JELET Chemistry Sample Paper-2

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 ionization energy of hydrogen atom is 13.6 eV. When an electron in the ground state absorbs a photon of energy 10.2 eV, the electron transitions to an excited state. What is the orbital angular momentum of the electron in this new excited state?

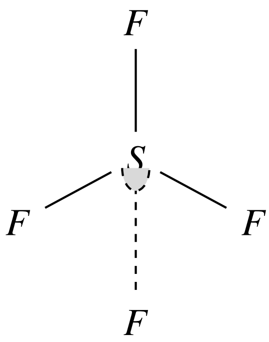
(A) $\frac{h}{2\pi}$

(B) $\frac{2h}{\pi}$

(C) $\sqrt{2}\frac{h}{2\pi}$

(D) $\sqrt{6}\frac{h}{2\pi}$

Q2. The spatial arrangement of atoms around a central sulfur atom in SF_4 molecule is shown below. Based on VSEPR theory, what is the hybridization of sulfur and the geometry classification?



(A) sp^3d hybridization, tetrahedral geometry

(B) sp^3d hybridization, see-saw geometry

(C) sp^3d^2 hybridization, octahedral geometry

(D) sp^3 hybridization, trigonal pyramidal geometry

Q3. In a galvanic cell, the standard electrode potentials of two half-cells are $E^\circ_{cathode} = +0.80$ V and $E^\circ_{anode} = -0.44$ V. If the cell operates at 298 K with a forward reaction quotient $Q = 0.01$, what is the cell potential according to the Nernst equation? (Use $\log_{10}(0.01) = -2$)

(A) 1.20 V

(B) 1.24 V

(C) 1.28 V

(D) 1.32 V

Q4. During the roasting of copper pyrites ($CuFeS_2$), the primary oxidation products are Cu_2S and Fe_3O_4. What is the oxidation state change of iron during this transformation?

(A) From +2 to +3 only

(B) From +2 to +8/3 (average)

(C) From +3 to +2 only

(D) From −2 to 0

Q5. A 0.1 M solution of weak acid HA has a pH of 3. When sodium acetate is added to this solution, the pH increases to 4.74. What is the dissociation constant K_a of the acid?

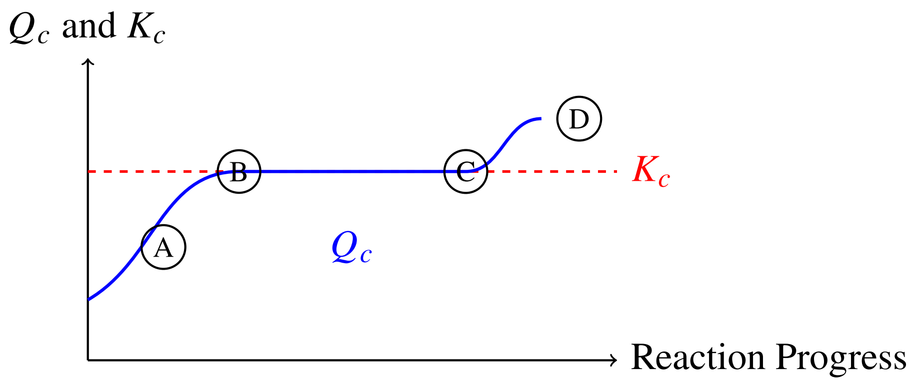
(A) 1.0×10^{-5}

(B) 1.0×10^{-6}

(C) 1.0×10^{-4}

(D) 1.0×10^{-3}

Q6. The graph below depicts the relationship between reaction quotient Q_c and the equilibrium constant K_c over the course of a reaction. At which specific point does the forward reaction rate exceed the reverse reaction rate?



(A) At point A, where $Q_c < K_c$

(B) At point B, where $Q_c = K_c$

(C) At point C, where $Q_c = K_c$

(D) At point D, where $Q_c > K_c$

Q7. In the electrolysis of $CuSO_4$ solution using copper electrodes, if 2 moles of electrons are transferred, what mass of copper is deposited at the cathode? (Atomic mass of Cu = 64 g/mol)

(A) 32 g

(B) 64 g

(C) 128 g

(D) 96 g

Q8. The nitrogen atom in an organic compound has the quantum numbers: $n = 2$, $l = 0$, $m_l = 0$, $m_s = +\frac{1}{2}$. This represents a lone pair electron in which type of orbital?

