JEE Main Chemistry

Sample Paper – 11

Duration: 60 Minutes **Maximum Marks: 100**

Instructions

- This paper contains **30 questions** modelled on the Chemistry portion of **JEE Main** entrance examination.
- **Section A** (Q1–Q20): 20 Single Correct Multiple Choice Questions. **+4 marks** for correct answer; **−1 mark** for wrong answer; **0** for unattempted.
- **Section B** (Q21–Q30): 10 Numerical Value Questions. Attempt **any 5**. **+4 marks** for correct answer; **0 marks** for incorrect or unattempted.
- Syllabus: Class 11 & 12 NCERT Chemistry (JEE Main official syllabus).
- Personal calculators, log tables, and electronic gadgets are strictly prohibited. A simple on-screen virtual calculator is provided in the CBT interface.
- Rough sheets will be provided at the examination centre. Write your roll number on every sheet.

Section A — Single Correct
MCQ (Q1–Q20) [+4 / −1]

Q1. For a **3p** orbital ($n = 3$, $l = 1$), how many radial nodes, angular nodes, and total nodes does it possess?

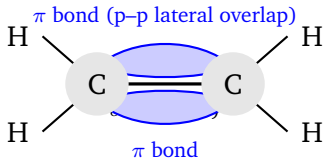
(A) 1 radial node, 1 angular node, 2 total nodes

(B) 2 radial nodes, 1 angular node, 3 total nodes

(C) 0 radial nodes, 1 angular node, 1 total node

(D) 1 radial node, 0 angular nodes, 1 total node

Q2. Ethylene (C_2H_4) contains a carbon–carbon double bond. The diagram below shows the orbital overlap in ethylene.



Which statement **correctly** describes the bonding in C_2H_4?

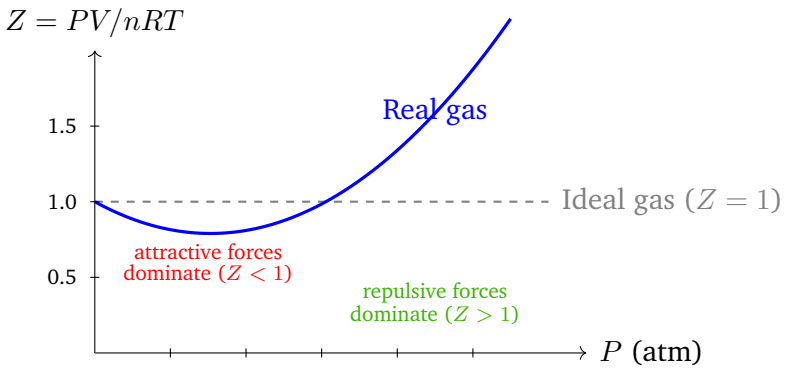
(A) Each C is sp^3 hybridised; the C=C bond consists of two σ bonds.

(B) Each C is sp hybridised; the π bond results from head-on overlap of p orbitals.

(C) Each C is sp^2 hybridised; the π bond results from lateral (sideways) overlap of unhybridised p orbitals perpendicular to the molecular plane.

(D) Each C is sp^2 hybridised; the π bond is formed by end-on overlap of two sp^2 orbitals.

Q3. The graph below shows the compressibility factor Z ($= PV/nRT$) as a function of pressure P for a real gas at constant temperature.



Which statement **correctly** identifies the region where intermolecular attractive forces dominate?

(A) The region where $Z > 1$ (above the ideal gas line).

(B) The region where $Z = 1$ (along the ideal gas line).

(C) The region at very high pressure where Z rises steeply.

(D) The region where $Z < 1$ (below the ideal gas line).

Q4. The standard enthalpy of neutralization of a strong acid with a strong base is $-57.1\,\text{kJ/mol}$. The neutralization of acetic acid (CH_3COOH, a weak acid) with NaOH involves an additional step — the ionization of acetic acid — which is endothermic ($\Delta H_{\text{ionization}} = +2.1\,\text{kJ/mol}$). What is the enthalpy of neutralization of acetic acid with NaOH?

(A) $-57.1\,\text{kJ/mol}$

(B) $-55.0\,\text{kJ/mol}$

(C) $-59.2\,\text{kJ/mol}$

(D) $+2.1\,\text{kJ/mol}$

Q5. Consider the equilibrium:

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$$

If the volume of the container is **decreased** at constant temperature, which of the following correctly describes the effect on the equilibrium?

(A) Equilibrium shifts to the left because pressure increase always disfavours the reaction.

(B) No shift occurs because the temperature is unchanged.

(C) Equilibrium shifts to the right, increasing the yield of SO_3.

(D) Equilibrium shifts to the left, decreasing the yield of SO_3.

Q6. A buffer solution is prepared by dissolving 0.1 mol of NH_3 and 0.1 mol of NH_4Cl in 1 L of water. Given that $pK_b(NH_3) = 4.74$, what is the pH of the buffer solution?

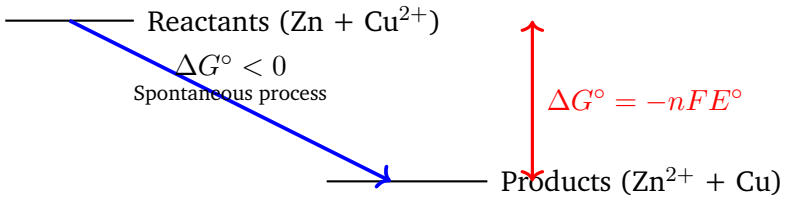
(A) 9.26

(B) 4.74

(C) 7.00

(D) 8.52

Q7. For the Daniell cell, $E^\circ_{\text{cell}} = 1.10\,\text{V}$ and $n = 2$. The relationship between Gibbs free energy change and cell EMF is shown in the energy level diagram below.



Calculate ΔG° for the Daniell cell reaction. ($F = 96500\,\text{C mol}^{-1}$)

(A) $+212.3\,\text{kJ/mol}$

(B) $-106.2\,\text{kJ/mol}$

(C) $+106.2\,\text{kJ/mol}$

(D) $-212.3\,\text{kJ/mol}$

Q8. For the reaction A + B $\rightarrow$ products with rate $= k[\text{A}]^m[\text{B}]^n$, a chemist wants to determine m (the order with respect to A) experimentally using the **isolation method**. Which of the following correctly describes this approach?

(A) Vary concentrations of A and B simultaneously and measure the overall rate.

(B) Keep B in a large excess so its concentration is effectively constant, then determine the apparent order with respect to A from the pseudo-order rate law.

(C) Keep A in large excess and measure the rate as only [A] is varied.

(D) Perform the reaction at very high temperature to make the order irrelevant.

Q9. Acetic acid (CH_3COOH) dimerizes in benzene solvent:

$$2\,CH_3COOH \rightleftharpoons (CH_3COOH)_2$$

If the degree of association $\alpha = 0.80$, what is the van't Hoff factor (i) and what happens to the observed colligative properties?

