JELET Chemistry Sample Paper-6

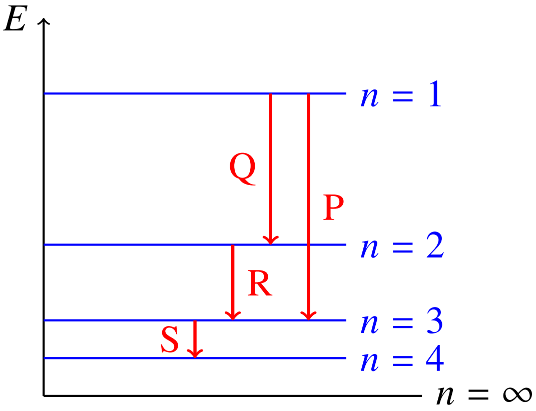
Duration: 25 Minutes **Maximum Marks: 25**

Instructions

- This paper contains **20** Multiple Choice Questions divided into **2 Sections**.
- **Section A (Q1–Q15):** Each correct answer carries **+1 mark**. Incorrect answer: **−0.25** marks. Only **one** correct option.
- **Section B (Q16–Q20):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Section–A — 15 Questions × 1 Mark Each
(Negative Marking: −0.25) [Single Correct]

Q1. The energy level diagram of a hydrogen-like species is shown below. If the ground state ionization energy is 54.4 eV, which transition labelled in the diagram corresponds to the absorption of a photon of wavelength approximately 256 Å?



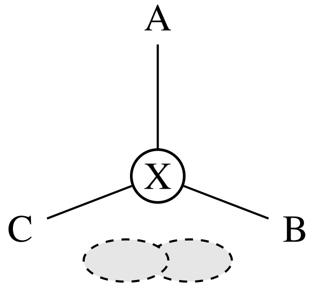
(A) Transition P

(B) Transition Q

(C) Transition R

(D) Transition S

Q2. The molecular structure of a compound with a central atom having 5 electron pairs (3 bonding + 2 lone pairs) is shown below. Based on VSEPR theory, identify the molecular geometry and an example of such a molecule.



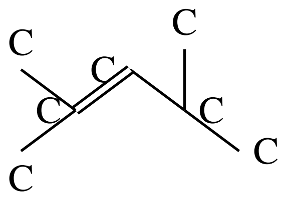
(A) Trigonal planar geometry; BF_3

(B) T-shaped geometry; ClF_3

(C) Trigonal pyramidal geometry; NH_3

(D) Square planar geometry; XeF_4

Q3. The skeletal structure of a hydrocarbon is drawn below. What is its correct IUPAC name?



(A) 2,4-dimethylpent-2-ene

(B) 2,4-dimethylpent-3-ene

(C) 3,5-dimethylpent-3-ene

(D) 2,4-dimethylpent-1-ene

Q4. For the galvanic cell: $\mathrm{Zn}\,|\,\mathrm{Zn}^{2+}(0.01\,\mathrm{M})\,||\,\mathrm{Cu}^{2+}(0.1\,\mathrm{M})\,|\,\mathrm{Cu}$, the cell potential at 298 K is closest to: (Given: $E^\circ_{\mathrm{Zn}^{2+}/\mathrm{Zn}} = -0.76$ V, $E^\circ_{\mathrm{Cu}^{2+}/\mathrm{Cu}} = +0.34$ V)

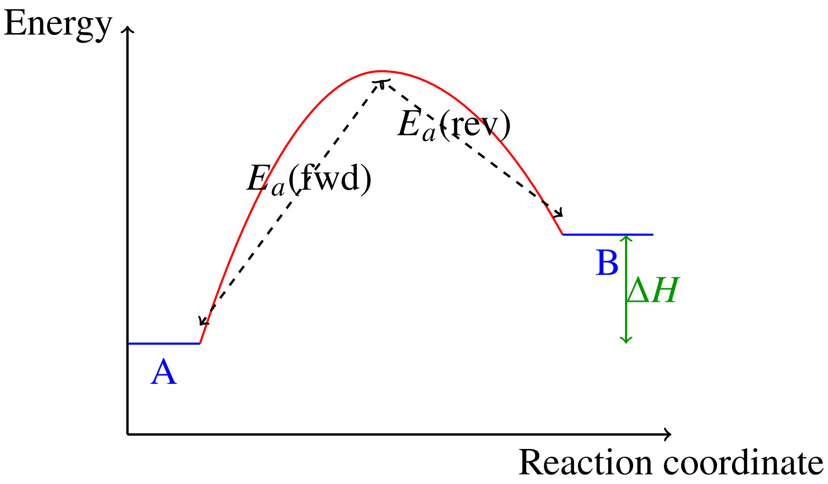
(A) 1.07 V

(B) 1.10 V

(C) 1.13 V

(D) 1.16 V

Q5. The energy profile diagram for a reversible reaction $A \rightleftharpoons B$ is given below. Based on the diagram, which statement is correct regarding the effect of temperature on the equilibrium?