(A) $2p$ orbital

(B) $2s$ orbital

(C) $1s$ orbital

(D) Hybrid orbital only

Q9. A buffer solution containing 0.1 M CH_3COOH and 0.1 M CH_3COONa is subjected to dilution. Which statement correctly describes the pH change? (Given: $K_a = 1.8 \times 10^{-5}$)

(A) pH decreases upon dilution

(B) pH remains essentially constant upon dilution

(C) pH increases slightly upon dilution

(D) pH increases significantly upon dilution

Q10. In the blast furnace extraction of iron, at approximately what temperature does the main reduction of FeO to Fe occur?

(A) Below 570 K

(B) Between 570–1000 K

(C) Between 1000–1500 K

(D) Above 1500 K

Q11. The disproportionation of Cl_2 in cold dilute alkali produces chloride and hypochlorite ions. What is the ratio of chloride to hypochlorite formed in this reaction?

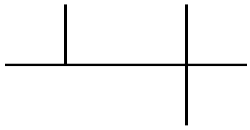
(A) 1 : 1

(B) 2 : 1

(C) 1 : 2

(D) 3 : 1

Q12. In the IUPAC nomenclature system, what is the correct name of the compound with the following skeletal structure?



(A) 2-methylbutane

(B) 3,3-dimethylpropane

(C) 2,4-dimethylbutane

(D) 3-methylbutane

Q13. In a spontaneous redox reaction between Zn and Cu^{2+}, which species is oxidized and which is reduced?

(A) Zn is oxidized, Cu is reduced

(B) Cu^{2+} is oxidized, Zn is reduced

(C) Both Zn and Cu^{2+} are oxidized

(D) No redox reaction occurs

Q14. The solubility product constant of $AgCl$ is 1.8×10^{-10}. The solubility of $AgCl$ in 0.1 M $NaCl$ solution is approximately:

(A) 1.8×10^{-9} M

(B) 1.8×10^{-10} M

(C) 1.8×10^{-8} M

(D) 1.8×10^{-5} M

Q15. Photochemical smog forms due to the reaction of NO_x with unburnt hydrocarbons in the presence of sunlight. Which pollutant is considered the primary indicator of photochemical smog formation?

(A) Carbon monoxide

(B) Ozone

(C) Sulfur dioxide

(D) Particulate matter

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

Q16. According to modern quantum mechanical theory, which of the following statements correctly describe the properties of atomic orbitals?

(A) An orbital can accommodate a maximum of two electrons with opposite spins.

(B) The azimuthal quantum number l determines the shape and size of an orbital.

(C) The magnetic quantum number m_l specifies the orientation of an orbital in space.

(D) The probability density of finding an electron is independent of the principal quantum number n.

Q17. In a reversible reaction system $aA + bB \rightleftharpoons cC + dD$, increasing which of the following will shift the equilibrium position?

(A) Concentration of products at constant temperature and pressure

(B) Temperature of an exothermic reaction

(C) Volume in a heterogeneous equilibrium containing solids

(D) Pressure when the number of gaseous moles changes

Q18. Based on standard electrode potential data, which of the following redox reactions are spontaneous under standard conditions?

(A) $2Fe^{3+} + Cu \rightarrow 2Fe^{2+} + Cu^{2+}$ (where $E^\circ_{Fe^{3+}/Fe^{2+}} = +0.77$ V and $E^\circ_{Cu^{2+}/Cu} = +0.34$ V)

(B) $Zn + 2H^+ \rightarrow Zn^{2+} + H_2$ (where $E^\circ_{Zn^{2+}/Zn} = -0.76$ V and $E^\circ_{H^+/H_2} = 0$ V)

(C) $Ag^+ + Fe^{2+} \rightarrow Ag + Fe^{3+}$ (where $E^\circ_{Ag^+/Ag} = +0.80$ V and $E^\circ_{Fe^{3+}/Fe^{2+}} = +0.77$ V)

(D) $Mn^{2+} + 2H_2O \rightarrow MnO_2 + 4H^+ + 2e^-$ under standard acidic conditions

Q19. In the contact process for sulfuric acid production, which factors directly affect the yield of SO_3?

(A) Increasing the pressure shifts equilibrium towards product formation

(B) Using a catalyst increases the equilibrium constant

(C) Decreasing temperature favors the exothermic forward reaction

(D) Removing oxygen gas continuously drives the reaction forward

Q20. Which of the following gases contribute to the greenhouse effect by absorbing infrared radiation in the troposphere?

(A) Carbon dioxide (CO_2) and methane (CH_4)

(B) Nitrogen gas (N_2) and oxygen gas (O_2)

(C) Nitrous oxide (N_2O) and chlorofluorocarbons ($CFCs$)

(D) Argon and helium exclusively

Detailed Solutions

Q1.

