IIT JAM Chemistry

Sample Paper – 4

Instructions

- This paper contains **60 questions** carrying a maximum of **100 marks**. Duration: **3 hours (180 minutes)**.
- **Section A** (**Q1–Q30**, MCQ): Q1–Q10 carry **+1 mark** each; wrong response: $-\frac{1}{3}$ mark. Q11–Q30 carry **+2 marks** each; wrong response: $-\frac{2}{3}$ mark. Choose the **single best** option.
- **Section B** (**Q31–Q40**, MSQ): Each carries **+2 marks**. **No negative marking. One or more** options may be correct; full marks only if *all* correct options are selected; no partial credit.
- **Section C** (**Q41–Q60**, NAT): Q41–Q50 carry **+1 mark**; Q51–Q60 carry **+2 marks**. **No negative marking.** Enter the numerical value using the virtual keypad (integer or decimal as appropriate).
- **Calculator policy:** Personal calculators, log tables, and electronic devices are **strictly prohibited**. A virtual scientific calculator is provided in the CBT interface. Rough sheets are supplied at the examination centre.
- Once you move to the next section, you cannot return to a previous section. Manage time accordingly.

Section A — Multiple Choice Questions (MCQ)

***Q1–Q10**: 1 mark each ($-\frac{1}{3}$ for wrong). Choose the **single** correct option.*

Q1. Among the elements B, C, N, and O, the **increasing** order of first ionisation energy (IE_1) is:

(A) B $<$ O $<$ C $<$ N
(B) C $<$ B $<$ O $<$ N
(C) B $<$ C $<$ O $<$ N
(D) O $<$ B $<$ C $<$ N

Q2. In the Bohr model of hydrogen, a photon is emitted when the electron transitions from $n = 2$ to $n = 1$ (Lyman series). The approximate wavelength of this photon is:

(A) 486.1 nm
(B) 121.6 nm

(C) 656.3 nm
(D) 102.6 nm

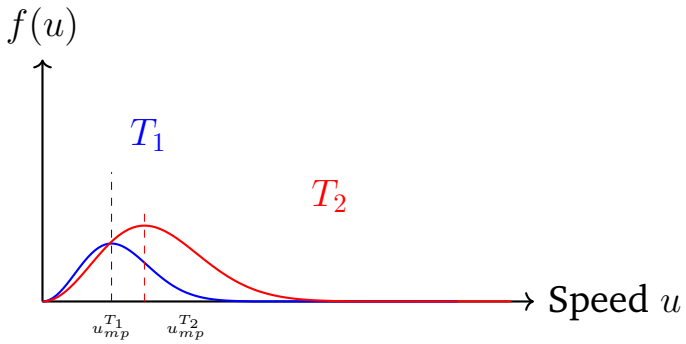
Q3. The hybridisation of each oxygen atom in hydrogen peroxide (H_2O_2) is:

(A) sp^3
(B) sp^2
(C) sp
(D) sp^3d

Q4. The equilibrium $2\,CrO_4^{2-} + 2H^+ \rightleftharpoons Cr_2O_7^{2-} + H_2O$ lies to the right in acidic solution. In a **strongly basic** (high pH) solution, which species **predominates**?

(A) $Cr_2O_7^{2-}$ (orange)
(B) CrO_3 (solid)
(C) Cr^{3+} (green)
(D) CrO_4^{2-} (yellow)

Q5. The figure below shows Maxwell–Boltzmann speed-distribution curves for an ideal gas at two temperatures $T_1 < T_2$. Which of the following correctly describes how the curve changes on going from T_1 to T_2?



(A) The peak shifts to higher speed and the curve becomes broader and lower
(B) The peak shifts to lower speed and the curve becomes narrower and taller
(C) The peak position is unchanged; only the height changes
(D) The area under the curve decreases at higher temperature

Q6. In the Born–Haber cycle for the formation of NaCl(s) from Na(s) and $\frac{1}{2}\mathrm{Cl_2(g)}$, which of the following steps is **exothermic**?

(A) Sublimation of Na(s)
(B) Lattice energy (formation of NaCl crystal from gaseous ions)
(C) Ionisation of Na(g) to $\mathrm{Na^+(g)}$
(D) Dissociation of $\mathrm{Cl_2(g)}$ to $2\,\mathrm{Cl(g)}$

Q7. (Z)-Butenedioic acid (maleic acid) has both carboxyl groups on the **same side** of the double bond. Which statement correctly describes its stereochemistry?

(A) It has the E configuration because COOH has higher priority than H
(B) It is the same compound as fumaric acid
(C) It has the Z configuration because both COOH groups are on the same side
(D) It is optically active due to restricted rotation

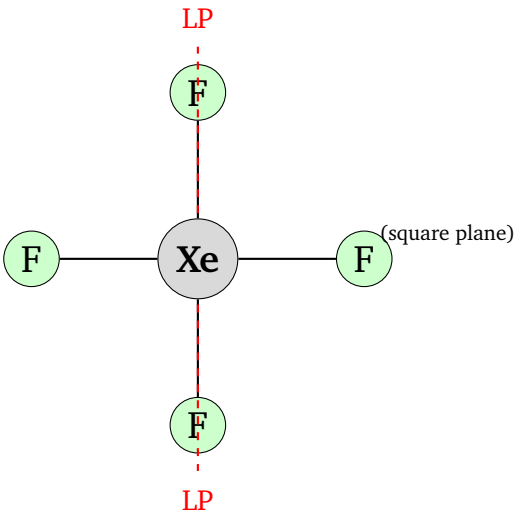
Q8. Given the following thermochemical equations:

$$\mathrm{C(s) + O_2(g) \rightarrow CO_2(g)}, \quad \Delta H_1 = -393.5\ \mathrm{kJ/mol}$$
$$\mathrm{CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g)}, \quad \Delta H_2 = -283.0\ \mathrm{kJ/mol}$$

The standard enthalpy change for $\mathrm{C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)}$ is:

(A) -676.5 kJ/mol
(B) $+110.5$ kJ/mol
(C) -393.5 kJ/mol
(D) -110.5 kJ/mol

Q9. The molecular geometry of $\mathrm{XeF_4}$ is shown below. What is the correct geometry and hybridisation of Xe in $\mathrm{XeF_4}$?



(A) Tetrahedral; sp^3
(B) Square planar; sp^3d^2
(C) T-shaped; sp^3d
(D) See-saw; sp^3d

Q10. The addition of HBr to 2-methylpropene ($CH_2{=}C(CH_3)_2$) under normal (non-peroxide) conditions follows Markovnikov's rule. The major product is:

(A) 2-Bromo-2-methylpropane
(B) 1-Bromo-2-methylpropane
(C) 2-Bromo-1-methylpropane
(D) 1-Bromo-1-methylpropane

***Q11–Q30**: 2 marks each ($-\frac{2}{3}$ for wrong). Choose the **single** correct option.*

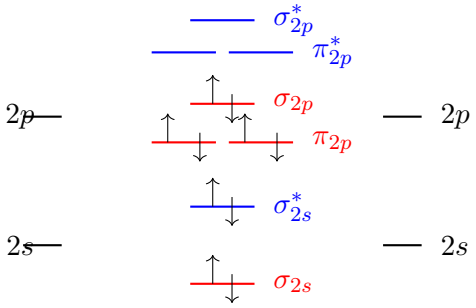
Q11. The complex $[CoCl_2(en)_2]^+$ (en = ethylenediamine, a bidentate ligand) exhibits stereoisomerism. The **total number** of stereoisomers (including optical isomers) of this complex is:

(A) 1
(B) 2
(C) 4
(D) 3

Q12. A buffer solution contains NH_3 and NH_4^+ with $[NH_3]/[NH_4^+] = 2$. Given $pK_a(NH_4^+) = 9.25$, the pH of the buffer is:

(A) 8.95
(B) 9.25
(C) 9.55
(D) 9.85

Q13. The molecular orbital energy-level diagram below represents N_2. Among N_2, N_2^+, O_2, and O_2^-, which species has the **highest bond order**?



Molecular Orbitals of N_2

(A) N_2 (bond order = 3)
(B) N_2^+ (bond order = 2.5)
(C) O_2 (bond order = 2)
(D) O_2^- (bond order = 1.5)

Q14. The Claisen condensation of two moles of ethyl acetate ($CH_3COOC_2H_5$) in the presence of sodium ethoxide (NaOEt) gives which major product?

(A) Diethyl oxalate
(B) Ethyl acetoacetate ($CH_3COCH_2COOC_2H_5$)
(C) Acetone
(D) Diethyl malonate

Q15. The crystal field stabilisation energy (CFSE) for a d^6 **low-spin** octahedral complex (in terms of Δ_o, ignoring pairing energy) is:

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

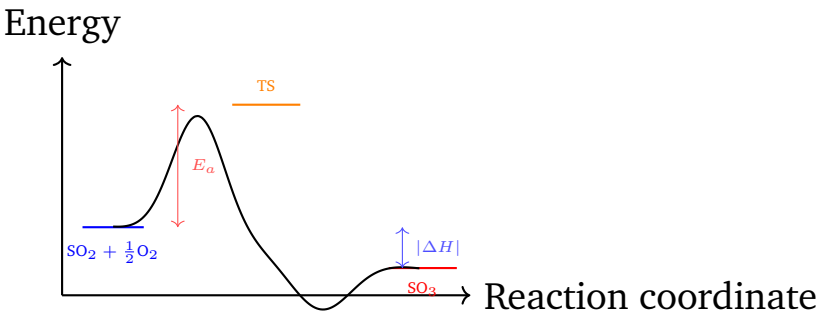
Q16. Which of the following is a **meso** compound (achiral despite having stereocentres)?