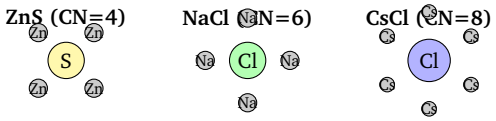
(A) $i = 1.8$; colligative properties are greater than expected.

(B) $i = 1.0$; colligative properties are unchanged.

(C) $i = 0.6$; colligative properties (e.g., osmotic pressure) are less than expected because $i < 1$.

(D) $i = 0.8$; colligative properties are slightly less than expected.

Q10. The coordination number and crystal structure adopted by an ionic compound depend on the cation-to-anion radius ratio (r^+/r^-). The three common structures are illustrated below.



Which statement is **correct** regarding the NaCl crystal structure?

(A) NaCl has octahedral coordination (CN = 6) with r^+/r^- in the range 0.414–0.732.

(B) NaCl has tetrahedral coordination (CN = 4) with r^+/r^- in the range 0.225–0.414.

(C) NaCl has cubic coordination (CN = 8) with r^+/r^- in the range 0.732–1.0.

(D) NaCl has linear coordination (CN = 2) because Na^+ is much smaller than Cl^-.

Q11. In the Haber process for the industrial synthesis of ammonia ($N_2 + 3\,H_2 \rightarrow 2\,NH_3$), finely divided iron (Fe) is used as a heterogeneous catalyst, with K_2O and Al_2O_3 as promoters. Which statement **correctly** explains the role of the Fe catalyst?

(A) The catalyst increases the temperature of the reaction, providing enough energy to break the N≡N bond directly.

(B) The catalyst shifts the equilibrium position to the right, increasing the equilibrium constant K_c.

(C) The catalyst provides nitrogen atoms from its surface, acting as a reactant that is regenerated at the end.

(D) The Fe catalyst lowers the activation energy by adsorbing N_2 and H_2 on its surface, weakening the N≡N triple bond and facilitating hydrogen addition to form NH_3.

Q12. Hard water contains dissolved calcium and magnesium salts. Which of the following statements about water hardness is **correct**?

(A) Permanent hardness is caused by $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ and can be removed by boiling.

(B) Temporary hardness is caused by $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ and is removed by boiling.

(C) Temporary hardness is caused by $CaSO_4$ and $MgSO_4$ and cannot be removed by boiling.

(D) Both temporary and permanent hardness are removed by adding Na_2SO_4 (sodium sulphate).

Q13. Phosphine (PH_3) is the phosphorus analogue of ammonia (NH_3). Which of the following statements **correctly** compares the Lewis base character of PH_3 and NH_3?

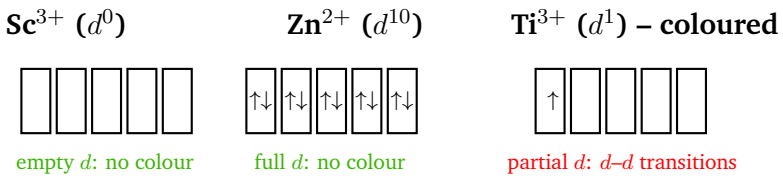
(A) PH_3 is a stronger Lewis base than NH_3 because P is larger and its lone pair is more available.

(B) NH_3 and PH_3 have identical Lewis base strengths since both have one lone pair.

(C) PH_3 is a weaker Lewis base than NH_3 because the lone pair on the larger P atom is less available due to the lower electronegativity of P and the more diffuse orbital character.

(D) PH_3 is a stronger Lewis base than NH_3 because the P–H bond is weaker than the N–H bond.

Q14. The d-orbital filling diagrams for three metal ions are shown below.



Which statement **correctly** explains why Sc^{3+}, Cu^{+}, and Zn^{2+} form colourless aqueous solutions?

(A) Sc^{3+}, Cu^{+}, and Zn^{2+} form colourless solutions because they have empty or completely filled d-orbitals, making d–d transitions impossible.

(B) They are colourless because they do not dissolve in water and therefore form no solution.

(C) They are colourless because they absorb light only in the infrared, not the visible range.

(D) Sc^{3+} and Zn^{2+} are coloured but Cu^{+} is not; the statement in the question is incorrect.

Q15. The Effective Atomic Number (EAN) or 18-electron rule predicts stability of metal complexes. For $[Cr(CO)_6]$, chromium has atomic number $Z = 24$. Each CO donates **2 electrons** as a ligand. What is the EAN of Cr in $[Cr(CO)_6]$ and which noble gas does it correspond to?

(A) EAN = 30, corresponding to Zn.

(B) EAN = 34, corresponding to Se.

(C) EAN = 24 (no change), corresponding to no noble gas.

(D) EAN = 36, corresponding to Kr; the complex satisfies the 18-electron rule.

Q16. Amines can react with acetic anhydride $[(CH_3CO)_2O]$ in an acetylation reaction. Which statement **correctly** describes the reactivity of different classes of amines towards acetic anhydride?

(A) Primary amines do not react with acetic anhydride because they are too weakly nucleophilic.

(B) Tertiary amines do not react with acetic anhydride because they have no N–H bond available for the reaction.

(C) All amines (primary, secondary, and tertiary) react equally well with acetic anhydride.

(D) Secondary amines react with acetic anhydride but primary amines do not.

Q17. Phenyl magnesium bromide (PhMgBr), a Grignard reagent, reacts with formaldehyde (HCHO) followed by aqueous acid workup (H_3O^+). What is the **major organic product**?

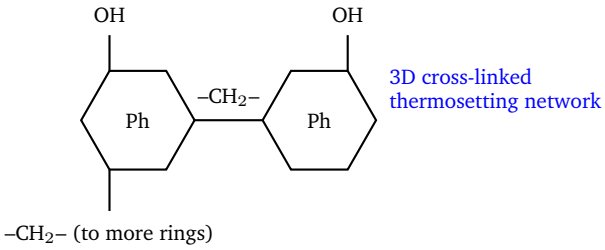
(A) $PhCH_2OH$ (benzyl alcohol, a primary alcohol)

(B) Ph_2CHOH (diphenylmethanol, a secondary alcohol)

(C) PhCHO (benzaldehyde)

(D) Ph_3COH (triphenylmethanol, a tertiary alcohol)

Q18. The polymer Bakelite is formed by a condensation polymerization reaction. The schematic below represents its cross-linked network.



Which statement **correctly** describes the formation and nature of Bakelite?

(A) Bakelite is a linear addition polymer of phenol formed under UV irradiation.

(B) Bakelite is a thermoplastic polymer that can be re-melted and re-shaped.

(C) Bakelite is formed by condensation polymerization of phenol and formaldehyde, forming a thermosetting 3D cross-linked structure via methylene ($–CH_2–$) bridges between phenol rings.

