JEE Main Chemistry

Sample Paper – 6

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. The uncertainty in the position of an electron is $1\,\text{Å}$ ($= 1 \times 10^{-10}\,\text{m}$). Using the Heisenberg Uncertainty Principle $\Delta x \cdot \Delta p \geq \dfrac{h}{4\pi}$, calculate the minimum uncertainty in the velocity (Δv) of the electron. (Given: $h = 6.626 \times 10^{-34}\,\text{J·s}$, $m_e = 9.11 \times 10^{-31}\,\text{kg}$)

(A) $5.8 \times 10^{3}\,\text{m/s}$

(B) $5.8 \times 10^{5}\,\text{m/s}$

(C) $1.6 \times 10^{5}\,\text{m/s}$

(D) 2.3×10^6 m/s

Q2. Using Molecular Orbital (MO) theory, which of the following statements **correctly** describes the superoxide ion O_2^- (formed when one electron is added to O_2)?

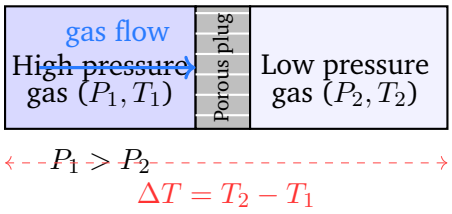
(A) Bond order of O_2^- is 2 and it is diamagnetic.

(B) Bond order of O_2^- is 2 and it is paramagnetic.

(C) Bond order of O_2^- is 1.5 and it is paramagnetic.

(D) Bond order of O_2^- is 1 and it is diamagnetic.

Q3. The Joule-Thomson effect describes the change in temperature of a real gas when it is forced through a porous plug or throttle valve from a region of high pressure to low pressure without any heat exchange with surroundings (adiabatic process). Consider the diagram below:



Which of the following statements about the Joule-Thomson effect is **correct**?

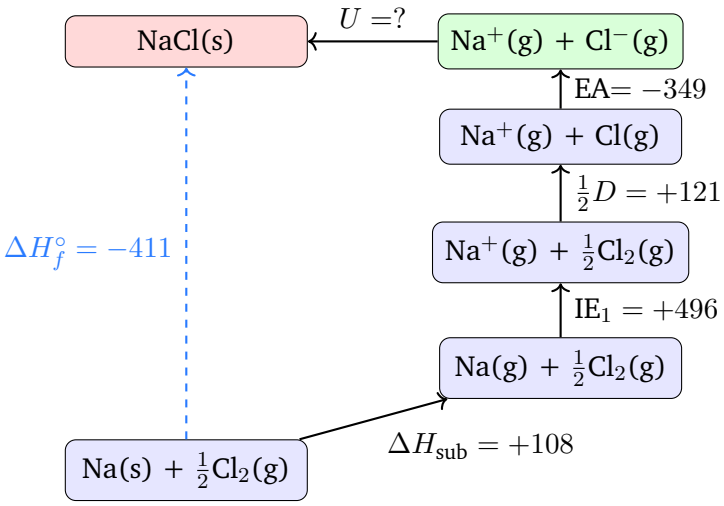
(A) For an ideal gas, the Joule-Thomson coefficient $\mu_{JT} > 0$; the gas always cools on expansion.

(B) For a real gas above the inversion temperature, the gas cools upon expansion through the porous plug.

(C) The Joule-Thomson effect is an isobaric process (constant pressure on both sides).

(D) The Joule-Thomson effect is used in the liquefaction of gases; hydrogen and helium must first be precooled below their inversion temperatures before the effect causes cooling.

Q4. Using the Born-Haber cycle shown below, calculate the lattice energy (U) of NaCl(s). Given data: $\Delta H_f^\circ(\text{NaCl}) = -411\,\text{kJ/mol}$, enthalpy of sublimation of Na(s) $= +108\,\text{kJ/mol}$, first ionisation energy of Na $= +496\,\text{kJ/mol}$, bond dissociation energy of $\frac{1}{2}\text{Cl}_2 = +121\,\text{kJ/mol}$, electron affinity of Cl $= -349\,\text{kJ/mol}$.



(A) $-787\,\text{kJ/mol}$

(B) $-411\,\text{kJ/mol}$

(C) $-598\,\text{kJ/mol}$

(D) $+787\,\text{kJ/mol}$

Q5. The standard enthalpy of combustion of benzene (C_6H_6) is experimentally found to be $-3268\,\text{kJ/mol}$. The enthalpy of combustion calculated from bond enthalpies for the hypothetical Kekulé structure of benzene (with alternating single and double C–C bonds) is $-3418\,\text{kJ/mol}$. What is the resonance energy of benzene?

(A) 36 kJ/mol

(B) 150 kJ/mol

(C) 264 kJ/mol

(D) 418 kJ/mol

Q6. Which of the following statements **correctly** describes the effect of a catalyst on the equilibrium constant (K_c) of a reversible reaction?

(A) A catalyst increases the equilibrium constant K_c because it lowers the activation energy of the forward reaction only.

(B) A catalyst shifts the equilibrium position in the direction of the products, increasing the yield.

(C) A catalyst increases the rates of both the forward and reverse reactions equally, so K_c remains unchanged, but equilibrium is reached faster.

(D) A catalyst decreases the equilibrium constant K_c by stabilising the reactants.

Q7. The solubility product of $BaSO_4$ is $K_{sp} = 1.1 \times 10^{-10}$ at 298 K. The molar solubility of $BaSO_4$ in pure water is approximately 1.05×10^{-5} mol/L. What is the molar solubility of $BaSO_4$ in 0.1 M Na_2SO_4 solution (common ion effect)?

(A) 1.05×10^{-5} mol/L

(B) 3.3×10^{-6} mol/L

(C) 1.05×10^{-3} mol/L

(D) 1.1×10^{-9} mol/L

Q8. Which of the following statements **correctly** distinguishes a galvanic (voltaic) cell from an electrolytic cell?

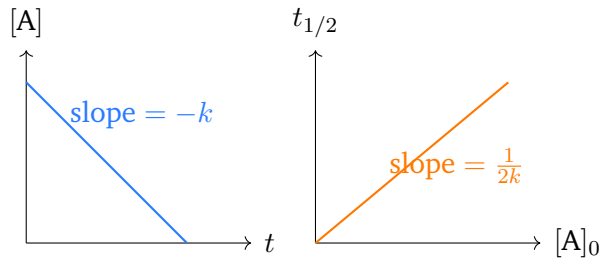
(A) In a galvanic cell, chemical energy is spontaneously converted to electrical energy ($\Delta G < 0$, $E^\circ_{\text{cell}} > 0$); in an electrolytic cell, electrical energy drives a non-spontaneous chemical reaction ($\Delta G > 0$).

(B) In a galvanic cell, electrical energy is converted to chemical energy; in an electrolytic cell, chemical energy is spontaneously converted to electrical energy.

(C) Both galvanic and electrolytic cells require an external power source to operate.

(D) In a galvanic cell, oxidation occurs at the cathode and reduction at the anode; in an electrolytic cell, the reverse is true.

Q9. Which of the following statements about a **zero-order** reaction is **correct**?