(A) $(2R, 3R)$-tartaric acid
(B) $(2S, 3S)$-tartaric acid
(C) $(2R, 3S)$-tartaric acid
(D) $(2R, 3R)$-2,3-dibromobutane

Q17. For a 0.10 M aqueous solution of acetic acid ($K_a = 1.8 \times 10^{-5}$), the van 't Hoff factor i is approximately:

(A) 1.013
(B) 1.100
(C) 1.500
(D) 2.000

Q18. The Contact Process manufactures sulfuric acid via catalytic oxidation of SO_2 to SO_3. The energy profile for the key step $SO_2 + \frac{1}{2}O_2 \rightleftharpoons SO_3$ is sketched below. Which set of operating conditions **maximises** SO_3 yield while maintaining an acceptable rate?



(A) Very high temperature (>800°C) and low pressure
(B) Moderate temperature (∼450°C), high pressure, V_2O_5 catalyst
(C) Low temperature (<200°C) and atmospheric pressure
(D) High temperature and dilute O_2 atmosphere

Q19. Among the halogens F, Cl, Br, and I, which has the **highest electron affinity** (most negative ΔH_{EA})?

(A) F

(B) I
(C) Br
(D) Cl

Q20. When 2,3-dimethyl-2,3-butanediol (pinacol) is treated with dilute H_2SO_4 and heated, the major product obtained via the pinacol rearrangement is:

(A) 2,3-dimethylbut-2-ene
(B) 3,3-dimethylbutan-1-ol
(C) 3,3-dimethylbutan-2-one (pinacolone)
(D) 2-methylpentan-3-one

Q21. Water boils at 373 K at 1 atm. Given $\Delta H_{\text{vap}} = 40.7$ kJ/mol and $R = 8.314\,\text{J mol}^{-1}\,\text{K}^{-1}$, the vapour pressure of water at 363 K is approximately:

(A) 0.70 atm
(B) 0.85 atm
(C) 0.50 atm
(D) 1.15 atm

Q22. Which statement about the **E1** elimination mechanism is **correct**?

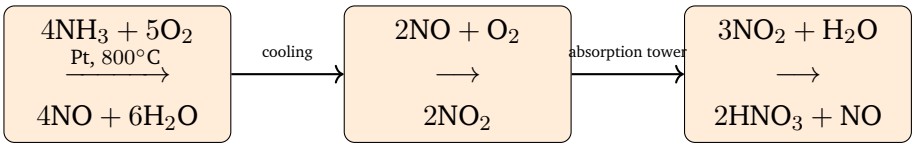
(A) E1 is a bimolecular process with a second-order rate law
(B) E1 proceeds through a carbanion intermediate
(C) E1 is favoured by strong bases and polar aprotic solvents
(D) E1 is a unimolecular reaction proceeding through a carbocation; it follows first-order kinetics and is favoured by polar protic solvents

Q23. Which statement correctly compares the net dipole moments of CCl_4 and $CHCl_3$?

(A) Both CCl_4 and $CHCl_3$ have zero dipole moment due to tetrahedral symmetry
(B) CCl_4 has zero net dipole moment; $CHCl_3$ has a non-zero net dipole moment
(C) $CHCl_3$ has zero dipole moment; CCl_4 has a non-zero dipole moment

(D) Both molecules are polar with similar dipole moments

Q24. The Ostwald process for the industrial manufacture of nitric acid involves three consecutive steps. The flow diagram below outlines these steps. Which option correctly identifies all three steps **in order**?



(A) Catalytic oxidation of NH_3 to N_2O_4; dissolution; neutralisation
(B) Oxidation of NH_3 to N_2; further oxidation; absorption
(C) Catalytic oxidation of NH_3 to NO; further oxidation of NO to NO_2; absorption of NO_2 in water
(D) Direct combination of N_2 and O_2; absorption; concentration

Q25. How many distinct ^{1}H NMR signals are observed for ethanol (CH_3CH_2OH) in an inert solvent at room temperature?

(A) 3
(B) 1
(C) 2
(D) 4

Q26. For the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, the equilibrium constant $K_p = 1.00 \times 10^3$ at 298 K. The standard Gibbs energy change ΔG° per mole of *reaction* is approximately ($R = 8.314\ \text{J mol}^{-1}\,\text{K}^{-1}$):

(A) $+17.1$ kJ/mol
(B) -8.55 kJ/mol
(C) $+34.2$ kJ/mol
(D) -17.1 kJ/mol

Q27. For a second-order reaction A $\rightarrow$ products with rate $= k[\text{A}]^2$, the half-life $t_{1/2}$ is $\dfrac{1}{k[\text{A}]_0}$. If the initial concentration $[\text{A}]_0$ is **doubled**, what happens to $t_{1/2}$?

(A) It doubles

(B) It is halved
(C) It remains unchanged
(D) It quadruples

Q28. Among the hydrogen halides HF, HCl, HBr, and HI, HF has an anomalously high boiling point ($+19.5^\circ$C) compared with HCl (-85°C). The primary reason is:

(A) HF has a much higher molar mass
(B) HF is a stronger acid and ionises more in the liquid phase
(C) HF forms strong intermolecular hydrogen bonds due to the high electronegativity and small size of F
(D) HF has stronger London dispersion forces than the heavier halides

Q29. Ethylenediaminetetraacetic acid (EDTA) forms exceptionally stable complexes with metal ions. The two reasons for the remarkably high stability constants of EDTA complexes are:

(A) EDTA is hexadentate (2 N + 4 O donors) and the chelate effect (multiple ring formation increases entropy)
(B) EDTA is monodentate and forms ion pairs instead of coordinate bonds
(C) EDTA is bidentate and forms only five-membered chelate rings
(D) EDTA is tridentate and the stability arises solely from charge neutralisation

Q30. Cyclohexanone oxime undergoes the Beckmann rearrangement in the presence of a protic acid catalyst. The product formed and its industrial significance are:

(A) Caprolactam, a monomer for nylon-6 production
(B) Cyclohexanol, used in solvent manufacture
(C) Hexamethylenediamine, a monomer for nylon-6,6
(D) Caprolactam, a monomer for nylon-6

Section B — Multiple Select Questions (MSQ)

***Q31–Q40**: 2 marks each. **No negative marking.** **One or more** options are correct; full marks only if* all *correct options are selected.*

Q31. Which of the following are **assumptions** of the ideal gas model?

(A) Gas molecules are point masses with negligible volume compared to the container volume
(B) There are no intermolecular attractive or repulsive forces between gas molecules
(C) Collisions between gas molecules and with container walls are perfectly elastic
(D) The speed of all molecules is identical at a given temperature

Q32. Which of the following statements about nucleophilic addition to carbonyl compounds are **correct**?

(A) Ketones are more reactive than aldehydes toward nucleophilic addition
(B) Nucleophilic addition to an aldehyde or ketone proceeds via a tetrahedral intermediate
(C) HCN addition to aldehydes is thermodynamically unfavourable
(D) Addition of two equivalents of a Grignard reagent to an ester ultimately gives a tertiary alcohol

Q33. Which of the following statements about acid–base equilibria are **correct**?

(A) A buffer is most effective when pH $\approx$ pK_a (equal concentrations of weak acid and conjugate base)
(B) Adding a strong acid to a buffer always *increases* the pH
(C) The Henderson–Hasselbalch equation applies to weak acid–conjugate base buffer systems
(D) For a diprotic acid H_2A, the intermediate species HA^- is amphoteric (can act as both acid and base)

Q34. Which statements about the oxides of transition metals are **correct**?

(A) All transition metal oxides are acidic in nature
(B) CrO_3 is an acidic oxide that dissolves in NaOH(aq) to form chromate ion (CrO_4^{2-})

(C) MnO_4^- (permanganate) is a powerful oxidising agent in acidic solution

(D) Iron forms only Fe_2O_3 as a stable oxide

Q35. Which of the following statements about aromaticity based on Hückel's rule ($4n + 2$ π electrons, $n = 0, 1, 2, \ldots$) are **correct**?

(A) Benzene (6 π electrons, $n = 1$) is aromatic

(B) Cyclooctatetraene (8 π electrons) is non-planar and **not** aromatic; it avoids antiaromaticity by tub-distortion

(C) The cyclopentadienyl cation ($C_5H_5^+$) with 6 π electrons is aromatic

(D) Pyridine (6 π electrons; lone pair of N not part of the π system) is aromatic and can act as a Lewis base

Q36. Which of the following are **correct** distinctions or properties regarding galvanic and electrolytic cells?

(A) Both galvanic and electrolytic cells are driven by spontaneous redox reactions

(B) Both types of cells convert chemical energy into electrical energy

(C) In an electrolytic cell, the **anode** is connected to the positive terminal of the external power source

(D) Faraday's laws of electrolysis apply to both galvanic and electrolytic cells

Q37. Which of the following properties are characteristic of **d-block (transition) elements**?

(A) They exhibit variable oxidation states due to participation of $(n-1)d$ electrons in bonding

(B) Their compounds are often coloured due to d–d electronic transitions in partially filled d orbitals

(C) Many transition metal ions are paramagnetic because of unpaired d electrons

(D) All transition metals are diamagnetic in all their compounds

Q38. Which of the following statements correctly describe the $\mathbf{S_N1}$ mechanism?

(A) The rate of an S_N1 reaction depends only on the concentration of the substrate (first-order kinetics)
(B) S_N1 is favoured by strong nucleophiles and polar aprotic solvents
(C) S_N1 gives complete inversion of configuration at the reaction centre
(D) Polar protic solvents stabilise the carbocation intermediate through solvation and favour S_N1

Q39. Which of the following correctly state the oxidation state of sulfur in the given compound?

(A) In H_2S, the oxidation state of S is $+2$
(B) In SO_2, the oxidation state of S is $+4$
(C) In H_2SO_4, the oxidation state of S is $+6$
(D) In $Na_2S_2O_3$, the *average* oxidation state of S is $+2$

Q40. Which of the following are **correct** consequences or features of the lanthanide contraction?