(D) Bakelite is formed from aniline and formaldehyde by electrophilic substitution.

Q19. Vitamins are classified as either fat-soluble or water-soluble based on their chemical nature and the medium in which they dissolve. Which of the following vitamins is **water-soluble**?

(A) Vitamin A (retinol)

(B) Vitamin D (calciferol)

(C) Vitamin E (tocopherol)

(D) Vitamin C (ascorbic acid)

Q20. Reducing sugars are those that can reduce Tollens' reagent (Ag^{+}) or Fehling's solution (Cu^{2+}). The key structural feature is the presence of a **free anomeric** –OH group. Which of the following is **NOT** a reducing sugar?

(A) Maltose (glucose–glucose, α-1,4-glycoside with a free anomeric –OH)

(B) Sucrose (glucose–fructose linked at both anomeric carbons, no free anomeric –OH)

(C) Lactose (galactose–glucose, β-1,4-glycoside with a free anomeric –OH)

(D) Glucose (free aldehyde group in open-chain form acts as a reducing agent)

Section B — Numerical Value Questions (Q21–Q30) [Attempt Any 5]

Q21. Count the total number of sigma (σ) bonds in one molecule of ethylene (C_2H_4). Consider all C–C and C–H bonds formed by head-on orbital overlap.

(Enter the exact numerical value as your answer.)

Q22. 4 g of H_2 gas (molar mass $= 2$ g/mol) reacts completely with excess O_2 according to:

$$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(l)$$

What mass of water (in grams) is produced? (Molar mass of $H_2O = 18$ g/mol)

(Enter the exact numerical value as your answer.)

Q23. A liquid mixture is prepared by mixing **equal moles** of benzene (M $= 78$ g/mol) and toluene (M $= 92$ g/mol). What is the mole fraction of benzene expressed as a percentage (%)?

(Enter the exact numerical value as your answer.)

Q24. Calculate the degree of unsaturation (DoU, also called index of hydrogen deficiency) for acetic acid (CH_3COOH), whose molecular formula is $C_2H_4O_2$.

$$\text{DoU} = \frac{2C + 2 - H}{2}$$

where C = number of carbon atoms and H = number of hydrogen atoms (oxygen does not affect DoU).

(Enter the exact numerical value as your answer.)

Q25. How many moles of HCl are required to completely neutralize 2 mol of $Ca(OH)_2$? The balanced equation is:

$$Ca(OH)_2 + 2\,HCl \rightarrow CaCl_2 + 2\,H_2O$$

(Enter the exact numerical value as your answer.)

Q26. How many moles of CO_2 are produced from the complete combustion of 2 mol of benzene (C_6H_6)? The balanced equation is:

$$C_6H_6 + \tfrac{15}{2}\,O_2 \rightarrow 6\,CO_2 + 3\,H_2O$$

(Enter the exact numerical value as your answer.)

Q27. A first-order reaction has a rate constant $k = 0.0231\ \text{min}^{-1}$. Calculate the half-life ($t_{1/2}$) of the reaction in minutes. (Use $\ln 2 = 0.693$)

(Enter the exact numerical value as your answer.)

Q28. What is the oxidation state of manganese (Mn) in potassium permanganate ($KMnO_4$)? (Oxidation state of K $= +1$, O $= -2$; the compound is neutral.)

(Enter the exact numerical value as your answer.)

Q29. For the reaction $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$, $\Delta n = 0$. If $K_c = 2$ at a given temperature, what is the value of K_p at the same temperature? (Use the relation $K_p = K_c(RT)^{\Delta n}$.)

(Enter the exact numerical value as your answer.)

Q30. Two gases in a sealed container have partial pressures of 3 atm (N_2) and 5 atm (O_2). Using Dalton's law of partial pressures, what is the total pressure (in atm) of the gas mixture?

(Enter the exact numerical value as your answer.)

Detailed Solutions

Q1.

Solution

Concept — Nodes in Atomic Orbitals: For any orbital with principal quantum number n and azimuthal quantum number l:

- Number of **radial nodes** $= n - l - 1$
- Number of **angular nodes** $= l$
- **Total nodes** $= n - 1$

Step 1 — Identify quantum numbers for 3p: For the 3p orbital: $n = 3$, $l = 1$.

Step 2 — Calculate nodes:

$$\text{Radial nodes} = n - l - 1 = 3 - 1 - 1 = 1$$

$$\text{Angular nodes} = l = 1$$

$$\text{Total nodes} = n - 1 = 3 - 1 = 2 \quad \checkmark \text{ (also } = 1 + 1 = 2)$$

Why other options are wrong:

- Option B (2 radial, 1 angular, 3 total): Would require $n = 4$ ($n - l - 1 = 4 - 1 - 1 = 2$), not $n = 3$.
- Option C (0 radial, 1 angular): This describes a 2p orbital where $n = 2$, $l = 1$: $n - l - 1 = 2 - 1 - 1 = 0$.
- Option D (1 radial, 0 angular): Zero angular nodes would mean $l = 0$, which is an s-orbital, not a p-orbital.

Final Answer: 3p orbital has 1 radial node, 1 angular node, 2 total nodes $\Rightarrow$ Option A

Answer: (A) Go Back to Q#1

Q2.

Solution

Concept — Hybridization and Bonding in Ethylene (VB Theory): In C_2H_4, each carbon atom undergoes sp^2 hybridization, forming three sp^2 hybrid orbitals and leaving one unhybridised $2p_z$ orbital perpendicular to the molecular plane.

Step 1 — sp^2 hybridization: Three sp^2 hybrid orbitals on each C form:

- One σ bond between the two carbon atoms (sp^2–sp^2 head-on overlap).
- Two σ bonds with hydrogen atoms (sp^2–1s head-on overlap).

Step 2 — π bond formation: The unhybridised $2p_z$ orbital on each carbon overlaps *laterally* (sideways) above and below the molecular plane, forming one π bond. This π bond is weaker than a σ bond and is responsible for the restricted rotation about the C=C double bond.

Why other options are wrong:

- Option A (sp^3, two σ bonds): sp^3 hybridization gives four σ bonds and no π bond; this is the bonding in ethane (C_2H_6), not ethylene.
- Option B (sp hybridized, head-on p overlap): sp hybridization is found in acetylene (C_2H_2), which has two π bonds; head-on p overlap gives a σ bond, not a π bond.
- Option D (sp^2, π from sp^2 end-on overlap): The π bond arises from *unhybridised* p orbitals overlapping sideways, not from sp^2 orbitals overlapping end-on.

Final Answer: Each C is sp^2 hybridised; π bond from lateral p–p overlap $\Rightarrow$ Option C

Answer: (C) Go Back to Q#2

Q3.

Solution

Concept — Compressibility Factor and Real Gas Behaviour: The compressibility factor $Z = PV/nRT$ measures the deviation of a real gas from ideal behaviour. For an ideal gas, $Z = 1$ at all pressures.