(i) [A] vs t for zero-order (ii) $t_{1/2}$ vs $[A]_0$ for zero-order

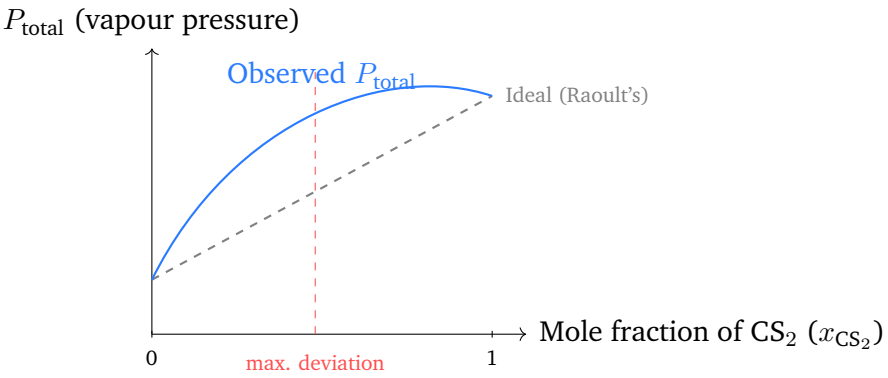
(A) The rate depends on the concentration of the reactant; higher concentration gives higher rate.

(B) The rate is independent of concentration; concentration decreases linearly with time, and the half-life is directly proportional to the initial concentration ($t_{1/2} = [A]_0/2k$).

(C) The half-life of a zero-order reaction is independent of initial concentration (constant $t_{1/2}$).

(D) The concentration vs. time plot is exponential for a zero-order reaction.

Q10. The mixture of acetone and carbon disulphide (CS_2) shows a **positive deviation** from Raoult's law. The vapour pressure vs. mole fraction diagram is shown schematically below. Which explanation is **correct**?



(A) The acetone–CS_2 interactions are *stronger* than pure-component interactions; molecules are held more tightly, reducing vapour pressure below ideal.

(B) The mixture shows positive deviation because CS_2 and acetone react chemically, forming a less volatile product.

(C) The acetone–CS_2 interactions are *weaker* than the acetone–acetone and CS_2–CS_2 interactions; molecules escape the liquid more easily than expected, giving a higher vapour pressure than ideal.

(D) Both components have the same intermolecular forces, so there is no deviation from Raoult's law.

Q11. Which of the following statements **correctly** distinguishes Frenkel defects from Schottky defects in ionic crystals?

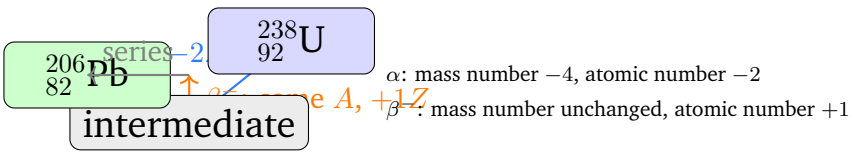
(A) Both Frenkel and Schottky defects lower the density of the crystal by creating vacancies at lattice sites.

(B) In a Frenkel defect, equal numbers of cation and anion vacancies are created; in a Schottky defect, only cation vacancies exist.

(C) Schottky defects are observed in crystals where the cation is much smaller than the anion; Frenkel defects occur in crystals with ions of similar size.

(D) In a Frenkel defect, a smaller ion (usually the cation) is displaced from its normal lattice site to an interstitial site, preserving electrical neutrality without changing overall density; in a Schottky defect, equal numbers of cation and anion vacancies are created, which lowers the density of the crystal.

Q12. The nucleus $^{238}_{92}$U decays by a series of α- and β^--particle emissions to ultimately reach the stable nucleus $^{206}_{82}$Pb. The decay process is illustrated schematically below. How many α-particles and β^--particles are emitted in the complete decay series?



(A) 8 α-particles and 6 β^--particles

(B) 6 α-particles and 8 β^--particles

(C) 8 α-particles and 4 β^--particles

(D) 4 α-particles and 6 β^--particles

Q13. The solubility of alkaline earth metal carbonates in water follows the order: $MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$ (solubility decreases down the group). Which of the following **correctly** explains this trend?

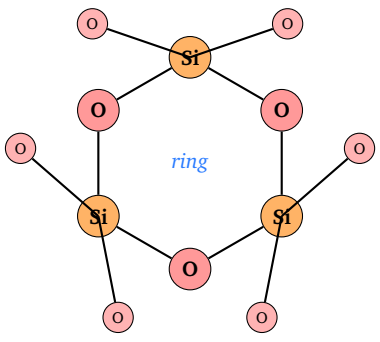
(A) As cation size increases down Group 2, the lattice energy decreases more than the hydration enthalpy, making the salts more soluble as you go down.

(B) As the cation size increases down Group 2, both the lattice energy and hydration enthalpy decrease, but the hydration enthalpy decreases more steeply; the relatively small hydration enthalpy of Ba^{2+} does not compensate the lattice energy, making $BaCO_3$ the least soluble.

(C) The solubility decreases because the molar mass increases down the group, making it harder for water molecules to dissolve the salt.

(D) The carbonate ion CO_3^{2-} forms a stronger bond with the lighter metal ions, making $MgCO_3$ least soluble and $BaCO_3$ most soluble.

Q14. Cyclic silicates contain ring-shaped silicate anions where SiO_4 tetrahedra share two oxygen atoms each with neighbouring tetrahedra. The structure of the cyclic silicate $[Si_3O_9]^{6-}$ is shown below. What is the Si : O ratio in a cyclic silicate?



$[Si_3O_9]^{6-}$ (cyclic silicate ring)

(A) $\text{Si} : \text{O} = 1 : 2$

(B) $\text{Si} : \text{O} = 1 : 2.5$

(C) $\text{Si} : \text{O} = 1 : 3$

(D) $\text{Si} : \text{O} = 1 : 4$

Q15. Xenon difluoride (XeF_2) is a linear molecule. Using VSEPR theory, the Xe atom in XeF_2 has 2 bond pairs and 3 lone pairs, giving a *trigonal bipyramidal* electron-pair geometry. Which statement about the structure of XeF_2 is **correct**?

(A) XeF_2 is bent with a F–Xe–F bond angle of approximately 120° because the lone pairs occupy axial positions.

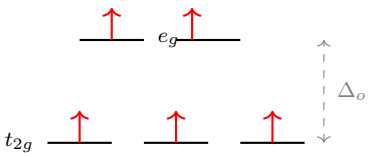
(B) XeF_2 is T-shaped because three lone pairs occupy equatorial positions and two bond pairs occupy axial positions.

(C) XeF_2 is trigonal bipyramidal with the F atoms at equatorial positions.

(D) XeF_2 is linear with a F–Xe–F bond angle of 180°, formed because the three lone pairs occupy the three equatorial positions in the trigonal bipyramidal electron-pair geometry, minimising lone-pair repulsion.

Q16. The Fe^{3+} ion has the electronic configuration $[Ar]3d^5$ with all five $3d$ electrons unpaired in the high-spin state. The spin-only magnetic moment is $\mu = \sqrt{n(n+2)}$ BM. What is the magnetic moment of Fe^{3+} in BM?