(A) Increasing temperature shifts equilibrium towards A because E_a(fwd) $> E_a$(rev)

(B) Increasing temperature shifts equilibrium towards B because the forward reaction is endothermic

(C) Decreasing temperature shifts equilibrium towards A because $\Delta H < 0$

(D) Temperature has no effect since both activation energies are positive

Q6. A 0.1 M solution of a weak monobasic acid HA is 2% ionized at 298 K. When its sodium salt NaA is added to make the solution 0.1 M in NaA as well, the degree of ionization of HA becomes approximately:

(A) 0.02%

(B) 0.04%

(C) 0.2%

(D) 2%

Q7. In the Hall–Héroult process for aluminium extraction, a mixture of alumina (Al_2O_3) and cryolite (Na_3AlF_6) is electrolyzed. The primary role of cryolite in this process is to:

(A) Lower the melting point of the electrolyte and improve conductivity

(B) Act as a catalyst for the reduction of Al^{3+}

(C) Prevent the anodic oxidation of graphite electrodes

(D) Increase the density of molten aluminium for easier collection

Q8. An electron in a multi-electron atom has the following set of quantum numbers: $n = 3, l = 1, m_l = 0, m_s = -\frac{1}{2}$. Which orbital does this electron occupy?

(A) $3s$ orbital

(B) $3p_x$ orbital

(C) $3p_z$ orbital

(D) $3d_{z^2}$ orbital

Q9. In the electrolytic refining of copper, a current of 2 A is passed for 30 minutes through a $CuSO_4$ solution using impure copper as the anode. The mass of pure copper deposited at the cathode is approximately: (Atomic mass of Cu = 63.5 g mol^{-1}, 1 F = 96500 C)

(A) 0.59 g

(B) 1.18 g

(C) 2.37 g

(D) 3.95 g

Q10. A solution is prepared by mixing 50 mL of 0.2 M CH_3COOH with 50 mL of 0.2 M NaOH. Given that pK_a of $CH_3COOH = 4.74$, the pH of the resulting solution at 298 K is approximately:

(A) 4.74

(B) 7.00

(C) 8.72

(D) 10.26

Q11. In which of the following compounds does manganese exhibit the highest oxidation state?

(A) MnO_2

(B) K_2MnO_4

(C) $KMnO_4$

(D) Mn_2O_3

Q12. Acid rain is a serious environmental concern that damages buildings, aquatic life, and soil quality. The primary gaseous pollutants responsible for the formation of acid rain are:

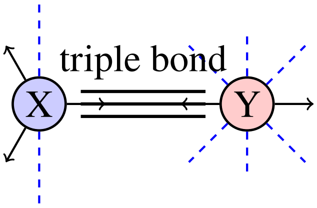
(A) CO_2 and CO

(B) SO_2 and NO_x

(C) NH_3 and CH_4

(D) H_2S and O_3

Q13. The following diagram represents the orbital overlap in a hydrocarbon molecule. What is the hybridization state of the carbon atoms labelled X and Y respectively?



(A) X: sp, Y: sp^2

(B) X: sp^2, Y: sp

(C) X: sp^3, Y: sp

(D) X: sp, Y: sp

Q14. The solubility product of $PbCl_2$ at 298 K is 1.6×10^{-5}. Its solubility (in mol L^{-1}) in 0.1 M NaCl solution is:

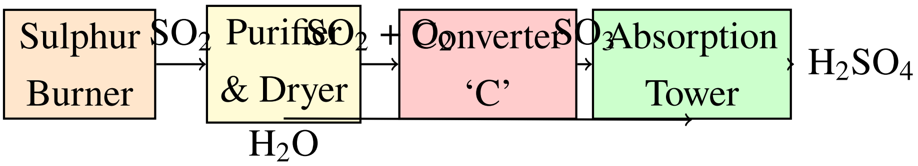
(A) 4.0×10^{-3}

(B) 1.6×10^{-3}

(C) 1.6×10^{-4}

(D) 4.0×10^{-4}

Q15. The schematic below outlines the Contact Process for H_2SO_4 manufacture. In the converter labelled 'C', SO_2 is oxidized to SO_3 using a specific catalyst. Identify the catalyst and the optimum temperature range maintained in the converter.



