Rajasthan JET Chemistry Sample Paper-5

Duration: 40 Minutes **Maximum Marks: 160**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries: **−1 marks**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Q1. Which of the following sets of quantum numbers is not permissible for an electron in an atom?

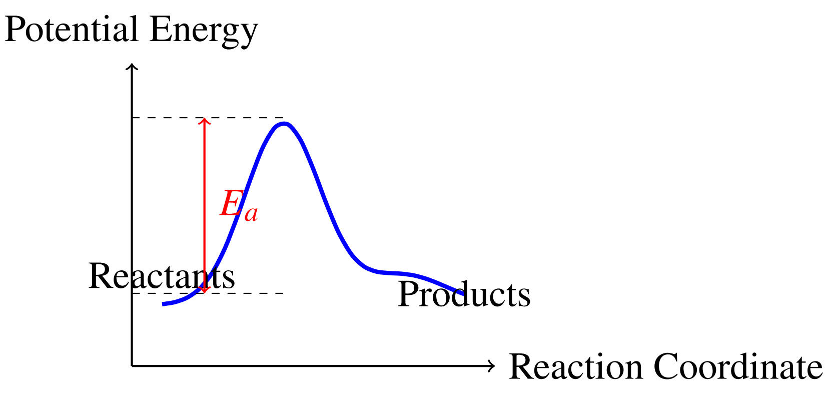
(A) $n = 3, l = 2, m_l = -2, m_s = +\frac{1}{2}$

(B) $n = 4, l = 0, m_l = 0, m_s = -\frac{1}{2}$

(C) $n = 3, l = 3, m_l = -1, m_s = +\frac{1}{2}$

(D) $n = 2, l = 1, m_l = 0, m_s = -\frac{1}{2}$

Q2. Consider the potential energy profile for a chemical reaction shown below:



If the activation energy (E_a) for the forward reaction is 150 kJ mol^{-1} and the enthalpy change (ΔH) for the reaction is −50 kJ mol^{-1}, what is the activation energy for the reverse reaction?

(A) 100 kJ mol^{-1}

(B) 200 kJ mol^{-1}

(C) 150 kJ mol^{-1}

(D) 50 kJ mol^{-1}

Q3. The IUPAC name of the compound $CH_3 - CH(OH) - CH_2 - CO - CH_3$ is:

(A) 4-Hydroxypentan-2-one

(B) 2-Hydroxypentan-4-one

(C) 4-Oxopentan-2-ol

(D) Pentan-2-ol-4-one

Q4. Black alkali (sodic) soils are characterized by having an exchangeable sodium percentage (ESP) of:

(A) Less than 15%

(B) Greater than 15%

(C) Exactly 5%

(D) Zero

Q5. The pair of molecules having identical geometry according to VSEPR theory is:

(A) BF_3 and NH_3

(B) H_2O and CO_2

(C) CH_4 and SF_4

(D) BF_3 and $AlCl_3$

Q6. For a reversible process occurring in a closed system at constant temperature and pressure, the criterion for dynamic equilibrium is:

(A) $\Delta H = 0$

(B) $\Delta S = 0$

(C) $\Delta G = 0$

(D) $\Delta U = 0$

Q7. Which type of structural isomerism is exhibited by the coordination pair $[Co(NH_3)_5(SO_4)]Br$ and $[Co(NH_3)_5Br]SO_4$?

(A) Ionization isomerism

(B) Linkage isomerism

(C) Coordination isomerism

(D) Geometrical isomerism

Q8. Which of the following highly concentrated nitrogenous fertilizers is extremely hygroscopic in nature and contains approximately 46% Nitrogen?

(A) Ammonium sulfate

(B) Urea

(C) Calcium ammonium nitrate

Q9. In the balanced chemical equation for the oxidation of oxalate ion by permanganate ion in an acidic medium:

$$MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + CO_2 + H_2O$$

The oxidation number of Manganese changes from:

(A) +7 to +2

(B) +6 to +2

(C) +7 to +4

(D) +4 to +2

Q10. The osmotic pressure (π) of a dilute solution can be explicitly increased by which of the following measures?

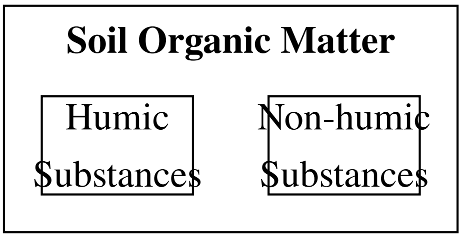
(A) Increasing the temperature of the solution

(B) Decreasing the concentration of the solute particles

(C) Increasing the total volume of the solvent

(D) Adding a solute with a higher molecular mass at constant weight

Q11. The schematic diagram below represents the components of soil organic matter:



The major portion of dark-colored, amorphous, organic colloidal material that is highly resistant to further microbial decomposition is called:

(A) Biomass

(B) Humus

(C) Peat

(D) Compost

Q12. The correct order of electron gain enthalpy ($\Delta_{eg}H$, from most negative to least negative values) among the given halogens is:

(A) F > Cl > Br > I

(B) Cl > F > Br > I

(C) I > Br > Cl > F

(D) Cl > Br > I > F

Q13. What is the pH value of a 10^{-3} M NaOH aqueous solution at 25°C?