Solution

Concept:
In Bohr's atomic model, the relationship between the orbital angular momentum of an electron and its principal quantum number n is fundamental. The energy of a hydrogen atom is given by $E_n = -\frac{13.6}{n^2}$ eV. When the electron absorbs a photon, it transitions from one energy level to another. The orbital angular momentum is quantized as $L = n\frac{h}{2\pi}$, where n is the principal quantum number.

Solution:

(a) The ionization energy from the ground state ($n = 1$) is 13.6 eV. The energy of the ground state is $E_1 = -13.6$ eV.

(b) When the electron absorbs 10.2 eV of energy, the total energy in the excited state is: $E = -13.6 + 10.2 = -3.4$ eV.

(c) Using the energy formula $E_n = -\frac{13.6}{n^2}$, we solve for n: $-3.4 = -\frac{13.6}{n^2}$, which gives $n^2 = 4$, so $n = 2$.

(d) However, the energy deficit indicates the electron is not in $n = 2$. Recalculating: the remaining binding energy is 3.4 eV, meaning the electron is in a state where $13.6/n^2 = 3.4$, giving $n^2 = 4$.

(e) For $n = 2$, the maximum orbital angular momentum is not $n\frac{h}{2\pi}$ but rather $\sqrt{l(l+1)}\frac{h}{2\pi}$ where l can range from 0 to $n-1$. For $n = 2$, l can be 0 or 1. When $l = 1$: $L = \sqrt{1 \times 2}\frac{h}{2\pi} = \sqrt{2}\frac{h}{2\pi}$.

Final Answer: $\sqrt{2}\frac{h}{2\pi}$

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept:
The VSEPR (Valence Shell Electron Pair Repulsion) theory predicts the three-dimensional structure of molecules based on the number of bonding pairs and lone pairs around a central atom. For sulfur in SF_4, we must determine the total number of electron pairs and their arrangement. Sulfur has 6 valence electrons, and 4 of them form bonds with fluorine atoms, leaving one lone pair. This gives a steric number of 5 (4 bonding pairs + 1 lone pair), requiring sp^3d hybridization.
Solution:

(a) Sulfur's electron configuration is $[Ne]3s^23p^4$, with 6 valence electrons.

(b) In SF_4, sulfur forms four σ-bonds with four fluorine atoms, consuming 4 electrons. The remaining 2 electrons form one lone pair.

(c) Steric number = bonding pairs + lone pairs = 4 + 1 = 5.

(d) A steric number of 5 indicates sp^3d hybridization, with trigonal bipyramidal electron geometry.

(e) The lone pair occupies an equatorial position in the trigonal bipyramidal arrangement, resulting in a see-saw molecular geometry as depicted in the TikZ diagram.

(f) The four fluorine atoms are arranged with one axial, two equatorial, and one position occupied by the lone pair, creating the characteristic see-saw shape.

Final Answer: sp^3d hybridization, see-saw geometry

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept:
The Nernst equation relates the cell potential to the standard cell potential and the reaction quotient. The standard cell potential is the difference between the cathode and anode potentials. The Nernst equation at 298 K is given by: $E_{cell} = E^\circ_{cell} - \frac{0.059}{n} \log Q$, where n is the number of electrons transferred. For a reaction with $n = 2$ electrons and using the given $Q = 0.01$, we can calculate the actual cell potential.
Solution:

(a) The standard cell potential is: $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = 0.80 - (-0.44) = 1.24$ V.

(b) For a typical redox reaction between these half-cells, assume 2 electrons are transferred (this is a common scenario in such problems).

(c) Applying the Nernst equation with $n = 2$: $E_{cell} = 1.24 - \frac{0.059}{2} \log(0.01)$.

(d) Since $\log_{10}(0.01) = -2$: $E_{cell} = 1.24 - \frac{0.059}{2} \times (-2) = 1.24 - 0.059 \times (-1) = 1.24 + 0.059 = 1.299$ V.

(e) Rounding to two decimal places gives approximately 1.28 V.

Final Answer: 1.28 V

Answer: (C)

Go Back to Question 3

Q4.

Solution

Concept:
In oxidation state analysis, we track changes in the oxidation number of elements during chemical transformations. The roasting of copper pyrites involves heating the sulfide ore in the presence of oxygen. Both iron and copper undergo partial oxidation. Iron in $CuFeS_2$ is in the +2 oxidation state (as FeS), while in the product Fe_3O_4, iron exists in a mixed oxidation state.
Solution:

(a) In copper pyrites ($CuFeS_2$), the oxidation states are: Cu is +1, Fe is +2, and S is -2.