Step 1 — Region where $Z < 1$: At low to moderate pressures, intermolecular **attractive forces** reduce the effective pressure (and volume) compared to an ideal gas. This causes $PV < nRT$, so $Z < 1$. The gas is more compressed than predicted

by ideal gas law.

Step 2 — Region where $Z > 1$: At very high pressures, the finite volume of molecules (repulsive forces) dominates. Molecules resist compression; $PV > nRT$, so $Z > 1$. This is called the repulsive (excluded volume) regime.

Why other options are wrong:

- Option A ($Z > 1$): This region is dominated by *repulsive* forces, not attractive forces.
- Option B ($Z = 1$): This is the ideal gas line; a real gas behaves ideally here only momentarily (at a specific pressure called the Boyle temperature).
- Option C (steep rise at high P): The steep rise occurs due to repulsive/excluded volume effects, not attractive interactions.

Final Answer: Attractive forces dominate in the region where $Z < 1 \Rightarrow$ Option D

Answer: (D) Go Back to Q#3

Q4.

Solution

Concept — Enthalpy of Neutralization of Weak Acid: The standard enthalpy of neutralization of any strong acid with a strong base (e.g., HCl + NaOH) is -57.1 kJ/mol, corresponding entirely to the reaction:

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l), \quad \Delta H = -57.1\,\text{kJ/mol}$$

When a *weak* acid is used, it must first ionize (an endothermic step) before the H^+ can neutralize OH^-.

Step 1 — Set up the energy cycle:

$$CH_3COOH \rightarrow CH_3COO^- + H^+, \quad \Delta H_{\text{ionization}} = +2.1\,\text{kJ/mol (endothermic)}$$

$$H^+ + OH^- \rightarrow H_2O, \quad \Delta H = -57.1\,\text{kJ/mol}$$

Step 2 — Calculate net $\Delta H_{\text{neutralization}}$:

$$\Delta H_{\text{neutralization}} = \Delta H_{\text{ionization}} + (-57.1) = +2.1 + (-57.1) = -55.0\,\text{kJ/mol}$$

Since the ionization step is endothermic, it *reduces* the net heat released.

Why other options are wrong:

- Option A (-57.1 kJ/mol): This applies to strong acid–strong base neutralization only; it ignores the endothermic ionization energy of the weak acid.
- Option C (-59.2 kJ/mol): This would arise if the ionization were *exothermic* (-2.1), which is incorrect.
- Option D ($+2.1$ kJ/mol): This is only the ionization enthalpy, not the overall neutralization enthalpy.

Final Answer: $\Delta H_{\text{neutralization}}(CH_3COOH + NaOH) = -55.0\,\text{kJ/mol} \Rightarrow \boxed{-55.0\,\text{kJ/mol}}$

Answer: (B) Go Back to Q#4

Q5.

Solution

Concept — Le Chatelier's Principle and Pressure Changes: For a gaseous equilibrium, decreasing the volume increases the total pressure. By Le Chatelier's principle, the system responds to oppose this change by shifting equilibrium towards the side with *fewer* moles of gas.

Step 1 — Count moles of gas on each side:

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$$

$$\Delta n_{\text{gas}} = 2 - (2 + 1) = -1$$

The products side has **fewer** moles of gas (2 moles SO_3) than the reactants side (3 moles total: 2 SO_2 + 1 O_2).

Step 2 — Predict the shift: Decreasing volume $\Rightarrow$ increasing pressure $\Rightarrow$ equilibrium shifts towards the side with fewer moles of gas $\Rightarrow$ **shifts right**, towards SO_3. This increases the yield of SO_3.

Why other options are wrong:

- Option A (shifts left): Incorrect; pressure increase shifts toward fewer gas moles (right side), not more (left side).
- Option B (no shift): Temperature changes do not shift equilibrium in this context; pressure change does.
- Option D (shifts left, less SO_3): The left side has more gas moles; increased pressure disfavours the side with more gas.

Final Answer: Equilibrium shifts to the right; yield of SO_3 increases $\Rightarrow$ $\boxed{\text{Option C}}$

Answer: (C) Go Back to Q#5

Q6.

Solution

Concept — Henderson–Hasselbalch Equation for Basic Buffer: For an NH_3/NH_4^+ buffer, the relevant equation is:

$$\text{pOH} = pK_b + \log \frac{[NH_4^+]}{[NH_3]}$$

Then $\text{pH} = 14 - \text{pOH}$.

Step 1 — Identify concentrations: $[NH_4Cl] = [NH_3] = 0.1$ mol/L in 1 L, so the ratio $[NH_4^+]/[NH_3] = 1$.

Step 2 — Calculate pOH:

$$\text{pOH} = pK_b + \log(1) = 4.74 + 0 = 4.74$$

Step 3 — Calculate pH:

$$\text{pH} = 14 - \text{pOH} = 14 - 4.74 = \mathbf{9.26}$$

Why other options are wrong:

- Option B (4.74): This is the pOH (or pK_b), not the pH; the buffer is basic (pH > 7).
- Option C (7.00): This is the pH of pure water; an ammonia buffer is always basic, not neutral.
- Option D (8.52): This would correspond to $pK_b = 5.48$ and $pOH = 5.48$; neither matches the given $pK_b = 4.74$.

Final Answer: $\text{pH} = 9.26 \Rightarrow \boxed{9.26}$

Answer: (A) Go Back to Q#6

Q7.

Solution

Concept — Relationship between ΔG° and E°_{cell}: The Gibbs free energy change for an electrochemical cell reaction is related to the cell EMF by:

$$\Delta G^\circ = -nFE^\circ_{\text{cell}}$$

A negative ΔG° confirms the spontaneity of the cell reaction.

Step 1 — Identify values:

- $n = 2$ (2 electrons transferred in the Daniell cell reaction)
- $F = 96500\,\text{C mol}^{-1}$
- $E^\circ_{\text{cell}} = 1.10\,\text{V}$

Step 2 — Calculate ΔG°:

$$\Delta G^\circ = -nFE^\circ = -2 \times 96500 \times 1.10 = -212300\,\text{J/mol} = -\mathbf{212.3}\,\text{kJ/mol}$$

Why other options are wrong:

- Option A ($+212.3\,\text{kJ/mol}$): The positive sign would indicate a non-spontaneous reaction; the Daniell cell is spontaneous so $\Delta G^\circ < 0$.
- Option B ($-106.2\,\text{kJ/mol}$): This corresponds to $n = 1$; the Daniell cell transfers $n = 2$ electrons.
- Option C ($+106.2\,\text{kJ/mol}$): Wrong sign and wrong n.

Final Answer: $\Delta G^\circ = -212.3\,\text{kJ/mol} \Rightarrow \boxed{-212.3\,\text{kJ/mol}}$

Answer: (D) Go Back to Q#7

Q8.