(A) 3

(B) 11

(C) 7

(D) 10

Q14. Ozonolysis of 2-Methylbut-2-ene followed by reductive cleavage with Zn/H_2O yields:

(A) Propanone and Ethanal

(B) Ethanal and Methanal

(C) Propanone and Methanal

(D) Only Propanal

Q15. According to the Modern Periodic Law, the physical and chemical properties of the elements are periodic functions of their:

(A) Atomic masses

(B) Atomic volumes

(C) Atomic numbers

(D) Mass numbers

Q16. How many total moles of ions are produced when one mole of the coordination complex $[Co(NH_3)_6]Cl_3$ completely dissociates in water?

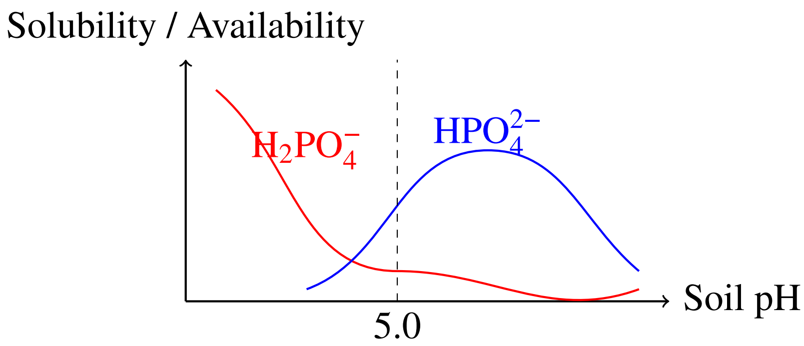
(A) 6

(B) 4

(C) 3

(D) 2

Q17. Consider the solubility chart of phosphate ions as a function of soil pH shown below:



Which ionic species represents the primary source of phosphorus nutrition absorbed by plants in strongly acidic soils (pH < 5.0)?

(A) PO_4^{3-}

(B) HPO_4^{2-}

(C) $H_2PO_4^-$

(D) P_2O_5

Q18. With reference to electrolytic conductance, as the concentration of an electrolytic solution decreases (dilution increases), the specific conductance (κ):

(A) Increases

(B) Decreases

(C) Remains constant

(D) First increases then decreases

Q19. For the industrial synthesis of ammonia via Haber's process:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92.4 \text{ kJ}$$

According to Le Chatelier's principle, the equilibrium yield of ammonia is maximized under which set of conditions?

(A) High temperature and low pressure

(B) Low temperature and high pressure

(C) Low temperature and low pressure

(D) High temperature and high pressure

Q20. Which of the following highly reactive carbon intermediates possesses a planar geometry with sp^2 hybridization of the central carbon atom?

(A) Methyl carbocation (CH_3^+)

(B) Methyl carbanion (CH_3^-)

(C) Methyl free radical ($\cdot CH_3$)

(D) Both (A) and (C)

Q21. The total number of sigma (σ) and pi (π) covalent bonds present in a single molecule of benzene (C_6H_6) are respectively:

(A) 12 and 3

(B) 6 and 3

(C) 9 and 3

(D) 15 and 0

Q22. The coordination number and the oxidation state of the central metal atom in the complex $[Fe(C_2O_4)_3]^{3-}$ are respectively:

(A) 3 and +3

(B) 6 and +3

(C) 6 and +6

(D) 3 and +6

Q23. Which of the following thermodynamic parameters constitutes an intensive property of matter?

(A) Enthalpy (H)

(B) Internal energy (U)

(C) Entropy (S)

(D) Temperature (T)

Q24. The reclamation of sodic (alkali) soils to replace exchangeable sodium ions with calcium ions on the soil exchange complex is traditionally achieved by adding:

(A) Calcium carbonate ($CaCO_3$)

(B) Gypsum ($CaSO_4 \cdot 2H_2O$)

(C) Calcium hydroxide ($Ca(OH)_2$)

(D) Ammonium chloride (NH_4Cl)

Q25. An element has the electronic configuration $[Ar]3d^{10}4s^1$ in its ground state. To which group of the modern periodic table does it belong?

(A) Group 1

(B) Group 11

(C) Group 3

(D) Group 12

Q26. Equal volumes of 0.1 M HCl and 0.1 M NaOH are thoroughly mixed together. The pH value of the resulting aqueous mixture will be:

(A) 1

(B) 13

(C) 7

(D) 0

Q27. When propyne ($CH_3 - C \equiv CH$) is treated with dilute H_2SO_4 in the presence of $HgSO_4$ catalyst at elevated temperature, the major organic product obtained is:

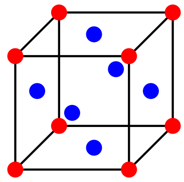
(A) Propanal

(B) Propanone

(C) Propan-1-ol

(D) Propanoic acid

Q28. Consider the face-centered cubic (FCC) unit cell architecture below:



The total net number of atoms contained within a single face-centered cubic (fcc) unit cell is:

(A) 1

(B) 2

(C) 4

(D) 6

Q29. Which of the primary essential macro plant nutrients is predominantly responsible for healthy root growth, early maturity, and structural strength in grain crops?