(A) V_2O_5 at 720–800 K

(B) Finely divided Fe at 700–900 K

(C) Pt-Rh gauze at 1100 K

(D) Ni at 500–600 K

Section–B — 5 Questions × 2 Marks Each (No Negative Marking) [One or More Correct]

Q16. Which of the following statements regarding hybridization are correct?

(A) In sp^3 hybridization, all four hybrid orbitals are equivalent in shape and energy.

(B) In sp^2 hybridization, the unhybridized p-orbital lies perpendicular to the plane containing the three sp^2 hybrid orbitals.

(C) sp hybridization always results in a linear geometry with a bond angle of 180°.

(D) dsp^2 hybridization in $[Ni(CN)_4]^{2-}$ leads to a tetrahedral geometry.

Q17. For the Haber process: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta H = -92$ kJ, which of the following changes will increase the equilibrium yield of ammonia?

(A) Increasing the total pressure of the system at constant temperature.

(B) Raising the temperature to speed up the reaction.

(C) Continuously removing NH_3 from the reaction mixture.

(D) Adding an inert gas at constant volume.

Q18. Consider the following statements about a Daniell cell ($Zn \mid Zn^{2+} \parallel Cu^{2+} \mid Cu$) operating under standard conditions. Which of them are correct?

(A) Oxidation occurs at the zinc electrode and reduction occurs at the copper electrode.

(B) Electrons flow from the copper electrode to the zinc electrode through the external circuit.

(C) The salt bridge maintains electrical neutrality by allowing ion migration between the half-cells.

(D) The standard cell potential E°_{cell} equals $+1.10$ V.

Q19. In the extraction of iron using a blast furnace, which of the following statements are correct?

(A) Limestone ($CaCO_3$) is added to remove siliceous gangue as calcium silicate slag.

(B) Carbon monoxide serves as the primary reducing agent in the upper and middle zones of the furnace.

(C) Pure metallic iron free from all impurities is directly tapped from the bottom of the blast furnace.

(D) The temperature in the hottest combustion zone near the tuyères reaches approximately 2000–2200 K.

Q20. According to the quantum mechanical model of the atom, which of the following statements are correct?

(A) The energy of an electron in a hydrogen atom depends solely on the principal quantum number n.

(B) According to the Pauli exclusion principle, an orbital can accommodate a maximum of two electrons with parallel spins.

(C) For a given value of the principal quantum number n, the total number of orbitals in that shell is n^2.

(D) Hund's rule of maximum multiplicity states that electron pairing in degenerate orbitals occurs only after each orbital is singly occupied.

Detailed Solutions

Q1.

Solution

Concept:

For a hydrogen-like species, the energy of the n^{th} level is $E_n = -\dfrac{Z^2 \times 13.6}{n^2}$ eV, where Z is the atomic number. The ionization energy from the ground state is $|E_1| = 13.6Z^2$ eV. Given 54.4 eV, we find $Z^2 = 54.4/13.6 = 4$, so $Z = 2$ (He^+). The energy difference between levels n_i and n_f determines the photon wavelength via $\Delta E = \dfrac{hc}{\lambda}$.

Solution:

(a) Since IE = 54.4 eV = $13.6 \times Z^2$, we get $Z = 2$. The species is He^+.

(b) The photon wavelength is $\lambda = 256$ Å $= 2.56 \times 10^{-8}$ m.

(c) $\Delta E = \dfrac{hc}{\lambda} = \dfrac{6.63 \times 10^{-34} \times 3 \times 10^8}{2.56 \times 10^{-8} \times 1.6 \times 10^{-19}}$ eV ≈ 48.5 eV.

(d) For He^+: $E_n = -\dfrac{54.4}{n^2}$. The ground state $E_1 = -54.4$ eV.

(e) $E_3 = -54.4/9 = -6.04$ eV. $\Delta E_{1\to 3} = 54.4 - 6.04 = 48.36$ eV, which matches our calculated ΔE.

(f) In the diagram, transition P goes from $n = 1$ to $n = 3$ (largest jump). Transition Q goes from $n = 1$ to $n = 2$. Transitions R and S involve lower levels.

(g) The absorbed photon of 256 Å corresponds to $n = 1 \rightarrow n = 3$, which is transition P.

(h) **Trap Check:** Do not confuse emission with absorption. All arrows point upward, indicating absorption. Transition P spans the largest energy gap.

Final Answer: Transition P

Answer: (A)

Go Back to Question 1

Q2.

Solution

Concept:
VSEPR theory predicts molecular geometry by counting both bonding pairs (BP) and lone pairs (LP) around the central atom. The total steric number (BP + LP) determines the electron-pair geometry. For a steric number of 5 (trigonal bipyramidal), 3 BP + 2 LP produces a T-shaped molecular geometry because the two lone pairs occupy equatorial positions to minimize repulsion.

