KEAM Chemistry

Sample Paper – 3

Duration: 36 Minutes **Maximum Marks: 120**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer), modelled on the Chemistry portion of **KEAM** entrance.
- Each correct answer carries **+4 marks**. There is **a penalty of** -1 **mark** for each incorrect answer. Unattempted questions carry no penalty.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 & 12 (NCERT / Kerala State Board) — Physical, Inorganic and Organic Chemistry.**
- Use of mobile phones, personal calculators, log tables, or any electronic gadgets is strictly prohibited inside the examination hall.

Questions

Q1. Consider the reaction:

$$2\,\mathrm{Al} + 3\,\mathrm{Cl_2} \longrightarrow 2\,\mathrm{AlCl_3}$$

If 4 moles of Al and 9 moles of $\mathrm{Cl_2}$ are mixed together, how many moles of $\mathrm{AlCl_3}$ are formed?

(A) 4 moles
(B) 6 moles
(C) 4 moles ($\mathrm{Cl_2}$ is in excess; Al is limiting)
(D) 3 moles

Q2. The threshold frequency for a metal is 6.0×10^{14} Hz. If light of frequency 8.0×10^{14} Hz is incident on the surface, the kinetic energy of the ejected electron is (use $h = 6.626 \times 10^{-34}$ J·s):

(A) 1.325×10^{-19} J
(B) 5.301×10^{-19} J
(C) 3.313×10^{-19} J
(D) 2.651×10^{-19} J

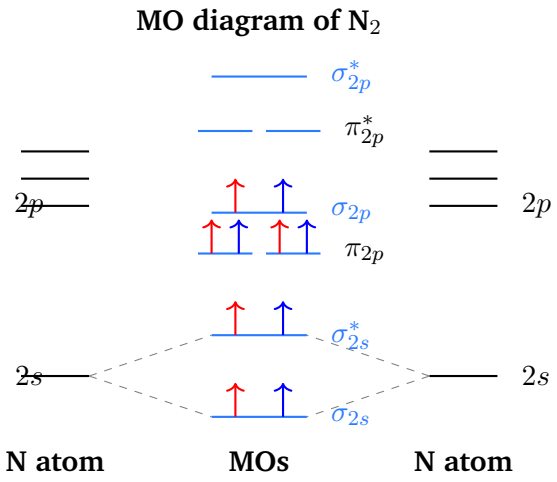
Q3. Using Molecular Orbital theory, the bond order of O_2 is calculated from its MO electron configuration. The correct bond order of O_2 is:

(A) 1
(B) 2
(C) 3
(D) 2.5

Q4. Which of the following is the correct increasing order of bond lengths for N_2, O_2, and F_2?

(A) $F_2 < O_2 < N_2$
(B) $N_2 < F_2 < O_2$
(C) $O_2 < N_2 < F_2$
(D) $N_2 < O_2 < F_2$

Q5. The Molecular Orbital (MO) energy level diagram for N_2 is shown below. Based on this diagram, what is the bond order of N_2?



What is the bond order of N_2 according to the MO diagram?

(A) 3

(B) 2
(C) 2.5
(D) 1

Q6. The critical temperature (T_c) of a gas is defined as the temperature above which it cannot be liquefied by pressure alone. Which of the following statements about T_c is **correct**?

(A) A gas below T_c cannot be liquefied at any pressure.
(B) Gases with weaker intermolecular forces have higher T_c values.
(C) T_c is the temperature above which a gas cannot be liquefied regardless of applied pressure.
(D) CO_2 has a lower T_c than O_2.

Q7. From the following Born-Haber cycle data for NaCl, calculate the lattice enthalpy (ΔH_L):

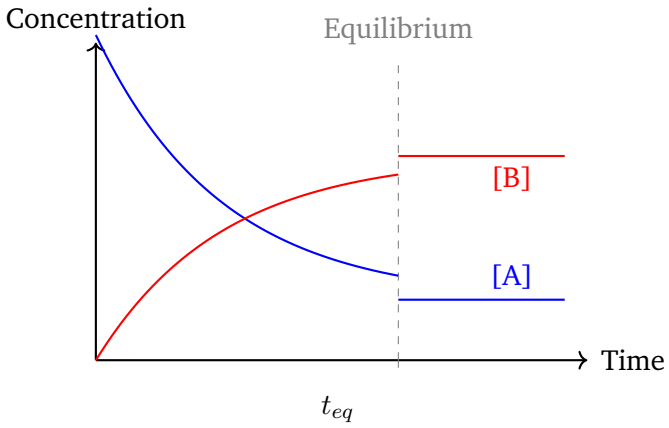
- $\Delta H_f^\circ(\mathrm{NaCl}) = -411$ kJ/mol
- Sublimation energy of Na: $+108$ kJ/mol
- Ionisation energy of Na: $+496$ kJ/mol
- Bond dissociation energy of Cl_2: $+244$ kJ/mol (half $= +122$ kJ/mol)
- Electron affinity of Cl: -349 kJ/mol

(A) -500 kJ/mol
(B) -788 kJ/mol
(C) -700 kJ/mol
(D) -850 kJ/mol

Q8. For which of the following reactions is the sign of ΔS **negative**?

(A) $\mathrm{N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)}$
(B) $\mathrm{CaCO_3(s) \rightarrow CaO(s) + CO_2(g)}$
(C) $\mathrm{H_2O(l) \rightarrow H_2O(g)}$
(D) $\mathrm{N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)}$ and $\mathrm{2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)}$

Q9. For the reversible reaction $\mathrm{A \rightleftharpoons B}$, the concentration-vs-time graph is shown below. Which statement correctly describes the equilibrium state?