(A) Nitrogen

(B) Potassium

(C) Phosphorus

(D) Zinc

Q30. The geometric shape of the xenon tetrafluoride (XeF_4) molecule according to VSEPR theory is:

(A) Tetrahedral

(B) Square planar

(C) Octahedral

(D) See-saw

Q31. According to the Arrhenius equation $k = Ae^{-E_a/RT}$, a linear plot of $\ln k$ versus $\frac{1}{T}$ gives a straight line with a slope mathematically equal to:

(A) $-E_a/R$

(B) E_a/R

(C) $-E_a/2.303R$

(D) A/R

Q32. When methyl iodide (CH_3I) is reacted with metallic sodium in the presence of dry ether solvent (Wurtz reaction), the hydrocarbon produced is:

(A) Methane

(B) Ethane

(C) Propane

(D) Butane

Q33. If exactly 96500 Coulombs of electricity is passed through an aqueous solution of $CuSO_4$, the mass of copper metal deposited at the cathode is: (Given atomic mass of Cu = 63.5 g mol^{-1})

(A) 63.5 g

(B) 31.75 g

(C) 127.0 g

(D) 15.8 g

Q34. Which of the following sequences correctly illustrates the increasing order of acidic character among simple hydrocarbons?

(A) Ethane < Ethene < Ethyne

(B) Ethyne < Ethene < Ethane

(C) Ethene < Ethane < Ethyne

(D) Ethane < Ethyne < Ethene

Q35. The Principal Quantum Number (n) explicitly determines which fundamental property of an atomic electron orbital?

(A) Spatial orientation of the orbital

(B) Three-dimensional shape of the orbital

(C) Size and principal energy level of the orbital

(D) Spin orientation of the electron

Q36. An aqueous solution that undergoes minimal changes in its hydronium ion concentration (pH) upon the addition of fractional quantities of strong acids or bases is designated as a:

(A) Ideal solution

(B) Buffer solution

(C) Concentrated solution

(D) Saturated solution

Q37. Which of the following coordinate ligands serves as a classic illustration of an ambidentate ligand?

(A) NH_3

(B) H_2O

(C) SCN^-

(D) en (ethylenediamine)

Q38. The addition of a positive catalyst to an ongoing chemical system modifies the speed of the reaction by directly altering the:

(A) Overall equilibrium constant (K_{eq})

(B) Enthalpy change of the reaction (ΔH)

(C) Activation energy pathway (E_a)

(D) Net entropy change (ΔS)

Q39. The inductive displacement effect observed in organic molecules involves the permanent shift or polarization of:

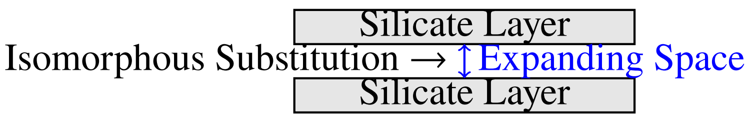
(A) σ-bonding electrons

(B) π-bonding electrons

(C) Non-bonding lone pair electrons

(D) Unpaired free radical electrons

Q40. Consider the relative structural charge distribution of soil inorganic colloids shown below:



Which of the following organic or inorganic soil colloids exhibits the highest Cation Exchange Capacity (CEC) value?

(A) Kaolinite

(B) Illite

(C) Montmorillonite

(D) Humus

Detailed Solutions

Q1.

Solution

Concept: Quantum numbers describe the state of an electron in an atom. The principal quantum number n defines the shell. The azimuthal quantum number l defines the subshell shape and ranges from 0 to $n-1$. The magnetic quantum number m_l defines orbital orientation and ranges from $-l$ to $+l$. The spin quantum number m_s can be $+\frac{1}{2}$ or $-\frac{1}{2}$.

Solution:

(a) For option (C), the given values are $n = 3$ and $l = 3$.

(b) According to the rules of quantum mechanics, the value of the azimuthal quantum number l must always be strictly less than the principal quantum number n, such that $l \in [0, n-1]$.

(c) If $n = 3$, the allowed values for l are 0, 1, and 2 (corresponding to $3s$, $3p$, and $3d$ subshells respectively).

(d) A value of $l = 3$ would represent a $3f$ subshell, which does not exist in atomic structure.

(e) All other options follow the permissible rules where $l < n$, $|m_l| \leq l$, and $m_s = \pm\frac{1}{2}$.

Final Answer: The value $l = 3$ is not possible when $n = 3$.

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: The activation energy energy barrier relates the forward and reverse directions of a chemical process. The enthalpy change (ΔH) of a chemical reaction represents the net thermodynamic energy change between products and reactants. It is related to activation energies by the equation $\Delta H = E_{a(\text{forward})} - E_{a(\text{reverse})}$.

Solution:

(a) We are given that the activation energy for the forward reaction $E_{a(\text{forward})} = 150 \text{ kJ mol}^{-1}$.

(b) The net enthalpy change for this exothermic profile is given as $\Delta H = -50 \text{ kJ mol}^{-1}$.

(c) Rearranging our core thermodynamic formula to solve for the reverse activation energy gives the equation: $E_{a(\text{reverse})} = E_{a(\text{forward})} - \Delta H$.

(d) Substituting the values into the equation: $E_{a(\text{reverse})} = 150 - (-50) = 150 + 50 = 200 \text{ kJ mol}^{-1}$.

