy of the n^{th} level of hydrogen:

$$E_n = -\frac{13.6}{n^2}\,\text{eV}$$

The energy required to excite the electron from level n_1 to n_2 is $\Delta E = E_{n_2} - E_{n_1}$.

Step 1 — Energies of levels:

$$E_1 = -\frac{13.6}{1^2} = -13.6\,\text{eV}$$

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

Step 2 — Energy of excitation:

$$\Delta E = E_2 - E_1 = (-3.4) - (-13.6) = +10.2\,\text{eV}$$

The positive sign indicates energy must be absorbed (endothermic process).

Step 3 — Wavelength of photon: This $10.2\,\text{eV}$ photon corresponds to $\lambda = hc/\Delta E \approx 121.6\,\text{nm}$ (Lyman-α line, UV region).

Common trap: Students sometimes subtract $|E_1| - |E_2| = 13.6 - 3.4 = 10.2$ directly, which works here but is conceptually flawed. Always compute $E_{final} - E_{initial}$.

Final Answer: $10.2\,\text{eV} \Rightarrow \boxed{\text{C}}$

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

Q3.

Solution

Concept — Electronic configuration of transition metal ions: Electrons are removed from the highest principal quantum number first (outermost shell). For transition metals, $4s$ electrons are lost before $3d$ electrons when forming cations.

Step 1 — Ground state of Fe: Fe has atomic number 26.

$$\mathrm{Fe} : [\mathrm{Ar}]\, 3d^6\, 4s^2$$

Step 2 — Fe^{3+} (loss of 3 electrons): First remove the two $4s$ electrons, then one $3d$:

$$\mathrm{Fe}^{2+} : [\mathrm{Ar}]\, 3d^6\, 4s^0$$

$$\mathrm{Fe}^{3+} : [\mathrm{Ar}]\, 3d^5\, 4s^0 = [\mathrm{Ar}]\, 3d^5$$

Step 3 — Extra stability of d^5: $3d^5$ with all five d orbitals singly occupied (half-filled) is extra stable due to exchange energy. This is why Fe^{3+} is more stable than Fe^{2+} in many contexts, and why Mn^{2+} ($3d^5$) is relatively stable.

Option A check: $[\mathrm{Ar}]\, 3d^5\, 4s^2$ is the neutral Fe atom minus 1 electron from $3d$ but keeping $4s^2$ — this is wrong. $4s$ electrons are always removed first.

Final Answer: $[\mathrm{Ar}]\, 3d^5 \Rightarrow \boxed{\text{C}}$

$\boxed{\textbf{Answer: (C)}}$ **Go Back to Q3**

Q4.

Solution

Concept — Lattice energy (Born-Landé equation factors): Lattice energy (U) is the energy released when gaseous ions come together to form the ionic crystal. Magnitude depends on:

$$U \propto \frac{|z^+||z^-|}{r_0}$$

where z^+, z^- are the ionic charges and r_0 is the interionic distance (sum of radii).

Step 1 — Compare the options:

Compound	z^+	z^-	Product $\lvert z^+\rvert\lvert z^-\rvert$
NaF	$+1$	-1	1
NaCl	$+1$	-1	1
KCl	$+1$	-1	1
MgO	$+2$	-2	**4**

Step 2 — Effect of charge: MgO has $z^+ \cdot |z^-| = 4$, which is four times larger than NaF, NaCl, or KCl. Additionally, Mg^{2+} (ionic radius $72\,\mathrm{pm}$) is smaller than Na^+ ($102\,\mathrm{pm}$), and O^{2-} ($140\,\mathrm{pm}$) is smaller than Cl^- ($181\,\mathrm{pm}$), so r_0 is also smaller for MgO.

Step 3 — Numerical comparison: $U(\mathrm{MgO}) \approx 3795\,\mathrm{kJ\,mol^{-1}}$ vs $U(\mathrm{NaCl}) \approx 787\,\mathrm{kJ\,mol^{-1}}$ — a factor of ~5 due to both charge and size effects.

Final Answer: MgO has the highest lattice energy $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q4

Q5.

Solution

Concept — Lewis structure with expanded octet and formal charges: Sulfur (Period 3) has d-orbitals available for bonding and can form more than 4 bonds (expanded octet). In $\mathrm{SO_3}$, using three S=O double bonds minimises formal charges on all atoms.

Step 1 — Formal charge formula: FC $=$ valence electrons $-$ lone pair electrons $-$ $\frac{1}{2}$bonding electrons

Step 2 — Check three S=O bonds: S: $6 - 0 - \frac{1}{2}(12) = 6 - 6 = 0$

Each O in S=O: $6 - 4 - \frac{1}{2}(4) = 6 - 4 - 2 = 0$

All formal charges are **zero** $\Rightarrow$ this is the best Lewis structure.

Step 3 — Geometry and hybridisation: Three bonding pairs, no lone pairs on S $\Rightarrow$ trigonal planar, bond angle $120°$, S is sp^2 hybridised. The d_π-p_π back bonding explains the short, strong S–O bonds.