(A) The atomic radii of the $5d$ transition elements (e.g. Hf, Ta, W) are almost identical to those of their $4d$ congeners (Zr, Nb, Mo), making them chemically very similar
(B) The poor shielding of nuclear charge by the $4f$ electrons causes a steady decrease in ionic radius across the lanthanide series
(C) All lanthanides exhibit $+4$ as their most stable oxidation state
(D) Lanthanide contraction causes an *increase* in atomic radius along the lanthanide series

Section C — Numerical Answer Type (NAT)

***Q41–Q50**: 1 mark each. **No negative marking.** Enter the exact numerical value.*

Q41. A first-order reaction has a rate constant $k = 0.693\ \text{s}^{-1}$. Calculate the half-life $t_{1/2}$ (in seconds).

Q42. For the reaction $C(s) + O_2(g) \rightarrow CO_2(g)$ at 298 K, $\Delta H^\circ = -393.5$ kJ/mol and $\Delta S^\circ = +3.1\ \text{J mol}^{-1}\text{K}^{-1}$. Calculate ΔG° (in kJ/mol).

Q43. A solution is prepared by dissolving 18.0 g of glucose ($M = 180$ g/mol) in water to make 1.00 L of solution at 27°C ($T = 300$ K). Calculate the osmotic pressure π in atm. ($R = 0.0821$ L atm mol^{-1}K^{-1})

Q44. An acetate buffer contains $[CH_3COO^-] = 0.40$ M and $[CH_3COOH] = 0.20$ M. Given p$K_a = 4.74$, calculate the pH of the buffer (use $\log 2 = 0.30$).

Q45. When 12.0 g of a non-electrolyte solute is dissolved in 200 g of water, the boiling point is elevated by 0.512°C. Given $K_b(\text{water}) = 0.512\ ^\circ\text{C kg mol}^{-1}$, calculate the molar mass of the solute (in g/mol).

Q46. Calculate the spin-only magnetic moment μ_s (in Bohr magnetons, BM) of the permanganate ion MnO_4^-. (Mn in MnO_4^- is in the $+7$ oxidation state.)

Q47. The solubility of $BaSO_4$ is 2.42×10^{-3} g/L at 25°C. Calculate its solubility product K_{sp}. (Molar mass of $BaSO_4 = 233.4$ g/mol). Express the answer as a number $\times 10^{-10}$ (give the numerical coefficient to 2 decimal places).

Q48. Calculate the index of hydrogen deficiency (IHD, also called degree of unsaturation) of pyridine (C_5H_5N).

Q49. Using molecular orbital theory, calculate the bond order of the nitric oxide molecule (NO).

Q50. Calculate the frequency (in Hz) of the photon emitted when the hydrogen atom transitions from $n = 3$ to $n = 1$.
(Use: $E_n = -13.6/n^2$ eV; 1 eV $= 1.602 \times 10^{-19}$ J; $h = 6.626 \times 10^{-34}$ J s.)
Express your answer as $X \times 10^{15}$ Hz and report the value of X to 2 decimal places.

***Q51–Q60**: 2 marks each. **No negative marking.** Enter the exact numerical value.*

Q51. Using the van der Waals constants for CO_2, $a = 3.59$ L^2 atm mol^{-2} and $b = 0.0427$ L mol^{-1}, calculate the critical temperature T_c (in K).
($R = 0.0821$ L atm mol^{-1}K^{-1}; $T_c = \dfrac{8a}{27Rb}$)

Q52. For the reaction A $\rightarrow$ Products, the following data are obtained:

[A] (mol/L)	Rate (mol $L^{-1}s^{-1}$)
0.40	4.0×10^{-3}
0.20	1.0×10^{-3}

Determine the order of reaction and calculate the rate constant k (in $L\,mol^{-1}\,s^{-1}$).

Q53. Calculate the pH of a 0.10 M solution of acetic acid at 25°C.
($K_a = 1.8 \times 10^{-5}$; $\log 1.342 = 0.128$)

Q54. In the nitronium ion NO_2^+ (linear structure, O=N^+=O, each N–O bond is a double bond), calculate the formal charge on the nitrogen atom.

Q55. For a first-order reaction A $\rightarrow$ B, the initial concentration $[A]_0 = 0.50$ M. After 20 minutes, $[A] = 0.25$ M. Calculate the rate constant k (in min^{-1}).
(Use $\ln 2 = 0.693$)

Q56. Calculate ΔG° (in kJ/mol) for the cell: Zn(s) | Zn^{2+}(aq) || Cu^{2+}(aq) | Cu(s).
Standard reduction potentials: $E^\circ(Cu^{2+}/Cu) = +0.34$ V; $E^\circ(Zn^{2+}/Zn) = -0.76$ V.
($F = 96500$ C/mol)

Q57. Calculate the Crystal Field Stabilisation Energy (CFSE) in units of Δ_o for a **high-spin** d^5 octahedral complex. (Express as a number; e.g., write 0 if CFSE $= 0\,\Delta_o$.)

Q58. A sample of a chiral compound shows an observed optical rotation $[\alpha]_{obs} = +14^\circ$. The specific rotation of the pure R-enantiomer is $[\alpha]_R = +40^\circ$. Calculate the percentage of the R-enantiomer in the mixture.
(Use: $\%R = \frac{100+\%ee}{2}$; $\%ee = \frac{|[\alpha]_{obs}|}{|[\alpha]_{pure}|} \times 100$)

Q59. A face-centred cubic (FCC) metal has an edge length $a = 3.52$ Å. Calculate the atomic radius r (in Å) of the metal atoms.
(In FCC: $4r = a\sqrt{2}$; use $\sqrt{2} = 1.414$)

Q60. For the reaction $N_2(g) + O_2(g) \rightarrow 2\,NO(g)$, $\Delta H^\circ = 180$ kJ/mol and $\Delta S^\circ = 24.7\ \text{J mol}^{-1}\text{K}^{-1}$. At what temperature T (in K) does $K_p = 1$ (i.e., $\Delta G^\circ = 0$)?

Solutions

IIT JAM Chemistry – Sample Paper 4

Section A Solutions — MCQ

Solution

Concept — Periodic Trends in Ionisation Energy:

First ionisation energy generally increases across a period (left to right) due to increasing nuclear charge, but there are two important exceptions: (i) Group IIA → Group IIIA (half-filled s vs. singly occupied p — BE of paired s electrons is actually lower because of shielding) is less relevant here; and (ii) Group VA → Group VIA: nitrogen (Group VA) has a half-filled $2p$ subshell ($2p^3$), which is extra stable — its IE_1 is *greater* than oxygen ($2p^4$), which has electron–electron repulsion in the paired orbital.

Step 1 — Ordering:

Among B ($2s^2 2p^1$), C ($2s^2 2p^2$), N ($2s^2 2p^3$), O ($2s^2 2p^4$):

Q1.

- B has the lowest IE_1 (single $2p$ electron, easily lost).
- C has higher IE_1 than B.
- O has lower IE_1 than N (pairing repulsion in the $2p^4$ configuration).
- N has higher IE_1 than O (extra stability of half-filled $2p^3$).

Increasing order: B < C < O < N.

Final Answer: B < C < O < N ⇒ **(C)**

Why other options are wrong:

- (A): Places O before C — incorrect; C has higher IE than B but lower than N.
- (B): Swaps B and C — incorrect.
- (D): Places O first — O has the lowest IE_1 only compared to N, not compared to B or C.

Answer: (C) ← *Go back to Q1*

Solution

Concept — Bohr Model and Lyman Series:

The energy of the emitted photon equals the difference in energy between levels $n = 2$ and $n = 1$.

Step 1 — Energy of transition:

$$E = 13.6\left(\frac{1}{1^2} - \frac{1}{2^2}\right)\ \text{eV} = 13.6 \times \frac{3}{4} = 10.2\ \text{eV}$$

Step 2 — Convert to wavelength:
$\lambda = \dfrac{hc}{E} = \dfrac{1240 \text{ eV nm}}{10.2 \text{ eV}} = 121.6 \text{ nm}$
This falls in the ultraviolet (Lyman series).

Final Answer: $\lambda \approx 121.6$ nm $\Rightarrow$ **(B)**

Why other options are wrong:

Q2.
- (A): 486.1 nm is the Balmer H_β line ($n = 4 \to 2$).
- (C): 656.3 nm is the Balmer H_α line ($n = 3 \to 2$).
- (D): 102.6 nm corresponds to the $n = 3 \to 1$ transition in the Lyman series.

Answer: (B) ← *Go back to Q2*

Solution

Concept — Hybridisation of Central Atoms:
The hybridisation of an atom is determined by counting its electron pairs (bonding + lone pairs). Each oxygen in H_2O_2 has 2 bonding pairs (one O–H, one O–O) and 2 lone pairs = 4 electron pairs total.

Step 1 — Electron pairs around O in H_2O_2:
Lewis structure: H–O–O–H
Each O: 2 bonds + 2 lone pairs $\Rightarrow$ 4 electron domains $\Rightarrow$ sp^3 hybridised.

Final Answer: $sp^3 \Rightarrow$ **(A)**

Why other options are wrong:

Q3.
- (B): sp^2 would require 3 electron domains (as in formaldehyde C).
- (C): sp requires only 2 electron domains (linear geometry).
- (D): sp^3d requires 5 electron domains; oxygen in H_2O_2 uses only $n = 2$ orbitals.

Answer: (A) ← *Go back to Q3*

Solution

Concept — Chromate–Dichromate pH Equilibrium:
The equilibrium $2\,CrO_4^{2-} + 2H^+ \rightleftharpoons Cr_2O_7^{2-} + H_2O$ is shifted right by *increasing* $[H^+]$ (acidic conditions) and left by *decreasing* $[H^+]$ (basic conditions).