(e) This matches our chemical graph, where the barrier from the lower product well back to the transition state peak is larger than the forward barrier.

Final Answer: The activation energy for the reverse reaction is 200 kJ mol^{-1}.

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: IUPAC nomenclature dictates that the principal functional group determines the suffix of the molecule name and takes numbering priority. Ketones hold a higher priority status in the principal functional hierarchy than hydroxyl (alcohol) groups.

Solution:

(a) Find the longest carbon chain containing both functional groups: the molecule has five carbons, making it a derivative of pentane.

(b) Number the carbon chain from the end that gives the lowest locant to the principal functional group, which is the carbonyl group (C=O).

(c) Numbering from right to left gives the ketone position 2 (C – 2), whereas numbering from left to right would give it position 4. Thus, right-to-left numbering is correct.

(d) With this numbering scheme, the hydroxyl group (−OH) is attached to carbon position 4 (C – 4).

(e) The hydroxyl group is designated as a prefix named hydroxyl, yielding the name 4-hydroxypentan-2-one.

Final Answer: The IUPAC name is 4-hydroxypentan-2-one.

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: Agricultural soil chemistry classifies salt-affected soils into saline, sodic, and saline-sodic based on parameters like Electrical Conductivity (EC), Exchangeable Sodium Percentage (ESP), and pH. Sodic soils are structurally called black alkali soils due to organic matter dispersion.

Solution:

(a) Black alkali (sodic) soils contain high amounts of exchangeable sodium ions relative to other cations on the soil clay exchange complex.

(b) By standard definition, a soil is classified as sodic or black alkali when its Exchangeable Sodium Percentage (ESP) exceeds the threshold limit of 15%.

(c) These soils show an electrical conductivity of the saturation extract less than 4 dS m^{-1} and high pH values usually ranging between 8.5 and 10.0.

(d) The high sodium content causes swelling and dispersion of clay particles and humic material, which moves upwards and darkens the soil surface layer.

(e) This visual blackening gives them their descriptive name, distinguishing them from white alkali soils.

Final Answer: Sodic soils have an ESP value greater than 15%.

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: According to Valence Shell Electron Pair Repulsion (VSEPR) theory, molecular geometry is determined by the total steric number, which is the sum of bonding pairs and lone pairs of electrons around the central atom.

Solution:

(a) In BF_3, Boron has 3 valence electrons, forming 3 bond pairs with zero lone pairs. Its geometry is trigonal planar.

(b) In $AlCl_3$, Aluminum belongs to the same group as Boron, possessing 3 valence electrons. It similarly forms 3 bond pairs with zero lone pairs, producing a trigonal planar geometry.

(c) In contrast, NH_3 contains 3 bond pairs and 1 lone pair, which distorts its geometry into a trigonal pyramidal structure.

(d) H_2O has a bent or V-shaped geometry due to its 2 bond pairs and 2 lone pairs, whereas CO_2 is strictly linear.

(e) Therefore, only the pair BF_3 and $AlCl_3$ share a completely identical trigonal planar molecular geometry.

Final Answer: The molecules BF_3 and $AlCl_3$ share identical trigonal planar geometry.

Answer: (D)

Go Back to Question 5

Q6.

Solution

Concept: Thermodynamic criteria dictate spontaneity and equilibrium in chemical systems. Gibbs Free Energy (G) combines enthalpy and entropy under constant pressure and temperature conditions through the equation $G = H - TS$.

Solution:

(a) For a process occurring at constant temperature (T) and pressure (P), the change in Gibbs Free Energy is given by $\Delta G = \Delta H - T\Delta S$.

(b) If ΔG is negative ($\Delta G < 0$), the forward process is spontaneous. If ΔG is positive ($\Delta G > 0$), the process is non-spontaneous.

(c) When a reversible process reaches a state of dynamic equilibrium, the rate of the forward process equals the rate of the reverse process.

(d) At this point, the system achieves its lowest potential energy state under the specified conditions, meaning no further net change can occur.

(e) Consequently, the net change in Gibbs free energy drops to exactly zero ($\Delta G = 0$).

Final Answer: The dynamic equilibrium criterion is $\Delta G = 0$.

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: Structural isomerism in coordination chemistry arises from variations in the arrangement of ligands within the coordination sphere. Ionization isomerism occurs when a coordinated ligand switches places with a counter-ion outside the coordination sphere.

Solution:

(a) Examine the two formulas: $[Co(NH_3)_5(SO_4)]Br$ and $[Co(NH_3)_5Br]SO_4$. They have identical overall empirical chemical compositions.

(b) In the first complex, the sulfate ion (SO_4^{2-}) is directly bound to the central cobalt ion as a ligand, while the bromide ion (Br^-) acts as the balancing counter-ion.

(c) In the second complex, the bromide ion serves as the internal ligand, while the sulfate ion is positioned outside the coordination sphere.

(d) When dissolved in an aqueous solvent, the first compound yields free bromide ions, whereas the second compound yields free sulfate ions.

(e) This behavior matches the definition of ionization isomerism, where dissolving the isomers produces different ions in solution.

Final Answer: The complexes display ionization isomerism.

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept: Fertilizer chemistry studies the physical properties and nutrient percentages of compounds added to soil. Urea is an organic amide compound used globally as a nitrogenous fertilizer due to its high nutrient density.