Step 4 — Verify option C: Option C proposes three single S–O bonds: FC on each O^- would be $6 - 6 - 1 = -1$, and FC on S would be $6 - 0 - 3 = +3$. Total charge is $+3 + 3(-1) = 0$, OK for neutral molecule but formal charges are large and unfavorable.

Final Answer: Three S=O; all formal charges zero; $120°$; $\mathrm{sp}^2 \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q5

Q6.

Solution

Concept — Enthalpy of ionisation from neutralisation data: For a weak acid HA neutralised by a strong base:

$$\Delta H(\text{weak acid + strong base}) = \Delta H_{\text{neutralisation}} + \Delta H_{\text{ionisation of HA}}$$

Standard neutralisation ($H^+ + OH^- \rightarrow H_2O$) is always $-57.3\,\text{kJ mol}^{-1}$.

Step 1 — Set up equation:

$$-55.2 = -57.3 + \Delta H_{\text{ionisation}}$$

Step 2 — Solve:

$$\Delta H_{\text{ionisation}} = -55.2 + 57.3 = +2.1\,\text{kJ mol}^{-1}$$

Step 3 — Interpretation: The *positive* value means ionisation of acetic acid ($CH_3COOH \rightleftharpoons CH_3COO^- + H^+$) is endothermic (+2.1 kJ/mol). This makes physical sense — breaking the O–H bond requires energy. The overall neutralisation is exothermic but less so because some energy goes into ionising the weak acid.

If the acid were strong (like HCl, already fully ionised), no extra energy is needed for ionisation, so $\Delta H = -57.3\,\text{kJ mol}^{-1}$ directly.

Final Answer: $\Delta H_{\text{ionisation}} = +2.1\,\text{kJ mol}^{-1} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q6

Q7.

Solution

Concept — Hess's Law (Born-Haber type cycle): Hess's Law: the total enthalpy change for a reaction is independent of the path taken. The enthalpy of formation equals the sum of enthalpies along any alternative path.

Step 1 — Identify the cycle: Path 1 (direct): $\mathrm{C(s) + O_2(g) \xrightarrow{\Delta H_f^\circ} CO_2(g)}$

Path 2 (via atoms): $\mathrm{C(graphite) \xrightarrow{+715} C(g)}$ (sublimation) $\mathrm{O_2(g) \xrightarrow{+498} 2O(g)}$ (bond dissociation, full mole needed for 2 O atoms) $\mathrm{C(g) + 2O(g) \xrightarrow{-1608} CO_2(g)}$ (bond formation from atoms)

Step 2 — Apply Hess's Law:

$$\Delta H_f^\circ(\mathrm{CO_2}) = +715 + 498 - 1608$$

$$= 1213 - 1608 = -\mathbf{395}\,\mathrm{kJ\,mol^{-1}}$$

Step 3 — Check units: All values are in kJ/mol. The bond dissociation of O_2 requires the full 498 kJ to produce 2 O atoms (needed for one CO_2 molecule).

Practical significance: $\Delta H_f^\circ(\mathrm{CO_2}) = -393.5\,\mathrm{kJ\,mol^{-1}}$ experimentally; our Hess calculation gives -395, close agreement.

Final Answer: $\Delta H_f^\circ(\mathrm{CO_2}) = -395\,\mathrm{kJ\,mol^{-1}} \Rightarrow \boxed{\mathrm{A}}$

Answer: (A)

Go Back to Q7

Q8.

Solution

Concept — Relationship between K_p for forward and reverse reactions: If the forward reaction has equilibrium constant K_p, then the reverse reaction has:

$$K_p(\text{reverse}) = \frac{1}{K_p(\text{forward})}$$

Step 1 — Forward reaction: $SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$, $K_p = 1.8 \times 10^{-3}\,\text{atm}^{-1/2}$ (units from $\Delta n_g = 1 - 1.5 = -0.5$).

Step 2 — Reverse reaction: $SO_3(g) \rightleftharpoons SO_2(g) + \frac{1}{2}O_2(g)$, $\Delta n_g = +0.5$.

$$K_p(\text{reverse}) = \frac{1}{K_p(\text{forward})} = \frac{1}{1.8 \times 10^{-3}} = 556\,\text{atm}^{+1/2}$$

Step 3 — Units check: Forward K_p has units $\text{atm}^{-0.5}$ (because $\Delta n_g = -0.5$). Reverse has $\Delta n_g = +0.5$, so units are $\text{atm}^{+0.5}$ — consistent.

Physical interpretation: $K_p = 556\,\text{atm}^{0.5}$ for decomposition is large, meaning SO_3 decomposes readily at 700 K — this is why the contact process must operate at lower temperatures for better yield.

Final Answer: $K_p(\text{reverse}) = 556\,\text{atm}^{0.5} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Hydrolysis of the salt of a weak acid and strong base: At the equivalence point in the titration of a weak acid (CH_3COOH) with a strong base (NaOH), all the acetic acid has been converted to sodium acetate ($\mathrm{CH_3COONa}$).