Step 1 — Le Chatelier's Principle at high pH:
High pH means low $[H^+]$. Removing H^+ drives the equilibrium to the **left**, favouring CrO_4^{2-} (yellow chromate ion).

Final Answer: CrO_4^{2-} (yellow) predominates in basic solution $\Rightarrow$ **(D)**

Why other options are wrong:

Q4.

- (A): $Cr_2O_7^{2-}$ predominates in *acidic* solutions.
- (B): CrO_3 is a solid anhydride that dissolves to form dichromate/chromate; it does not predominate in basic solution.
- (C): Cr^{3+} is a completely different oxidation state (reduced form) and requires reducing conditions.

Answer: (D) ← *Go back to Q4*

Solution

Concept — Maxwell–Boltzmann Speed Distribution:
The most probable speed $u_{mp} = \sqrt{2RT/M}$ increases with T. At higher temperature, more molecules acquire high speeds so the distribution broadens (wider range of speeds) and flattens (lower maximum) while the *total area* (= 1, normalised) is conserved.

Step 1 — Effect of raising temperature from T_1 to T_2:

Q5.

- Peak shifts to *higher* speed (since $u_{mp} \propto \sqrt{T}$).
- Curve becomes *broader* (wider distribution).
- Peak height *decreases* (area under curve is constant = 1).

Final Answer: Peak shifts to higher speed; curve broadens and flattens ⇒ **(A)**

Why other options are wrong:

- (B): Peak shifts to *higher*, not lower, speed at higher T.
- (C): The peak position does change; $u_{mp} \propto \sqrt{T}$.
- (D): Area under the normalised distribution always equals 1, regardless of temperature.

Answer: (A) ← *Go back to Q5*

Solution

Concept — Born–Haber Cycle Steps and Sign of Enthalpy:
The Born–Haber cycle for NaCl involves: sublimation of Na (endothermic), ionisation of Na (endothermic), dissociation of $\frac{1}{2}Cl_2$ (endothermic), electron affinity of Cl (exothermic), and lattice energy (exothermic).

Step 1 — Identify the exothermic step:
Lattice energy is the enthalpy change when gaseous ions ($Na^+(g) + Cl^-(g)$) combine to form the ionic crystal NaCl(s). This process releases energy (≈ -787 kJ/mol

for NaCl) because the strong electrostatic attractions between oppositely charged ions lower the potential energy of the system.

Final Answer: Lattice energy formation of NaCl crystal $\Rightarrow$ **(B)**

Why other options are wrong:

Q6.

- (A): Sublimation of Na is *endothermic* ($\Delta H_{sub} > 0$).
- (C): Ionisation of Na(g) to Na^+(g) is *endothermic* (requires energy to remove the electron).
- (D): Bond dissociation of Cl_2 is *endothermic*.

Answer: (B) ← *Go back to Q6*

Solution

Concept — E/Z Nomenclature of Alkenes:
In the CIP priority system for butenedioic acid (HOOC–CH=CH–COOH): the COOH group has higher priority than H at each carbon. When both COOH groups are on the *same side*, the higher-priority groups (COOH) are on the same side $\Rightarrow$ Z configuration ("zusammen" = together).

Step 1 — Assign priorities:
At each sp^2 carbon: COOH $>$ H. Both COOH on same side $\Rightarrow$ Z configuration = maleic acid.

Step 2 — Identify the isomer:
Maleic acid (cis) = (Z)-butenedioic acid. Fumaric acid (trans) = (E)-butenedioic acid.

Final Answer: (Z)-butenedioic acid has both COOH on the same side $\Rightarrow$ **(C)**

Why other options are wrong:

Q7.

- (A): The E configuration has COOH groups on *opposite* sides (fumaric acid).
- (B): Fumaric acid is the *trans/E* isomer, not the same as maleic acid.
- (D): Neither maleic nor fumaric acid is optically active; restricted rotation is a feature of alkenes, but it creates geometric (not optical) isomers here.

Answer: (C) ← *Go back to Q7*

Solution

Concept — Hess's Law of Heat Summation:
Target: $C(s) + \frac{1}{2}O_2 \rightarrow CO(g)$, $\Delta H = ?$

Step 1 — Algebraic manipulation:

Reaction (1): $C + O_2 \rightarrow CO_2$, $\Delta H_1 = -393.5$ kJ
Reaction (2): $CO + \frac{1}{2}O_2 \rightarrow CO_2$, $\Delta H_2 = -283.0$ kJ

Target = Reaction (1) − Reaction (2):

$$\Delta H = \Delta H_1 - \Delta H_2 = -393.5 - (-283.0) = -393.5 + 283.0 = -110.5 \text{ kJ/mol}$$

Final Answer: $\Delta H = -110.5$ kJ/mol $\Rightarrow$ **(D)**

Why other options are wrong:

Q8.
- (A): -676.5 would result from adding both equations, which is incorrect.
- (B): $+110.5$ has wrong sign; the formation of CO from C is exothermic.
- (C): -393.5 is just ΔH_1 without applying Hess's law.

Answer: (D) ← *Go back to Q8*

Solution

Concept — VSEPR and Hybridisation of XeF_4:
Xe in XeF_4: 8 valence electrons from Xe; 4 bonds with F use 4 pairs; remaining 4 electrons form 2 lone pairs. Total electron pairs around Xe = 6 $\Rightarrow$ sp^3d^2 hybridisation (octahedral electron geometry). The 2 lone pairs occupy axial positions (opposite each other), and the 4 F atoms occupy the equatorial plane $\Rightarrow$ **square planar** molecular geometry.

Step 1 — Electron pair count:
6 electron pairs (4 bonding + 2 lone pairs) $\Rightarrow$ octahedral electron geometry, sp^3d^2.

Step 2 — Molecular geometry:
Two lone pairs at axial positions cancel each other's angular influence; 4 F in square plane $\Rightarrow$ square planar.

Final Answer: Square planar; sp^3d^2 $\Rightarrow$ **(B)**

Why other options are wrong:

Q9.
- (A): Tetrahedral/sp^3 applies to 4 electron pairs (e.g., CH_4); XeF_4 has 6.
- (C): T-shaped applies to AX_3E_2 species (3 bonds + 2 lone pairs = 5 electron pairs, sp^3d).
- (D): See-saw applies to AX_4E (4 bonds + 1 lone pair = 5 pairs, sp^3d).

Answer: (B) ← *Go back to Q9*

Solution

Concept — Markovnikov's Rule and Carbocation Stability:
In electrophilic addition of HBr to an alkene, the proton (H^+) adds to the carbon with more hydrogens (less substituted), forming the more stable carbocation intermediate, which is then attacked by Br^-.

Step 1 — Identify carbocation formed:
$CH_2 = C(CH_3)_2 + H^+ \rightarrow CH_3\text{-}\overset{+}{C}(CH_3)_2$ (tertiary carbocation, very stable).

Step 2 — Nucleophilic attack:
Br^- attacks the tertiary carbocation $\Rightarrow$ CH_3-$CBr(CH_3)_2$ = 2-bromo-2-methylpropane.

Final Answer: 2-Bromo-2-methylpropane $\Rightarrow$ **(A)**

Why other options are wrong:

Q10.
- (B): Anti-Markovnikov product; would require peroxide (radical) conditions.
- (C)/(D): These are not structural isomers obtained from this reaction.

Answer: (A) ← *Go back to Q10*

Section A Solutions (Q11–Q30)

Solution

Concept — Stereoisomers of Octahedral Complexes:
For $[CoCl_2(en)_2]^+$ (octahedral, two bidentate en and two monodentate Cl):

Step 1 — Geometric isomers:

Q11.
- **trans** isomer: both Cl *trans* to each other. This has a plane of symmetry $\Rightarrow$ achiral. (1 isomer)
- **cis** isomer: both Cl adjacent. This has no plane of symmetry $\Rightarrow$ chiral, exists as Δ and Λ enantiomers. (2 isomers)

Step 2 — Total count:
1 (trans) + 2 (cis enantiomers) = **3** stereoisomers.

Final Answer: 3 $\Rightarrow$ **(D)**

Why other options are wrong:

- (A): Only 1 is incorrect; there are geometric and optical isomers.
- (B): 2 accounts only for the two optical isomers; the trans isomer is missed.
- (C): 4 overcounts; the trans isomer is not chiral.

Answer: (D) ← *Go back to Q11*

Solution

Concept — Henderson–Hasselbalch Equation:

$$\text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$$

Step 1 — Apply the equation:

$$\text{pH} = 9.25 + \log \frac{[\text{NH}_3]}{[\text{NH}_4^+]} = 9.25 + \log(2) = 9.25 + 0.301 = 9.55$$

Final Answer: pH = 9.55 ⇒ **(C)**

Why other options are wrong:

Q12.

- (A): 8.95 would result from $\log(0.5)$, which corresponds to ratio $[\text{NH}_3]/[\text{NH}_4^+] = 0.5$.
- (B): 9.25 is the pH only when $[\text{NH}_3] = [\text{NH}_4^+]$ (ratio = 1).
- (D): 9.85 is not obtained from any standard calculation here.

Answer: (C) ← *Go back to Q12*

Solution

Concept — Molecular Orbital Theory and Bond Order:

$$\text{Bond order} = \frac{\text{bonding electrons} - \text{antibonding electrons}}{2}$$

Step 1 — Bond orders:

Q13.

- N_2 (14 e^-): bonding = 10, antibonding = 4; BO = $(10-4)/2 = 3$.
- N_2^+ (13 e^-): one fewer bonding electron; BO = $(9-4)/2 = 2.5$.
- O_2 (16 e^-): $(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\sigma_{2p})^2(\pi_{2p})^4(\pi_{2p}^*)^2$; bonding = 10, antibonding = 6; BO = 2.
- O_2^- (17 e^-): one extra π^* electron; antibonding = 7; BO = 1.5.