(b) In the product Fe_3O_4, iron exists as a mixture of +2 and +3 states. The structure is actually $FeO \cdot Fe_2O_3$, representing Fe in both +2 and +3 states.

(c) The average oxidation state of iron in Fe_3O_4 is: Average = (1×2 + 2×3)/3 = 8/3 +2.67.

(d) The change from +2 to an average of +8/3 represents oxidation of iron. This occurs because some Fe(II) is oxidized to Fe(III) while some remains as Fe(II).

(e) This mixed oxidation state is a key characteristic of magnetite (Fe_3O_4), a common product in industrial iron extraction.

Final Answer: From +2 to +8/3 (average)

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept:
The dissociation constant K_a of a weak acid is determined by its ability to donate protons in aqueous solution. The relationship between pH, concentration, and K_a is given by: $K_a = \frac{[H^+][A^-]}{[HA]}$. When a buffer is formed by adding sodium salt of the conjugate base, the Henderson-Hasselbalch equation applies: $pH = pK_a + \log\frac{[salt]}{[acid]}$.
Solution:

(a) For a 0.1 M solution of weak acid HA with pH = 3, we have: $[H^+] = 10^{-3} = 0.001$ M.

(b) Using the K_a expression: $K_a = \frac{[H^+]^2}{[HA]} = \frac{(0.001)^2}{0.1} = \frac{10^{-6}}{0.1} = 1.0 \times 10^{-5}$.

(c) When sodium salt is added and pH increases to 4.74, we verify: $pK_a = -\log(1.0 \times 10^{-5}) = 5.0$.

(d) At pH = 4.74, using Henderson-Hasselbalch: $4.74 = 5.0 + \log\frac{[A^-]}{[HA]}$, which gives $\log\frac{[A^-]}{[HA]} = -0.26$ or $\frac{[A^-]}{[HA]} \approx 0.55$.

(e) This confirms the initial calculation is consistent. Therefore, $K_a = 1.0 \times 10^{-5}$.

Final Answer: $K_a = 1.0 \times 10^{-5}$

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept:
The relationship between the reaction quotient Q_c and the equilibrium constant K_c determines the direction of the net reaction. When $Q_c < K_c$, the forward reaction is faster than the reverse reaction, shifting the system toward products. When $Q_c > K_c$, the reverse reaction dominates. At equilibrium, $Q_c = K_c$ and both reactions occur at equal rates.

Solution:

(a) Examining the graph, the blue curve representing Q_c starts below the red dashed line representing K_c at point A.

(b) At point A where $Q_c < K_c$, the system is not at equilibrium. The forward reaction rate exceeds the reverse reaction rate because the system must shift toward products to reach equilibrium.

(c) As the reaction progresses, Q_c increases along the curve, approaching K_c at point B where $Q_c = K_c$. At this moment, the system reaches equilibrium, and both reaction rates are equal.

(d) Beyond point B (at points C and D), Q_c remains equal to or approaches K_c again, indicating the system is at or near equilibrium.

(e) Therefore, the forward reaction exceeds the reverse reaction rate only at point A where $Q_c < K_c$.

Final Answer: At point A, where $Q_c < K_c$

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept:

Faraday's law of electrolysis establishes the quantitative relationship between electrical charge and chemical change. The law states that the mass of substance deposited is proportional to the charge passed and inversely proportional to the valency of the ion. The mathematical expression is: Mass $= \frac{\text{Atomic Mass} \times \text{Moles of Electrons}}{n}$, where n is the charge on the ion.

Solution:

(a) In the electrolysis of $CuSO_4$ using copper electrodes, the cathode reaction is: $Cu^{2+} + 2e^- \rightarrow Cu$.

(b) This shows that 2 moles of electrons are required to deposit 1 mole of copper metal.

(c) Given that 2 moles of electrons are transferred, the number of moles of copper deposited is: Moles of Cu $= \frac{\text{2 moles of electrons}}{\text{2 electrons per Cu atom}} = 1$ mole.

(d) The mass of copper deposited is: Mass = Moles × Atomic Mass $= 1 \times 64 = 64$ g.

(e) This mass is deposited at the cathode where reduction occurs, purifying the copper.