Fe^{3+} ($3d^5$, high spin) in octahedral field



(A) 5.92 BM

(B) 3.87 BM

(C) 4.90 BM

(D) 2.83 BM

Q17. In electrophilic aromatic substitution (EAS), the methyl group in toluene is an ortho/para director. When toluene is treated with a mixture of concentrated HNO_3 and H_2SO_4 (nitration), which of the following statements is **correct**?

(A) The methyl group deactivates the aromatic ring and directs the incoming NO_2^+ electrophile to the meta position.

(B) The methyl group activates the ring toward EAS and directs the incoming NO_2^+ electrophile preferentially to the ortho and para positions.

(C) Nitration of toluene is not possible because the methyl group blocks the electrophile.

(D) The methyl group is a meta director because it is an electron-donating group.

Q18. The Hoffmann bromamide (Hofmann) rearrangement involves the conversion of a primary amide ($RCONH_2$) to a primary amine (RNH_2) using Br_2 and NaOH. Which of the following statements about this reaction is **correct**?

(A) The Hoffmann rearrangement proceeds via a free radical mechanism and gives a product with the same number of carbon atoms as the starting amide.

(B) The nitrogen atom does not migrate in the Hoffmann rearrangement; instead, the carbon chain is shortened by decarboxylation.

(C) In the Hoffmann rearrangement, the nitrogen atom of the amide migrates to the carbonyl carbon to form an isocyanate intermediate, and the final amine has one fewer carbon atom than the original amide.

(D) The Hoffmann rearrangement gives a secondary amine as the major product by double alkylation.

Q19. Aniline ($C_6H_5NH_2$) is treated with $NaNO_2$ and HCl at 0–5°C to form benzene diazonium chloride ($C_6H_5N_2^+Cl^-$). Upon treatment of the diazo-

nium salt with CuCN, what is the major product?

(A) Chlorobenzene (C_6H_5Cl)

(B) Benzene (C_6H_6)

(C) Phenol (C_6H_5OH)

(D) Benzonitrile (C_6H_5CN)

Q20. When ethyl acetate ($CH_3COOC_2H_5$) is treated with sodium ethoxide (NaOEt, a strong base) and the reaction mixture is then acidified, which of the following is the major product?

(A) Ethyl 3-oxobutanoate (ethyl acetoacetate, $CH_3COCH_2COOC_2H_5$), formed by Claisen self-condensation.

(B) Acetic acid (CH_3COOH), formed by saponification.

(C) Diethyl ether ($C_2H_5OC_2H_5$), formed by Williamson synthesis.

(D) Acetaldehyde (CH_3CHO), formed by reduction of the ester.

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

Q21. Using the following thermodynamic data, calculate the magnitude (absolute value) of the lattice energy of NaCl in kJ/mol:

Quantity	Value (kJ/mol)
ΔH_f° (NaCl, s)	-411
Sublimation enthalpy of Na(s)	$+108$
First ionisation energy of Na(g)	$+496$
Bond dissociation energy: $\frac{1}{2}Cl_2(g) \rightarrow Cl(g)$	$+121$
Electron affinity of Cl(g)	-349

(Enter the exact numerical value as your answer.)

Q22. $^{226}_{88}$Ra decays to $^{206}_{82}$Pb by a series of α- and β^--particle emissions. Find the total number of α-particles and β^--particles emitted. Enter the **total** number of particles ($\alpha + \beta^-$).

(Enter the exact numerical value as your answer.)

Q23. When a current of 5 A is passed through molten NaCl for 9650 s, Cl_2 gas is liberated at the anode by the half-reaction: $2Cl^- \rightarrow Cl_2 + 2e^-$. Calculate the moles of Cl_2 produced $\times 100$. (Faraday constant $F = 96500$ C/mol)

(Enter the exact numerical value as your answer.)

Q24. Assuming complete dissociation, what is the van't Hoff factor (i) for $FeCl_3$ in aqueous solution? ($FeCl_3$ dissociates as: $FeCl_3 \rightarrow Fe^{3+} + 3\,Cl^-$)

(Enter the exact numerical value as your answer.)

Q25. For the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, the equilibrium constant $K_p = 1.78$ atm at 500 K. At a total pressure of $P = 1$ atm, the degree of dissociation α satisfies $K_p = \dfrac{\alpha^2 P}{1 - \alpha^2}$. Calculate $\alpha \times 100$ (round to the nearest integer).

(Enter the exact numerical value as your answer.)

Q26. Naphthalene ($C_{10}H_8$) consists of two fused benzene rings. How many π bonds are present in one molecule of naphthalene (considering the Kekulé structure with alternating single and double C–C bonds)?

(Enter the exact numerical value as your answer.)

Q27. The complex $[Fe(H_2O)_6]^{2+}$ has Fe^{2+} ($3d^6$) with H_2O as a weak-field ligand (high-spin configuration: $t_{2g}^4 e_g^2$). The crystal field stabilisation energy (CFSE) is calculated as:

$$\text{CFSE} = 4 \times (-0.4\,\Delta_o) + 2 \times (+0.6\,\Delta_o) = -0.4\,\Delta_o$$

Enter the value of the CFSE coefficient $\times 10$ (i.e., enter 4 if CFSE $= -0.4\,\Delta_o$).

(Enter the exact numerical value as your answer.)

Q28. An electron is accelerated through a potential difference of 100 V. Using the de Broglie relation $\lambda = \dfrac{h}{\sqrt{2meV}}$, calculate the wavelength λ in angstroms (Å) and enter the value $\lambda \times 100$ rounded to the nearest integer. (Given: $h = 6.626 \times 10^{-34}$ J·s, $m_e = 9.11 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C)

(Enter the exact numerical value as your answer.)

Q29. Benzene (C_6H_6) undergoes complete combustion according to:

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

For the combustion of 1 mol of C_6H_6, how many moles of O_2 are required? Enter the value $\times 2$.

(Enter the exact numerical value as your answer.)

Q30. How many σ (sigma) bonds are present in one molecule of ethyne (acetylene, HC≡CH)? Count all σ bonds including C–H and C–C.

(Enter the exact numerical value as your answer.)

Detailed Solutions

Q1.

Solution

Concept — Heisenberg Uncertainty Principle: The principle states that the product of uncertainties in position (Δx) and momentum (Δp) cannot be less than $h/(4\pi)$:

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

Since $\Delta p = m_e \cdot \Delta v$, the minimum uncertainty in velocity is:

$$\Delta v_{\text{min}} = \frac{h}{4\pi \cdot m_e \cdot \Delta x}$$

Step 1 — Substitute values:

$$\Delta v_{\text{min}} = \frac{6.626 \times 10^{-34}}{4\pi \times 9.11 \times 10^{-31} \times 1 \times 10^{-10}}$$

$$= \frac{6.626 \times 10^{-34}}{4 \times 3.1416 \times 9.11 \times 10^{-31} \times 10^{-10}}$$

$$= \frac{6.626 \times 10^{-34}}{1.145 \times 10^{-39}} \approx 5.79 \times 10^{5}\ \text{m/s}$$

Why other options are wrong:

- Option A (5.8×10^{3} m/s): This is 10^{2} times too small; likely from forgetting that $\Delta x = 10^{-10}$ m (not 10^{-8} m).
- Option C (1.6×10^{5} m/s): Approximately one-quarter of the correct value; may arise from using $\Delta x \cdot \Delta p \geq h/(2\pi)$ instead of $h/(4\pi)$ and further arithmetic error.
- Option D (2.3×10^{6} m/s): About 4 times the correct value; results from using $\Delta x \cdot \Delta v \geq h/(m_e)$ without the 4π factor.