(A) At equilibrium, the concentrations of A and B become constant, though not necessarily equal.
(B) At equilibrium, the reaction stops completely.
(C) At equilibrium, [A] = [B] always.
(D) The rate of forward reaction becomes zero at equilibrium.

Q10. AgCl is sparingly soluble in water with $K_{sp} = 1.8 \times 10^{-10}$. When NaCl is added to a saturated solution of AgCl, which of the following occurs due to the common ion effect?

(A) Solubility of AgCl increases.
(B) Solubility of AgCl decreases.
(C) K_{sp} of AgCl changes.
(D) NaCl and AgCl react to form a precipitate of NaAg.

Q11. In the electrolysis of $CuSO_4$ solution using copper electrodes, how many grams of copper are deposited at the cathode when a current of 2 A is passed for 965 seconds? (Atomic mass of Cu $= 63.5$, Faraday constant $= 96500$ C/mol)

(A) 0.635 g
(B) 1.27 g
(C) 0.635 g (exact)
(D) 2.54 g

Q12. Using Kohlrausch's law, the limiting molar conductivity of a weak elec-

trolyte (e.g., acetic acid, CH_3COOH) can be calculated as:

$$\Lambda_m^\infty(CH_3COOH) = \Lambda_m^\infty(HCl) + \Lambda_m^\infty(CH_3COONa) - \Lambda_m^\infty(NaCl)$$

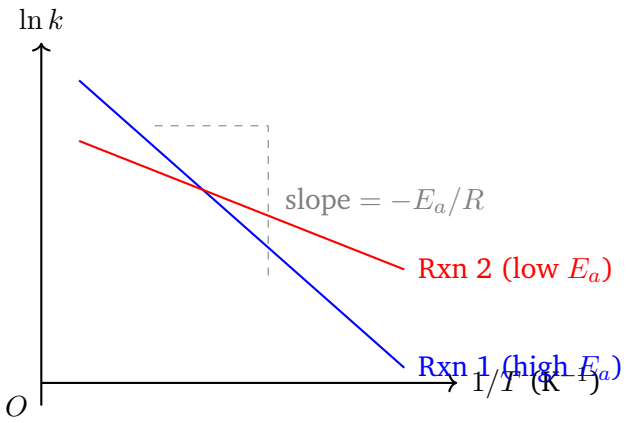
Given: $\Lambda_m^\infty(HCl) = 426$, $\Lambda_m^\infty(CH_3COONa) = 91$, $\Lambda_m^\infty(NaCl) = 126$ (all in S cm^2 mol^{-1}). What is Λ_m^∞ of CH_3COOH?

(A) 517 S cm^2 mol^{-1}
(B) 643 S cm^2 mol^{-1}
(C) 300 S cm^2 mol^{-1}
(D) 391 S cm^2 mol^{-1}

Q13. For a zero-order reaction, the relationship between concentration [A] and time t is:

(A) $[A] = [A]_0 - kt$ (linear decrease; the rate is constant and equal to k)
(B) $\ln[A] = \ln[A]_0 - kt$
(C) $\dfrac{1}{[A]} = \dfrac{1}{[A]_0} + kt$
(D) $[A] = [A]_0\, e^{-kt}$

Q14. The Arrhenius plot ($\ln k$ vs $1/T$) for two reactions is shown below. The slope of the plot equals $-E_a/R$.



Which of the following statements is **correct** about the Arrhenius plot?

(A) A steeper slope corresponds to a lower activation energy.
(B) A steeper (more negative) slope indicates a higher activation energy E_a.

(C) The y-intercept gives $-E_a/R$.
(D) $\ln k$ vs T gives a straight line.

Q15. According to Raoult's law, if the vapour pressure of pure solvent is 100 mmHg and a non-volatile solute is dissolved to give a solution with mole fraction of solvent $= 0.85$, what is the vapour pressure of the solution?

(A) 100 mmHg
(B) 80 mmHg
(C) 85 mmHg
(D) 90 mmHg

Q16. The freezing point of pure water is $0°$C. A solution is prepared by dissolving a non-electrolyte in water and the freezing point is observed to be $-0.372°$C. If K_f of water $= 1.86$ K·kg/mol, what is the molality of the solution?

(A) 0.200 mol/kg
(B) 0.372 mol/kg
(C) 0.186 mol/kg
(D) 0.100 mol/kg

Q17. Beryllium (Be) shows anomalous behaviour and resembles Aluminium (Al) more than Magnesium (Mg). Which of the following is **NOT** a reason for the diagonal relationship between Be and Al?

(A) Similar charge-to-radius (charge density) ratio
(B) Both form amphoteric oxides
(C) Both form covalent, polymeric chlorides
(D) Be has a much larger atomic radius than Al

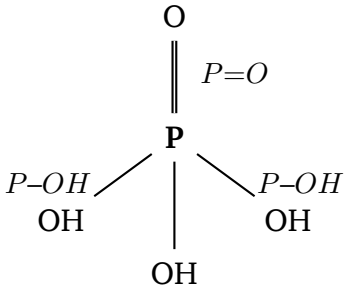
Q18. The thermal stability of Group 2 carbonates ($MgCO_3$, $CaCO_3$, $SrCO_3$, $BaCO_3$) increases down the group. The main reason for this trend is:

(A) Decrease in lattice enthalpy down the group
(B) Decrease in the polarising power of the cation down the group (larger cation distorts carbonate ion less)

(C) Increase in the size of the oxide ion down the group
(D) Increase in covalent character of M–O bond down the group

Q19. The structure of phosphoric acid (H_3PO_4) is drawn below. Identify the correct description of bonding in H_3PO_4.