Solution:

(a) The chemical formula for urea is NH_2CONH_2. Calculating its molar mass shows that nitrogen makes up approximately 46.6% of its total weight.

(b) This high concentration makes it the most nutrient-dense solid nitrogenous fertilizer available to agricultural producers.

(c) A notable physical property of urea is its hygroscopic nature, meaning it readily absorbs moisture from the surrounding atmosphere.

(d) Because of this property, urea particles can cake or dissolve if stored improperly in humid conditions.

(e) Ammonium sulfate contains only about 21% nitrogen, making urea the correct match for the specified concentration and properties.

Final Answer: The highly concentrated hygroscopic fertilizer is Urea.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: Redox reactions involve simultaneous reduction and oxidation processes, tracked using formal oxidation numbers assigned to each element according to standard electronegativity rules.

Solution:

(a) In the reactant permanganate ion (MnO_4^-), oxygen has its standard oxidation state of -2.

(b) Let x be the oxidation number of Manganese. The sum of oxidation numbers must equal the overall ionic charge: $x + 4(-2) = -1$.

(c) Solving the linear equation: $x - 8 = -1$, which gives $x = +7$. Thus, Manganese begins in the +7 oxidation state.

(d) On the product side, Manganese exists as a monoatomic ion (Mn^{2+}). The oxidation number of a monoatomic ion equals its net charge, which is +2.

(e) Therefore, during this acidic redox reaction, the oxidation number of manganese changes from +7 to +2.

Final Answer: The oxidation number changes from +7 to +2.

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: Osmotic pressure (π) is a colligative property governed by the van 't Hoff equation for dilute solutions: $\pi = iCRT$, where i is the van 't Hoff factor, C is molar concentration, R is the gas constant, and T is absolute temperature.

Solution:

(a) The mathematical relationship shows that osmotic pressure (π) is directly proportional to both the molar concentration (C) of the solute and the absolute temperature (T).

(b) If we increase the temperature (T) of the system while keeping the concentration constant, the product $iCRT$ increases, raising the osmotic pressure.

(c) Decreasing solute concentration or increasing solvent volume reduces C, lowering the osmotic pressure.

(d) Adding a solute with a higher molecular weight at constant mass reduces the total number of moles, which decreases concentration and osmotic pressure.

(e) Thus, raising the temperature is the only measure listed that increases the osmotic pressure of the solution.

Final Answer: Osmotic pressure is increased by increasing the temperature.

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept: Soil organic matter can be broadly divided into humic substances and non-humic substances. Humic substances are high-molecular-weight, complex, dark-colored materials formed during secondary synthesis reactions in soil, distinguishing them from simple raw organic molecules.

Solution:

(a) Soil organic matter undergoing active microbial decay reaches a stabilized endpoint through the process of humification. This produces complex, dark-colored organic materials.

(b) This major stabilized component is known as humus, which represents an amorphous, colloidal organic phase lacking definite physical cellular structures.

(c) Humus contains highly complex aromatic rings and polymeric functional groups, which make it chemically stable and highly resistant to further enzymatic decomposition by soil microorganisms.

(d) Its colloidal structure provides a massive surface area per unit mass, drastically improving essential agricultural soil behaviors such as moisture retention and structural aggregation.

(e) Other components like fresh biomass represent living tissue, while peat represents partially decayed plant materials accumulated under saturated anaerobic environments rather than standard agricultural soil humus.

Final Answer: The dark-colored, amorphous colloidal organic material is Humus.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Electron gain enthalpy ($\Delta_{eg}H$) represents the enthalpy change accompanying the addition of an isolated electron to a gaseous atom. While electron affinity generally decreases down a group due to increasing atomic size, anomalies occur in the second period due to inter-electronic repulsions.

Solution:

(a) Moving down Group 17 from Chlorine to Iodine, the valence shell increases in distance from the nucleus, reducing the electrostatic attraction for an incoming electron and making the value less negative.

(b) However, Fluorine lies in the second period and has an exceptionally compact $2p$ subshell with a high electron cloud density.

(c) The incoming electron experiences significant inter-electronic repulsion within this tight space, which reduces the net energy released during electron capture.

(d) Chlorine possesses a larger $3p$ subshell that accommodates the extra electron with minimal repulsion, resulting in the highest energy release in the halogen group.

(e) Consequently, the correct descending order of negative electron gain enthalpy value follows the explicit trend: Cl > F > Br > I.

Final Answer: The correct order of negative electron gain enthalpy is Cl > F > Br > I.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: The acidity or alkalinity of an aqueous solution is governed by the water autoionization equilibrium constant (K_w). At 25°C, this constant is fixed such that pH + pOH = 14, where pOH = $-\log[OH^-]$.

Solution:

(a) Sodium hydroxide (NaOH) is a strong base that completely dissociates into constituent ions when dissolved in dilute aqueous solutions.

(b) For a 10^{-3} M solution of NaOH, the concentration of free hydroxide ions $[OH^-]$ is exactly 10^{-3} M.

(c) Using the logarithmic definition for hydroxide ion concentration, we calculate: pOH = $-\log(10^{-3}) = 3$.

(d) Utilizing the standard autoionization relationship for water at room temperature: pH = 14 − pOH.