Final Answer: $\Delta v_{\text{min}} \approx 5.8 \times 10^{5}$ m/s $\Rightarrow$ $\boxed{5.8 \times 10^{5}\ \text{m/s}}$

Answer: (B) Go Back to Q#1

Q2.

Solution

Concept — Molecular Orbital Theory for O_2 and O_2^-: The MO configuration of O_2 (16 electrons) is:

$$(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi^*_{2p})^2$$

Bond order of $O_2 = (8-4)/2 = 2$; two unpaired electrons in π^*_{2p} (paramagnetic).

Step 1 — O_2^- (superoxide): add one electron to π^*_{2p}:

$$(\pi^*_{2p})^3 \Rightarrow \text{bonding electrons} = 8, \quad \text{antibonding electrons} = 5$$

$$\text{Bond order} = \frac{8-5}{2} = \frac{3}{2} = 1.5$$

Step 2 — Magnetic character: The π^*_{2p} orbital now has 3 electrons (2 paired + 1 unpaired). There is still 1 unpaired electron, so O_2^- is **paramagnetic**.

Why other options are wrong:

- Option A (BO = 2, diamagnetic): This would be neutral O_2 without the extra electron; also wrong because O_2 itself is paramagnetic.
- Option B (BO = 2, paramagnetic): Incorrect bond order; adding an electron to an antibonding MO decreases bond order from 2 to 1.5.
- Option D (BO = 1, diamagnetic): Bond order 1 would require removing yet another electron from bonding MOs, and O_2^- does have one unpaired electron.

Final Answer: Bond order of O_2^- is 1.5 and it is paramagnetic $\Rightarrow$ Option C

Answer: (C) Go Back to Q#2

Q3.

Solution

Concept — Joule-Thomson Effect: When a real gas expands through a throttle (porous plug) under adiabatic conditions, its temperature changes. The Joule-Thomson coefficient is $\mu_{JT} = (\partial T/\partial P)_H$. For an ideal gas, $\mu_{JT} = 0$ (no temperature change). For real gases:

- Below the inversion temperature: $\mu_{JT} > 0$ (gas *cools* on expansion).
- Above the inversion temperature: $\mu_{JT} < 0$ (gas *heats up* on expansion).

Step 1 — Application to liquefaction: Gases like H_2 (inversion temp $\approx 202\,K$) and He (inversion temp $\approx 40\,K$) have very low inversion temperatures. At room temperature (300 K), both are *above* their inversion temperatures, so a simple JT expansion would heat them, not cool them. They must be **precooled below their inversion temperatures** before the JT effect causes cooling.

Why other options are wrong:

- Option A: For an ideal gas, $\mu_{JT} = 0$, *not* greater than 0; there is no temperature change at all.
- Option B: Real gases *above* the inversion temperature actually *warm up* (not cool) upon JT expansion.
- Option C: The JT process is *isenthalpic* (constant enthalpy), not isobaric; pressure *does* change across the plug.

Final Answer: H_2 and He must be precooled below their inversion temperatures for the JT effect to cause cooling $\Rightarrow$ Option D

Answer: (D) Go Back to Q#3

Q4.

Solution

Concept — Born-Haber Cycle: Hess's law applied to ionic crystal formation allows the lattice energy to be calculated from experimentally measurable quantities:

$$\Delta H_f^\circ = \Delta H_{\text{sub}} + \text{IE} + \tfrac{1}{2}D + \text{EA} + U$$

Rearranging to solve for lattice energy U:

$$U = \Delta H_f^\circ - \Delta H_{\text{sub}} - \text{IE} - \tfrac{1}{2}D - \text{EA}$$

Step 1 — Substitute values:

$$U = (-411) - (108) - (496) - (121) - (-349)$$

$$U = -411 - 108 - 496 - 121 + 349$$

$$U = -(411 + 108 + 496 + 121) + 349 = -1136 + 349 = \mathbf{-787}\,\text{kJ/mol}$$

Why other options are wrong:

- Option B (-411 kJ/mol): This is ΔH_f°, not the lattice energy.

- Option C (-598 kJ/mol): Arises from forgetting the IE or another term.
- Option D ($+787$ kJ/mol): Correct magnitude but wrong sign; lattice energy of NaCl is exothermic (crystal is stabilised when ions combine), hence negative.

Final Answer: Lattice energy of NaCl $= -787$ kJ/mol $\Rightarrow \boxed{-787\,\text{kJ/mol}}$

Answer: (A) Go Back to Q#4

Q5.

Solution

Concept — Resonance Energy: The resonance energy of benzene is the difference between the calculated (theoretical, Kekulé) enthalpy of combustion and the experimentally measured value. The real benzene is more stable than the hypothetical Kekulé structure due to delocalisation of π electrons.

Step 1 — Calculate resonance energy:

$$\text{Resonance energy} = |\Delta H_{\text{combustion (Kekulé)}}| - |\Delta H_{\text{combustion (actual)}}|$$

$$= |-3418| - |-3268| = 3418 - 3268 = \mathbf{150}\,\text{kJ/mol}$$

The negative sign convention: the actual combustion releases *less* energy (3268 kJ/mol) than the hypothetical structure (3418 kJ/mol) because benzene is *more stable* (lower energy) than the Kekulé structure. The extra stability is the resonance energy.

Why other options are wrong:

- Option A (36 kJ/mol): This is far too small and does not correspond to any standard calculation for benzene.
- Option C (264 kJ/mol): This is roughly $3268 - 3004$; the value 3004 does not match standard data.
- Option D (418 kJ/mol): This approaches the value of ΔH_f°(benzene) not the resonance energy.

Final Answer: Resonance energy of benzene $= 150$ kJ/mol $\Rightarrow \boxed{150\,\text{kJ/mol}}$

Answer: (B) Go Back to Q#5

Q6.

Solution

Concept — Catalyst and Equilibrium Constant: A catalyst provides an alternative reaction pathway with a lower activation energy. It speeds up *both* the forward and reverse reactions by exactly the same factor. Therefore:

- K_c is **unchanged** — because $K_c = k_f/k_r$, and both k_f and k_r increase by the same factor.
- Equilibrium is reached **faster** (shorter time to reach the same equilibrium position).
- The equilibrium **position** (concentrations at equilibrium) is the same.

Why other options are wrong:

- Option A: A catalyst lowers activation energy of *both* forward and reverse reactions equally; K_c is not increased.
- Option B: A catalyst does not shift the equilibrium position; the same equilibrium concentrations are attained, just more quickly.
- Option D: A catalyst does not decrease K_c; it has no effect on the thermodynamics, only the kinetics.

Final Answer: Catalyst increases rate of both reactions equally; K_c is unchanged but equilibrium is reached faster $\Rightarrow$ Option C

Answer: (C) Go Back to Q#6

Q7.