Step 1 — Nature of the solution: $\mathrm{CH_3COO^-}$ is the conjugate base of the weak acid CH_3COOH. It undergoes hydrolysis:

$$\mathrm{CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-}$$

This produces OH^- ions, making the solution **basic** (pH > 7).

Step 2 — Quantitative estimate: $K_b(\mathrm{CH_3COO^-}) = K_w/K_a = 10^{-14}/(1.8 \times 10^{-5}) = 5.6 \times 10^{-10}$. Even though small, this hydrolysis is enough to raise pH above 7.

At equivalence point, 20 mL of 0.1 M CH_3COONa in 40 mL total: $c = 0.05\,\mathrm{M}$; $\mathrm{pOH} \approx 5.27$; $\mathrm{pH} \approx 8.73$.

Step 3 — Why other options are wrong: Option B (neutral): incorrect; Na^+ doesn't hydrolyse, but CH_3COO^- does. Option A (acidic): incorrect; the hydrolysis produces OH^-, not H^+. Option D (acetic acid still present): incorrect at the equivalence point.

Final Answer: Basic pH due to hydrolysis of $\mathrm{CH_3COO^-} \Rightarrow \boxed{\text{C}}$

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

Q10.

Solution

Concept — Electrolysis of dilute H_2SO_4: With inert Pt electrodes and dilute H_2SO_4, the electrode reactions are governed by reduction potentials. SO_4^{2-} is a very stable anion with a very high oxidation potential — it is *not* discharged at the anode.

Step 1 — Cathode (reduction): H^+ ions are reduced in preference to water:

$$4H^+ + 4e^- \rightarrow 2H_2(g) \quad (E^\circ = 0\,\text{V})$$

H_2 is evolved at the cathode (negative electrode).

Step 2 — Anode (oxidation): SO_4^{2-} requires very high energy to oxidise. Water is preferentially oxidised:

$$2H_2O \rightarrow O_2(g) + 4H^+ + 4e^- \quad (E^\circ = +1.23\,\text{V})$$

O_2 is evolved at the anode (positive electrode).

Step 3 — Net cell reaction:

$$2H_2O \xrightarrow{\text{electrolysis}} 2H_2 + O_2$$

Ratio: 2 vol H_2 : 1 vol O_2 (by Faraday's laws). The H_2SO_4 acts as an electrolyte to conduct current but is not consumed overall.

Final Answer: Cathode: H_2; Anode: O_2; anode reaction: $2H_2O \rightarrow O_2 + 4H^+ + 4e^- \Rightarrow \boxed{B}$

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

Q11.

Solution

Concept — Effect of changing concentrations on reaction rate: Rate law: $r = k[\text{A}]^2[\text{B}]$. Rate is second-order in A and first-order in B. Changes are multiplicative.

Step 1 — Apply the changes: New $[\text{A}]' = 2[\text{A}]$; new $[\text{B}]' = [\text{B}]/2$.

Step 2 — New rate:

$$r' = k(2[\text{A}])^2\left(\frac{[\text{B}]}{2}\right) = k \cdot 4[\text{A}]^2 \cdot \frac{[\text{B}]}{2} = 2k[\text{A}]^2[\text{B}] = 2r$$

Step 3 — Breakdown of effects:

- Doubling [A] increases rate by $2^2 = 4$ (second order)
- Halving [B] decreases rate by $\frac{1}{2}$ (first order)
- Net effect: $4 \times \frac{1}{2} = 2 \Rightarrow$ rate doubles.

Note: If the reaction were second-order in both A and B, halving [B] would reduce rate by 4, and the net factor would be $4 \times \frac{1}{4} = 1$ (unchanged). The order of the reaction with respect to each reactant is crucial.

Final Answer: Rate doubles (factor of 2) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept — Disproportionation of P_4 in NaOH (alkaline hydrolysis): White phosphorus (P_4) undergoes disproportionation in hot concentrated NaOH. Phosphorus(0) simultaneously oxidises to NaH_2PO_2 (hypophosphite, P = +1) and reduces to PH_3 (phosphine, P = −3).

Step 1 — Identify oxidation states:

- P in P_4: 0 (elemental)
- P in PH_3: -3 (gains $3e^-$)
- P in $H_2PO_2^-$: $+1$ (loses $1e^-$)

Step 2 — Electron balance: Each P going to PH_3 gains 3 electrons. Each P going to $H_2PO_2^-$ loses 1 electron. To balance: 1 P(to PH_3) per 3 P(to $H_2PO_2^-$). Total P per P_4 molecule: $1 + 3 = 4 \Rightarrow$ 1 mol P_4 gives 1 mol PH_3 + 3 mol NaH_2PO_2.

Step 3 — Balanced equation:

$$P_4 + 3NaOH + 3H_2O \to PH_3 + 3NaH_2PO_2$$

Check atoms — P: $4 = 1 + 3$ ✓; H: LHS $= 3 + 6 = 9$; RHS $= 3 + 3 \times 2 = 9$ ✓; O: $3 = 3 \times 2 - 3$ ✓.