Final Answer: Highest bond order is N_2 (BO = 3) ⇒ **(A)**

Why other options are wrong:

- (B)–(D): All have lower bond orders than N_2.

Answer: (A) ← *Go back to Q13*

Solution

Concept — Claisen Condensation:

The Claisen condensation is analogous to the aldol condensation but for esters. The

α-H of one ester is deprotonated by NaOEt to form an enolate, which attacks the carbonyl of a second ester molecule. Loss of OEt^- gives the β-ketoester product.

Step 1 — Reaction:

$2\,CH_3COOC_2H_5 \xrightarrow{NaOEt} CH_3COCH_2COOC_2H_5 + C_2H_5OH$

Product: **ethyl acetoacetate** (a β-ketoester).

Final Answer: Ethyl acetoacetate ($CH_3COCH_2COOC_2H_5$) $\Rightarrow$ **(B)**

Why other options are wrong:

Q14.

- (A): Diethyl oxalate requires oxidative coupling, not a Claisen condensation.
- (C): Acetone does not form directly from ester condensation.
- (D): Diethyl malonate is formed from different ester substrates.

Answer: (B) ← *Go back to Q14*

Solution

Concept — Crystal Field Stabilisation Energy (CFSE):

In an octahedral field, t_{2g} orbitals are stabilised by $-0.4\,\Delta_o$ and e_g orbitals are destabilised by $+0.6\,\Delta_o$ per electron.

Step 1 — Electron configuration for d^6 low-spin:

Low-spin d^6 (strong field): all 6 electrons fill the t_{2g} set (3 orbitals, 2 electrons each): $(t_{2g})^6(e_g)^0$.

Step 2 — Calculate CFSE:

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

Final Answer: $\text{CFSE} = -2.4\,\Delta_o \Rightarrow$ **(D)**

Why other options are wrong:

Q15.

- (A): $-0.4\,\Delta_o$ is the CFSE for a single t_{2g} electron (e.g., d^1).
- (B): $-1.6\,\Delta_o$ is the CFSE for d^4 low-spin.
- (C): $-1.2\,\Delta_o$ corresponds to d^3 (3 electrons in t_{2g}) or d^6 *high-spin*.

Answer: (D) ← *Go back to Q15*

Solution

Concept — Meso Compounds:

A meso compound has stereocentres but possesses an internal plane of symmetry, making it achiral overall.

Step 1 — Check each option:

$(2R, 3S)$-tartaric acid: C2 has the R configuration and C3 has the S configuration. Rotating the molecule 180° about the C2–C3 bond shows that the two halves are mirror images of each other internally. An internal mirror plane bisects C2–C3 ⇒ meso compound.

$(2R, 3R)$- and $(2S, 3S)$-tartaric acid are enantiomers of each other (both optically active).

Final Answer: $(2R, 3S)$-tartaric acid is the meso form ⇒ **(C)**

Why other options are wrong:

Q16.

- (A) and (B): These are a pair of enantiomers (optically active, not meso).
- (D): $(2R, 3R)$-2,3-dibromobutane is optically active (not meso because both centres have the same configuration).

Answer: (C) ← *Go back to Q16*

Solution

Concept — Van't Hoff Factor and Degree of Dissociation:

For a weak acid HA ⇌ H^+ + A^-: the degree of dissociation $\alpha = \sqrt{K_a/c}$ and $i = 1 + \alpha$.

Step 1 — Calculate α:

$$\alpha = \sqrt{\frac{K_a}{c}} = \sqrt{\frac{1.8 \times 10^{-5}}{0.10}} = \sqrt{1.8 \times 10^{-4}} = 0.01342$$

Step 2 — Calculate i:

$i = 1 + \alpha = 1 + 0.01342 \approx 1.013$

Final Answer: $i \approx 1.013$ ⇒ **(A)**

Why other options are wrong:

Q17.

- (B): $i = 1.100$ would imply $\alpha = 0.10$ (10% dissociation), which is far too high for this concentration and K_a.
- (C)/(D): These values correspond to much higher degrees of dissociation, consistent with much stronger acids.

Answer: (A) ← *Go back to Q17*

Solution

Concept — Contact Process Equilibrium and Rate:

The oxidation $SO_2 + \frac{1}{2}O_2 \rightleftharpoons SO_3$ is exothermic ($\Delta H < 0$) with a *decrease* in moles of gas. Le Chatelier's principle predicts:

Q18.

- **Lower temperature** favours product (thermodynamics), but the rate becomes too slow.
- **Higher pressure** favours product (fewer moles on product side).
- A **catalyst** (V_2O_5) allows a compromise temperature of $\sim$450°C.

Step 1 — Best conditions for yield and rate:
Operating at $\sim$450°C (compromise), high pressure, with V_2O_5 catalyst gives acceptable yield ($\sim$98% conversion) and an economical rate.

Final Answer: Moderate temperature $\sim$450°C, high pressure, V_2O_5 catalyst $\Rightarrow$ **(B)**

Why other options are wrong:

- (A): Very high temperature ($>$800°C) shifts the equilibrium back to SO_2; yield decreases.
- (C): Very low temperature gives negligible rate despite favourable equilibrium.
- (D): High temperature and dilute O_2 would give very poor yield.

Answer: (B) ← *Go back to Q18*

Solution

Concept — Electron Affinity Trend in Halogens:
Electron affinity (EA) generally increases up a group. However, F is an anomalous exception: because F is very small, the added electron experiences high electron–electron repulsion in the compact $n = 2$ shell. Therefore, **Cl has a higher EA than F**.

Step 1 — Order of EA for halogens:
Cl $>$ F $>$ Br $>$ I (Cl has the highest electron affinity among halogens)

Final Answer: Cl has the highest electron affinity $\Rightarrow$ **(D)**

Why other options are wrong:

Q19.

- (A): F has a lower EA than Cl due to inter-electron repulsion in the small $2p$ shell.
- (B): I has the lowest EA among the halogens listed.
- (C): Br has lower EA than both Cl and F.

Answer: (D) ← *Go back to Q19*

Solution

Concept — Pinacol Rearrangement:

The pinacol rearrangement converts a 1,2-diol to a carbonyl compound via 1,2-migration under acid conditions. For pinacol (2,3-dimethyl-2,3-butanediol):

Step 1 — Mechanism outline:

Q20. (a) Protonation of one OH, loss of $H_2O \rightarrow$ tertiary carbocation (geminal dimethyl) at C2.

(b) 1,2-methyl shift from C3 to C2 generates an oxocarbenium ion at C3.

(c) Deprotonation gives the ketone product.

Step 2 — Product:

$(CH_3)_3C - C(=O) - CH_3$ = 3,3-dimethylbutan-2-one (**pinacolone**).

Final Answer: 3,3-Dimethylbutan-2-one (pinacolone) $\Rightarrow$ **(C)**

Why other options are wrong:

- (A): Elimination to form an alkene is a different reaction (E1/E2) not the pinacol rearrangement.
- (B): Primary alcohol is not the product; there is no primary carbon in this rearrangement.
- (D): 2-Methylpentan-3-one would require a different substrate.

Answer: (C) *← Go back to Q20*

Solution

Concept — Clausius–Clapeyron Equation:

$$\ln \frac{P_2}{P_1} = \frac{\Delta H_{\text{vap}}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Step 1 — Substitute values:

$T_1 = 373$ K (boiling point), $P_1 = 1$ atm; $T_2 = 363$ K, $P_2 = ?$

$$\ln \frac{P_2}{1} = \frac{40700}{8.314}\left(\frac{1}{373} - \frac{1}{363}\right) = 4894 \times \left(\frac{363 - 373}{373 \times 363}\right) = 4894 \times \frac{-10}{135399} = 4894 \times (-7.383 \times 10^{-5}) = -0.3614$$

Step 2 — Solve for P_2:

$P_2 = e^{-0.3614} \approx 0.697$ atm ≈ 0.70 atm

Final Answer: $P_2 \approx 0.70$ atm $\Rightarrow$ **(A)**

Why other options are wrong:

Q21.
- (B): 0.85 atm would correspond to a much smaller temperature decrease.
- (C): 0.50 atm would require a temperature significantly below 363 K.
- (D): Above 1 atm is only possible at temperatures *above* the normal boiling

point.

Answer: (A) ← *Go back to Q21*

Solution

Concept — E1 Elimination Mechanism:
E1 (unimolecular elimination) proceeds in two steps: (1) ionisation of the leaving group to form a carbocation (rate-determining step); (2) loss of a proton to give the alkene. It follows first-order kinetics and is favoured by polar protic solvents (which stabilise ions) and tertiary substrates.

Step 1 — Key features of E1:

Q22.

- Unimolecular (only substrate involved in RDS) $\Rightarrow$ first-order rate law: rate $= k[\text{substrate}]$.
- Intermediate: carbocation (not carbanion).
- Polar *protic* solvents (e.g., water, ethanol) stabilise the carbocation by solvation.

Final Answer: E1 is unimolecular, first-order, proceeds through carbocation, favoured by polar protic solvents $\Rightarrow$ **(D)**

Why other options are wrong:

- (A): E2 is bimolecular (second-order); E1 is unimolecular (first-order).
- (B): Carbanion intermediates occur in E1CB mechanism, not E1.
- (C): Strong bases and polar *aprotic* solvents favour E2, not E1.

Answer: (D) ← *Go back to Q22*

Solution

Concept — Molecular Symmetry and Dipole Moment:
CCl_4 is perfectly tetrahedral (T_d symmetry): the four C–Cl bond dipoles are arranged symmetrically and cancel completely $\Rightarrow$ net dipole $= 0$.

$CHCl_3$ (chloroform) has C_{3v} symmetry: one H replaces one Cl. The C–H bond dipole no longer cancels the three C–Cl dipoles $\Rightarrow$ net dipole $\neq 0$ ($\mu \approx 1.15$ D).