Solution

Concept — Common Ion Effect on Solubility: When $BaSO_4$ dissolves in a solution already containing SO_4^{2-} (from Na_2SO_4), the common ion suppresses dissolution. Let molar solubility in 0.1 M Na_2SO_4 be s mol/L. Then:

$$[Ba^{2+}] = s, \quad [SO_4^{2-}] = 0.1 + s \approx 0.1 \quad (\text{since } s \ll 0.1)$$

$$K_{sp} = [Ba^{2+}][SO_4^{2-}] = s \times 0.1 = 1.1 \times 10^{-10}$$

Step 1 — Solve for s:

$$s = \frac{1.1 \times 10^{-10}}{0.1} = 1.1 \times 10^{-9}\ \text{mol/L}$$

This is $\approx 10^4$ times smaller than solubility in pure water (1.05×10^{-5} mol/L), demonstrating the strong common ion suppression.

Why other options are wrong:

- Option A (1.05×10^{-5} mol/L): This is the solubility in pure water; it ignores the common ion effect.
- Option B (3.3×10^{-6} mol/L): This results from $\sqrt{K_{sp}}$ calculation, treating it as if there is no common ion.
- Option C (1.05×10^{-3} mol/L): Far too large; larger than solubility in pure water, which contradicts the common ion effect.

Final Answer: Molar solubility of $BaSO_4$ in 0.1 M $Na_2SO_4 = 1.1 \times 10^{-9}$ mol/L $\Rightarrow$ $\boxed{1.1 \times 10^{-9} \text{ mol/L}}$

Answer: (D) Go Back to Q#7

Q8.

Solution

Concept — Galvanic vs Electrolytic Cell: The fundamental distinction lies in the spontaneity of the cell reaction:

- **Galvanic (voltaic) cell:** The cell reaction is *spontaneous* ($\Delta G < 0$, $E^\circ_{\text{cell}} > 0$). Chemical energy is converted to electrical energy. No external power source is needed.
- **Electrolytic cell:** The reaction is *non-spontaneous* ($\Delta G > 0$, $E_{\text{cell}} < 0$). An external power source must supply electrical energy to drive the reaction.

Why other options are wrong:

- Option B: This reverses the definitions; in a galvanic cell, chemical energy is spontaneously converted to electrical energy (not the reverse).
- Option C: Galvanic cells do *not* require an external power source; only electrolytic cells do.
- Option D: In a galvanic cell, oxidation always occurs at the *anode* and reduction at the *cathode*; this convention is the same for both cell types.

Final Answer: Galvanic cell: chemical $\rightarrow$ electrical energy spontaneously; Electrolytic cell: electrical energy drives non-spontaneous reaction $\Rightarrow$ $\boxed{\text{Option A}}$

Answer: (A) Go Back to Q#8

Q9.

Solution

Concept — Zero-Order Reactions: For a zero-order reaction A $\rightarrow$ products:

$$[\mathrm{A}] = [\mathrm{A}]_0 - kt$$

Key features:

- Rate $= k$ (constant; independent of [A]).
- Concentration decreases *linearly* with time.
- Half-life: $t_{1/2} = \dfrac{[\mathrm{A}]_0}{2k}$ (directly proportional to initial concentration).

Why other options are wrong:

- Option A: Zero-order reactions have *rate* $= k$ (constant), independent of reactant concentration. Higher concentration does *not* give a higher rate.
- Option C: A constant $t_{1/2}$ is the hallmark of *first-order* reactions, not zero-order. For zero-order, $t_{1/2}$ depends on $[\mathrm{A}]_0$.
- Option D: An exponential [A] vs. t curve is characteristic of *first-order* reactions; for zero-order it is a straight line.

Final Answer: Zero-order reaction: rate is constant; [A] decreases linearly; $t_{1/2} = [\mathrm{A}]_0/(2k) \Rightarrow$ Option B

Answer: (B) Go Back to Q#9

Q10.

Solution

Concept — Positive Deviation from Raoult's Law: Raoult's law holds for ideal solutions where solute–solvent interactions equal solute–solute and solvent–solvent interactions. Positive deviation occurs when:

- Solute–solvent (A–B) interactions are **weaker** than A–A and B–B interactions.
- Molecules escape the liquid phase more easily $\Rightarrow$ actual vapour pressure $>$ ideal (Raoult's) prediction.

For acetone–CS_2: In pure acetone, there are strong dipole–dipole interactions. In pure CS_2, London dispersion forces dominate. When mixed, acetone–CS_2 interactions are weaker than either pure-component interaction. Molecules leave the

solution more easily than predicted by Raoult's law $\Rightarrow$ observed vapour pressure is **higher** than ideal.

Why other options are wrong:

- Option A: If A–B interactions were *stronger* than pure-component interactions, molecules would be held more tightly, giving *negative* deviation from Raoult's law, not positive.
- Option B: Acetone and CS_2 do not react chemically to form a new compound.
- Option D: If both components had the same intermolecular forces, the solution would be ideal (zero deviation from Raoult's law).

Final Answer: A–B interactions are weaker; vapour pressure is higher than ideal (positive deviation) $\Rightarrow$ Option C

Answer: (C) Go Back to Q#10

Q11.

Solution

Concept — Crystal Defects (Frenkel and Schottky):

Frenkel Defect: A smaller ion (usually the cation) *leaves* its lattice site and occupies an *interstitial* position. The lattice site is vacant, but the ion is still within the crystal. Electrical neutrality is maintained. Because no atom actually leaves the crystal, the *overall density remains unchanged*. Example: AgCl, AgBr, ZnS.

Schottky Defect: *Equal numbers* of cations and anions are completely absent from their lattice positions (creating paired vacancies). Electrical neutrality is maintained. Since atoms actually leave the crystal, the *density decreases*. Example: NaCl, KCl, CsCl.

Why other options are wrong:

- Option A: Only Schottky defects lower density; Frenkel defects do *not* change density because the displaced ion stays in the crystal.
- Option B: This reverses the definitions; equal cation–anion vacancies characterise the *Schottky* defect, not Frenkel.
- Option C: Frenkel defects occur in crystals with a large *difference* in cation and anion sizes (small cation), not in crystals with similar-sized ions. Schottky defects occur in crystals where ions are of similar size and comparable numbers.

Final Answer: Frenkel: cation displaced to interstitial site, density unchanged;

Schottky: paired vacancies, density decreases $\Rightarrow$ Option D

Answer: (D) Go Back to Q#11

Q12.

Solution

Concept — Radioactive Decay Series: In α-decay, the mass number decreases by 4 and the atomic number decreases by 2. In β^--decay, the mass number is unchanged and the atomic number increases by 1.

Step 1 — Count α-particles from mass number change:

$$\text{Mass decrease} = 238 - 206 = 32$$

Each α-particle removes 4 mass units:

$$n_\alpha = \frac{32}{4} = 8 \quad \alpha\text{-particles}$$

Step 2 — Count β^--particles from atomic number balance: After 8 α-decays, the atomic number would be $92 - 8 \times 2 = 92 - 16 = 76$. The final atomic number of Pb is 82. Each β^--decay increases the atomic number by 1:

$$n_\beta = 82 - 76 = 6 \quad \beta^-\text{-particles}$$

Why other options are wrong:

- Option B (6α, $8\beta^-$): With 6 α-particles, mass decrease $= 24$; final mass $= 238 - 24 = 214 \neq 206$.
- Option C (8α, $4\beta^-$): With 8α and $4\beta^-$: final $Z = 92 - 16 + 4 = 80 \neq 82$ (Pb).
- Option D (4α, $6\beta^-$): Mass decrease $= 16$; final mass $= 222 \neq 206$.