Final Answer: $P_4 + 3NaOH + 3H_2O \to PH_3 + 3NaH_2PO_2 \Rightarrow \boxed{A}$

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

Q13.

Solution

Concept — Boiling points of hydrogen halides and hydrogen bonding anomaly: Expected trend (van der Waals/London dispersion forces): boiling point increases with molar mass and polarisability.

Step 1 — Expected order without anomalies: M: HCl (36) $<$ HBr (81) $<$ HI (128) g/mol. So expected: HCl $<$ HBr $<$ HI for boiling points. Actual bp: HCl $(-85°\text{C})$ $<$ HBr $(-67°\text{C})$ $<$ HI $(-35°\text{C})$ — this order holds.

Step 2 — HF anomaly: HF has $M = 20$ g/mol (smallest of the four), yet its bp is $+19.5°$C — far higher than HCl $(-85°\text{C})$. This is due to *strong intermolecular hydrogen bonding* (F–H$\cdots$F), which persists even in the liquid state and requires substantial energy to break.

Step 3 — Correct increasing order: HCl $(-85°\text{C})$ $<$ HBr $(-67°\text{C})$ $<$ HI $(-35°\text{C})$ $<$ HF $(+19.5°\text{C})$

This is option B.

Note: The same anomaly is seen in H_2O (bp $100°$C) vs H_2S (bp $-60°$C) and NH_3 (bp $-33°$C) vs PH_3 (bp $-87°$C).

Final Answer: HCl $<$ HBr $<$ HI $<$ HF $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q13

Q14.

Solution

Concept — Properties of $[\mathrm{Ni(CO)_4}]$ (tetracarbonylnickel):

Step 1 — Oxidation state of Ni: CO is a neutral ligand. In $[\mathrm{Ni(CO)_4}]$: $x + 4(0) = 0 \implies x = 0$. Nickel is in the **zero oxidation state**.

Step 2 — Electron configuration of Ni(0): Ground state of Ni: $[\mathrm{Ar}]\,3d^8\,4s^2$. In the complex, electrons reorganise: Ni(0) in $[\mathrm{Ni(CO)_4}]$: $[\mathrm{Ar}]\,3d^{10}$ (all 10 d electrons paired + CO σ-donation fills the sp^3 hybrids).

All 10 d-electrons are paired ⇒ **diamagnetic** (no unpaired electrons, $\mu = 0$).

Step 3 — Geometry and hybridisation: 4 CO ligands; no lone pairs; sp^3 hybridisation; **tetrahedral geometry**.

Industrial relevance: $[\mathrm{Ni(CO)_4}]$ is formed in the Mond process for purifying nickel. Impure Ni reacts with CO at $50°$C to give the volatile $[\mathrm{Ni(CO)_4}]$, which is then decomposed at $200°$C to give pure Ni metal.

Final Answer: Ni(0); tetrahedral; diamagnetic (sp^3) $\Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Non-stoichiometric metal-deficiency defect: In $\mathrm{Fe_{0.93}O}$, some $\mathrm{Fe^{2+}}$ sites are vacant to maintain electrical neutrality. Since the overall crystal must remain neutral, some Fe atoms are $\mathrm{Fe^{3+}}$ (higher charge) to compensate for the vacancies.

Step 1 — Set up charge balance: Let x = number of $\mathrm{Fe^{3+}}$ ions in one formula unit of $\mathrm{Fe_{0.93}O}$. Number of $\mathrm{Fe^{2+}}$ ions $= 0.93 - x$.

Charge of all ions = charge of $\mathrm{O^{2-}}$:

$$2(0.93 - x) + 3x = 2 \times 1$$

$$1.86 - 2x + 3x = 2$$

$$1.86 + x = 2 \implies x = 0.14$$

Step 2 — Percentage of $\mathrm{Fe^{3+}}$:

$$\%\,\mathrm{Fe^{3+}} = \frac{0.14}{0.93} \times 100 = 15.05\% \approx \mathbf{15\%}$$

Step 3 — Type of defect: Since cation ($\mathrm{Fe^{2+}}$) vacancies are present (some Fe sites are empty), this is a **metal deficiency defect** (also called cation vacancy defect). This is different from Schottky (equal cation and anion vacancies) and Frenkel (cation in interstitial).

Final Answer: $\approx 15\%$ $\mathrm{Fe^{3+}}$; metal deficiency defect $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Cryoscopy (depression of freezing point):

$$\Delta T_f = K_f \times m$$

where $K_f = 5.12\,\mathrm{K\,kg\,mol^{-1}}$ for benzene and m is the molality of the solute.