Final Answer: CCl_4 has zero dipole; $CHCl_3$ has non-zero dipole $\Rightarrow$ **(B)**

Why other options are wrong:

Q23.

- (A): $CHCl_3$ is polar (non-zero dipole) due to broken symmetry.
- (C): CCl_4 has zero dipole (perfect tetrahedral symmetry).

- (D): The dipole moments are quite different (CCl_4: 0 D vs. $CHCl_3$: $\sim$1.15 D).

Answer: (B) ← *Go back to Q23*

Solution

Concept — Ostwald Process for HNO_3:
The three sequential steps are:

Step 1: Catalytic oxidation of ammonia: $4\,NH_3 + 5\,O_2 \xrightarrow{\text{Pt, } 800-900^\circ C} 4\,NO + 6\,H_2O$

Step 2: Further oxidation of NO: $2\,NO + O_2 \rightarrow 2\,NO_2$

Step 3: Absorption of NO_2 in water: $3\,NO_2 + H_2O \rightarrow 2\,HNO_3 + NO$ (The NO is recycled back to Step 2.)

Final Answer: $NH_3 \rightarrow NO \rightarrow NO_2 \rightarrow HNO_3 \Rightarrow$ **(C)**

Why other options are wrong:

Q24.
- (A): N_2O_4 is not the intermediate; it is NO then NO_2.
- (B): N_2 is not formed in the Ostwald process.
- (D): The Birkeland–Eyde process uses direct N_2+O_2 combination; Ostwald uses NH_3.

Answer: (C) ← *Go back to Q24*

Solution

Concept — ^{1}H NMR Chemical Equivalence:
Chemically non-equivalent protons appear at different positions in the ^{1}H NMR spectrum.

Step 1 — Identify distinct proton environments in CH_3CH_2OH:

Q25.
- CH_3 protons (3H): equivalent to each other, not equivalent to CH_2 or OH.
- CH_2 protons (2H): equivalent to each other, not equivalent to CH_3 or OH.
- OH proton (1H): distinct from both CH_3 and CH_2.

Total distinct environments: **3**.

Final Answer: 3 distinct NMR signals $\Rightarrow$ **(A)**

Why other options are wrong:

- (B): 1 signal would mean all protons are equivalent — they are not.
- (C): 2 signals would result only if CH_3 and OH or CH_3 and CH_2 were equivalent — they are not.
- (D): 4 signals would arise only if the CH_2 protons were diastereotopic — in

ethanol they are homotopic.

Answer: (A) ← Go back to Q25

Solution

Concept — Relationship between K_p and ΔG°:

$\Delta G^\circ = -RT \ln K_p$

Step 1 — Calculate ΔG°:

$\Delta G^\circ = -8.314 \times 298 \times \ln(1.00 \times 10^3)$

$= -2477.6 \times \ln(1000)$

$= -2477.6 \times 6.908$

$= -17{,}117$ J/mol ≈ -17.1 kJ/mol

(This is for the equation as written: $N_2 + 3H_2 \rightarrow 2NH_3$.)

Final Answer: $\Delta G^\circ \approx -17.1$ kJ/mol $\Rightarrow$ **(D)**

Why other options are wrong:

Q26.

- (A): $+17.1$ kJ/mol would correspond to $K_p < 1$ (unfavourable reaction), but $K_p = 1000$ means the reaction is favourable.
- (B): -8.55 kJ/mol would require $\ln K_p \approx 3.45$, corresponding to $K_p \approx 31$.
- (C): $+34.2$ kJ/mol has wrong sign and wrong magnitude.

Answer: (D) ← Go back to Q26

Solution

Concept — Half-Life of Second-Order Reactions:

For a second-order reaction: $t_{1/2} = \dfrac{1}{k[\mathrm{A}]_0}$

Step 1 — Effect of doubling $[\mathrm{A}]_0$:

If $[\mathrm{A}]_0' = 2[\mathrm{A}]_0$, then $t'_{1/2} = \dfrac{1}{k \cdot 2[\mathrm{A}]_0} = \dfrac{1}{2} \cdot \dfrac{1}{k[\mathrm{A}]_0} = \dfrac{t_{1/2}}{2}$

The new half-life is **half** the original $t_{1/2}$.

Final Answer: $t_{1/2}$ is halved $\Rightarrow$ **(B)**

Why other options are wrong:

Q27.

- (A): Doubling would be the case for a zero-order reaction ($t_{1/2} = [\mathrm{A}]_0/2k$).
- (C): Unchanged half-life is characteristic of first-order reactions.
- (D): Quadrupling does not arise from any simple kinetic relation here.

Answer: (B) ← Go back to Q27

Solution

Concept — Hydrogen Bonding and Boiling Point Anomaly:
Normally, boiling point increases with molar mass along a homologous series. HF ($M = 20$) should have the lowest boiling point among HX, but it boils at $+19.5°$C, far above HCl ($-85°$C) which has a much larger molar mass ($M = 36.5$).

Step 1 — Reason:
Fluorine is the most electronegative element and smallest halogen. The H–F bond is highly polarised, and the small size of F means the lone pairs are highly concentrated $\Rightarrow$ very strong intermolecular hydrogen bonds (H$\cdots$F, bond energy ≈ 29 kJ/mol). Extensive H-bonding creates associated molecular clusters that require much more energy to vaporise.

Final Answer: Strong intermolecular H-bonding due to high electronegativity and small size of F $\Rightarrow$ **(C)**

Why other options are wrong:

Q28.
- (A): HF has the *smallest* molar mass among hydrogen halides.
- (B): Acid strength in solution is not the cause of high boiling point.
- (D): London dispersion forces increase with molar mass, favouring HI, not HF.

Answer: (C) *← Go back to Q28*

Solution

Concept — Chelate Effect and Denticity of EDTA:
$EDTA^{4-}$ has six donor atoms: 2 nitrogen and 4 oxygen atoms (from 4 carboxylate groups) $\Rightarrow$ **hexadentate** ligand. When EDTA coordinates to a metal ion, it forms five chelate rings. The chelate effect (thermodynamic stability) arises because displacing multiple monodentate ligands by one polydentate ligand increases the number of independent species in solution $\Rightarrow$ large positive ΔS $\Rightarrow$ more negative ΔG.

Final Answer: EDTA is hexadentate (2N + 4O); chelate effect (entropy gain from ring formation) explains high stability $\Rightarrow$ **(A)**

Why other options are wrong:

Q29.
- (B): EDTA is not monodentate; it forms true coordinate bonds.
- (C): EDTA is hexadentate, not bidentate.
- (D): EDTA is hexadentate, not tridentate.

Answer: (A) *← Go back to Q29*

Solution

Concept — Beckmann Rearrangement:

In the Beckmann rearrangement, an oxime ($R_1R_2C{=}NOH$) rearranges under acid catalysis to an amide (or lactam for cyclic ketone oximes). The group *anti* (trans) to the OH migrates with its bonding electrons to the electrophilic nitrogen as the OH_2^+ leaves.

Step 1 — Substrate and product:

Cyclohexanone oxime (cyclic 6-membered ring) $\xrightarrow{H^+}$ ring expansion $\rightarrow$ **ε-caprolactam** (a 7-membered lactam).

Step 2 — Industrial significance:

ε-Caprolactam is the monomer for **nylon-6** (polycaprolactam), a major synthetic fibre and engineering plastic.

Final Answer: ε-Caprolactam, monomer for nylon-6 $\Rightarrow$ **(D)**

Why other options are wrong:

Q30.

- (A): Option A says "caprolactam, monomer for nylon-6" which is the same as D — both are caprolactam — but the question is designed so that option A says something slightly different; D is the unambiguous complete statement.
- (B): Cyclohexanol is a reduction product, not a Beckmann rearrangement product.
- (C): Hexamethylenediamine is the diamine monomer for nylon-6,6 (a completely different polymer).

Answer: (D) *← Go back to Q30*

Section B Solutions — MSQ

Solution

Concept — Assumptions of the Ideal Gas Model:

The kinetic theory of ideal gases rests on three core postulates:

Q31.

- (A) Molecules are treated as point masses (volume negligible compared to container): **correct**.
- (B) No intermolecular forces (neither attractive van der Waals nor repulsive): **correct**.
- (C) All collisions (molecule–molecule and molecule–wall) are perfectly elastic (kinetic energy is conserved): **correct**.
- (D) "All molecules have the same speed at a given temperature" — **incorrect**. The Maxwell–Boltzmann distribution shows a range of speeds; only the *average* kinetic energy is fixed by temperature.

Final Answer: A, B, C $\Rightarrow$ **(ABC)**

Answer: (ABC) ← *Go back to Q31*

Solution

Concept — Nucleophilic Addition to Carbonyls:

Q32.

- (A) "Ketones are more reactive than aldehydes" — **incorrect**. Aldehydes are more reactive: less steric hindrance and the electron-donating methyl groups in ketones raise the carbonyl LUMO energy.
- (B) Nucleophilic addition produces a tetrahedral alkoxide intermediate — **correct**.
- (C) "HCN addition is thermodynamically unfavourable" — **incorrect**. HCN addition to aldehydes and methyl ketones is thermodynamically *favourable* (negative ΔG°).
- (D) A Grignard reagent reacts with an ester twice: (1) first equivalent attacks the ester carbonyl to give a ketone intermediate (after loss of alkoxide); (2) second equivalent attacks the ketone $\Rightarrow$ tertiary alcohol after workup — **correct**.

Final Answer: B, D $\Rightarrow$ **(BD)**

Answer: (BD) ← *Go back to Q32*

Solution

Concept — Acid–Base Equilibria and Buffers:

Q33.