Final Answer: 8 α-particles and 6 β^--particles $\Rightarrow$ 8 α-particles and 6 β^--particles

Answer: (A) Go Back to Q#12

Q13.

Solution

Concept — Solubility of Alkaline Earth Carbonates (Group 2): The solubility of any ionic salt depends on the competition between lattice energy (which opposes dissolution) and hydration enthalpy (which favours dissolution):

$$\Delta H_{\text{sol}} = \Delta H_{\text{lattice}} + \Delta H_{\text{hydration}}$$

(Using the sign convention where lattice energy is the energy needed to separate ions from the crystal, which is positive, and hydration enthalpy is the energy released when ions are hydrated, which is negative.)

Trend down Group 2:

- As cation size increases ($Mg^{2+} < Ca^{2+} < Sr^{2+} < Ba^{2+}$), **both** lattice energy and hydration enthalpy decrease.
- Hydration enthalpy decreases *more steeply* than lattice energy (because hydration enthalpy is very sensitive to ionic size: $\Delta H_{\text{hyd}} \propto 1/r$).
- The net result: $|\Delta H_{\text{hyd}}|$ decreases more than $|\Delta H_{\text{lattice}}|$, so dissolution becomes *less* favourable down the group.
- $BaCO_3$ is the *least* soluble because Ba^{2+} has the smallest hydration enthalpy (largest ion) which cannot compensate the lattice energy.

Why other options are wrong:

- Option A: The statement contradicts the observed trend; if lattice energy decreased more than hydration enthalpy, solubility would *increase* down the group.
- Option C: Solubility is determined by thermodynamics (ΔG of dissolution), not directly by molar mass.
- Option D: This is backward; it is $MgCO_3$ that is most soluble (Mg^{2+} has highest hydration enthalpy), not least soluble.

Final Answer: Hydration enthalpy decreases more steeply than lattice energy; $BaCO_3$ is least soluble $\Rightarrow$ Option B

Answer: (B) Go Back to Q#13

Q14.

Solution

Concept — Si:O Ratio in Cyclic Silicates: In a cyclic silicate, SiO_4 tetrahedra are linked in a ring by sharing *two* oxygen atoms each. For a ring of n SiO_4 units:

- Each Si shares 2 bridging O atoms (each shared between 2 Si atoms).
- Each Si also has 2 terminal (non-bridging) O atoms.
- Per Si: $2 \times \frac{1}{2}(\text{shared}) + 2 \times 1(\text{terminal}) = 1 + 2 = 3$ oxygen atoms.

$$\text{Si : O ratio} = 1 : 3$$

Verification with $[Si_3O_9]^{6-}$: 3 Si atoms in the ring: 3 bridging O (each shared between 2 Si, contributing $\frac{1}{2}$ each to the formula per ring) + 6 terminal O. In the formula: 3 bridging O $\times 2 = 6$ O shared, contributing $6/2 = 3$ O to the anion; plus $3 \times 2 = 6$ terminal O. Total O per anion $= 3 + 6 = 9$ O for 3 Si. Ratio $= 3 : 9 = 1 : 3$. ✓

Why other options are wrong:

- Option A (1:2): This ratio applies to *sheet silicates* (phyllosilicates), where each SiO_4 shares 3 oxygen atoms.
- Option B (1:2.5): This is the ratio for *double-chain* (amphibole) silicates, where each Si shares 2.5 O on average (alternating sharing of 2 and 3).
- Option D (1:4): This is the ratio for an isolated SiO_4^{4-} tetrahedron (orthosilicate/nesosilicate), with no sharing.

Final Answer: Si : O $= 1 : 3$ in cyclic silicates $\Rightarrow$ Option C

Answer: (C) Go Back to Q#14

Q15.

Solution

Concept — Structure of XeF_2 using VSEPR: Xe in XeF_2 has 8 valence electrons. After forming 2 bonds with F, it retains $8 - 2 = 6$ non-bonding electrons $= 3$ lone pairs. Total electron pairs $= 2 + 3 = 5 \Rightarrow$ trigonal bipyramidal electron-pair geometry.

Step 1 — Placement of lone pairs: In a trigonal bipyramidal arrangement, **lone pairs prefer equatorial positions** (more space; 120° separation from each other vs. 90° in axial). With 3 lone pairs, all three occupy the three equatorial positions.

Step 2 — Molecular geometry: The two F atoms occupy the two **axial** positions. With F–Xe–F along the axial axis, the bond angle is $180°$. The molecule is **linear**.

Why other options are wrong:

- Option A (bent, $120°$): If lone pairs were in axial positions, the F atoms would be equatorial at $120°$ apart, but lone pairs preferentially occupy equatorial positions.
- Option B (T-shaped): T-shaped geometry arises when there are *2* lone pairs in equatorial positions and 1 bond pair in equatorial + 2 in axial (e.g., ClF_3). XeF_2 has 3 equatorial lone pairs.
- Option C (trigonal bipyramidal): This describes the electron-pair geometry, not the molecular geometry; XeF_2 is *linear* (based on positions of atoms only).

Final Answer: XeF_2 is linear with F–Xe–F bond angle $= 180° \Rightarrow$ Option D

Answer: (D) Go Back to Q#15

Q16.

Solution

Concept — Magnetic Moment using Spin-Only Formula: For transition metal ions, the spin-only magnetic moment is:

$$\mu = \sqrt{n(n+2)}\,\text{BM}$$

where n = number of unpaired electrons.

Step 1 — Electron configuration of Fe^{3+}:

$$\text{Fe} : [\text{Ar}]\,3d^6 4s^2 \xrightarrow{-3e^-} \text{Fe}^{3+} : [\text{Ar}]\,3d^5$$

In a high-spin octahedral field (weak field ligand or free ion), all 5 $3d$ orbitals are singly occupied (by Hund's rule): $t_{2g}^3 e_g^2$ with $n = 5$ unpaired electrons.

Step 2 — Calculate magnetic moment:

$$\mu = \sqrt{5(5+2)} = \sqrt{5 \times 7} = \sqrt{35} \approx 5.92\,\text{BM}$$

Why other options are wrong:

- Option B (3.87 BM): Corresponds to $n = 3$ ($\sqrt{3 \times 5} = \sqrt{15} \approx 3.87$ BM); e.g.,

Cr^{3+} with $3d^3$.

- Option C (4.90 BM): Corresponds to $n = 4$ ($\sqrt{4 \times 6} = \sqrt{24} \approx 4.90$ BM); e.g., Fe^{2+} with $3d^6$ in high spin ($t_{2g}^4 e_g^2$, 4 unpaired).
- Option D (2.83 BM): Corresponds to $n = 2$ ($\sqrt{2 \times 4} = \sqrt{8} \approx 2.83$ BM); e.g., Ni^{2+} with $3d^8$.