Solution

Concept — Isolation Method in Chemical Kinetics: The isolation method (also called the pseudo-order method) is used to determine the individual orders (m and n) in a rate law rate $= k[\text{A}]^m[\text{B}]^n$. By making one reactant present in a very large excess, its concentration remains essentially constant throughout the reaction.

Step 1 — Procedure to find order with respect to A: Keep [B] in large excess ([B] $\gg$ [A]). Then [B] $\approx$ [B]$_0$ = constant throughout the reaction. The rate law

simplifies to:

$$\text{rate} = k'[\text{A}]^m, \quad \text{where } k' = k[\text{B}]_0^n$$

This is a **pseudo-mth order** reaction. By plotting appropriate graphs (e.g., $\ln[\text{A}]$ vs time for $m = 1$), the value of m is determined.

Step 2 — Finding n: Repeat the experiment with [A] in large excess to determine the order n with respect to B in the same manner.

Why other options are wrong:

- Option A (vary both simultaneously): Varying both A and B simultaneously makes it impossible to isolate the individual orders.
- Option C (keep A in excess, vary only A): If A is in excess, its concentration is approximately constant and we cannot determine the order with respect to A; we would instead isolate the order with respect to B.
- Option D (high temperature): Temperature affects the rate constant k but does not eliminate the dependence on reactant concentrations.

Final Answer: Keep B in large excess; determine pseudo-order with respect to A $\Rightarrow$ Option B

Answer: (B) Go Back to Q#8

Q9.

Solution

Concept — Association and van't Hoff Factor: When solute molecules associate in solution, the number of solute particles decreases, leading to a van't Hoff factor $i < 1$. This reduces all colligative properties below the expected values for non-associating solutes.

Step 1 — Dimerization equilibrium: Let α = degree of association. Initially 1 mol of CH_3COOH is present. At equilibrium:

- Moles of monomer remaining $= 1 - \alpha$
- Moles of dimer formed $= \alpha/2$
- Total moles $= (1 - \alpha) + \alpha/2 = 1 - \alpha/2$

Step 2 — Calculate i:

$$i = \frac{\text{total moles at equilibrium}}{\text{initial moles}} = \frac{1 - \alpha/2}{1} = 1 - \frac{\alpha}{2}$$

With $\alpha = 0.80$:

$$i = 1 - \frac{0.80}{2} = 1 - 0.40 = \mathbf{0.60}$$

Step 3 — Effect on colligative properties: Since $i = 0.6 < 1$, all colligative properties (osmotic pressure, boiling point elevation, freezing point depression) are **less** than expected for a non-associating solute.

Why other options are wrong:

- Option A ($i = 1.8$): $i > 1$ occurs for dissociation (ionization), not association (dimerization).
- Option B ($i = 1.0$): $i = 1$ implies no association; with $\alpha = 0.80$, significant dimerization occurs.
- Option D ($i = 0.8$): This would correspond to $\alpha = 0.4$ (since $i = 1 - 0.4/2 = 0.8$), not $\alpha = 0.80$.

Final Answer: $i = 0.6 < 1$; colligative properties are less than expected $\Rightarrow$ Option C

Answer: (C) Go Back to Q#9

Q10.

Solution

Concept — Radius Ratio Rules for Crystal Structures: The coordination number and crystal structure of ionic compounds are governed by the radius ratio r^+/r^- (cation radius / anion radius):

r^+/r^- range	Coordination Number	Structure
< 0.225	3	triangular/planar
0.225–0.414	4	tetrahedral (ZnS)
0.414–0.732	6	octahedral (NaCl)
> 0.732	8	cubic (CsCl)

Step 1 — NaCl structure: In NaCl, $r(\text{Na}^+) = 102$ pm and $r(\text{Cl}^-) = 181$ pm, giving $r^+/r^- = 0.564$. This falls in the range 0.414–0.732, corresponding to **octahedral coordination** with CN = 6. Each Na^+ is surrounded by 6 Cl^- ions, and each Cl^- is surrounded by 6 Na^+ ions.

Why other options are wrong:

- Option B (CN = 4, tetrahedral): This describes the ZnS (zinc blende) structure for r^+/r^- in range 0.225–0.414.

- Option C (CN = 8, cubic): This describes CsCl structure for $r^+/r^- > 0.732$.
- Option D (CN = 2, linear): This is not a standard crystal structure; Na^+ and Cl^- have a similar ionic radius ratio that clearly places them in the octahedral range.

Final Answer: NaCl has CN = 6 (octahedral) with r^+/r^- in range 0.414–0.732 $\Rightarrow$ Option A

Answer: (A) Go Back to Q#10

Q11.

Solution

Concept — Heterogeneous Catalysis and Activation Energy: Heterogeneous catalysts lower the activation energy (E_a) of a reaction by providing an alternative reaction pathway. They do *not* shift the equilibrium position or change K_c.

Step 1 — Mechanism of Fe catalyst in the Haber process:

- N_2 and H_2 molecules **adsorb** onto the Fe surface (chemisorption).
- Adsorption **weakens** the N≡N triple bond (bond order 3, very stable), making it easier to break.
- H atoms also adsorb and react with N atoms step-wise to form NH, NH_2, and finally NH_3.
- NH_3 desorbs from the surface, freeing the catalyst.

Step 2 — Role of promoters: K_2O increases the electron density on Fe (increases adsorption of N_2); Al_2O_3 keeps the Fe particles finely dispersed (prevents sintering), increasing surface area.

Why other options are wrong:

- Option A (catalyst increases temperature): Catalysts do not increase the temperature; they lower the activation energy by providing an alternative pathway.
- Option B (shifts equilibrium, increases K_c): A catalyst never changes the equilibrium constant K_c; it only helps the system reach equilibrium faster.
- Option C (catalyst provides N atoms): Fe is a true catalyst — it is not consumed in the reaction. N_2 provides the nitrogen atoms, not Fe.

Final Answer: Fe catalyst lowers E_a by adsorbing and weakening N≡N bond $\Rightarrow$ Option D

Answer: (D) Go Back to Q#11

Q12.

Solution

Concept — Types of Water Hardness: Hard water contains dissolved salts of calcium and magnesium. The two types of hardness differ in the anion present:

Type	Salts	Removal
Temporary	$Ca(HCO_3)_2$, $Mg(HCO_3)_2$	Boiling or Clark's process (lime)
Permanent	$CaSO_4$, $MgSO_4$, $CaCl_2$, $MgCl_2$	Ion exchange, washing soda (Na_2CO_3), zeolite

Step 1 — Why boiling removes temporary hardness: On boiling, the soluble bicarbonates decompose:

$$Ca(HCO_3)_2(aq) \xrightarrow{\Delta} CaCO_3(s) \downarrow + H_2O(l) + CO_2(g)$$

The insoluble $CaCO_3$ precipitates and is removed. This is also why kettles develop limescale in hard water areas.