(tetrahedral geometry around P)



(A) H_3PO_4 contains one P–H bond and three P–OH bonds.
(B) H_3PO_4 contains no P=O bond; all four bonds from P are P–OH bonds.
(C) H_3PO_4 contains one P=O bond and three P–OH bonds; it is triprotic with no P–H bond.
(D) H_3PO_4 is a diprotic acid with two P–OH bonds.

Q20. Chlorine trifluoride (ClF_3) is an interhalogen compound. Which of the following correctly describes its geometry and hybridisation?

(A) T-shaped geometry; sp^3d hybridisation; two lone pairs on Cl
(B) Trigonal planar; sp^2 hybridisation; no lone pairs
(C) Pyramidal; sp^3 hybridisation; one lone pair on Cl
(D) Linear; sp hybridisation; no lone pairs

Q21. Interstitial compounds of transition metals (e.g., tungsten carbide, WC) differ from ionic and covalent compounds. Which of the following is a **characteristic** of interstitial compounds?

(A) They are non-metallic and brittle.
(B) They have fixed stoichiometry and follow the valence rules.
(C) They are soft and have low melting points.
(D) They are hard, chemically inert, and have higher melting points than pure metals.

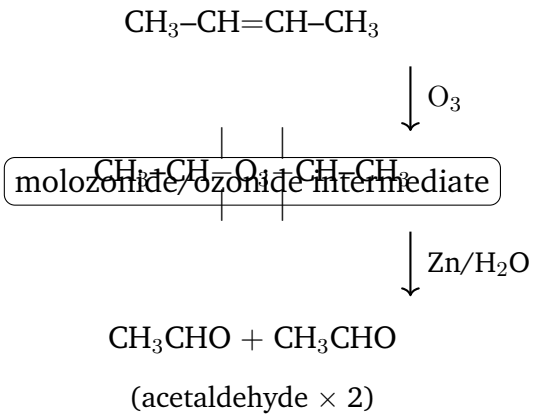
Q22. In the complex $[Fe(CN)_6]^{4-}$, CN^- is a strong-field ligand. The electronic configuration of Fe^{2+} is $[Ar]\,3d^6$. What is the crystal field stabilisation energy (CFSE) for this complex (in terms of Δ_o)?

(A) $-0.4\,\Delta_o$
(B) $-2.4\,\Delta_o$
(C) $-1.6\,\Delta_o$
(D) $-1.2\,\Delta_o$

Q23. In free radical halogenation of alkanes, which of the following correctly describes the relative selectivity of chlorine radical ($Cl^\bullet$) versus bromine radical ($Br^\bullet$)?

(A) $Br^\bullet$ is more selective but less reactive than $Cl^\bullet$; $Cl^\bullet$ is less selective but more reactive.
(B) $Cl^\bullet$ is more selective and more reactive than $Br^\bullet$.
(C) $Br^\bullet$ and $Cl^\bullet$ show the same selectivity.
(D) $Br^\bullet$ is more reactive and less selective than $Cl^\bullet$.

Q24. The ozonolysis of 2-butene and subsequent reductive workup (Zn/H_2O) is shown below:



What are the organic products of ozonolysis of 2-butene followed by reductive workup (Zn/H_2O)?

(A) Acetic acid and acetic acid
(B) Formaldehyde and acetaldehyde
(C) Acetaldehyde and acetaldehyde (ethanal)

(D) Acetone and acetaldehyde

Q25. A Grignard reagent (RMgX) reacts with CO_2 followed by acidic hydrolysis. The product obtained is:

(A) An alcohol
(B) An aldehyde
(C) A ketone
(D) A carboxylic acid

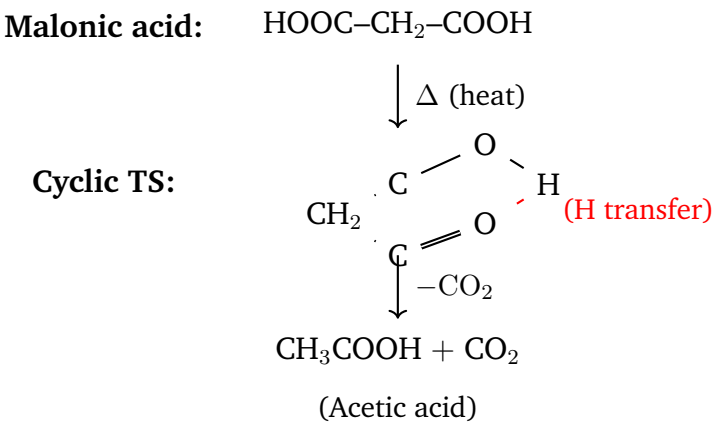
Q26. Dehydration of 2-methylbutan-2-ol with concentrated H_2SO_4 at 170°C gives predominantly which alkene, according to Zaitsev's rule?

(A) 2-methylbut-1-ene
(B) 2-methylbut-2-ene (more substituted, more stable alkene)
(C) 3-methylbut-1-ene
(D) But-1-ene

Q27. The self-condensation (aldol condensation) of acetaldehyde (CH_3CHO) in dilute NaOH gives which product?