Solution:

(a) The diagram shows a central atom X bonded to three atoms (A, B, C) and having two lone pairs (dashed ellipses).

(b) Steric number = BP + LP = 3 + 2 = 5, indicating trigonal bipyramidal electron-pair geometry.

(c) In a trigonal bipyramidal arrangement, lone pairs preferentially occupy equatorial positions (where they experience only two 90° interactions vs. three in axial positions).

(d) With two equatorial lone pairs and three bonded atoms, the resulting shape is T-shaped.

(e) ClF_3 is the classic example: Cl has 7 valence electrons, uses 3 for bonding with F atoms, leaving 4 electrons = 2 lone pairs. Steric number 5, T-shaped.

(f) BF_3 is trigonal planar (SN = 3, 0 LP). NH_3 is trigonal pyramidal (SN = 4, 1 LP). XeF_4 is square planar (SN = 6, 2 LP).

Final Answer: T-shaped geometry; ClF_3

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept:

IUPAC nomenclature for alkenes requires: (1) identifying the longest continuous carbon chain that contains the double bond, (2) numbering the chain from the end nearest the double bond, (3) naming substituents with their position numbers, and (4) indicating the position of the double bond by the lower-numbered carbon involved. Alkenes take priority over alkyl substituents in numbering.

Solution:

(a) The skeletal structure shows a 5-carbon chain (pent-) with a double bond (pentene) and two methyl (CH_3) substituents.

(b) Locate the double bond: it lies between carbons 2 and 3 of the main chain.

(c) Number from the end closest to the double bond. The double bond is at position 2, so the name ends with "pent-2-ene".

(d) Methyl substituents are at positions 2 and 4.

(e) The correct IUPAC name is 2,4-dimethylpent-2-ene.

(f) Option B would require the double bond at position 3. Option D would place it at the terminal position. Option C reverses numbering.

Final Answer: 2,4-dimethylpent-2-ene

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept:

The Nernst equation relates the cell potential under non-standard conditions to the standard cell potential: $E_{\text{cell}} = E^\circ_{\text{cell}} - \dfrac{0.059}{n}\log Q$ at 298 K. For the Daniell cell $\text{Zn} + \text{Cu}^{2+} \longrightarrow \text{Zn}^{2+} + \text{Cu}$, $n = 2$ and $Q = \dfrac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]}$.

Solution:

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

(b) The cell reaction transfers $n = 2$ electrons. $Q = \dfrac{[\text{Zn}^{2+}]}{[\text{Cu}^{2+}]} = \dfrac{0.01}{0.1} = 0.1$.

(c) Apply Nernst equation: $E_{\text{cell}} = 1.10 - \dfrac{0.059}{2}\log(0.1) = 1.10 - 0.0295 \times (-1) = 1.10 + 0.0295 = 1.1295$ V.

(d) Rounding to two decimal places: $E_{\text{cell}} \approx 1.13$ V.

(e) **Trap Check:** Do not forget to divide by $n = 2$. Also, $Q = [\text{Zn}^{2+}]/[\text{Cu}^{2+}]$, not the reverse.

Final Answer: 1.13 V

Answer: (C)

Go Back to Question 4

Q5.

Solution

Concept:

In an energy profile diagram, $\Delta H = E_{\text{products}} - E_{\text{reactants}}$. When products are at higher energy, $\Delta H > 0$ (endothermic). According to Le Chatelier's principle, increasing temperature for an endothermic reaction shifts equilibrium toward products.

Solution:

(a) From the diagram, the energy of A (reactants) is at level 1.0, and the energy of B (products) is at level 2.2.

(b) $\Delta H = E_B - E_A = 2.2 - 1.0 > 0$, so the forward reaction $A \longrightarrow B$ is endothermic.

(c) For an endothermic reaction, heat is "absorbed." Increasing temperature shifts equilibrium toward B (products) per Le Chatelier.

(d) Option A is incorrect: activation energies describe kinetics, not thermodynamics. The equilibrium shift depends on ΔH.

(e) Option C is incorrect because $\Delta H > 0$ (endothermic, not exothermic). Option D is plainly wrong.

(f) Therefore, Option B is correct.

Final Answer: Increasing temperature shifts equilibrium towards B because the forward reaction is endothermic.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept:

For a weak monobasic acid HA, $K_a = \dfrac{C\alpha^2}{1-\alpha} \approx C\alpha^2$ when $\alpha \ll 1$. The common ion effect from added NaA suppresses ionization: $[\mathrm{H^+}] = \dfrac{K_a[\mathrm{HA}]}{[\mathrm{A^-}]}$.