Step 1 — Calculate molality from ΔT_f:

$$m = \frac{\Delta T_f}{K_f} = \frac{0.512\,\mathrm{K}}{5.12\,\mathrm{K\,kg\,mol^{-1}}} = 0.100\,\mathrm{mol\,kg^{-1}}$$

Step 2 — Moles of solute: Solvent mass $= 100\,\mathrm{g} = 0.100\,\mathrm{kg}$.

$$n_{\text{solute}} = m \times W_{\text{solvent}}(\mathrm{kg}) = 0.100 \times 0.100 = 0.0100\,\mathrm{mol}$$

Step 3 — Molar mass:

$$M_{\text{solute}} = \frac{w_{\text{solute}}}{n_{\text{solute}}} = \frac{6.0\,\mathrm{g}}{0.0100\,\mathrm{mol}} = \mathbf{600}\,\mathrm{g\,mol^{-1}}$$

Significance: This large molar mass suggests the solute might be a polymer or a large organic molecule (e.g. a polycyclic compound, oligosaccharide, or polymer). Cryoscopy is one of the oldest methods for molar mass determination.

Final Answer: $M = 600\,\mathrm{g\,mol^{-1}} \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept — Free radical halogenation (chain mechanism): Halogenation of alkanes under UV light proceeds through a free radical chain mechanism:

Step 1 — Initiation: $Cl_2 \xrightarrow{h\nu} 2Cl\cdot$ (homolytic cleavage of Cl–Cl bond, energy $\approx 242\,kJ\,mol^{-1}$)

Step 2 — Propagation (chain-carrying steps):

$$Cl\cdot + C_6H_{12} \rightarrow C_6H_{11}\cdot + HCl \quad \text{(H abstraction)}$$

$$C_6H_{11}\cdot + Cl_2 \rightarrow C_6H_{11}Cl + Cl\cdot \quad \text{(chain propagation)}$$

Step 3 — Termination (chain-ending steps): $2Cl\cdot \rightarrow Cl_2$; $Cl\cdot + C_6H_{11}\cdot \rightarrow C_6H_{11}Cl$; $2C_6H_{11}\cdot \rightarrow C_{12}H_{22}$

Step 4 — Nature of reaction: This is **free radical substitution** (SR), not electrophilic addition (as in alkenes) or nucleophilic substitution. One H is replaced by Cl. Cyclohexane gives only one monochlorinated product (chlorocyclohexane) since all 12 H atoms are equivalent.

Selectivity note: Cl· is less selective than Br· (Cl reacts faster, Br reacts more selectively). For more selective halogenation, NBS (N-bromosuccinimide) is used.

Final Answer: Free radical substitution; Cl· abstracts H, then cyclohexyl radical + $Cl_2 \Rightarrow \boxed{C}$

Answer: (C) Go Back to Q17

Q18.

Solution

Concept — Directing effects in EAS — methyl group: The methyl group ($-\mathrm{CH_3}$) is an *activating ortho/para director*. It donates electrons to the ring by hyperconjugation and a weak inductive effect, increasing electron density at ortho and para positions.

Step 1 — Nitration mechanism: Electrophile: $\mathrm{NO_2^+}$ (nitronium ion) formed from $\mathrm{HNO_3} + \mathrm{H_2SO_4}$. The $\mathrm{NO_2^+}$ ion attacks the positions of highest electron density — ortho and para to $-\mathrm{CH_3}$.

Step 2 — Product distribution: Toluene nitration (mixed acid, $25°\mathrm{C}$) gives approximately:

- o-nitrotoluene: $\sim 58\%$
- p-nitrotoluene: $\sim 37\%$
- m-nitrotoluene: $\sim 5\%$ (minor, from para attack on resonance contributor)

Step 3 — Why not only para? Steric effects slightly favour the para product in industrial settings (less hindrance), but both o and p are formed. In BITSAT questions, "predominantly o- and p-" is the correct description.

Final Answer: o- and p-nitrotoluene (ortho/para directors) $\Rightarrow \boxed{\text{C}}$

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

Q19.

Solution

Concept — E1 elimination and Zaitsev's rule: E1 (unimolecular elimination): Step 1: protonation of OH by acid forms oxonium ion; then OH_2 leaves to form a carbocation. Step 2: base (or solvent) removes a proton from a β-carbon adjacent to the carbocation.

Zaitsev's rule: The major alkene formed is the more substituted (more stable) one.

Step 1 — Structure of 2-methylbutan-2-ol:

$$(CH_3)_2C(OH) \underset{C3}{-} CH_2CH_3$$

Upon protonation and loss of water, a tertiary carbocation forms at C2: $(CH_3)_2\overset{+}{C} - CH_2CH_3$.

Step 2 — Possible alkene products:

- Remove H from C3 (one of CH_2): gives $CH_3C(CH_3) = CHCH_3$ (2-methylbut-2-ene, *trisubstituted*)
- Remove H from the CH_3 at C1: gives $CH_2 = C(CH_3)CH_2CH_3$ (2-methylbut-1-ene, *disubstituted*)

Step 3 — Apply Zaitsev: 2-methylbut-2-ene (trisubstituted, more stable) is the **major product**.

Energetic basis: More substituted alkenes have more hyperconjugative stabilisation (more C–H bonds flanking the double bond). Thermodynamic stability increases with degree of substitution.