(A) 3-Hydroxybutanal (acetaldol): $CH_3CH(OH)CH_2CHO$
(B) Crotonaldehyde only (direct dehydration product)
(C) Butanal
(D) Acetic acid

Q28. Malonic acid (HOOC–CH_2–COOH) undergoes decarboxylation on heating to give acetic acid via a 6-membered cyclic transition state. The mechanism is illustrated below:



What is the product when malonic acid is heated strongly?

(A) Formic acid
(B) Oxalic acid
(C) Acetic acid (and CO_2)
(D) Propionic acid

Q29. In the Sandmeyer reaction, an aryl diazonium salt is treated with CuCl to give:

(A) Phenol
(B) Chlorobenzene
(C) Aniline
(D) Fluorobenzene

Q30. Which of the following statements correctly distinguishes DNA from RNA?

(A) DNA contains ribose sugar; RNA contains deoxyribose sugar.
(B) DNA contains uracil; RNA contains thymine.
(C) Both DNA and RNA are single-stranded.
(D) DNA contains deoxyribose sugar and thymine; RNA contains ribose sugar and uracil; DNA is usually double-stranded while RNA is usually single-stranded.

Solutions

Sol. 1.

Solution

Concept — Limiting Reagent: The limiting reagent is the reactant that is completely consumed first, determining the maximum amount of product formed.

Step 1 — Stoichiometry: Reaction: $2\,Al + 3\,Cl_2 \rightarrow 2\,AlCl_3$. To react 4 mol Al, we need $4 \times \frac{3}{2} = 6$ mol Cl_2. We have 9 mol Cl_2, so Al is the limiting reagent.

Step 2 — Product moles: 4 mol Al produces $4 \times \frac{2}{2} = 4$ mol $AlCl_3$.

Why other options are wrong:

- Option A: Same numerical value but doesn't note limiting reagent correctly.
- Option B: 6 mol would require 6 mol Al (not available).
- Option D: 3 mol is incorrect; 4 mol Al gives 4 mol $AlCl_3$.

Final Answer: 4 mol of $AlCl_3$ formed (Al is limiting) $\Rightarrow$ $\boxed{C}$

Answer: (C) Go Back to Q 1

Sol. 2.

Solution

Concept — Photoelectric Effect: $KE = h(\nu - \nu_0)$, where ν_0 is the threshold frequency.

Step 1 — Calculation:

$$KE = 6.626\times10^{-34}\times(8.0\times10^{14}-6.0\times10^{14}) = 6.626\times10^{-34}\times2.0\times10^{14} = 1.325\times10^{-19}\ \text{J}$$

Why other options are wrong:

- Option B: Uses total frequency instead of excess.
- Option C: Uses ν_0 alone ($h\nu_0$).
- Option D: Arithmetic error.

Final Answer: $KE = 1.325 \times 10^{-19}$ J $\Rightarrow$ $\boxed{A}$

Answer: (A) Go Back to Q 2

Sol. 3.

Solution

Concept — MO Theory Bond Order: Bond order $= \frac{N_b - N_a}{2}$, where N_b = bonding electrons, N_a = antibonding electrons.

Step 1 — MO configuration of O_2: $(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi^*_{2p})^2$

$N_b = 2 + 2 + 4 + 2 = 10$ (ignoring core), $N_a = 2 + 2 + 2 = 6$. Bond order $= (10 - 6)/2 = 2$.

Why other options are wrong:

- Option A: Bond order 1 is for F_2 analogy incorrectly applied.
- Option C: Bond order 3 belongs to N_2.
- Option D: 2.5 is for O_2^+ (one fewer antibonding electron).

Final Answer: Bond order of $O_2 = 2 \Rightarrow$ B

Answer: (B) Go Back to Q 3

Sol. 4.

Solution

Concept — Bond Length vs Bond Order: Higher bond order $\Rightarrow$ shorter bond length. N_2 (triple bond, BO=3), O_2 (double bond, BO=2), F_2 (single bond, BO=1).

Step 1 — Bond lengths: N_2: 110 pm; O_2: 121 pm; F_2: 143 pm. Increasing order: $N_2 < O_2 < F_2$.

Why other options are wrong:

- Option A: Puts F_2 first (shortest), incorrect.
- Option B: Places F_2 between O_2 and N_2, incorrect.
- Option C: Puts O_2 first, incorrect.

Final Answer: $N_2 < O_2 < F_2 \Rightarrow$ D

Answer: (D) Go Back to Q 4

Sol. 5.

Solution

Concept — MO Bond Order for N_2: From the MO diagram, N_2 has 10 bonding electrons and 4 antibonding electrons (considering $n = 2$ shell only: $\sigma_{2s}^2, \sigma_{2s}^{*\,2}, \pi_{2p}^4, \sigma_{2p}^2$; antibonding: $\sigma_{2s}^{*\,2}$).

Step 1 — Count electrons: N_2 has 14 electrons total. MO filling: $(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2p})^4(\sigma_{2p})^2$. Bond order $= (8-2)/2 = 3$.

Why other options are wrong:

- Option B: Bond order 2 belongs to O_2.
- Option C: 2.5 is for N_2^+.
- Option D: Bond order 1 is too low.

Final Answer: Bond order of $N_2 = 3 \Rightarrow$ A

Answer: (A) Go Back to Q 5

Sol. 6.

Solution

Concept — Critical Temperature: T_c is the highest temperature at which a substance can exist as a liquid. Above T_c, no amount of pressure can liquefy the gas.