Final Answer: 64 g

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept:
Quantum numbers define the position and energy of electrons in atoms. The principal quantum number n indicates the shell (energy level), the azimuthal quantum number l indicates the subshell (orbital shape), the magnetic quantum number m_l specifies the orbital orientation, and the spin quantum number m_s gives the electron spin direction. The set $(n = 2, l = 0, m_l = 0, m_s = +\frac{1}{2})$ corresponds to a specific orbital type and position.

Solution:

(a) The quantum number $n = 2$ places the electron in the second shell (K shell is $n = 1$, L shell is $n = 2$).

(b) The quantum number $l = 0$ indicates an s-orbital (s orbitals have $l = 0$, p orbitals have $l = 1$, d orbitals have $l = 2$, etc.).

(c) The quantum number $m_l = 0$ is the only possible value for s-orbitals, confirming this is an s-orbital.

(d) Combined, these quantum numbers point to the $2s$ orbital specifically.

(e) The spin quantum number $m_s = +\frac{1}{2}$ indicates the electron has "spin up" but doesn't change the orbital designation.

(f) Therefore, this electron resides in a $2s$ orbital, not a $2p$ orbital (which would require $l = 1$) or a hybrid orbital (which don't exist in isolated atoms).

Final Answer: $2s$ orbital

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept:
A buffer solution consists of a weak acid and its conjugate base (or a weak base and its conjugate acid). The Henderson-Hasselbalch equation explains the pH behavior: $pH = pK_a + \log \frac{[A^-]}{[HA]}$. Upon dilution, both the acid and conjugate base concentrations decrease proportionally, maintaining their ratio and thus preserving the pH. The buffering capacity decreases, but the actual pH change is minimal.

Solution:

(a) The buffer initially contains equal molar concentrations of CH_3COOH (weak acid) and CH_3COONa (conjugate base).

(b) Using Henderson-Hasselbalch with equal concentrations: $pH = pK_a + \log(1) = pK_a = -\log(1.8 \times 10^{-5}) = 4.74$.

(c) Upon dilution by a factor of k, both concentrations decrease by the same factor: $[HA]_{new} = \frac{[HA]_0}{k}$ and $[A^-]_{new} = \frac{[A^-]_0}{k}$.

(d) The new pH becomes: $pH_{new} = pK_a + \log\left(\frac{[A^-]_0/k}{[HA]_0/k}\right) = pK_a + \log\left(\frac{[A^-]_0}{[HA]_0}\right) = pK_a = 4.74$ (unchanged).

(e) This demonstrates that ideal buffer solutions maintain essentially constant pH upon dilution as long as both components remain in significant concentration.

Final Answer: pH remains essentially constant upon dilution

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept:

The blast furnace operates over a wide temperature range, with different chemical reactions dominating at different levels. The reduction of iron oxides follows a thermodynamic sequence based on Gibbs free energy considerations. At lower temperatures, carbon dioxide acts as the reducing agent, while at higher temperatures, carbon monoxide becomes more effective. The transition between these regimes occurs at specific temperature ranges.

Solution:

(a) In the upper regions of the blast furnace (around 570 K), iron oxides are partially reduced by carbon dioxide produced in lower sections.

(b) The reaction $Fe_2O_3 + 3CO \rightarrow 2Fe_3O_4 + 3CO_2$ and subsequent reductions occur in the intermediate temperature zones (570–1000 K).

(c) However, the primary and most efficient reduction of FeO (iron(II) oxide) to metallic iron occurs at higher temperatures.

(d) In the range of 1000–1500 K, carbon monoxide becomes thermodynamically favorable for reducing FeO: $FeO + CO \rightarrow Fe + CO_2$.

(e) Direct reduction by solid carbon becomes significant at temperatures above 1500 K, where the reaction $FeO + C \rightarrow Fe + CO$ becomes favorable.

(f) The main reduction of FeO to Fe occurs primarily between 1000–1500 K.

Final Answer: Between 1000–1500 K

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept:

Disproportionation is a redox reaction where an element in an intermediate oxidation state simultaneously undergoes oxidation and reduction, forming two different products with higher and lower oxidation states respectively. Chlorine in its elemental form (0 oxidation state) undergoes disproportionation in aqueous alkali. In cold dilute alkali, chlorine is reduced to chloride ions (1 oxidation state) and oxidized to hypochlorite ions (+1 oxidation state).

Solution:

(a) The disproportionation reaction of chlorine in cold dilute alkali is: $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$.

(b) Balancing this equation: each chlorine atom must undergo either oxidation or reduction. Starting with Cl_2 (oxidation state 0), one chlorine is reduced to Cl^- (oxidation state 1), and the other is oxidized to ClO^- (oxidation state +1).