Final Answer: 2-methylbut-2-ene (most substituted, Zaitsev product) $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Cannizzaro reaction (self-oxidation-reduction): Aldehydes without α-hydrogen atoms cannot undergo aldol condensation. Instead, in concentrated NaOH, they undergo a *disproportionation* where one molecule is oxidised to a carboxylate and another is reduced to an alcohol.

Step 1 — Why benzaldehyde undergoes Cannizzaro: C_6H_5CHO: the α-carbon to the CHO is the benzene ring (no H). No α-H $\Rightarrow$ no aldol possible.

Step 2 — Mechanism overview:

(a) OH^- attacks C=O of one benzaldehyde $\rightarrow$ alkoxide intermediate.
(b) This alkoxide acts as a hydride donor and transfers H^- to the carbonyl of the second benzaldehyde.
(c) One benzaldehyde becomes benzoate ($C_6H_5COO^-$, oxidised).
(d) The other becomes benzyl alkoxide $\rightarrow$ benzyl alcohol ($C_6H_5CH_2OH$, reduced).

Step 3 — Products:

$$2\,C_6H_5CHO + NaOH \rightarrow C_6H_5CH_2OH + C_6H_5COO^-Na^+$$

Acidification of the reaction mixture gives benzoic acid from the sodium benzoate.

Application: The Cannizzaro reaction of formaldehyde (HCHO, no α-H) gives methanol and formate — used in the Tollens-Cannizzaro synthesis.

Final Answer: Benzyl alcohol + sodium benzoate $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q20

Q21.

Solution

Concept — Tollens' reagent as a distinguishing test for aldehydes: Both aldehydes and ketones react with Brady's reagent (2,4-DNPH) to give orange/yellow precipitates (tests for C=O group in general). However, Tollens' reagent differentiates them:

Tollens' reagent mechanism: The complex $[Ag(NH_3)_2]^+$ (silver-ammine) oxidises aldehydes:

$$RCHO + 2[Ag(NH_3)_2]^+ + 2OH^- \rightarrow RCOO^- + 2Ag(s) + 4NH_3 + H_2O$$

The silver mirror deposited on the test tube is the positive result.

Why ketones don't react: Ketones lack the aldehydic H ($R_2C{=}O$ has no H directly on the carbonyl carbon). They cannot be further oxidised under mild conditions by Tollens' reagent.

Other distinguishing tests for aldehydes vs ketones:

- Fehling's solution (Cu^{2+}): red Cu_2O precipitate with aldehydes only
- Schiff's reagent (fuchsin + SO_2): pink/red colour with aldehydes
- Tollen's silver mirror test

Why not $NaHSO_3$? Sodium bisulfite forms adducts with both aldehydes and *methyl* ketones, so it does not cleanly distinguish all aldehydes from ketones.

Final Answer: Tollens' reagent distinguishes aldehyde from ketone $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept — Fischer esterification (acid-catalysed, reversible):

$$\mathrm{CH_3COOH + C_2H_5OH \overset{H^+,\,\Delta}{\rightleftharpoons} CH_3COOC_2H_5 + H_2O}$$

Step 1 — Mechanism (simplified):

(a) Protonation of the carbonyl oxygen of acetic acid (H^+ catalyst).
(b) Nucleophilic attack of ethanol oxygen on the activated carbonyl carbon.
(c) Tetrahedral intermediate formed.
(d) Proton transfers and elimination of water give ethyl acetate.
(e) H^+ is regenerated (catalyst, not consumed).

Step 2 — Reversibility and Le Chatelier: The reaction is an equilibrium. To drive it forward (increase yield), one can:

- Remove water (e.g., with molecular sieves, anhydrous $CaCl_2$, azeotropic distillation)
- Use excess of one reactant (usually the cheaper one)

Step 3 — Products: Ethyl acetate ($CH_3COOC_2H_5$) + **water**. Both form in equimolar amounts.

Common trap: Option C says H_2SO_4 is consumed — incorrect. H_2SO_4 is a catalyst that is regenerated. Option B says acetaldehyde forms — completely wrong (ethanol would need to be oxidised for that).

Final Answer: Ethyl acetate + water; reversible equilibrium $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

Q23.

Solution

Concept — Gabriel synthesis of primary amines: Gabriel synthesis is a classical method that ensures only *primary* amines are produced, without secondary or tertiary amine contamination.

Step 1 — The sequence:

(a) Phthalimide (p$K_a \approx 8.3$): the NH is acidic. Treated with KOH to give potassium phthalimide (K-salt of the conjugate base).

(b) Potassium phthalimide is N-alkylated with an alkyl halide RX via S_N2: $\text{K-phthalimide} + \text{RX} \rightarrow N\text{-alkylphthalimide} + \text{KX}$.

(c) Hydrolysis (with KOH/H_2O or better with hydrazine, N_2H_4): cleaves the two C–N bonds of the imide, releasing the primary amine RNH_2 and phthalic acid (or phthalyl hydrazide).