Final Answer: Magnetic moment of Fe^{3+} ($3d^5$, 5 unpaired electrons) $= \sqrt{35} \approx 5.92$ BM $\Rightarrow$ $\boxed{5.92\,\text{BM}}$

Answer: (A) Go Back to Q#16

Q17.

Solution

Concept — Electrophilic Aromatic Substitution (EAS) and Directing Groups: Substituents on an aromatic ring affect both the rate and position of electrophilic attack:

- **Electron-donating groups (EDG)** like $-CH_3$: *activate* the ring (increase rate of EAS) and direct electrophiles to the *ortho* and *para* positions.
- **Electron-withdrawing groups (EWG)** like $-NO_2$, $-COOH$: *deactivate* the ring and direct to *meta*.

For toluene nitration: The methyl group is an EDG via hyperconjugation and inductive electron donation. It activates the ring toward EAS (toluene reacts faster than benzene). The positive charge in the arenium ion intermediate is best stabilised at the ortho and para positions when methyl is present. Product distribution: $\sim 58\%$ ortho, $\sim 38\%$ para, $\sim 4\%$ meta.

Why other options are wrong:

- Option A: The methyl group *activates* the ring (not deactivates) and does *not* direct to meta.
- Option C: Nitration of toluene is a well-known reaction; methyl group does not block the electrophile.
- Option D: The methyl group is an *ortho/para* director, not meta; meta direction requires EWG.

Final Answer: Methyl group activates ring, directs NO_2^+ to ortho/para positions $\Rightarrow$ $\boxed{\text{Option B}}$

Answer: (B) Go Back to Q#17

Q18.

Solution

Concept — Hoffmann Bromamide Rearrangement: The Hoffmann rearrangement converts a primary amide ($RCONH_2$) to a primary amine (RNH_2) using Br_2/NaOH. The key steps are:

Mechanism outline:

(a) $RCONH_2 + Br_2/NaOH \rightarrow RCONHBr$ (N-bromamide)
(b) Base removes N-H: $RCON^-Br$
(c) **1,2-Nitrene rearrangement:** The nitrogen migrates to the carbonyl carbon with loss of Br^-, forming an **isocyanate** intermediate (RNCO).
(d) Hydrolysis of isocyanate: $RNCO + H_2O \rightarrow RNH_2 + CO_2$

The product amine RNH_2 has **one fewer carbon atom** than the starting amide $RCONH_2$ (the carbonyl carbon is lost as CO_2).

Why other options are wrong:

- Option A: The mechanism is not free radical; it involves an ionic/concerted rearrangement. The product has *fewer* carbons than the amide.
- Option B: In the Hoffmann rearrangement, nitrogen *does* migrate; the mechanism is fundamentally a 1,2-N to C rearrangement via an isocyanate.
- Option D: The product is always a *primary* amine (RNH_2), not secondary. No double alkylation occurs.

Final Answer: N migrates to carbonyl C forming isocyanate; amine product has one fewer carbon $\Rightarrow$ Option C

Answer: (C) Go Back to Q#18

Q19.

Solution

Concept — Sandmeyer Reaction: The Sandmeyer reaction involves the reaction of a diazonium salt with a cuprous (Cu^+) salt to introduce a substituent in place of the diazonium group ($-N_2^+$).

Reaction sequence:

(a) **Diazotization:**

$$C_6H_5NH_2 + NaNO_2 + HCl \xrightarrow{0\text{–}5^\circ C} C_6H_5N_2^+Cl^- + NaCl + H_2O$$

(b) **Sandmeyer reaction with CuCN:**

$$C_6H_5N_2^+Cl^- + CuCN \rightarrow C_6H_5CN + N_2 + CuCl$$

The CN^- nucleophile replaces the diazonium group to give **benzonitrile**.

Why other options are wrong:

- Option A (chlorobenzene): Chlorobenzene is obtained using CuCl (Sandmeyer), not CuCN.
- Option B (benzene): Benzene is obtained by reducing the diazonium salt with H_3PO_2 (hypophosphorous acid), not CuCN.
- Option C (phenol): Phenol is obtained by warming the diazonium salt with water or steam; not with CuCN.

Final Answer: CuCN replaces $-N_2^+$ to give benzonitrile $C_6H_5CN \Rightarrow$ C_6H_5CN (Option D)

Answer: (D) Go Back to Q#19

Q20.

Solution

Concept — Claisen Condensation: The Claisen condensation is the base-catalyzed self-condensation of an ester bearing α-hydrogens. With a strong alkoxide base (NaOEt), an α-hydrogen of one ester molecule is removed to form an enolate. The enolate attacks the carbonyl carbon of a second ester molecule, followed by elimination of alkoxide.

Mechanism outline for ethyl acetate:

(a) NaOEt deprotonates α-C of $CH_3COOC_2H_5 \rightarrow$ enolate: $^-CH_2COOC_2H_5$.
(b) Enolate attacks carbonyl C of another $CH_3COOC_2H_5 \rightarrow$ tetrahedral intermediate.
(c) EtO^- is expelled $\rightarrow \beta$-keto ester: $CH_3CO\mathbf{CH_2}COOC_2H_5$ (ethyl acetoacetate).
(d) Acidification $\rightarrow$ protonation of the enolate gives ethyl 3-oxobutanoate (ethyl acetoacetate).

$$2\,CH_3COOC_2H_5 \xrightarrow{\text{NaOEt, then } H^+} CH_3COCH_2COOC_2H_5 + C_2H_5OH$$

Why other options are wrong:

- Option B (acetic acid): Saponification requires aqueous NaOH (base hydrolysis); NaOEt in anhydrous conditions promotes Claisen condensation, not

hydrolysis.

- Option C (diethyl ether): Williamson ether synthesis requires an alkoxide and an alkyl halide; no ether is formed here.
- Option D (acetaldehyde): Reduction of ester requires a reducing agent such as $LiAlH_4$; NaOEt is a base, not a reductant.

Final Answer: Self-Claisen condensation of ethyl acetate gives ethyl acetoacetate $\Rightarrow \boxed{CH_3COCH_2COOC_2H_5}$ (Option A)

Answer: (A) Go Back to Q#20

Q21.

Solution

Concept — Born-Haber Cycle (Lattice Energy): Using Hess's law:

$$\Delta H_f^\circ = \Delta H_{\text{sub}} + \text{IE} + \tfrac{1}{2}D + \text{EA} + U$$

$$U = \Delta H_f^\circ - \Delta H_{\text{sub}} - \text{IE} - \tfrac{1}{2}D - \text{EA}$$

Step 1 — Substitute:

$$U = (-411) - (108) - (496) - (121) - (-349)$$

$$U = -411 - 108 - 496 - 121 + 349 = -787\,\text{kJ/mol}$$

Step 2 — Magnitude:

$$|U| = \boxed{787}$$

Answer: (787) Go Back to Q#21

Q22.

Solution

Concept — Radioactive Decay Counting: $^{226}_{88}\text{Ra} \rightarrow {}^{206}_{82}\text{Pb}$.

Step 1 — Count α-particles (from mass change):

$$226 - 206 = 20 \Rightarrow n_\alpha = \frac{20}{4} = 5$$

Step 2 — Count β^--particles (from atomic number balance):

After 5 α-decays: $Z = 88 - 5 \times 2 = 88 - 10 = 78$.