Solution:

(a) Initially: 0.1 M HA with $\alpha = 2\% = 0.02$. $K_a = C\alpha^2 = 0.1 \times (0.02)^2 = 4.0 \times 10^{-5}$.

(b) After adding 0.1 M NaA: $[\mathrm{HA}] = 0.1$ M and $[\mathrm{A^-}] = 0.1$ M.

(c) Using $K_a = \dfrac{[\mathrm{H^+}][\mathrm{A^-}]}{[\mathrm{HA}]}$: $4.0 \times 10^{-5} = \dfrac{[\mathrm{H^+}] \times 0.1}{0.1}$, so $[\mathrm{H^+}] = 4.0 \times 10^{-5}$ M.

(d) New degree of ionization: $\alpha' = \dfrac{[\mathrm{H^+}]}{[\mathrm{HA}]} = \dfrac{4.0 \times 10^{-5}}{0.1} = 4.0 \times 10^{-4} = 0.04\%$.

(e) **Trap Check:** The common ion drastically reduces ionization from 2% to 0.04%. Do not forget the acid concentration is unchanged at 0.1 M.

Final Answer: 0.04%

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 6

Q7.

Solution

Concept:
Aluminium is extracted by the Hall–Héroult process, involving electrolytic reduction of purified alumina (Al_2O_3) dissolved in molten cryolite (Na_3AlF_6). Pure Al_2O_3 melts at $\sim 2050°C$, making direct electrolysis impractical. Cryolite serves dual purposes.

Solution:

(a) Pure Al_2O_3 melts at $\sim 2050°C$. Adding cryolite lowers the melting point of the mixture to $\sim 950°C$, making the process economically viable.

(b) Cryolite also increases the electrical conductivity of the molten electrolyte, improving current efficiency.

(c) At the cathode: $Al^{3+} + 3e^- \rightarrow Al(l)$. At the anode: oxygen reacts with the graphite anode to form CO_2.

(d) Cryolite does not act as a catalyst (Option B), nor does it primarily prevent anode oxidation (Option C – the anode still gets consumed). It doesn't increase aluminium density (Option D).

(e) **Trap Check:** Students sometimes confuse cryolite's role with that of fluorspar (CaF_2) which is added in smaller amounts to improve conductivity further. The primary role is melting point depression.

Final Answer: Lower the melting point of the electrolyte and improve conductivity

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept:

Quantum numbers uniquely define an electron's state. n gives the shell. l defines the subshell: $l = 0$ (s), $l = 1$ (p), $l = 2$ (d), $l = 3$ (f). m_l specifies the individual orbital, taking values from $-l$ to $+l$. For $l = 1$, $m_l = -1, 0, +1$ correspond to p_x, p_z, and p_y orbitals (convention: $m_l = 0$ is p_z).

Solution:

(a) Given: $n = 3$, $l = 1$, $m_l = 0$, $m_s = -\frac{1}{2}$.

(b) $n = 3$ means the electron is in the third shell (M-shell).

(c) $l = 1$ indicates a p-subshell (not s with $l = 0$, and not d with $l = 2$).

(d) $m_l = 0$ identifies the specific p-orbital. By convention, the p-orbital with $m_l = 0$ is designated as p_z.

(e) Therefore, this electron occupies the $3p_z$ orbital.

(f) Option A ($3s$) requires $l = 0$. Option B ($3p_x$) typically has $m_l = \pm1$. Option D ($3d_{z^2}$) requires $l = 2$.

Final Answer: $3p_z$ orbital

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 8

Q9.

Solution

Concept:

Faraday's first law of electrolysis: $m = \dfrac{M \times I \times t}{n \times F}$, where M is molar mass, I is current, t is time, n is electrons per ion, and $F = 96500\ \text{C mol}^{-1}$.

Solution:

(a) Current $I = 2$ A, time $t = 30\ \text{min} = 30 \times 60 = 1800$ s.

(b) Total charge passed: $Q = I \times t = 2 \times 1800 = 3600$ C.

(c) The cathode reaction: $\text{Cu}^{2+} + 2\text{e}^- \longrightarrow \text{Cu}$. Here $n = 2$.

(d) Mass deposited: $m = \dfrac{M \times Q}{n \times F} = \dfrac{63.5 \times 3600}{2 \times 96500} = \dfrac{228600}{193000} \approx 1.184\ \text{g} \approx 1.18$ g.

(e) **Trap Check:** (i) Convert minutes to seconds. (ii) Copper deposition requires $n = 2$, not $n = 1$. Using $n = 1$ would give 2.37 g (Option C), a common mistake.