Step 2 — Why only primary amines? The nitrogen in phthalimide has only one N–H bond, which can only be alkylated once. After one alkylation, no further alkylation is possible, so a secondary amine cannot form.

Step 3 — Evaluate other options: Option C describes Hofmann rearrangement (not Gabriel). Option D describes nitro reduction followed by further alkylation (gives secondary/tertiary amines — not selective for primary).

Final Answer: Phthalimide $\xrightarrow{KOH}$ K-phthalimide $\xrightarrow{RX}$ N-alkylphthalimide $\xrightarrow{KOH/H_2O}$ $\text{RNH}_2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q23

Q24.

Solution

Concept — Glycosidic bonds in disaccharides: A glycosidic bond forms between the anomeric carbon (C1, the hemiacetal carbon) of one monosaccharide and a hydroxyl group of another monosaccharide, with loss of water. This is an acetal (or ketal) linkage.

Step 1 — Formation: The reaction: anomeric $-$OH of sugar 1 + any $-$OH of sugar 2 $\rightarrow$ glycosidic bond (C$-$O$-$C) + H_2O.

Step 2 — In maltose (example): In maltose, the C1 of one glucose (in α configuration) bonds to the C4-OH of the second glucose:

$$\alpha(1 \rightarrow 4) \text{ glycosidic bond}$$

This is still a reducing sugar because one anomeric carbon (C1 of the second glucose) remains free.

Step 3 — Distinguish from other bonds:

- Peptide bond (amide): between $-$COOH and $-NH_2$ in amino acids
- Ester bond: between $-$COOH and $-$OH (in fats/esters)
- Phosphodiester bond: in nucleic acids (DNA/RNA backbone)

The glycosidic bond is unique to carbohydrates.

Final Answer: Glycosidic bond (acetal linkage between anomeric C and $-$OH) $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B)

Go Back to Q24

Q25.

Solution

Concept — Fat-soluble vs water-soluble vitamins:

- **Fat-soluble**: A, D, E, K (stored in fatty tissues and liver; excess accumulates → toxicity possible)
- **Water-soluble**: B complex (B1, B2, B3, B5, B6, B7, B9, B12) and C (not stored; excreted in urine)

Vitamin A (retinol):

- Fat-soluble; stored in the liver
- Precursor: β-carotene (from carrots and other orange/yellow vegetables)
- Function: visual cycle (component of rhodopsin, the visual pigment in rod cells)
- Deficiency: night blindness (→ complete blindness if untreated)
- Excess: hypervitaminosis A (toxic)

Vitamins B complex and folic acid (option D) are water-soluble. Vitamin C (option B) is also water-soluble.

Final Answer: Vitamin A is fat-soluble $\Rightarrow \boxed{\text{C}}$

$\boxed{\textbf{Answer: (C)}}$ **Go Back to Q25**

Q26.

Solution

Concept — Addition polymerisation; polystyrene: Addition (chain-growth) polymerisation involves the opening of a double bond (>C=C<) without loss of any small molecule. Each monomer adds to the growing chain.

Step 1 — Monomer to polymer: Styrene: $C_6H_5CH = CH_2$ (vinyl benzene). Under radical/anionic/cationic initiation, the double bond opens:

$$n\, C_6H_5CH = CH_2 \xrightarrow{\text{initiator}} [-CH_2 - CH(C_6H_5)-]_n$$

Step 2 — Structure of polystyrene: The backbone is purely $-$C$-$C$-$ (all carbon). The phenyl groups ($-C_6H_5$) hang as side chains on alternate carbons. There is no by-product.

Step 3 — Distinguish from condensation polymers: Condensation polymers (e.g. nylon, polyester, Bakelite) lose small molecules (H_2O, HCl) at each polymerisation step. Addition polymers do not.

Applications of polystyrene: packaging, disposable cups, insulation (EPS = expanded polystyrene foam), CD cases. It is thermoplastic (can be remelted).

Final Answer: $[-CH_2 - CH(C_6H_5)-]_n$; addition polymer; no by-product $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q26

Q27.

Solution

Concept — Tyndall effect and particle size: When a beam of light passes through a colloid, the colloidal particles scatter the light in all directions. This scattering makes the beam visible (like a sunbeam through dust). This phenomenon is the **Tyndall effect**.

Step 1 — Why colloids show Tyndall effect: Colloidal particle size: $1\,\text{nm} - 1000\,\text{nm}$ (1 μm). This is comparable to the wavelength of visible light ($400 - 700\,\text{nm}$), so light scattering (Rayleigh scattering) occurs effectively.

Step 2 — Why true solutions do not: True solution particles (ions, small molecules): $< 1\,\text{nm}$. These are far smaller than the wavelength of visible light and do not scatter it. The solution appears transparent.