Why other options are wrong:

- Option A: Permanent hardness (not temporary) is caused by sulphates and chlorides; these are NOT removed by boiling.
- Option C: $CaSO_4$ and $MgSO_4$ cause *permanent* hardness, not temporary.
- Option D: Na_2SO_4 (sodium sulphate) does not soften water; Na_2CO_3 (washing soda) does, by precipitating Ca^{2+} and Mg^{2+} as their carbonates.

Final Answer: Temporary hardness ($Ca(HCO_3)_2$, $Mg(HCO_3)_2$) is removed by boiling $\Rightarrow$ Option B

Answer: (B) Go Back to Q#12

Q13.

Solution

Concept — Lewis Base Strength of PH_3 vs NH_3: Both NH_3 and PH_3 have a lone pair on the central atom that can be donated to a Lewis acid. However, the availability of that lone pair differs significantly.

Step 1 — Factors affecting Lewis base strength:

- **Electronegativity**: N is more electronegative ($\chi = 3.04$) than P ($\chi = 2.19$). Higher electronegativity means N holds its lone pair more tightly, reducing

donation... but the lone pair is concentrated in a small, more directional orbital, making it *more available* for donation to small Lewis acids (like H^+).

- **Orbital size**: P uses 3p orbitals (larger, more diffuse) for its lone pair. The larger, more diffuse orbital overlaps poorly with Lewis acid orbitals $\Rightarrow$ weaker Lewis base.
- **Net effect**: NH_3 is a significantly *stronger* Lewis base than PH_3 towards most Lewis acids (e.g., BF_3, H^+).

Why other options are wrong:

- Option A (PH_3 stronger): Incorrect; the larger, more diffuse lone pair on P overlaps *less* effectively with Lewis acid orbitals, making PH_3 a weaker Lewis base.
- Option B (equal strength): NH_3 and PH_3 have very different basicities; NH_3 has $K_b \approx 1.8 \times 10^{-5}$ in water, while PH_3 is essentially non-basic in water.
- Option D (weaker P–H bond = stronger Lewis base): Lewis base strength depends on lone pair availability, not bond strength; these are different properties.

Final Answer: PH_3 is a weaker Lewis base than NH_3 due to more diffuse lone pair on larger P atom $\Rightarrow$ Option C

Answer: (C) Go Back to Q#13

Q14.

Solution

Concept — Colour and d-orbital Occupancy in Transition Metal Ions: Transition metal ions are coloured because electrons in partially filled d-orbitals can undergo d–d electronic transitions by absorbing visible light. For d–d transitions to occur, the d-orbitals must be *partially filled* — i.e., neither completely empty nor completely filled.

Step 1 — Electronic configurations:

- Sc^{3+}: [Ar]$3d^0$ (empty d-orbitals $\Rightarrow$ no d–d transitions $\Rightarrow$ colourless)
- Cu^+: [Ar]$3d^{10}$ (completely filled d-orbitals $\Rightarrow$ no d–d transitions $\Rightarrow$ colourless)
- Zn^{2+}: [Ar]$3d^{10}$ (completely filled d-orbitals $\Rightarrow$ no d–d transitions $\Rightarrow$ colourless)
- Ti^{3+}: [Ar]$3d^1$ (partially filled, 1 electron $\Rightarrow$ d–d transitions possible $\Rightarrow$ purple/violet colour)

Why other options are wrong:

- Option B (they don't dissolve): Sc^{3+}, Cu^{+}, and Zn^{2+} do dissolve in water; their colourlessness is due to electronic structure, not insolubility.
- Option C (IR absorption): These ions absorb at UV frequencies (if at all), but the reason for colourlessness is the inability to perform d–d transitions in the visible range.
- Option D (Sc^{3+} and Zn^{2+} coloured): All three ions listed are colourless for the reason given in Option A.

Final Answer: Colourless because of empty (d^0) or filled (d^{10}) d-orbitals, making d–d transitions impossible $\Rightarrow$ Option A

Answer: (A) Go Back to Q#14

Q15.

Solution

Concept — EAN (18-Electron) Rule for Metal Complexes: The Effective Atomic Number (EAN) rule states that stable metal complexes tend to have 18 electrons around the metal centre (analogous to the noble gas configuration). Each CO ligand donates **2 electrons** as a σ-donor (and also back-accepts π electrons from metal, making it a strong field ligand).

Step 1 — Calculate EAN for $[Cr(CO)_6]$:

- Cr has atomic number $Z = 24$; in OS $= 0$, it has 24 electrons.
- Electrons from 6 CO ligands: $6 \times 2 = 12$ electrons.
- EAN $= 24 + 12 =$ **36**

Step 2 — Noble gas identity: EAN $= 36$ corresponds to krypton (Kr, $Z = 36$). The complex satisfies the 18-electron rule:

$$24\,(\text{Cr electrons}) + 12\,(\text{CO donation}) = 36 = \text{Kr configuration}$$

Why other options are wrong:

- Option A (EAN = 30): This would correspond to Zn ($Z = 30$). The calculation $24 + 12 = 36$, not 30.
- Option B (EAN = 34): $Z = 34$ corresponds to Se. This would require only 10 electrons from ligands (5×2), i.e., 5 CO ligands.

- Option C (EAN = 24, no change): This ignores the electron donation from CO ligands entirely.

Final Answer: EAN of Cr in $[Cr(CO)_6] = 36$ (Kr); 18-electron rule satisfied $\Rightarrow$ Option D

Answer: (D) Go Back to Q#15

Q16.

Solution

Concept — Acetylation of Amines with Acetic Anhydride: The reaction of amines with acetic anhydride $[(CH_3CO)_2O]$ is an acylation reaction that replaces an N–H hydrogen with an acetyl group ($–COCH_3$):

$$R–NH_2 + (CH_3CO)_2O \rightarrow R–NHCOCH_3 + CH_3COOH$$

Step 1 — Classify reactivity by amine type:

- **Primary amines** ($R–NH_2$): Have two N–H bonds; react with acetic anhydride to give monosubstituted acetamides.
- **Secondary amines** (R_2NH): Have one N–H bond; also react to give disubstituted acetamides.
- **Tertiary amines** (R_3N): Have *no* N–H bond; the nitrogen is fully substituted. **Cannot react** with acetic anhydride because there is no N–H hydrogen to be replaced.

Why other options are wrong:

- Option A (primary amines don't react): Primary amines are nucleophilic and react readily with acetic anhydride via the N–H bond.
- Option C (all react equally): Tertiary amines do not react; primary and secondary amines do, but may differ in rate.
- Option D (secondary yes, primary no): Both primary and secondary amines react; the distinguishing factor is the presence of at least one N–H bond.

Final Answer: Tertiary amines have no N–H bond and do not react with acetic anhydride $\Rightarrow$ Option B

Answer: (B) Go Back to Q#16

Q17.