Step 1 — Analysis: This is the definition of T_c. Gases with stronger intermolecular forces have higher T_c (e.g., CO_2: 304 K; O_2: 154 K). Thus CO_2 has a higher T_c than O_2.

Why other options are wrong:

- Option A: Below T_c, gas CAN be liquefied by pressure.
- Option B: Weaker forces give LOWER T_c (opposite).
- Option D: CO_2 has a higher T_c than O_2, not lower.

Final Answer: T_c is the temperature above which liquefaction is impossible by pressure $\Rightarrow$ C

Answer: (C) Go Back to Q 6

Sol. 7.

Solution

Concept — Born-Haber Cycle (Hess's Law):

$$\Delta H_f = \Delta H_{sub} + IE + \tfrac{1}{2}D_{Cl_2} + EA + \Delta H_L$$

Step 1 — Substitute values:

$$-411 = 108 + 496 + 122 + (-349) + \Delta H_L$$

$$-411 = 377 + \Delta H_L \implies \Delta H_L = -411 - 377 = -788 \text{ kJ/mol}$$

Why other options are wrong:

- Option A: -500 kJ/mol ignores some terms.
- Option C: -700 kJ/mol is an arithmetic underestimate.
- Option D: -850 kJ/mol overestimates.

Final Answer: $\Delta H_L = -788$ kJ/mol $\Rightarrow$ B

Answer: (B) Go Back to Q 7

Sol. 8.

Solution

Concept — Sign of ΔS: $\Delta S < 0$ when the total number of moles of gas decreases or disorder decreases.

Step 1 — Analyse each reaction: Reaction (A/D): $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$: 4 mol gas $\rightarrow$ 2 mol gas; $\Delta n_{gas} = -2$, so $\Delta S < 0$. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$: 3 mol $\rightarrow$ 2 mol; $\Delta S < 0$. Both are negative.

Why other options are wrong:

- Option B: $CaCO_3$ decomposition produces CO_2(g) from solid; $\Delta S > 0$.
- Option C: Liquid to gas increases entropy; $\Delta S > 0$.

Final Answer: Both $N_2 + 3H_2 \rightarrow 2NH_3$ and $2SO_2 + O_2 \rightarrow 2SO_3$ have $\Delta S < 0 \Rightarrow$ D

Answer: (D) Go Back to Q 8

Sol. 9.

Solution

Concept — Chemical Equilibrium: At equilibrium, the forward and reverse rates are equal, so concentrations become constant. The equilibrium concentrations of A and B need not be equal.

Step 1 — Graph interpretation: As seen in the concentration-vs-time graph, [A] decreases and [B] increases until both reach constant plateau values at time t_{eq}. The final values $[\mathrm{A}]_{eq} \neq [\mathrm{B}]_{eq}$ in general.

Why other options are wrong:

- Option B: The reaction does not stop; microscopic forward and reverse reactions continue at equal rates.
- Option C: [A] = [B] only if $K_c = 1$ (special case).
- Option D: The forward rate equals the reverse rate, but neither is zero.

Final Answer: Concentrations become constant (not necessarily equal) $\Rightarrow \boxed{\mathrm{A}}$

Answer: (A) Go Back to Q 9

Sol. 10.

Solution

Concept — Common Ion Effect: Adding a common ion (Cl^- from NaCl) to a sparingly soluble salt (AgCl) shifts the dissolution equilibrium to the left, decreasing solubility.

Step 1 — Equilibrium: $\mathrm{AgCl(s)} \rightleftharpoons \mathrm{Ag^+(aq)} + \mathrm{Cl^-(aq)}$. Adding NaCl increases $[\mathrm{Cl^-}]$; the equilibrium shifts left, decreasing $[\mathrm{Ag^+}]$ and hence solubility of AgCl.

Why other options are wrong:

- Option A: Solubility decreases, not increases.
- Option C: K_{sp} is a constant at fixed temperature; adding NaCl does not change it.
- Option D: No such compound NaAg forms.

Final Answer: Solubility of AgCl decreases $\Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q 10

Sol. 11.

Solution

Concept — Faraday's First Law: Mass deposited $= \dfrac{M\,I\,t}{n\,F}$, where M = molar mass, n = electrons per ion, F = Faraday constant.

Step 1 — Calculation: $Cu^{2+} + 2e^- \rightarrow Cu$; $n = 2$.

$$m = \frac{63.5 \times 2 \times 965}{2 \times 96500} = \frac{63.5 \times 1930}{193000} = \frac{122555}{193000} \approx 0.635 \text{ g}$$

Why other options are wrong:

- Option B: 1.27 g corresponds to 4 A or 1930 s.
- Option D: 2.54 g corresponds to 4 times the current or time.

Final Answer: 0.635 g of Cu deposited $\Rightarrow$ C

Answer: (C) Go Back to Q 11

Sol. 12.

Solution

Concept — Kohlrausch's Law: The limiting molar conductivity of a weak electrolyte that cannot be measured directly can be computed from strong electrolytes sharing the same ions.

Step 1 — Apply the formula:

$$\Lambda_m^\infty(CH_3COOH) = 426 + 91 - 126 = 391 \text{ S cm}^2 \text{ mol}^{-1}$$

Why other options are wrong:

- Option A: 517 = 426 + 91 (forgets to subtract NaCl).
- Option B: 643 is a simple addition error.
- Option C: 300 has no basis in the given data.