Step 3 — Practical applications:

- Identifying colloids from true solutions (e.g. starch in water is a colloid; sugar solution is not)
- Car headlight beams visible in fog (fog = aerosol colloid)
- “Blue sky” and ”red sunset”: Rayleigh scattering of sunlight by atmospheric particles

Final Answer: Colloidal particles ($1\text{-}1000\,\text{nm}$) scatter light; true solution particles ($< 1\,\text{nm}$) too small $\Rightarrow \boxed{\text{B}}$

$\boxed{\textbf{Answer: (B)}}$ **Go Back to Q27**

Q28.

Solution

Concept — Effective Atomic Number (EAN) rule: The EAN rule (Sidgwick) states that stable metal carbonyls achieve the electron count of the next noble gas. The EAN = atomic number of metal + 2 × number of CO ligands (each CO donates 2 electrons).

Step 1 — Electron count for $[\mathrm{Fe(CO)_5}]$:

- Atomic number of Fe: 26
- Electrons from 5 CO ligands: $5 \times 2 = 10$
- EAN $= 26 + 10 = \mathbf{36}$

Step 2 — Verify against noble gas: Element with atomic number 36: **Krypton (Kr)**. So $[\mathrm{Fe(CO)_5}]$ achieves a krypton configuration (18-electron complex if we count only valence electrons: Fe has 8, 5 CO contribute 10, total = 18).

Step 3 — Additional examples following EAN rule:

- $[\mathrm{Ni(CO)_4}]$: Ni (28) + $4 \times 2 = 36$ (Kr)
- $[\mathrm{Cr(CO)_6}]$: Cr (24) + $6 \times 2 = 36$ (Kr)
- $[\mathrm{Mn_2(CO)_{10}}]$: Mn-Mn bond contributes 1 e^- each; total per Mn $= 25{+}10{+}1 = 36$ (Kr)

Final Answer: EAN = 36 (krypton configuration) $\Rightarrow \boxed{\text{A}}$

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

Q29.

Solution

Concept — Molar conductivity from conductivity:

$$\Lambda_m = \frac{\kappa \times 1000}{c}$$

where κ is the conductivity in $\mathrm{S\,cm^{-1}}$ and c is the molar concentration in $\mathrm{mol\,L^{-1}}$. The factor of 1000 converts from L to cm^3 ($1\,\mathrm{L} = 1000\,\mathrm{cm^3}$).

Step 1 — Apply formula:

$$\Lambda_m = \frac{1.41 \times 10^{-3}\,\mathrm{S\,cm^{-1}} \times 1000}{0.01\,\mathrm{mol\,L^{-1}}} = \frac{1.41}{0.01} = \mathbf{141}\,\mathrm{S\,cm^2\,mol^{-1}}$$

Step 2 — Interpretation: The limiting molar conductivity of KCl (Λ_m°) is about $149\,\mathrm{S\,cm^2\,mol^{-1}}$. At $c = 0.01\,\mathrm{M}$, $\Lambda_m = 141$, giving degree of dissociation $\approx 141/149 \approx 0.95$ — consistent with KCl being a strong electrolyte.

Kohlrausch's square root law: $\Lambda_m = \Lambda_m^\circ - K\sqrt{c}$. Extrapolating Λ_m vs $\sqrt{c}$ to $c \to 0$ gives Λ_m°.

Final Answer: $\Lambda_m = 141\,\mathrm{S\,cm^2\,mol^{-1}} \Rightarrow \boxed{\mathrm{A}}$

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

Q30.

Solution

Concept — Zero-order reaction: half-life and concentration-time relationship: For a zero-order reaction: $[\mathrm{A}] = [\mathrm{A}]_0 - kt$. Half-life: $t_{1/2} = \frac{[\mathrm{A}]_0}{2k}$ (proportional to initial concentration, unlike first-order).

Step 1 — Calculate $t_{1/2}$:

$$t_{1/2} = \frac{[\mathrm{A}]_0}{2k} = \frac{0.1\,\mathrm{mol\,L^{-1}}}{2 \times 2.5 \times 10^{-3}\,\mathrm{mol\,L^{-1}\,s^{-1}}} = \frac{0.1}{5.0 \times 10^{-3}} = 20\,\mathrm{s}$$

Step 2 — Verify using $[\mathrm{A}] = [\mathrm{A}]_0 - kt$: At $t = 20\,\mathrm{s}$: $[\mathrm{A}] = 0.1 - (2.5 \times 10^{-3})(20) = 0.1 - 0.05 = 0.05\,\mathrm{mol\,L^{-1}}$ = half of 0.1 ✓

Step 3 — Key feature of zero-order: Unlike first-order (where $t_{1/2}$ is constant), in zero-order reactions each successive half-life is shorter because $t_{1/2} \propto [\mathrm{A}]_0$, and $[\mathrm{A}]_0$ decreases. Eventually the reaction stops when $[\mathrm{A}] = 0$.

Examples: Enzyme-catalysed reactions at substrate saturation, photochemical reactions (rate = constant, depends only on light intensity), some surface-catalysed reactions.

Final Answer: $t_{1/2} = 20\,\mathrm{s} \Rightarrow \boxed{\mathrm{D}}$

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

Answer Key

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