Solution

Concept — Grignard Reagent Reaction with Carbonyl Compounds: A Grignard reagent (R–MgBr) is a powerful nucleophile. The carbon of the C–Mg bond attacks the electrophilic carbonyl carbon (δ^+). The type of carbonyl compound determines the class of alcohol produced:

- HCHO (formaldehyde) $\rightarrow$ **primary alcohol**
- RCHO (other aldehyde) $\rightarrow$ **secondary alcohol**
- R_2CO (ketone) $\rightarrow$ **tertiary alcohol**

Step 1 — Reaction of PhMgBr with HCHO:

$$\text{PhMgBr} + \text{HCHO} \xrightarrow{\text{1. ether}} \text{Ph–CH}_2\text{–OMgBr} \xrightarrow{\text{2. H}_3\text{O}^+} \text{Ph–CH}_2\text{–OH}$$

The intermediate alkoxide (Ph–CH_2–OMgBr) is hydrolyzed by acid to give **benzyl alcohol** ($PhCH_2OH$), which is a primary alcohol (the new C–C bond forms one carbon chain beyond the phenyl group, and the resulting OH-bearing carbon bears two H atoms).

Why other options are wrong:

- Option B (Ph_2CHOH, secondary): This would require PhMgBr reacting with PhCHO (benzaldehyde), not HCHO.
- Option C (PhCHO, benzaldehyde): Grignard reagents are nucleophiles; they add to the carbonyl, they do not produce aldehydes as products.
- Option D (Ph_3COH, tertiary): This would require PhMgBr reacting with Ph_2CO (benzophenone), not HCHO.

Final Answer: PhMgBr + HCHO $\xrightarrow{\text{H}_3\text{O}^+}$ $PhCH_2OH$ (benzyl alcohol, primary) $\Rightarrow$ $\boxed{PhCH_2OH}$

Answer: (A) Go Back to Q#17

Q18.

Solution

Concept — Bakelite: Condensation Polymerization of Phenol and Formaldehyde: Bakelite is one of the earliest synthetic polymers (developed by Leo Baekeland, 1907). It is formed by a step-growth (condensation) polymerization between phenol (C_6H_5OH) and formaldehyde (HCHO) in the presence of an acid or base catalyst.

Step 1 — Reaction mechanism:

- The reaction is electrophilic aromatic substitution: HCHO reacts at the ortho and para positions of phenol.
- Methylene ($–CH_2–$) bridges form between phenol rings, creating a 3D cross-linked network.
- The cross-linking proceeds through both ortho and para positions, giving a highly branched 3D structure.

Step 2 — Thermosetting nature: The 3D cross-linked network structure makes Bakelite a **thermosetting polymer**. Once formed, it cannot be re-melted or reshaped (unlike thermoplastics). It has high heat resistance and mechanical strength.

Why other options are wrong:

- Option A (linear addition polymer, UV): Bakelite is a condensation (not addition) polymer; it is 3D cross-linked, not linear; and UV is not used.
- Option B (thermoplastic): Thermoplastics can be re-melted; Bakelite is thermosetting and permanently hardened.
- Option D (aniline + formaldehyde): Bakelite uses phenol, not aniline. (Aniline + formaldehyde gives a different condensation product.)

Final Answer: Bakelite = condensation polymer of phenol + HCHO; thermosetting 3D cross-linked $\Rightarrow$ Option C

Answer: (C) Go Back to Q#18

Q19.

Solution

Concept — Classification of Vitamins (Fat-Soluble vs Water-Soluble):

Category	Vitamins	Key feature
Fat-soluble	A, D, E, K	Stored in body fat/liver; excess can cause toxi
Water-soluble	B-complex (B_1, B_2, B_6, B_{12}), C	Excreted in urine; daily intake needed

Step 1 — Analyse the options:

- Vitamin A (retinol): **fat-soluble**; needed for vision and immune function.
- Vitamin D (calciferol): **fat-soluble**; regulates calcium absorption; synthesized in skin by sunlight.
- Vitamin E (tocopherol): **fat-soluble**; antioxidant; stored in adipose tissue.
- Vitamin C (ascorbic acid): **water-soluble**; antioxidant; essential for collagen synthesis; deficiency causes scurvy.

Why other options are wrong:

- Options A, B, C (Vitamins A, D, E): All are fat-soluble vitamins (the mnemonic "ADEK" helps remember fat-soluble vitamins), stored in body fat.

Final Answer: Vitamin C (ascorbic acid) is water-soluble $\Rightarrow$ Option D (Vitamin C)

Answer: (D) Go Back to Q#19

Q20.

Solution

Concept — Reducing and Non-Reducing Sugars: A reducing sugar has a **free anomeric –OH group** (in the hemiacetal or hemiketal form) that can be oxidized. In sucrose, both anomeric –OH groups (from glucose C-1 and from fructose C-2) are involved in the glycosidic linkage, leaving no free anomeric –OH.

Step 1 — Examine each sugar:

- **Maltose** (glucose–glucose, α-1,4-glycoside): C-1 of one glucose is linked, but C-1 of the *other* glucose is **free** $\Rightarrow$ reducing sugar.
- **Sucrose** (glucose–fructose): C-1 of glucose is linked to C-2 of fructose (both anomeric carbons engaged) $\Rightarrow$ **NO free anomeric –OH** $\Rightarrow$ **non-reducing**

sugar.

- **Lactose** (galactose–glucose, β-1,4-glycoside): C-4 of glucose is linked; C-1 of glucose is **free** $\Rightarrow$ reducing sugar.
- **Glucose**: Has a free aldehyde group ($-$CHO) in open-chain form $\Rightarrow$ reducing sugar.

Why other options are wrong:

- Option A (maltose): Maltose has a free anomeric –OH and IS a reducing sugar; not the answer.
- Option C (lactose): Lactose also has a free anomeric –OH and IS a reducing sugar; not the answer.
- Option D (glucose): Glucose is the classic reducing sugar; not the answer.

Final Answer: Sucrose is **NOT** a reducing sugar (both anomeric OH groups are locked in the glycosidic bond) $\Rightarrow$ Option B (Sucrose)

Answer: (B) Go Back to Q#20

Q21.

Solution

Concept — Counting Sigma Bonds in Ethylene: In ethylene (C_2H_4), the C=C double bond consists of one σ bond and one π bond. All single bonds (C–H and C–C σ) are σ bonds. Only the π bond is not a σ bond.

Step 1 — Identify all bonds in C_2H_4: Structure: $H_2C{=}CH_2$

- C_1–C_2: 1 σ bond (part of the C=C double bond)
- C_1–H (first H): 1 σ bond
- C_1–H (second H): 1 σ bond
- C_2–H (third H): 1 σ bond
- C_2–H (fourth H): 1 σ bond

Step 2 — Count total σ bonds:

$$\text{Total } \sigma \text{ bonds} = 1\,(\text{C–C}) + 4\,(\text{C–H}) = \mathbf{5}$$

Note: The C=C also has 1 π bond, which is *not* counted as a σ bond.