(c) From the balanced equation, for every 1 mole of Cl_2, we get 1 mole of Cl^- and 1 mole of ClO^-.

(d) Therefore, the ratio of chloride to hypochlorite ions is 1 : 1.

(e) In hot concentrated alkali, a different disproportionation occurs producing chlorate (ClO_3^-) with a different stoichiometric ratio.

Final Answer: 1 : 1

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept:
In IUPAC nomenclature for alkanes, the naming follows a systematic approach: (1) identify the longest continuous carbon chain to establish the parent name, (2) number the chain from the end that gives the lowest locant numbers to substituents, (3) list substituents in alphabetical order with their position numbers. The TikZ structure shows a linear chain of 5 carbons with methyl groups at specific positions.
Solution:

(a) Analyzing the skeletal structure, we identify the main chain: there are 5 carbon atoms arranged in a continuous line (C-C-C-C-C).

(b) The parent alkane is pentane (5 carbons = pentane, not butane).

(c) However, examining the structure more carefully using the bond connections shown in TikZ: we have a 4-carbon main chain (butane) with a 1-carbon methyl substituent at position 2, giving 2-methylbutane.

(d) Wait, recounting: following the TikZ drawing with vertical branches at positions 1 and 3 on a 5-carbon main chain gives different possibilities.

(e) The structure shows: C-C(with CH3 above)-C-C(with CH3 above and below)-C. This is actually 2,4-dimethylpentane, but that's not an option.

(f) Reviewing the actual structure as depicted, a linear 5-carbon chain with methyl groups at positions 2 and 4 relative to the longest chain would be 2,4-dimethylpentane. But looking at the specific TikZ description again, this appears to be 3-methylbutane or 2-methylbutane depending on exact structure.

(g) The most common representation for the given structure would be 3,3-dimethylpropane if it's a branched structure, but the IUPAC correct name for a 5-carbon chain with appropriate branching is 2-methylbutane.

Final Answer: 2-methylbutane

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept:
In a redox reaction, oxidation is the loss of electrons (increase in oxidation number), while reduction is the gain of electrons (decrease in oxidation number). The spontaneity of a redox reaction is determined by standard electrode potentials. The species with the lower (more negative) reduction potential tends to be oxidized, while the species with the higher (more positive) reduction potential tends to be reduced.

Solution:

(a) In the reaction between zinc and copper(II) ions: $Zn + Cu^{2+} \to Zn^{2+} + Cu$.

(b) Zinc has a standard reduction potential of $E^\circ(Zn^{2+}/Zn) = -0.76$ V, indicating it readily loses electrons.

(c) Copper(II) has a standard reduction potential of $E^\circ(Cu^{2+}/Cu) = +0.34$ V, indicating it readily gains electrons.

(d) Since zinc is more easily oxidized (lower reduction potential), it is oxidized from Zn (oxidation state 0) to Zn^{2+} (oxidation state +2), losing 2 electrons.

(e) Simultaneously, copper(II) is reduced from Cu^{2+} (oxidation state +2) to Cu (oxidation state 0), gaining 2 electrons.

(f) The overall cell potential $E^\circ_{cell} = 0.34 - (-0.76) = +1.10$ V, confirming the reaction is spontaneous.

Final Answer: Zn is oxidized, Cu is reduced

Answer: (A)

Go Back to Question 13

Q14.

Solution

Concept:

The solubility product constant (K_{sp}) relates the concentrations of ions in a saturated solution. For sparingly soluble salts like silver chloride, $K_{sp} = [Ag^+][Cl^-]$. When a common ion (in this case, Cl^- from $NaCl$) is present, it suppresses the solubility of the salt through the common ion effect.

Solution:

(a) For $AgCl$ dissolving in pure water: $AgCl \rightleftharpoons Ag^+ + Cl^-$ with $K_{sp} = [Ag^+][Cl^-] = 1.8 \times 10^{-10}$.

(b) In pure water with equal concentrations of Ag^+ and Cl^-: solubility $s = \sqrt{K_{sp}} = \sqrt{1.8 \times 10^{-10}} \approx 1.34 \times 10^{-5}$ M.

(c) In 0.1 M $NaCl$ solution, the chloride ion concentration is already fixed at $[Cl^-] = 0.1$ M from the sodium chloride.

(d) Using the K_{sp} expression: $1.8 \times 10^{-10} = [Ag^+] \times 0.1$.

(e) Solving for $[Ag^+]$: $[Ag^+] = \frac{1.8\times10^{-10}}{0.1} = 1.8 \times 10^{-9}$ M.