(e) Substituting our calculated value into this relationship yields: pH = $14 - 3 = 11$, confirming a strongly alkaline solution.

Final Answer: The pH value of the solution is 11.

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Ozonolysis is an organic reaction that oxidatively cleaves unsaturated carbon-carbon double bonds. The structural substitution pattern of the alkene carbons determines whether ketones or aldehydes are produced during reductive workup.

Solution:

(a) The starting material 2-Methylbut-2-ene possesses the structural formula $(CH_3)_2C{=}CH\text{-}CH_3$.

(b) Treating this alkene with ozone (O_3) generates a cyclic ozonide intermediate across the original double bond site.

(c) Reductive cleavage using metallic zinc and water (Zn/H_2O) splits this intermediate cleanly at the double bond coordinates.

(d) Carbon-2 ($C-2$) is bonded to two methyl groups, so its cleavage forms a three-carbon ketone known as propanone (acetone).

(e) Carbon-3 ($C-3$) is bonded to a single methyl group and one hydrogen atom, so its cleavage forms a two-carbon aldehyde known as ethanal (acetaldehyde).

Final Answer: The products of ozonolysis are Propanone and Ethanal.

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept: The organization of the periodic table has evolved over time. Mendeleev's early periodic law relied on atomic mass, but the Modern Periodic Law uses the internal atomic structure of elements discovered through X-ray spectroscopy experiments.

Solution:

(a) Henry Moseley studied the characteristic X-ray spectra of various elements and discovered a linear relationship between the square root of the emitted X-ray frequency and the atomic number.

(b) This demonstrated that the properties of elements are governed by their atomic number rather than their total atomic mass.

(c) The modern periodic law states that the physical and chemical properties of elements are periodic functions of their atomic numbers.

(d) Organizing elements by increasing atomic number automatically groups them by valence shell electron configuration, which explains their repeating chemical behaviors.

(e) This arrangement resolved early anomalies found in mass-based tables, such as the positioning of isotopes and inverted element pairs.

Final Answer: Periodic properties are functions of atomic numbers.

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept: Coordination complexes consist of a central metal ion enclosed within a stable coordination sphere, surrounded by counter-ions that balance the net charge. Ions within the coordination sphere do not dissociate in aqueous solution.

Solution:

(a) The chemical formula $[Co(NH_3)_6]Cl_3$ indicates that the six neutral ammonia molecules are coordinated directly to the central cobalt ion.

(b) These components are held inside the square brackets, which represent the stable coordination sphere.

(c) The three chloride ions (Cl^-) located outside the square brackets are ionically bound as counter-ions.

(d) Dissolving one mole of this complex in water causes the counter-ions to ionize completely, while the coordination sphere remains intact.

(e) The dissociation yields one mole of the complex cation $[Co(NH_3)_6]^{3+}$ and three moles of chloride anions (Cl^-), producing a total of four moles of ions.

Final Answer: The dissociation produces 4 moles of ions.

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: Orthophosphate exists in soil solutions in different ionic forms that change with soil pH. Plants absorb phosphorus exclusively as dissolved orthophosphate ions, and the dominant ionic species depends on the acidity or alkalinity of the soil matrix.

Solution:

(a) The dissociation equilibria of orthophosphoric acid (H_3PO_4) produce three distinct anionic species: $H_2PO_4^-$, HPO_4^{2-}, and PO_4^{3-}.

(b) In strongly acidic soil environments with pH values below 5.0, high hydronium ion concentrations shift the solution equilibria toward protonated forms.

(c) Under these acidic conditions, the monovalent dihydrogen phosphate anion ($H_2PO_4^-$) becomes the dominant species in the soil solution.

(d) As the soil pH rises toward neutrality (6.0 – 7.0), the divalent monohydrogen phosphate anion (HPO_4^{2-}) increases in abundance.

(e) In alkaline soils ($pH > 8.0$), the trivalent phosphate anion (PO_4^{3-}) becomes common, though it often precipitates out with calcium ions.

Final Answer: The primary ionic species absorbed in acidic soils is $H_2PO_4^-$.

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: Electrolytic conductance parameters vary differently with solution concentration. Specific conductance (κ) measures the conducting power of a unit volume of solution, whereas molar conductance (Λ_m) measures the conducting power of all ions produced by one mole of electrolyte.

Solution:

(a) Specific conductance (κ) is defined as the conductance of a one-centimeter cube of an electrolytic solution.

(b) The value of specific conductance depends directly on the number of current-carrying ions present per unit volume of the solution.

(c) Diluting a solution increases its overall volume, which disperses the solute particles across a larger space.

(d) Consequently, the number of ions per milliliter or cubic centimeter of the solution decreases upon dilution.

(e) Because the ion density per unit volume falls, the specific conductance (κ) decreases as the electrolyte concentration decreases.

Final Answer: Specific conductance decreases with dilution.

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: Le Chatelier's principle states that when a chemical system at equilibrium experiences a change in temperature, pressure, or concentration, the position of equilibrium shifts to counteract the disturbance.

Solution:

(a) The forward reaction for the synthesis of ammonia via Haber's process features a negative enthalpy value ($\Delta H = -92.4$ kJ), classifying it as an exothermic process.

(b) According to Le Chatelier's principle, lowering the temperature shifts the equilibrium toward the exothermic forward direction to generate heat, maximizing ammonia yield.