$\boxed{5}$

Answer: (5) Go Back to Q#21

Q22.

Solution

Concept — Stoichiometry: Mass of H_2O from H_2 Combustion: Using molar ratios from the balanced equation to convert mass of reactant to mass of product.

Step 1 — Find moles of H_2:

$$n(\mathrm{H_2}) = \frac{4\,\mathrm{g}}{2\,\mathrm{g/mol}} = 2\,\mathrm{mol}$$

Step 2 — Apply stoichiometry: From $2\,H_2 + O_2 \rightarrow 2\,H_2O$: mole ratio $H_2 : H_2O = 2 : 2 = 1 : 1$.

$$n(\mathrm{H_2O}) = 2\,\mathrm{mol}$$

Step 3 — Convert to mass:

$$m(\mathrm{H_2O}) = 2\,\mathrm{mol} \times 18\,\mathrm{g/mol} = \mathbf{36}\,\mathrm{g}$$

$$\boxed{36}$$

Answer: (36) Go Back to Q#22

Q23.

Solution

Concept — Mole Fraction: The mole fraction of a component is the ratio of its moles to the total moles in the mixture.

Step 1 — Set up with equal moles: Let n = moles of each component. Then:

$$\chi(\text{benzene}) = \frac{n}{n+n} = \frac{n}{2n} = \frac{1}{2} = 0.50$$

Step 2 — Convert to percentage:

$$\chi(\text{benzene}) \times 100 = 0.50 \times 100 = \mathbf{50}\%$$

Note: The molar masses of benzene (78 g/mol) and toluene (92 g/mol) are irrel-

evant here because the question specifies *equal moles* (not equal masses).

$$\boxed{50}$$

Answer: (50) Go Back to Q#23

Q24.

Solution

Concept — Degree of Unsaturation (Index of Hydrogen Deficiency): The DoU formula for a compound with only C, H, and O is:

$$\text{DoU} = \frac{2C + 2 - H}{2}$$

Oxygen does not appear in this formula; nitrogen adds $+1$ per N atom; halogens count as H.

Step 1 — Identify molecular formula: Acetic acid: $CH_3COOH \equiv C_2H_4O_2$. So $C = 2$, $H = 4$.

Step 2 — Calculate DoU:

$$\text{DoU} = \frac{2 \times 2 + 2 - 4}{2} = \frac{4 + 2 - 4}{2} = \frac{2}{2} = \mathbf{1}$$

This corresponds to the one C=O double bond (the carbonyl in –COOH). There are no rings in acetic acid.

$$\boxed{1}$$

Answer: (1) Go Back to Q#24

Q25.

Solution

Concept — Stoichiometry of Neutralization: From the balanced equation $Ca(OH)_2 + 2\,HCl \rightarrow CaCl_2 + 2\,H_2O$, the mole ratio of $Ca(OH)_2$ to HCl is $1 : 2$.

Step 1 — Apply mole ratio:

$$n(\text{HCl}) = 2 \times n(\text{Ca(OH)}_2) = 2 \times 2\,\text{mol} = 4\,\text{mol}$$

$Ca(OH)_2$ is a dibasic base (furnishes 2 OH^- per formula unit), so it requires 2 mol

of HCl per mol of $Ca(OH)_2$.

$$\boxed{4}$$

Answer: (4) Go Back to Q#25

Q26.

Solution

Concept — Stoichiometry of Benzene Combustion: From $C_6H_6 + \frac{15}{2}O_2 \rightarrow 6\,CO_2 + 3\,H_2O$, 1 mol of benzene produces 6 mol of CO_2.

Step 1 — Calculate moles of CO_2:

$$n(CO_2) = 2\,\text{mol benzene} \times 6\,\frac{\text{mol } CO_2}{\text{mol benzene}} = \mathbf{12}\,\text{mol } \mathbf{CO_2}$$

$$\boxed{12}$$

Answer: (12) Go Back to Q#26

Q27.

Solution

Concept — Half-Life of a First-Order Reaction: For a first-order reaction:

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

Step 1 — Substitute values:

$$t_{1/2} = \frac{0.693}{0.0231\,\text{min}^{-1}} = \frac{0.693}{0.0231} = \mathbf{30}\,\text{min}$$

Verification: $0.0231 \times 30 = 0.693 = \ln 2$ ✓

$$\boxed{30}$$

Answer: (30) Go Back to Q#27

Q28.

Solution

Concept — Oxidation State Calculation in $KMnO_4$: In any neutral compound, the sum of all oxidation states equals zero.

Step 1 — Set up the equation: Let OS of Mn $= x$. K is $+1$; each O is -2; there are 4 oxygen atoms.

$$(+1) + x + 4(-2) = 0$$

$$1 + x - 8 = 0 \implies x = +7$$

Step 2 — Verify: $(+1) + (+7) + 4(-2) = +1 + 7 - 8 = 0$ ✓

$KMnO_4$ (potassium permanganate) is a strong oxidizing agent; Mn in its highest common oxidation state of $+7$ explains its strong oxidizing power (it is reduced to Mn^{2+} in acid, Mn^{4+} in neutral, or Mn^{6+} in alkaline medium).

$$\boxed{7}$$

Answer: (7) Go Back to Q#28

Q29.

Solution

Concept — Relationship between K_p and K_c: The general relation is:

$$K_p = K_c(RT)^{\Delta n}$$

where Δn is the change in moles of gaseous species (products − reactants).

Step 1 — Determine Δn: For $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$:

$$\Delta n = (1 + 1) - (1 + 1) = 2 - 2 = 0$$

Step 2 — Calculate K_p:

$$K_p = K_c(RT)^0 = K_c \times 1 = K_c = \mathbf{2}$$

When $\Delta n = 0$, $K_p = K_c$ regardless of temperature (since $(RT)^0 = 1$ for any T).

$$\boxed{2}$$

Answer: (2) Go Back to Q#29

Q30.

Solution

Concept — Dalton's Law of Partial Pressures: For a mixture of non-reacting ideal gases in a closed container, the total pressure is the sum of the partial pressures of each component gas:

$$P_{\text{total}} = P_{\text{N}_2} + P_{\text{O}_2}$$

Step 1 — Apply Dalton's law:

$$P_{\text{total}} = 3\,\text{atm} + 5\,\text{atm} = \mathbf{8}\,\text{atm}$$

Each gas exerts pressure independently, as if it were the only gas in the container.

$$\boxed{8}$$

Answer: (8) Go Back to Q#30

Answer Key

Section A (MCQ):

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	C	3	D	4	B	5	C
6	A	7	D	8	B	9	C	10	A
11	D	12	B	13	C	14	A	15	D
16	B	17	A	18	C	19	D	20	B

Section B (Numerical Value):

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
21	5	22	36						
23	50	24	1						
25	4	26	12						
27	30	28	7						
29	2	30	8						