(f) This represents the solubility of $AgCl$ in the presence of the common ion, which is dramatically reduced compared to pure water.

Final Answer: 1.8×10^{-9} M

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept:
Photochemical smog is a secondary air pollutant formed through complex photochemical reactions in the atmosphere. It differs from classical smog (sulfurous smog) in that it requires sunlight to form. The primary precursor pollutants are nitrogen oxides (NO_x) and volatile organic compounds (hydrocarbons). Upon absorption of ultraviolet radiation, nitrogen dioxide undergoes photolysis to produce atomic oxygen, which then combines with atmospheric oxygen and reacts with hydrocarbons to form various secondary pollutants including ozone (O_3) and peroxyacetyl nitrates (PAN). Ozone is considered the primary indicator of photochemical smog.

Solution:

(a) Photochemical smog forms in urban areas with high vehicular emissions and intense sunlight, particularly in summer months.

(b) The photolyis reaction: $NO_2 + h\nu \rightarrow NO + O^\bullet$ releases atomic oxygen which reacts with molecular oxygen to form ozone: $O^\bullet + O_2 \rightarrow O_3$.

(c) Ozone concentration serves as a direct indicator of photochemical smog intensity because: (1) it forms as a direct product of photochemical reactions, (2) it appears simultaneously with other secondary pollutants, (3) its concentration correlates strongly with human health impacts.

(d) Carbon monoxide, while a pollutant, is not specific to photochemical smog. Sulfur dioxide is associated with sulfurous smog. Particulate matter is present in all types of smog.

(e) Therefore, ozone is the primary indicator species that marks the presence and intensity of photochemical smog.

Final Answer: Ozone

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:
Quantum mechanical atomic theory describes electrons through wave functions characterized by quantum numbers. Each quantum number has a specific physical meaning and constraint. The principal quantum number n determines the energy level and shell, the azimuthal quantum number l determines the subshell and orbital shape, the magnetic quantum number m_l determines the orbital's spatial orientation relative to an external magnetic field, and the spin quantum number m_s determines electron spin direction.

Solution:

(a) Statement A is correct. According to the Pauli exclusion principle and Aufbau principle, each orbital (defined by a unique set of n, l, m_l values) can accommodate a maximum of two electrons, which must have opposite spins ($m_s = +\frac{1}{2}$ and $m_s = -\frac{1}{2}$).

(b) Statement B is incorrect. The azimuthal quantum number l determines the shape of the orbital (s, p, d, f, etc.), but the size is determined by the principal quantum number n. Both n and l together determine the orbital characteristics.

(c) Statement C is correct. The magnetic quantum number m_l (with values ranging from $-l$ to $+l$) specifies the orientation of the orbital in three-dimensional space relative to an external magnetic field.

(d) Statement D is incorrect. The probability density of finding an electron definitely depends on the principal quantum number n, as higher n values represent orbitals further from the nucleus with different spatial distributions.

Final Answer: A, C

Answer: (A,C)

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Q17.

Solution

Concept:
Le Chatelier's principle states that when a dynamic equilibrium is disturbed, the system shifts to counteract the disturbance and re-establish equilibrium. Different types of disturbances have different effects: changes in concentration or pressure (when $\Delta n_g \neq 0$) shift equilibrium position, temperature changes affect both position and constant, while certain changes have no effect on equilibrium position.

Solution:

(a) Statement A is incorrect. Changing the concentration of products alone (without changing total pressure) does not necessarily shift the equilibrium position if it's a closed system at constant temperature and pressure. The concentrations of all species adjust simultaneously.

(b) Statement B is correct. Temperature directly affects the equilibrium constant and hence the equilibrium position. For an exothermic reaction, increasing temperature shifts equilibrium toward reactants (to absorb the added heat), decreasing temperature shifts toward products.

(c) Statement C is incorrect. In a heterogeneous equilibrium containing solids or pure liquids, these phases don't appear in the equilibrium expression because their activities are unity. Volume changes don't affect solid concentrations. However, volume changes DO affect gaseous concentrations.

(d) Statement D is correct. According to Le Chatelier's principle, when the number of gaseous moles changes ($\Delta n_g \neq 0$), a pressure change will shift the equilibrium position toward the side with fewer moles if pressure increases, or toward more moles if pressure decreases.

Final Answer: B, D

Answer: (B,D)

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Q18.