Final Answer: $\Lambda_m^\infty(CH_3COOH) = 391 \text{ S cm}^2 \text{ mol}^{-1} \Rightarrow$ D

Answer: (D) Go Back to Q 12

Sol. 13.

Solution

Concept — Zero-Order Kinetics: For a zero-order reaction, rate $= k$ (independent of concentration). Integrating: $[\mathrm{A}] = [\mathrm{A}]_0 - kt$.

Step 1 — Integrated Rate Law: The concentration decreases linearly with time. The graph of [A] vs t is a straight line with slope $-k$ and y-intercept $[\mathrm{A}]_0$.

Why other options are wrong:

- Option B: $\ln[\mathrm{A}]$ vs t is the first-order integrated rate law.
- Option C: $1/[\mathrm{A}]$ vs t is the second-order integrated rate law.
- Option D: Exponential decay describes first-order reactions.

Final Answer: $[\mathrm{A}] = [\mathrm{A}]_0 - kt$ (zero-order) $\Rightarrow \boxed{\mathrm{A}}$

Answer: (A) Go Back to Q 13

Sol. 14.

Solution

Concept — Arrhenius Equation: $\ln k = \ln A - \dfrac{E_a}{R} \cdot \dfrac{1}{T}$. The plot of $\ln k$ vs $1/T$ is a straight line with slope $= -E_a/R$.

Step 1 — Interpretation: A steeper (more negative) slope means a larger value of E_a/R, i.e., higher activation energy. In the diagram, Reaction 1 (steeper slope) has the higher E_a.

Why other options are wrong:

- Option A: Steeper slope $\Rightarrow$ higher E_a, not lower.
- Option C: The y-intercept gives $\ln A$ (pre-exponential factor), not $-E_a/R$.
- Option D: $\ln k$ vs T is not linear; linearity requires $1/T$ on the x-axis.

Final Answer: Steeper slope $\Rightarrow$ higher $E_a \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q 14

Sol. 15.

Solution

Concept — Raoult's Law: $P_{solution} = x_{solvent} \times P^{\circ}_{solvent}$.

Step 1 — Calculation:

$$P = 0.85 \times 100 = 85 \text{ mmHg}$$

Why other options are wrong:

- Option A: 100 mmHg is the vapour pressure of pure solvent, not the solution.
- Option B: 80 mmHg corresponds to $x_{solvent} = 0.80$.
- Option D: 90 mmHg corresponds to $x_{solvent} = 0.90$.

Final Answer: $P = 85$ mmHg $\Rightarrow$ C

Answer: (C) Go Back to Q 15

Sol. 16.

Solution

Concept — Depression of Freezing Point: $\Delta T_f = K_f \times m$, where m = molality.

Step 1 — Calculation:

$$m = \frac{\Delta T_f}{K_f} = \frac{0.372}{1.86} = 0.200 \text{ mol/kg}$$

Why other options are wrong:

- Option B: 0.372 mol/kg uses $K_f = 1$ (incorrect).
- Option C: 0.186 mol/kg uses $K_f = 2$ (incorrect).
- Option D: 0.100 mol/kg gives $\Delta T_f = 0.186$ (not 0.372).

Final Answer: Molality $= 0.200$ mol/kg $\Rightarrow$ A

Answer: (A) Go Back to Q 16

Sol. 17.

Solution

Concept — Diagonal Relationship (Be and Al): Be resembles Al due to similar charge density, amphoteric nature of oxides, and covalent chlorides. Be is actually smaller than Al (Be: 112 pm, Al: 143 pm).

Step 1 — Identify the incorrect statement: Option D states Be has a "much larger atomic radius than Al." This is false — Be is smaller than Al.

Why other options are correct reasons:

- Option A: Similar charge density (Z/r^2) – true, as smaller Be^{2+} and larger Al^{3+} end up comparable.
- Option B: Both BeO and Al_2O_3 are amphoteric – true.
- Option C: $BeCl_2$ and $AlCl_3$ are both covalent and polymeric – true.

Final Answer: Option D (Be has larger radius than Al) is NOT a reason $\Rightarrow$ $\boxed{D}$

Answer: (D) Go Back to Q 17

Sol. 18.

Solution

Concept — Thermal Stability of Group 2 Carbonates: Down the group, cation size increases and its polarising power decreases, so the carbonate ion is less distorted and harder to decompose.

Step 1 — Reasoning: $MgCO_3$ (small Mg^{2+}, high polarising power) decomposes at lower temperature. $BaCO_3$ (large Ba^{2+}, low polarising power) decomposes at higher temperature. The determining factor is the ability of the cation to polarise/distort the CO_3^{2-} ion.

Why other options are wrong:

- Option A: Lattice enthalpy decreasing would lower stability, not increase it.
- Option C: Oxide ion size is not the key factor.
- Option D: Bonding in these compounds is ionic, not covalent.

Final Answer: Decreasing polarising power of cation down the group $\Rightarrow$ $\boxed{B}$

Answer: (B) Go Back to Q 18

Sol. 19.

Solution

Concept — Structure of H_3PO_4: Phosphoric acid is triprotic. The P atom is tetrahedral with one P=O bond and three P–OH bonds. There is no P–H bond (unlike phosphorous acid H_3PO_3).

Step 1 — Bond count: P: sp^3 hybridisation. Four bonds: one $\mathrm{P=O}$ (double bond to non-ionisable O) and three $\mathrm{P-OH}$ (ionisable, giving three acidic protons). No P–H bonds are present.