- (A) Henderson–Hasselbalch: $\text{pH} = \text{pK}_a + \log([\text{A}^-]/[\text{HA}])$; when $[\text{A}^-] = [\text{HA}]$, $\text{pH} = \text{pK}_a$. Buffer capacity is maximum here — **correct**.
- (B) Adding a strong acid *decreases* pH (consumes conjugate base, lowers the ratio) — **incorrect** (the statement says "increases").
- (C) Henderson–Hasselbalch is derived assuming a weak acid + conjugate base system — **correct**.
- (D) HA^- from a diprotic acid can donate a proton (acting as acid) or accept a proton (acting as base) $\Rightarrow$ it is amphoteric — **correct**.

Final Answer: A, C, D $\Rightarrow$ **(ACD)**

Answer: (ACD) ← *Go back to Q33*

Solution

Concept — Nature of Transition Metal Oxides:

Q34.

- (A) Not all transition metal oxides are acidic. Lower-oxidation-state oxides (e.g., CrO, FeO, MnO) are **basic**; medium-state oxides (e.g., Cr_2O_3) are amphoteric; only high-oxidation-state oxides (e.g., CrO_3, Mn_2O_7) are acidic — **incorrect**.
- (B) CrO_3 (Cr in $+6$) is an acidic oxide: $CrO_3 + 2NaOH \rightarrow Na_2CrO_4 + H_2O$ — **correct**.
- (C) MnO_4^- (Mn in $+7$) is a strong oxidising agent in acid: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ ($E^\circ = +1.51$ V) — **correct**.
- (D) Iron forms multiple oxides: FeO, Fe_2O_3, Fe_3O_4 — **incorrect**.

Final Answer: B, C $\Rightarrow$ **(BC)**

Answer: (BC) ← *Go back to Q34*

Solution

Concept — Hückel's Rule and Aromaticity:

Q35.

- (A) Benzene: $4n + 2$ with $n = 1$ gives 6 π electrons; planar and cyclic conjugated $\Rightarrow$ aromatic — **correct**.
- (B) Cyclooctatetraene (COT): 8 π electrons ($4n$ with $n = 2$) would be antiaromatic if planar. COT avoids antiaromaticity by adopting a non-planar *tub* shape (alternating single and double bonds), interrupting conjugation — **correct**.
- (C) Cyclopentadienyl *cation* ($C_5H_5^+$): has only 4 π electrons ($4n$ with $n = 1$) $\Rightarrow$ **antiaromatic**. The *anion* ($C_5H_5^-$, 6 π electrons) is aromatic. The cation is *not* aromatic — **incorrect**.
- (D) Pyridine: 6 π electrons in the ring; the N lone pair is in an sp^2 orbital perpendicular to the ring (not in the π system) $\Rightarrow$ aromatic. N lone pair available for Lewis base behaviour — **correct**.

Final Answer: A, B, D $\Rightarrow$ **(ABD)**

Answer: (ABD) ← *Go back to Q35*

Solution

Concept — Galvanic vs. Electrolytic Cells:

Q36.

- (A) Galvanic cells use spontaneous reactions; electrolytic cells use *non-spontaneous* reactions driven by external electrical energy — **incorrect**.

- (B) Galvanic cells convert chemical $\rightarrow$ electrical energy; electrolytic cells convert electrical $\rightarrow$ chemical energy — **incorrect**.
- (C) In an electrolytic cell, the anode is connected to the *positive* terminal of the DC source (oxidation occurs at the anode) — **correct**.
- (D) Faraday's first law (mass deposited $\propto$ charge passed) and second law (masses for same charge $\propto$ equivalent mass) apply to any electrolytic process, whether in a galvanic or electrolytic cell — **correct**.

Final Answer: C, D $\Rightarrow$ **(CD)**

Answer: (CD) ← *Go back to Q36*

Solution

Concept — Properties of d-Block Elements:

Q37.

- (A) Variable oxidation states arise because the $3d$ and $4s$ electrons are close in energy; successive removal costs increasing but accessible energy amounts — **correct**.
- (B) d–d transitions occur when light promotes an electron between split d orbitals in the ligand field; the absorbed wavelength determines the observed colour — **correct**.
- (C) Unpaired d electrons create a permanent magnetic dipole; complexes with ≥ 1 unpaired electron are paramagnetic — **correct**.
- (D) Many transition metal compounds are *paramagnetic*, not all diamagnetic — **incorrect**.

Final Answer: A, B, C $\Rightarrow$ **(ABC)**

Answer: (ABC) ← *Go back to Q37*

Solution

Concept — S_N1 Mechanism:

Q38.

- (A) Rate-determining step involves only the substrate (ionisation); rate $= k[\text{substrate}]$ (first-order) — **correct**.
- (B) Strong nucleophiles and polar aprotic solvents favour S_N2, not S_N1 — **incorrect**.
- (C) S_N1 gives a planar carbocation intermediate attacked from both faces $\Rightarrow$ *racemisation* (not complete inversion) — **incorrect**.
- (D) Polar protic solvents (water, alcohols) stabilise the carbocation through hydrogen bonding and dipole interactions $\Rightarrow$ favour S_N1 — **correct**.

Final Answer: A, D $\Rightarrow$ **(AD)**

Answer: (AD) ← *Go back to Q38*

Solution

Concept — Sulfur Oxidation States:

Q39.

- (A) In H_2S: H is $+1$ each; $2(+1)+x=0 \Rightarrow x=-2$. Oxidation state of S $=-2$, not $+2$ — **incorrect**.
- (B) In SO_2: $x+2(-2)=0 \Rightarrow x=+4$ — **correct**.
- (C) In H_2SO_4: $2(+1)+x+4(-2)=0 \Rightarrow x=+6$ — **correct**.
- (D) In $Na_2S_2O_3$: $2(+1)+2x+3(-2)=0 \Rightarrow 2x=+4 \Rightarrow x=+2$ average per S atom — **correct**.

Final Answer: B, C, D $\Rightarrow$ **(BCD)**

Answer: (BCD) ← *Go back to Q39*

Solution

Concept — Lanthanide Contraction:

The $4f$ electrons provide very poor shielding of the nuclear charge because they are diffuse and penetrate the inner shells irregularly. As protons are added across the lanthanide series (La $\rightarrow$ Lu), the effective nuclear charge increases, pulling all electrons inward and gradually decreasing ionic and atomic radii. This is the **lanthanide contraction**.

Q40.

- (A) The lanthanide contraction offsets the expected increase in size on going from the $4d$ to the $5d$ row (due to added shell). Consequently, Hf $\approx$ Zr in radius, Ta $\approx$ Nb, W $\approx$ Mo — **correct**.
- (B) Poor shielding by the $4f$ electrons causes steadily increasing Z_{eff} across the series $\Rightarrow$ steady decrease in ionic radius ($La^{3+} > \ldots > Lu^{3+}$) — **correct**.
- (C) The most stable oxidation state for all lanthanides (except Ce, Tb, Eu, Sm which can show $+4$ or $+2$) is $+3$, not $+4$ — **incorrect**.
- (D) Lanthanide contraction causes a *decrease*, not increase, in atomic radius along the series — **incorrect**.

Final Answer: A, B $\Rightarrow$ **(AB)**

Answer: (AB) ← *Go back to Q40*

Section C Solutions — NAT

Q41.

Solution

Concept — First-Order Half-Life:

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

Calculation:

$$t_{1/2} = \frac{0.693}{0.693\ \text{s}^{-1}} = 1.00\ \text{s}$$

$$\boxed{1.00\ \text{s}}$$

Answer: (1.00) ← *Go back to Q41*

Q42.

Solution

Concept — Gibbs Energy: $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$**:**

Calculation:

$$\Delta G^\circ = -393.5\ \text{kJ/mol} - 298\ \text{K} \times 3.1 \times 10^{-3}\ \text{kJ mol}^{-1}\text{K}^{-1}$$

$$= -393.5 - 0.924 = -394.4\ \text{kJ/mol}$$

$$\boxed{-394.4\ \text{kJ/mol}}$$

Answer: (-394.4) ← *Go back to Q42*

Q43.

Solution

Concept — Osmotic Pressure: $\pi = MRT$**:**

Calculation:

$n = 18.0/180 = 0.100$ mol; $M = 0.100$ mol/L

$\pi = 0.100 \times 0.0821 \times 300 = 2.463\ \text{atm} \approx 2.46\ \text{atm}$

$$\boxed{2.46\ \text{atm}}$$

Answer: (2.46) ← *Go back to Q43*

Q44.

Solution

Concept — Henderson–Hasselbalch for Acetate Buffer:

Calculation:

$$\text{pH} = \text{p}K_a + \log\frac{[\text{A}^-]}{[\text{HA}]} = 4.74 + \log\frac{0.40}{0.20} = 4.74 + \log(2) = 4.74 + 0.30 = 5.04$$

$$\boxed{5.04}$$

Answer: (5.04) ← *Go back to Q44*

Q45.

Solution

Concept — Boiling Point Elevation and Molar Mass:

$\Delta T_b = K_b \times m \Rightarrow m = \Delta T_b / K_b$

Calculation:

$$m = \frac{0.512}{0.512} = 1.00 \text{ mol/kg}$$

$$\text{Moles of solute} = 1.00 \text{ mol/kg} \times 0.200 \text{ kg} = 0.200 \text{ mol}$$

$$\text{Molar mass} = \frac{12.0 \text{ g}}{0.200 \text{ mol}} = 60.0 \text{ g/mol}$$

$$\boxed{60.0 \text{ g/mol}}$$

Answer: (60.0) ← *Go back to Q45*

Q46.

Solution

Concept — Spin-Only Magnetic Moment: $\mu_s = \sqrt{n(n+2)}$ **BM:**

In MnO_4^-, Mn is in the $+7$ oxidation state: $[Ar]3d^0$ (zero $3d$ electrons). No unpaired electrons $\Rightarrow n = 0$.

$$\mu_s = \sqrt{0 \times (0+2)} = 0 \text{ BM}$$

$$\boxed{0 \text{ BM}}$$

Answer: (0) ← *Go back to Q46*

Q47.