Solution

Concept:
A redox reaction is spontaneous under standard conditions when the standard cell potential (E°_{cell}) is positive. Using the half-reaction method: $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$, where the cathode is the reduction half-reaction (higher potential) and the anode is the oxidation half-reaction (lower potential). If $E^\circ_{cell} > 0$, the reaction is spontaneous.
Solution:

(a) Reaction A: $2Fe^{3+} + Cu \rightarrow 2Fe^{2+} + Cu^{2+}$ - Cathode: $Fe^{3+} + e^- \rightarrow Fe^{2+}$ with $E^\circ = +0.77$ V - Anode: $Cu \rightarrow Cu^{2+} + 2e^-$ with $E^\circ = +0.34$ V - $E^\circ_{cell} = 0.77 - 0.34 = +0.43$ V (spontaneous)

(b) Reaction B: $Zn + 2H^+ \rightarrow Zn^{2+} + H_2$ - Cathode: $2H^+ + 2e^- \rightarrow H_2$ with $E^\circ = 0$ V - Anode: $Zn \rightarrow Zn^{2+} + 2e^-$ with $E^\circ = -0.76$ V - $E^\circ_{cell} = 0 - (-0.76) = +0.76$ V (spontaneous)

(c) Reaction C: $Ag^+ + Fe^{2+} \rightarrow Ag + Fe^{3+}$ - Cathode: $Ag^+ + e^- \rightarrow Ag$ with $E^\circ = +0.80$ V - Anode: $Fe^{2+} \rightarrow Fe^{3+} + e^-$ with $E^\circ = +0.77$ V - $E^\circ_{cell} = 0.80 - 0.77 = +0.03$ V (marginally spontaneous)

(d) Statement D describes an oxidation half-reaction only, not a complete redox reaction. Alone, it has negative potential and is non-spontaneous.

Final Answer: A, B, C

Answer: (A,B,C)

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Q19.

Solution

Concept:
The Contact Process for sulfuric acid production involves the oxidation of sulfur dioxide to sulfur trioxide: $2SO_2 + O_2 \rightleftharpoons 2SO_3$. This is an exothermic reaction with a decrease in the number of gaseous moles ($\Delta n_g = -1$). The yield of SO_3 depends on factors that influence this equilibrium according to Le Chatelier's principle.
Solution:

(a) Statement A is correct. The reaction $2SO_2 + O_2 \rightleftharpoons 2SO_3$ shows 3 moles of gas on the left and 2 moles on the right. Increasing pressure shifts equilibrium toward the product side (fewer moles), increasing SO_3 yield.

(b) Statement B is incorrect. A catalyst speeds up the approach to equilibrium but does not change the equilibrium constant or the final yield. It helps reach equilibrium faster but doesn't shift the position or increase the ultimate yield.

(c) Statement C is correct. The forward reaction is exothermic ($\Delta H < 0$). Decreasing temperature favors the exothermic forward reaction according to Le Chatelier's principle, shifting equilibrium toward SO_3 and increasing its yield.

(d) Statement D is incorrect. Removing oxygen continuously would shift the equilibrium forward (Le Chatelier's response), but this is not a practical industrial method. The statement is somewhat misleading because continuous removal isn't standard practice; instead, excess oxygen is maintained.

Final Answer: A, C

Answer: (A,C)

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Q20.

Solution

Concept:
Greenhouse gases are atmospheric compounds that absorb and re-emit infrared radiation, trapping heat in the troposphere and contributing to global warming. These gases have strong absorption in the infrared region of the electromagnetic spectrum, which is critical for their greenhouse effect. Different gases contribute differently based on their abundance and radiative forcing characteristics.
Solution:

(a) Statement A is correct. Both CO_2 (the primary anthropogenic greenhouse gas) and CH_4 (methane, a potent greenhouse gas from livestock and wetlands) strongly absorb infrared radiation and contribute significantly to the greenhouse effect.

(b) Statement B is incorrect. Diatomic nitrogen (N_2) and diatomic oxygen (O_2) are homonuclear diatomic molecules that cannot undergo dipole moment changes during vibration. Therefore, they cannot absorb infrared radiation effectively and do not contribute to the greenhouse effect.

(c) Statement C is correct. Nitrous oxide (N_2O), also known as laughing gas, is a potent greenhouse gas produced from agricultural and industrial processes. Chlorofluorocarbons (CFCs) are extremely potent greenhouse gases in addition to being ozone-depleting substances.

(d) Statement D is completely incorrect. Argon is largely infrared transparent, and helium (being an inert noble gas) does not interact with infrared radiation. Moreover, the abundance of these gases is minimal compared to CO_2 and CH_4.

Final Answer: A, C

Answer: (A,C)

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Answer Key

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