(c) Evaluating the molar volumes: the reactant side contains four moles of gas (1 mol N_2 + 3 mol H_2), while the product side contains two moles of gas (2 mol NH_3).

(d) Increasing the total pressure shifts the equilibrium toward the side with fewer gas moles to relieve the pressure stress.

(e) Therefore, the forward reaction is favored by a combination of low temperature and high pressure conditions.

Final Answer: Ammonia yield is maximized under low temperature and high pressure.

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: The geometry and spatial orientation of reactive organic intermediates depend on the hybridization state of the central carbon atom, which is determined by its valence shell electron configuration and bonding pairs.

Solution:

(a) A methyl carbocation (CH_3^+) has three bonding pairs of electrons and zero lone pairs around its central carbon atom, giving it a steric number of 3.

(b) This configuration results in sp^2 hybridization, which produces a trigonal planar geometry with bond angles of exactly 120°.

(c) A methyl free radical ($\cdot CH_3$) contains three bonding pairs and a single unpaired electron in an unhybridized p-orbital, allowing it to maintain a largely planar structure.

(d) In contrast, a methyl carbanion (CH_3^-) holds three bonding pairs and a full lone pair, giving it a steric number of 4.

(e) This leads to sp^3 hybridization, which creates a distorted trigonal pyramidal geometry rather than a planar one.

Final Answer: Both methyl carbocation and methyl free radical exhibit planar geometry.

Answer: (D)

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Q21.

Solution

Concept: Covalent chemical bonds are classified as either sigma (σ) or pi (π) bonds based on atomic orbital overlap. Every single covalent connection contains exactly one σ-bond, while any additional shared electron pairs in double or triple bonds constitute localized π-bonds.

Solution:

(a) Benzene possesses a cyclic molecular formula represented as C_6H_6, containing a six-membered ring structure of carbon atoms.

(b) Within the ring architecture, each individual carbon atom forms a single localized σ-bond with one peripheral hydrogen atom, totaling six $C-H$ σ-bonds.

(c) The carbon skeletal framework consists of alternating single and double carbon-carbon bonds around the cyclic pathway.

(d) The six carbon-carbon connections consist of three single $C-C$ bonds and three double $C=C$ bonds, contributing six additional σ-bonds.

(e) Summing these framework connections yields twelve total σ-bonds ($6+6=12$). The three double bonds also contain three shared pairs of sideways-overlapping π-electrons.

Final Answer: Benzene has 12 sigma bonds and 3 pi bonds.

Answer: (A)

Go Back to Question 21

Q22.

Solution

Concept: The coordination number corresponds to the total number of individual coordinate dative bonds formed between ligands and the central transition metal atom. The oxidation state tracks the apparent formal charge remaining on that metal center.

Solution:

(a) The complex contains three oxalate groups ($C_2O_4^{2-}$) serving as surrounding coordination ligands for the iron center.

(b) Oxalate is a bidentate chelate ligand that uses two oxygen donor atoms to form two separate coordinate bonds simultaneously.

(c) With three bidentate oxalate ligands bound, the absolute total number of coordinate attachments equals six ($3 \times 2 = 6$).

(d) Let x represent the unknown oxidation state of the iron atom. The sum of all component charges must match the outer ionic charge.

(e) Setting up the equation: $x + 3(-2) = -3$, which simplifies to $x - 6 = -3$, yielding $x = +3$ for the metal center.

Final Answer: The coordination number is 6 and the oxidation state is +3.

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept: Thermodynamic properties are divided into extensive and intensive categories based on system mass dependence. Extensive variables scale with material volume or quantity, while intensive parameters remain independent of bulk size variations.

Solution:

(a) Enthalpy (H) reflects total heat content and expands proportionally when more matter or chemical substance is added to the system.

(b) Internal energy (U) and entropy (S) track molecular configuration and total kinetic particle storage, scaling directly with mass.

(c) Temperature (T) measures the average translational kinetic energy of molecules within a zone, rather than total stored heat.

(d) If a thermal system at a uniform temperature is divided into separate parts, each section maintains that exact same temperature value.

(e) Because it is independent of sample size or quantity, temperature serves as a classic intensive thermodynamic parameter.

Final Answer: Temperature is an intensive property.

Answer: (D)

Go Back to Question 23

Q24.

Solution

Concept: Sodic or alkali soils suffer from poor structure due to excessive exchangeable sodium ions adsorbed on clay surfaces. Chemical reclamation requires adding an amendment that replaces these sodium ions with structural calcium ions.

Solution:

(a) Sodic soils possess high exchangeable sodium percentages that cause soil particles to swell and disperse, sealing porous channels.

(b) Reclamation requires replacing the adsorbed sodium ions with divalent calcium ions (Ca^{2+}) to flocculate the clay.

(c) Calcium carbonate ($CaCO_3$) is insoluble at the high pH levels typical of alkali soils, making it ineffective for reclamation.

(d) Gypsum ($CaSO_4 \cdot 2H_2O$) provides a soluble source of calcium ions that displace sodium from the exchange complex.

(e) The displaced sodium combines with sulfate ions to form soluble sodium sulfate (Na_2SO_4), which is then leached out of the root zone with irrigation water.

Final Answer: Sodic soils are reclaimed by adding Gypsum.