Why other options are wrong:

- Option A: Describes H_3PO_3 (phosphorous acid), which has one P–H bond.
- Option B: H_3PO_4 does have a P=O bond.
- Option D: H_3PO_4 is triprotic, not diprotic.

Final Answer: One P=O and three P–OH; triprotic, no P–H $\Rightarrow$ C

Answer: (C) Go Back to Q 19

Sol. 20.

Solution

Concept — Hybridisation and Geometry of ClF_3: Cl in ClF_3 has 7 valence electrons; three are used in bonding with F, leaving two lone pairs. Total electron pairs = 5, giving sp^3d hybridisation.

Step 1 — VSEPR: 5 electron pairs (3 bonding + 2 lone pairs) around Cl $\Rightarrow$ trigonal bipyramidal electron geometry, but T-shaped molecular geometry (lone pairs occupy equatorial positions).

Why other options are wrong:

- Option B: Trigonal planar requires 3 bond pairs, 0 lone pairs (sp^2), not correct here.
- Option C: sp^3 gives tetrahedral/pyramidal (4 pairs); Cl has 5 pairs.
- Option D: Linear (sp) requires only 2 bond pairs.

Final Answer: T-shaped, sp^3d, two lone pairs $\Rightarrow$ A

Answer: (A) Go Back to Q 20

Sol. 21.

Solution

Concept — Interstitial Compounds: Small atoms (H, C, N) fit into interstitial voids of transition metal lattices, forming non-stoichiometric compounds with enhanced hardness, high melting points, and chemical inertness.

Step 1 — Properties: WC (tungsten carbide) is used in cutting tools due to extreme hardness, high melting point, and resistance to chemical attack. Metallic conductivity is retained.

Why other options are wrong:

- Option A: They are metallic (not non-metallic) and hard (not brittle in the classical sense).
- Option B: They are non-stoichiometric and do not follow simple valence rules.
- Option C: They have higher (not lower) melting points than pure metals.

Final Answer: Hard, chemically inert, high melting point $\Rightarrow$ D

Answer: (D) Go Back to Q 21

Sol. 22.

Solution

Concept — Crystal Field Stabilisation Energy (CFSE): For a d^6 complex with strong-field ligands (low spin), all 6 electrons occupy the t_{2g} level. CFSE $= 6 \times (-0.4\Delta_o) = -2.4\Delta_o$.

Step 1 — Electron distribution: Fe^{2+} is d^6. CN^- is a strong field ligand $\Rightarrow$ low spin: $t_{2g}^6\, e_g^0$.

$$\text{CFSE} = 6 \times (-0.4\Delta_o) + 0 \times (0.6\Delta_o) = -2.4\Delta_o$$

Why other options are wrong:

- Option A: $-0.4\Delta_o$ is CFSE for a single d^1 electron.
- Option C: $-1.6\Delta_o$ is for d^4 low spin (t_{2g}^4).
- Option D: $-1.2\Delta_o$ is for d^3 (t_{2g}^3).

Final Answer: CFSE $= -2.4\Delta_o \Rightarrow$ B

Answer: (B) Go Back to Q 22

Sol. 23.

Solution

Concept — Radical Halogenation Selectivity: Reactivity order: $F_2 > Cl_2 > Br_2 > I_2$. More reactive radicals are less selective (Hammond's postulate: exothermic H-abstraction has early TS with little C–H bond character).

Step 1 — Reactivity vs Selectivity: $Cl^\bullet$ is highly reactive (exothermic H-abstraction) and attacks primary, secondary, and tertiary C–H bonds with lower selectivity. $Br^\bullet$ is less reactive (endothermic H-abstraction) and strongly prefers more stable carbon radicals (tertiary $\gg$ secondary $\gg$ primary).

Why other options are wrong:

- Option B: $Cl^\bullet$ is more reactive but less selective, not more selective.
- Option C: They show very different selectivities.
- Option D: $Br^\bullet$ is less reactive and more selective (opposite of Option D).

Final Answer: $Br^\bullet$ is more selective; $Cl^\bullet$ is more reactive $\Rightarrow$ $\boxed{A}$

Answer: (A) Go Back to Q 23

Sol. 24.

Solution

Concept — Ozonolysis: Ozonolysis (O_3, then reductive workup with Zn/H_2O) cleaves the C=C double bond. Each carbon of the double bond becomes a carbonyl (CHO for internal alkene carbons bearing one H).

Step 1 — Product identification: 2-Butene: $CH_3 - CH = CH - CH_3$. The double bond is between C2 and C3. Both carbons bear one H and one CH_3. After cleavage:

$$CH_3CH = CHCH_3 \xrightarrow{O_3,\ Zn/H_2O} 2 \times CH_3CHO \quad \text{(acetaldehyde)}$$

Why other options are wrong:

- Option A: Acetic acid would require oxidative workup (H_2O_2).
- Option B: Formaldehyde would form from ethene; acetaldehyde from 1-butene C1.
- Option D: Acetone forms from internal alkene carbons without H (e.g., 2-methylbut-2-ene).

Final Answer: Two equivalents of acetaldehyde (CH_3CHO) $\Rightarrow$ C

Answer: (C) Go Back to Q 24

Sol. 25.

Solution

Concept — Grignard Reagent with CO_2: RMgX reacts with CO_2 as a nucleophile (R^-) attacking the electrophilic carbon of CO_2, then acidic hydrolysis gives RCOOH.