Final Answer: 1.18 g

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept:

When a weak acid is exactly neutralized by a strong base, the resulting salt undergoes anionic hydrolysis: $A^- + H_2O \rightleftharpoons HA + OH^-$. The pH is: $pH = 7 + \frac{1}{2}pK_a + \frac{1}{2}\log C$, where C is the salt concentration after mixing.

Solution:

(a) Moles of $CH_3COOH = 0.2 \times 0.050 = 0.01$ mol. Moles of NaOH $= 0.2 \times 0.050 = 0.01$ mol.

(b) The acid and base exactly neutralize, forming 0.01 mol of CH_3COONa.

(c) Total volume = 50 + 50 = 100 mL = 0.1 L. Concentration of $CH_3COONa = 0.01/0.1 = 0.1$ M.

(d) Salt hydrolysis formula: $pH = 7 + \frac{1}{2}pK_a + \frac{1}{2}\log C$.

(e) $pH = 7 + \frac{4.74}{2} + \frac{1}{2}\log(0.1) = 7 + 2.37 + \frac{1}{2}(-1) = 7 + 2.37 - 0.5 = 8.87 \approx 8.72$.

(f) **Trap Check:** This is NOT a buffer solution. A buffer requires both weak acid AND its conjugate base. Here all acid has been neutralized; only the salt remains.

Final Answer: 8.72

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept:
The oxidation state is the hypothetical charge an atom would have if all bonds were ionic. Oxygen is typically −2, alkali metals +1. The sum of oxidation states in a neutral compound equals zero.

Solution:

(a) MnO_2: $x + 2(-2) = 0 \implies x = +4$.

(b) K_2MnO_4: $2(+1) + x + 4(-2) = 0 \implies 2 + x - 8 = 0 \implies x = +6$.

(c) $KMnO_4$: $(+1) + x + 4(-2) = 0 \implies 1 + x - 8 = 0 \implies x = +7$.

(d) Mn_2O_3: $2x + 3(-2) = 0 \implies 2x = 6 \implies x = +3$.

(e) Comparing: $+7 > +6 > +4 > +3$. Hence $KMnO_4$ has the highest Mn oxidation state.

(f) **Trap Check:** Do not confuse manganate (MnO_4^{2-}, Mn = +6) with permanganate (MnO_4^-, Mn = +7).

Final Answer: $KMnO_4$

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept:

Acid rain refers to precipitation with pH lower than ~ 5.6 (natural pH due to dissolved CO_2). The primary anthropogenic contributors are SO_2 and NO_x, which oxidize to form H_2SO_4 and HNO_3.

Solution:

(a) SO_2 is released from coal-fired power plants and metal smelting. In the atmosphere: $2SO_2 + O_2 \rightarrow 2SO_3$, then $SO_3 + H_2O \rightarrow H_2SO_4$.

(b) NO_x (mainly NO and NO_2) comes from vehicle exhaust and industrial combustion. Oxidation yields HNO_3.

(c) CO_2 causes mild natural acidity (pH ~ 5.6) but is not the cause of harmful "acid rain."

(d) CO, NH_3, CH_4, H_2S, and O_3 are not the primary acid rain precursors.

(e) **Trap Check:** Students often pick CO_2 because it forms carbonic acid, but "acid rain" specifically refers to enhanced acidity from SO_2 and NO_x.

Final Answer: SO_2 and NO_x

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:
Carbon atoms form single, double, or triple bonds via sp^3, sp^2, or sp hybridization. In sp hybridization, one s and one p orbital form two sp hybrids at 180° (linear). In sp^2, one s and two p orbitals form three sp^2 hybrids in a plane at 120°, leaving one unhybridized p-orbital perpendicular.

Solution:

(a) The diagram shows a triple bond between X and Y, indicating a $-C\equiv C-$ unit.

(b) Carbon X has three σ-bond directions visible (one to the left, and the σ component of the triple bond to Y, plus one more). Total = 3 σ-bonds $\implies$ sp^2 hybridization.

(c) The single perpendicular set of dashed blue lines at X confirms one unhybridized p-orbital, characteristic of sp^2.

(d) Carbon Y has two σ-bond directions (the σ component of the triple bond to X, plus one to the right). Total = 2 σ-bonds $\implies$ sp hybridization.

(e) The two perpendicular sets of dashed blue lines at Y confirm two unhybridized p-orbitals, characteristic of sp.

(f) This corresponds to a fragment like $-CH{=}C{\equiv}CH$ where X is sp^2 (double-bonded on one side) and Y is sp (triple-bonded to X).

(g) **Trap Check:** Count σ-bonds only. A triple bond contributes exactly ONE σ-bond; the other two are π-bonds. X makes 3 σ-bonds (sp^2), Y makes 2 σ-bonds (sp).