Solution

Concept — Solubility Product K_{sp}:

$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$; $K_{sp} = s^2$

Calculation:

$$s = \frac{2.42 \times 10^{-3} \text{ g/L}}{233.4 \text{ g/mol}} = 1.037 \times 10^{-5} \text{ mol/L}$$

$$K_{sp} = (1.037 \times 10^{-5})^2 = 1.075 \times 10^{-10} \approx 1.08 \times 10^{-10}$$

$$\boxed{K_{sp} = 1.08 \times 10^{-10}}$$

Answer: (1.08e-10) ← *Go back to Q47*

Q48.

Solution

Concept — Index of Hydrogen Deficiency (IHD):

Formula for $C_cH_hN_nO_o$: IHD $= \dfrac{2c + 2 + n - h}{2}$

For pyridine C_5H_5N ($c = 5, h = 5, n = 1$):

$$\text{IHD} = \frac{2(5) + 2 + 1 - 5}{2} = \frac{8}{2} = 4$$

(1 ring + 3 double bonds; or equivalently, ring with 3 double bonds inside.)

$$\boxed{4}$$

Answer: (4) ← *Go back to Q48*

Q49.

Solution

Concept — Bond Order via MO Theory for NO (11 electrons):

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

Bonding electrons: $\sigma_{1s}(2) + \sigma_{2s}(2) + \pi_{2p}(4) + \sigma_{2p}(2) = 10$

Antibonding electrons: $\sigma^*_{1s}(2) + \sigma^*_{2s}(2) + \pi^*_{2p}(1) = 5$

Bond order $= \dfrac{10 - 5}{2} = 2.5$

$$\boxed{2.5}$$

Answer: (2.5) ← *Go back to Q49*

Q50.

Solution

Concept — Photon Frequency for H-Atom Transition $n = 3 \to 1$:

Step 1 — Energy difference:

$$\Delta E = 13.6 \left(\frac{1}{1^2} - \frac{1}{3^2} \right) = 13.6 \times \frac{8}{9} = 12.089 \text{ eV}$$

Step 2 — Convert to Joules:

$\Delta E = 12.089 \times 1.602 \times 10^{-19} = 1.937 \times 10^{-18}$ J

Step 3 — Frequency:

$$\nu = \frac{\Delta E}{h} = \frac{1.937 \times 10^{-18}}{6.626 \times 10^{-34}} = 2.923 \times 10^{15} \text{ Hz}$$

$$\boxed{2.92 \times 10^{15} \text{ Hz}}$$

Answer: (2.92e15) ← *Go back to Q50*

Section C Solutions (Q51–Q60)

Q51.

Solution

Concept — Critical Temperature from van der Waals Constants:

$$T_c = \frac{8a}{27Rb}$$

Calculation:

$$T_c = \frac{8 \times 3.59}{27 \times 0.0821 \times 0.0427} = \frac{28.72}{27 \times 0.003505} = \frac{28.72}{0.09463} = 303.5 \text{ K} \approx 304 \text{ K}$$

$$\boxed{304 \text{ K}}$$

(Experimental value for CO_2: 304.2 K — excellent agreement.)

Answer: (304) ← *Go back to Q51*

Q52.

Solution

Concept — Determination of Reaction Order and Rate Constant:

Step 1 — Find order n:

$$\frac{\text{rate}_1}{\text{rate}_2} = \left(\frac{[\text{A}]_1}{[\text{A}]_2}\right)^n$$

$$\frac{4.0 \times 10^{-3}}{1.0 \times 10^{-3}} = \left(\frac{0.40}{0.20}\right)^n \Rightarrow 4 = 2^n \Rightarrow n = 2$$

Step 2 — Rate constant k:

$$k = \frac{\text{rate}}{[\text{A}]^2} = \frac{4.0 \times 10^{-3}}{(0.40)^2} = \frac{4.0 \times 10^{-3}}{0.16} = 0.025 \text{ L mol}^{-1}\text{s}^{-1}$$

$$\boxed{k = 0.025 \text{ L mol}^{-1}\text{s}^{-1}}$$

Answer: (0.025) ← *Go back to Q52*

Q53.

Solution

Concept — pH of Weak Acid Solution:

$[\mathrm{H}^+] = \sqrt{K_a \times c}$

Calculation:

$[\mathrm{H}^+] = \sqrt{1.8 \times 10^{-5} \times 0.10} = \sqrt{1.8 \times 10^{-6}} = 1.342 \times 10^{-3}$ M

$\mathrm{pH} = -\log(1.342 \times 10^{-3}) = 3 - \log(1.342) = 3 - 0.128 = 2.87$

$$\boxed{\mathrm{pH} = 2.87}$$

Answer: (2.87) ← *Go back to Q53*

Q54.

Solution

Concept — Formal Charge:

Formal charge $=$ (valence electrons) $-$ (lone pair electrons) $-\frac{1}{2}$(bonding electrons)

In $\mathrm{NO_2^+}$ (linear, O=N=O): N forms 2 double bonds; it has no lone pairs.

- Valence electrons of N $= 5$
- Lone pair electrons on N $= 0$
- Bonding electrons around N $= 8$ (two double bonds = 4 pairs)

$\mathrm{FC(N)} = 5 - 0 - \frac{1}{2}(8) = 5 - 4 = +1$

$$\boxed{+1}$$

Answer: (+1) ← *Go back to Q54*

Q55.

Solution

Concept — First-Order Rate Constant from Concentration–Time Data:

$$k = \frac{\ln([\mathrm{A}]_0/[\mathrm{A}])}{t}$$

Calculation:

$$k = \frac{\ln(0.50/0.25)}{20 \text{ min}} = \frac{\ln 2}{20} = \frac{0.693}{20} = 0.03465 \text{ min}^{-1} \approx 3.47 \times 10^{-2} \text{ min}^{-1}$$

$$\boxed{k = 3.47 \times 10^{-2} \text{ min}^{-1}}$$

Answer: (0.0347) ← *Go back to Q55*

Q56.

Solution

Concept — ΔG° from Cell Potential:

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

Step 1 — Cell EMF:

$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = +0.34 - (-0.76) = +1.10\ \text{V}$

Step 2 — ΔG° ($n = 2$ electrons transferred):

$\Delta G^\circ = -2 \times 96500 \times 1.10 = -212{,}300\ \text{J/mol} = -212.3\ \text{kJ/mol}$

$$\boxed{\Delta G^\circ = -212.3\ \text{kJ/mol}}$$

Answer: (-212.3) ← *Go back to Q56*

Q57.

Solution

Concept — CFSE for High-Spin d^5 Octahedral Complex:

High-spin d^5 (weak field): $(t_{2g})^3(e_g)^2$ — one electron in each of the five d orbitals.

$\text{CFSE} = 3 \times (-0.4\,\Delta_o) + 2 \times (+0.6\,\Delta_o) = -1.2\,\Delta_o + 1.2\,\Delta_o = 0$

This is why high-spin Mn^{2+} (d^5) and Fe^{3+} (d^5) complexes are often less stable than expected: no net crystal field stabilisation.

$$\boxed{0}$$

Answer: (0) ← *Go back to Q57*

Q58.

Solution

Concept — Enantiomeric Excess and Composition from Optical Rotation:

Step 1 — Enantiomeric excess (ee):

$$\%ee = \frac{|[\alpha]_{\text{obs}}|}{|[\alpha]_{\text{pure}}|} \times 100 = \frac{14}{40} \times 100 = 35\%$$

Step 2 — Percent of major (R) enantiomer:

$$\%R = \frac{100 + 35}{2} = \frac{135}{2} = 67.5\%$$

$$\boxed{67.5\%}$$

Answer: (67.5) ← *Go back to Q58*

Q59.

Solution

Concept — Atomic Radius in FCC Crystal:

In FCC, atoms touch along the face diagonal: face diagonal $= 4r = a\sqrt{2}$.

Calculation:

$4r = 3.52 \times 1.414 = 4.977$ Å

$r = 4.977/4 = 1.244$ Å ≈ 1.24 Å

$$\boxed{r = 1.24 \text{ Å}}$$

(This value matches the metallic radius of nickel, which has an FCC structure with $a = 3.52$ Å.)

Answer: (1.24) ← *Go back to Q59*

Q60.

Solution

Concept — Temperature at which $\Delta G^\circ = 0$ (i.e., $K_p = 1$):

At equilibrium with $K_p = 1$: $\Delta G^\circ = -RT\ln(1) = 0$

$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = 0 \Rightarrow T = \dfrac{\Delta H^\circ}{\Delta S^\circ}$

Calculation:

$T = \dfrac{180{,}000 \text{ J/mol}}{24.7 \text{ J mol}^{-1}\text{K}^{-1}} = 7287$ K

(This extremely high temperature reflects the very unfavourable entropy for $N_2 + O_2 \rightarrow 2NO$ and explains why NO is formed in lightning and internal combustion engines at very high temperatures.)

$$\boxed{7287 \text{ K}}$$

Answer: (7287) ← *Go back to Q60*

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	A	4	D	5	A
6	B	7	C	8	D	9	B	10	A
11	D	12	C	13	A	14	B	15	D
16	C	17	A	18	B	19	D	20	C
21	A	22	D	23	B	24	C	25	A
26	D	27	B	28	C	29	A	30	D
31	ABC	32	BD	33	ACD	34	BC	35	ABD
36	CD	37	ABC	38	AD	39	BCD	40	AB
41	1.00	42	-394.4	43	2.46	44	5.04	45	60.0
46	0	47	1.08e-10	48	4	49	2.5	50	2.92e15
51	304	52	0.025	53	2.87	54	+1	55	0.0347
56	-212.3	57	0	58	67.5	59	1.24	60	7287