Step 1 — Mechanism outline:

$$\mathrm{RMgX} + \mathrm{CO_2} \rightarrow \mathrm{RCOOMgX} \xrightarrow{\mathrm{H_3O^+}} \mathrm{RCOOH}$$

The product is a carboxylic acid with one more carbon than the original halide.

Why other options are wrong:

- Option A: Reaction with formaldehyde gives a primary alcohol; CO_2 gives acid.
- Option B: Reaction with CO gives an aldehyde (less common).
- Option C: Reaction with a ketone (or acid chloride) gives ketone/tertiary alcohol.

Final Answer: Grignard + CO_2 $\rightarrow$ carboxylic acid $\Rightarrow$ D

Answer: (D) Go Back to Q 25

Sol. 26.

Solution

Concept — Zaitsev's Rule: Dehydration of alcohols gives predominantly the most substituted (most stable) alkene.

Step 1 — Structure: 2-Methylbutan-2-ol: $(CH_3)_2C(OH)CH_2CH_3$. Dehydration can give:

- 2-methylbut-2-ene: $(CH_3)_2C = CHCH_3$ (trisubstituted, more stable)
- 2-methylbut-1-ene: $CH_2 = C(CH_3)CH_2CH_3$ (disubstituted, less stable)

Zaitsev product = more substituted alkene = 2-methylbut-2-ene.

Why other options are wrong:

- Option A: 2-methylbut-1-ene is less substituted (Hofmann product, minor).
- Option C: 3-methylbut-1-ene would require rearrangement to a different skeleton.
- Option D: But-1-ene requires loss of the methyl branch, not formed here.

Final Answer: 2-methylbut-2-ene (Zaitsev, trisubstituted) $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 26

Sol. 27.

Solution

Concept — Aldol Condensation: In dilute NaOH, one molecule of acetaldehyde acts as the nucleophile (α-carbon) and another acts as the electrophile (carbonyl). The product is an β-hydroxy aldehyde (aldol product).

Step 1 — Reaction:

$$2\,CH_3CHO \xrightarrow{\text{dil. NaOH}} CH_3CH(OH)CH_2CHO$$

Product: 3-Hydroxybutanal (acetaldol). Under stronger conditions (or heat), further dehydration gives crotonaldehyde (but the question asks for the aldol product).

Why other options are wrong:

- Option B: Crotonaldehyde is the dehydration product (aldol condensation product in a strict sense), but 3-hydroxybutanal is the direct aldol addition product first formed.
- Option C: Butanal is not formed by aldol condensation.
- Option D: Acetic acid requires oxidation, not base-catalysed condensation.

Final Answer: 3-Hydroxybutanal: $CH_3CH(OH)CH_2CHO$ $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 27

Sol. 28.

Solution

Concept — Decarboxylation of β-keto / malonic acids: Malonic acid has two adjacent COOH groups. On heating, one CO_2 is lost via a 6-membered cyclic transition state involving intramolecular hydrogen transfer to give acetic acid.

Step 1 — Mechanism:

$$HOOCCH_2COOH \xrightarrow{\Delta} CH_3COOH + CO_2$$

The cyclic 6-membered TS involves: carbonyl O$\cdots$H–O–C(=O)–CH_2 ring closure where the proton migrates from OH of one COOH to the carbonyl O of the other, simultaneously with C–C bond breaking.

Why other options are wrong:

- Option A: Formic acid (HCOOH) would require breaking the CH_2 group; not the case here.
- Option B: Oxalic acid is the starting material for a different decarboxylation.
- Option D: Propionic acid has three carbons (CH_3CH_2COOH); malonic acid loses one C as CO_2, giving the two-carbon acetic acid.

Final Answer: Acetic acid (and CO_2) $\Rightarrow$ C

Answer: (C) Go Back to Q 28

Sol. 29.

Solution

Concept — Sandmeyer Reaction: Treatment of an aryl diazonium salt ($ArN_2^+ X^-$) with CuCl replaces the diazonium group ($-N_2^+$) with Cl, giving the aryl chloride.

Step 1 — Reaction:

$$C_6H_5N_2^+ Cl^- \xrightarrow{CuCl} C_6H_5Cl + N_2$$

Why other options are wrong:

- Option A: Phenol is obtained by warming diazonium salt with water (H_2O), not CuCl.
- Option C: Aniline is the starting material before diazotisation.

- Option D: Fluorobenzene is obtained via Balz-Schiemann reaction (with HBF_4), not CuCl.

Final Answer: Chlorobenzene $\Rightarrow$ B

Answer: (B) Go Back to Q 29

Sol. 30.

Solution

Concept — DNA vs RNA: The two nucleic acids differ in sugar (deoxyribose vs ribose), one base (thymine in DNA replaced by uracil in RNA), and strand structure (DNA is double-stranded; RNA is usually single-stranded).

Step 1 — Key differences:

- DNA: deoxyribose sugar, bases A/T/G/C, double-stranded helix.
- RNA: ribose sugar (has 2'-OH), bases A/U/G/C (uracil replaces thymine), usually single-stranded.

Why other options are wrong:

- Option A: Reverses the sugars (DNA has deoxyribose, RNA has ribose).
- Option B: Reverses the bases (DNA has thymine, RNA has uracil).
- Option C: DNA is double-stranded (not single-stranded).

Final Answer: DNA: deoxyribose + thymine, double-stranded; RNA: ribose + uracil, single-stranded $\Rightarrow$ D

Answer: (D) Go Back to Q 30

Answer Key

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