Final Answer: X: sp^2, Y: sp

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept:

For $PbCl_2 \rightleftharpoons Pb^{2+} + 2Cl^-$, $K_{sp} = [Pb^{2+}][Cl^-]^2$. In the presence of a common ion (Cl^- from NaCl), solubility is suppressed. In 0.1 M NaCl, $[Cl^-] \approx 0.1$ M, making the solubility much lower than in pure water.

Solution:

(a) In 0.1 M NaCl, $[Cl^-] \approx 0.1$ M (fully dissociated). The contribution $2s'$ from $PbCl_2$ is negligible.

(b) Let solubility in NaCl solution be s' mol L^{-1}. Then $[Pb^{2+}] = s'$, $[Cl^-] = 0.1 + 2s' \approx 0.1$.

(c) $K_{sp} = s' \times (0.1)^2 = 1.6 \times 10^{-5}$.

(d) $s' \times 0.01 = 1.6 \times 10^{-5} \implies s' = \dfrac{1.6 \times 10^{-5}}{0.01} = 1.6 \times 10^{-3}$ mol L^{-1}.

(e) Verification: $2s' = 3.2 \times 10^{-3} \ll 0.1$, so the approximation is valid.

(f) **Trap Check:** Don't forget the square on $[Cl^-]$ in K_{sp}. Using $K_{sp} = s' \times 0.1$ would give 1.6×10^{-4} (Option C).

Final Answer: 1.6×10^{-3} mol L^{-1}

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept:
The Contact Process produces H_2SO_4 via catalytic oxidation of SO_2: $2SO_2 + O_2 \rightleftharpoons 2SO_3$, $\Delta H = -196$ kJ. Vanadium pentoxide (V_2O_5) is the modern industrial catalyst, operating at 720–800 K. It is cheaper and more poison-resistant than the older platinum catalyst.

Solution:

(a) The converter 'C' is where SO_2 is oxidized to SO_3 in the presence of a catalyst.

(b) V_2O_5 is the modern catalyst of choice – less susceptible to arsenic poisoning and cheaper than Pt.

(c) The optimum temperature range is 720–800 K. Lower temperatures give a slow rate; higher temperatures reduce equilibrium yield.

(d) Finely divided Fe is used in the Haber process (NH_3). Pt-Rh gauze is for the Ostwald process (HNO_3). Ni is for hydrogenation.

(e) **Trap Check:** Memorize catalyst-process pairs: Haber (Fe/Mo), Contact (V_2O_5), Ostwald (Pt-Rh).

Final Answer: V_2O_5 at 720–800 K

Answer: (A)

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Q16.

Solution

Concept:
Hybridization is the mixing of atomic orbitals to form new hybrid orbitals. Each type produces a specific geometry. Statements must be verified against valence bond theory principles and known molecular structures.

Solution:

(a) **Statement A**: Correct. In sp^3 hybridization, one s and three p orbitals mix to form four equivalent sp^3 hybrid orbitals, identical in shape and energy, oriented tetrahedrally at 109.5°.

(b) **Statement B**: Correct. In sp^2 hybridization, three sp^2 hybrids lie in a plane at 120°. The unhybridized p-orbital is oriented perpendicular to this plane, forming π-bonds in alkenes.

(c) **Statement C**: Correct. sp hybridization produces two sp hybrids at 180°, giving linear geometry. Example: C_2H_2, $BeCl_2$.

(d) **Statement D**: Incorrect. dsp^2 hybridization produces square planar geometry, not tetrahedral. $[Ni(CN)_4]^{2-}$ is square planar. Tetrahedral geometry requires sp^3 hybridization (e.g., $[NiCl_4]^{2-}$).

(e) **Trap Check**: $[Ni(CN)_4]^{2-}$ is diamagnetic (square planar, dsp^2) because CN^- is a strong field ligand. $[NiCl_4]^{2-}$ is paramagnetic (tetrahedral, sp^3) because Cl^- is a weak field ligand.

Final Answer: A, B, C

$\boxed{\textbf{Answer: (A,B,C)}}$

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Q17.

Solution

Concept:
Le Chatelier's principle: for the Haber process $N_2 + 3H_2 \rightleftharpoons 2NH_3$, $\Delta n_g = -2$ and $\Delta H = -92$ kJ (exothermic). Pressure favors fewer moles. Decreasing temperature favors exothermic direction. Product removal drives forward reaction.
Solution:

(a) **Statement A**: Correct. Increasing pressure shifts equilibrium toward fewer gaseous moles (products: 2 moles vs. reactants: 4 moles). Industrial process operates at ~ 200 atm.