Final Z of Pb $= 82$.

$$n_\beta = 82 - 78 = 4$$

Step 3 — Total particles:

$$\text{Total} = n_\alpha + n_\beta = 5 + 4 = \boxed{9}$$

Answer: (9) Go Back to Q#22

Q23.

Solution

Concept — Electrolysis (Faraday's First Law):

Step 1 — Total charge passed:

$$Q = I \times t = 5\,\text{A} \times 9650\,\text{s} = 48250\,\text{C}$$

Step 2 — Moles of electrons transferred:

$$n_{e^-} = \frac{Q}{F} = \frac{48250}{96500} = 0.5\,\text{mol}$$

Step 3 — Moles of Cl_2 at anode: Half-reaction: $2Cl^- \rightarrow Cl_2 + 2e^-$

2 moles of electrons produce 1 mole of Cl_2:

$$n_{Cl_2} = \frac{0.5}{2} = 0.25\,\text{mol}$$

Step 4 — Enter value $\times 100$:

$$0.25 \times 100 = \boxed{25}$$

Answer: (25) Go Back to Q#23

Q24.

Solution

Concept — van't Hoff Factor (i): For a strong electrolyte that dissociates completely, the van't Hoff factor i equals the total number of ions produced per formula unit.

Step 1 — Dissociation of $FeCl_3$:

$$FeCl_3 \rightarrow Fe^{3+} + 3\,Cl^-$$

Number of ions produced $= 1 + 3 = 4$.

Step 2 — van't Hoff factor:

$$i = 1 + (n-1)\alpha$$

For complete dissociation ($\alpha = 1$) and $n = 4$ particles:

$$i = 1 + (4-1) \times 1 = 1 + 3 = \boxed{4}$$

Answer: (4) Go Back to Q#24

Q25.

Solution

Concept — Degree of Dissociation from K_p: For $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ with degree of dissociation α at total pressure P:

$$K_p = \frac{\alpha^2 P}{1-\alpha^2}$$

Step 1 — Substitute $K_p = 1.78$ atm, $P = 1$ atm:

$$1.78 = \frac{\alpha^2 \times 1}{1-\alpha^2}$$

$$1.78(1-\alpha^2) = \alpha^2$$

$$1.78 - 1.78\alpha^2 = \alpha^2$$

$$1.78 = \alpha^2(1 + 1.78) = 2.78\,\alpha^2$$

$$\alpha^2 = \frac{1.78}{2.78} = 0.6403 \Rightarrow \alpha = \sqrt{0.6403} \approx 0.800$$

Step 2 — Enter $\alpha \times 100$:

$$\alpha \times 100 = 0.800 \times 100 = \boxed{80}$$

Answer: (80) Go Back to Q#25

Q26.

Solution

Concept — π Bonds in Naphthalene: Naphthalene ($C_{10}H_8$) is a polycyclic aromatic hydrocarbon consisting of two fused benzene rings. In a Kekulé structure of naphthalene, the π bonds (C=C double bonds) are drawn as alternating:

Step 1 — Count C=C double bonds in Kekulé structure:

Naphthalene has 10 carbon atoms and 8 hydrogen atoms. It has 7 C–C single bonds and 5 C=C double bonds in the Kekulé representation. Total π bonds $= 5$.

Alternatively: Degree of unsaturation $= (2 \times 10 + 2 - 8)/2 = 7$. Of these, 2 are from the rings (cyclic structure), and 5 are π bonds. (In naphthalene, 7 degrees of unsaturation: 2 rings each count as 1 from the ring closure, plus 5 double bonds $= 7$. ✓)

Step 2 — Answer:

$$\text{Number of } \pi \text{ bonds} = \boxed{5}$$

Answer: (5) Go Back to Q#26

Q27.

Solution

Concept — Crystal Field Stabilisation Energy (CFSE): For a d^6 high-spin complex in an octahedral field, the electron configuration is $t_{2g}^4 e_g^2$.

Step 1 — Calculate CFSE:

$$\text{CFSE} = 4 \times (-0.4\,\Delta_o) + 2 \times (+0.6\,\Delta_o) = -1.6\,\Delta_o + 1.2\,\Delta_o = -0.4\,\Delta_o$$

Step 2 — Enter coefficient $\times 10$: CFSE coefficient $= 0.4$.

$$0.4 \times 10 = \boxed{4}$$

(CFSE of $[Fe(H_2O)_6]^{2+} = -0.4\,\Delta_o$; if $\Delta_o = 10000\,\text{cm}^{-1}$, CFSE $= -4000\,\text{cm}^{-1}$.)

Answer: (4) Go Back to Q#27

Q28.

Solution

Concept — de Broglie Wavelength of Accelerated Electron: An electron accelerated through potential difference V acquires kinetic energy eV:

$$\lambda = \frac{h}{\sqrt{2m_e eV}}$$

Step 1 — Substitute values ($V = 100\,\text{V}$):

$$2m_e eV = 2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19} \times 100$$

$$= 2 \times 9.11 \times 1.6 \times 10^{-31-19+2} = 2 \times 14.576 \times 10^{-48} = 29.152 \times 10^{-48}$$

$$\sqrt{29.152 \times 10^{-48}} = \sqrt{29.152} \times 10^{-24} = 5.399 \times 10^{-24}\,\text{kg} \cdot \text{m/s}$$

Step 2 — Calculate λ:

$$\lambda = \frac{6.626 \times 10^{-34}}{5.399 \times 10^{-24}} = 1.227 \times 10^{-10}\,\text{m} = 1.227\,\text{Å}$$

Step 3 — Enter $\lambda \times 100$ (in Å):

$$1.227 \times 100 = 122.7 \approx \boxed{123}$$

Answer: (123) Go Back to Q#28

Q29.

Solution

Concept — Stoichiometry of Benzene Combustion:

Balanced equation:

$$\text{C}_6\text{H}_6 + \frac{15}{2}\,\text{O}_2 \rightarrow 6\,\text{CO}_2 + 3\,\text{H}_2\text{O}$$

Step 1 — Moles of O_2 per mole of C_6H_6:

$$n(\text{O}_2) = \frac{15}{2} = 7.5\,\text{mol}$$

Step 2 — Enter value $\times 2$:

$$7.5 \times 2 = \boxed{15}$$

Answer: (15) Go Back to Q#29

Q30.

Solution

Concept — Sigma Bonds in Ethyne (HC≡CH):

Step 1 — Identify all bonds in HC≡CH:

- H–C bond (left): 1 σ bond
- C≡C triple bond: consists of 1 σ bond + 2 π bonds
- C–H bond (right): 1 σ bond

Step 2 — Count σ bonds:

$$\sigma \text{ bonds} = 1(\text{H–C}) + 1(\text{C–C}) + 1(\text{C–H}) = \boxed{3}$$

The 2 π bonds in the triple bond are not counted (they are sideways π overlap).

Answer: (3) Go Back to Q#30

Answer Key

Section A (MCQ):

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

Section B (Numerical Value):

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
21	787	22	9						
23	25	24	4						
25	80	26	5						
27	4	28	123						
29	15	30	3						