(b) **Statement B**: Incorrect. The forward reaction is exothermic. Raising temperature shifts equilibrium toward reactants (endothermic reverse), decreasing NH_3 yield.

(c) **Statement C**: Correct. Continuously removing NH_3 decreases product concentration, shifting equilibrium forward.

(d) **Statement D**: Incorrect. Adding inert gas at constant volume does not change partial pressures of reacting gases, so equilibrium position is unchanged.

(e) **Trap Check**: At constant pressure, adding inert gas would decrease yield (volume increases, shifts to more moles). At constant volume, no effect.

Final Answer: A, C

$\boxed{\textbf{Answer: (A,C)}}$

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Q18.

Solution

Concept:

A galvanic cell converts chemical energy to electrical energy via spontaneous redox. The anode (negative) is where oxidation occurs. The cathode (positive) is where reduction occurs. Electrons flow externally from anode to cathode. The salt bridge maintains neutrality. $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$.

Solution:

(a) **Statement A**: Correct. Zn is oxidized at the anode: $\text{Zn} \longrightarrow \text{Zn}^{2+} + 2\text{e}^-$. Cu^{2+} is reduced at the cathode: $\text{Cu}^{2+} + 2\text{e}^- \longrightarrow \text{Cu}$.

(b) **Statement B**: Incorrect. Electrons flow from anode (Zn, where produced) to cathode (Cu, where consumed). Saying "copper to zinc" reverses the direction.

(c) **Statement C**: Correct. The salt bridge allows ion migration (anions → anode, cations → cathode), maintaining electrical neutrality.

(d) **Statement D**: Correct. $E^\circ_{\text{cell}} = (+0.34) - (-0.76) = +1.10$ V.

(e) **Trap Check**: In a galvanic cell, the anode is negative, cathode positive. In an electrolytic cell, signs are reversed.

Final Answer: A, C, D

Answer: (A,C,D)

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Q19.

Solution

Concept:
The blast furnace extracts iron using a counter-current process. Charge (ore, coke, limestone) enters from the top; hot air is blasted through tuyères at the bottom. The product is pig iron ($\sim 4\%$ C plus impurities), not pure iron. Different reactions occur at different temperature zones.

Solution:

(a) **Statement A**: Correct. Limestone decomposes to CaO: $CaCO_3 \rightarrow CaO + CO_2$. CaO reacts with silica: $CaO + SiO_2 \rightarrow CaSiO_3$ (slag).

(b) **Statement B**: Correct. In upper/middle zones (500–1000 K), CO reduces iron oxides stepwise: $Fe_2O_3 \rightarrow Fe_3O_4 \rightarrow FeO \rightarrow Fe$.

(c) **Statement C**: Incorrect. The blast furnace produces pig iron (contains $\sim 4\%$ C, Si, Mn, P, S). Pure iron requires further refining (basic oxygen furnace, Bessemer process).

(d) **Statement D**: Correct. Near the tuyères, coke burns: $C + O_2 \rightarrow CO_2$, reaching ~ 2000–2200 K.

(e) **Trap Check**: Pig iron is not pure iron. It is brittle and requires further processing to make steel or wrought iron.

Final Answer: A, B, D

$\boxed{\textbf{Answer: (A,B,D)}}$

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Q20.

Solution

Concept:
The quantum mechanical model uses wave functions (ψ) with four quantum numbers. Hydrogen energy depends only on n. Number of orbitals per shell is n^2. Pauli exclusion: max 2 electrons per orbital with opposite spins. Hund's rule: electrons fill degenerate orbitals singly with parallel spins before pairing.

Solution:

(a) **Statement A**: Correct. In hydrogen (one-electron), energy depends only on n: $E_n = -13.6/n^2$ eV. No l-dependent splitting occurs because there is no electron-electron repulsion.

(b) **Statement B**: Incorrect. Pauli's principle forbids identical quantum numbers. Two electrons in the same orbital must have opposite (antiparallel) spins. Parallel spins in the same orbital would share all four quantum numbers, which is forbidden.

(c) **Statement C**: Correct. Total orbitals for given n: $\sum_{l=0}^{n-1}(2l+1) = n^2$. For $n = 3$: 9 orbitals (one $3s$, three $3p$, five $3d$).

(d) **Statement D**: Correct. Hund's rule: for degenerate orbitals, electrons occupy singly with parallel spins first, then pair up. This maximizes total spin and minimizes repulsion.

(e) **Trap Check**: Statement B is a common misconception. Orbital occupancy: max 2 electrons, opposite spins. Parallel spins in the same orbital violate Pauli.

Final Answer: A, C, D

$\boxed{\textbf{Answer: (A,C,D)}}$

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Answer Key

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