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept: Elements are arranged in the modern periodic table based on their ground-state electron configurations. The specific column or group assignment is determined by the total number of valence electrons in the outermost shells.

Solution:

(a) The given configuration is $[Ar]3d^{10}4s^{1}$, which corresponds to an atomic number of 29 (Copper).

(b) For d-block elements, group determination is calculated by summing the electrons in the outermost s subshell and the underlying d subshell.

(c) Adding these values together yields a total valence count of eleven ($10 + 1 = 11$).

(d) This places the element in Group 11 of the periodic table, historically known as the coinage metal group.

(e) Although it has a single electron in its $4s$ orbital, the filled $3d$ subshell excludes it from the Group 1 alkali metal family.

Final Answer: The element belongs to Group 11.

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: The mixing of a strong acid with an equal amount of a strong base results in an acid-base neutralization reaction. The final hydronium ion concentration depends on the net excess of remaining acidic or basic equivalents.

Solution:

(a) Hydrochloric acid (HCl) is a strong monobasic acid that releases one mole of H^+ ions per mole of acid.

(b) Sodium hydroxide (NaOH) is a strong monoacidic base that releases one mole of OH^- ions per mole of base.

(c) Mixing equal volumes of solutions with identical molar concentrations (0.1 M) introduces equal chemical equivalents of H^+ and OH^- ions.

(d) The hydronium and hydroxide ions react completely to form water: $H^+ + OH^- \rightarrow H_2O$.

(e) Since both reactants are entirely consumed without leaving an excess of either ion, the solution remains neutral with a pH of 7.0 at 25°C.

Final Answer: The resulting mixture has a pH value of 7.

Answer: (C)

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Q27.

Solution

Concept: The hydration of alkynes involves the electrophilic addition of water across a carbon-carbon triple bond. The reaction requires an acidic catalyst, such as mercuric sulfate ($HgSO_4$), and follows Markovnikov's rule.

Solution:

(a) Propyne ($CH_3 - C \equiv CH$) reacts with water in the presence of H_2SO_4 and $HgSO_4$ catalysts.

(b) Following Markovnikov's rule, the hydroxyl group ($-OH$) adds to the more substituted internal carbon atom ($C - 2$).

(c) This addition produces an unstable enol intermediate structurally identified as prop-1-en-2-ol [$CH_3 - C(OH) = CH_2$].

(d) Enols readily undergo keto-enol tautomerism, a process involving rapid proton migration from the oxygen atom to the adjacent carbon.

(e) This structural rearrangement converts the enol tautomer into its more stable carbonyl form, yielding propanone ($CH_3 - CO - CH_3$).

Final Answer: The major organic product is Propanone.

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept: Crystal lattice structures contain a specific number of net atoms per unit cell, determined by the geometric positions of the atoms and how they are shared with neighboring cells.

Solution:

(a) In a face-centered cubic lattice, atoms are positioned at all eight corners and at the centers of all six faces.

(b) Each corner atom is shared equally among eight adjacent unit cells, contributing a fractional value of $\frac{1}{8}$ to any single cell.

(c) Multiplying these positions: $8 \times \frac{1}{8} = 1$ net atom from the corner sites.

(d) Each face-centered atom is shared between two adjacent unit cells, contributing a fractional value of $\frac{1}{2}$ to the cell.

(e) Multiplying these positions: $6 \times \frac{1}{2} = 3$ net atoms from the faces. Summing these values gives a total of 4 net atoms $(1 + 3 = 4)$.

Final Answer: The total net number of atoms in an FCC unit cell is 4.

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept: Essential macro plant nutrients govern specific physiological pathways in agricultural crops. Nitrogen, phosphorus, and potassium form the primary nutrient triad, and each element supports distinct structural or biochemical functions.

Solution:

(a) Nitrogen is an essential component of amino acids and chlorophyll, primarily driving vegetative shoot growth and green leaf development.

(b) Potassium regulates stomatal activity, maintains cellular turgor pressure, and activates enzyme systems related to stress tolerance.

(c) Phosphorus plays a vital role in cellular energy conservation and transfer as a core component of adenosine triphosphate (ATP) molecules.

(d) This energy transfer is critical for high-energy metabolic processes, including rapid cell division and early root development.

(e) Adequate phosphorus levels promote deep root growth, accelerate crop maturity, and increase the structural strength of stalks and grain heads.

Final Answer: Phosphorus is responsible for root growth and early maturity.

Answer: (C)

Go Back to Question 29

Q30.

Solution

Concept: Molecular geometry is determined by the total number of bonding pairs and non-bonding lone pairs surrounding the central atom, as defined by Valence Shell Electron Pair Repulsion (VSEPR) theory.

Solution:

(a) Xenon (Xe) belongs to the noble gas family and possesses eight valence electrons in its outer shell.

(b) In xenon tetrafluoride (XeF_4), xenon forms four single covalent bonds with four fluorine atoms, consuming four valence electrons.

(c) The remaining four valence electrons form two non-bonding lone pairs on the central xenon atom.

(d) The total steric number equals six (4 bond pairs + 2 lone pairs), which corresponds to an octahedral electron-pair geometry.

(e) To minimize electrostatic repulsion, the two lone pairs occupy opposite axial positions, resulting in a square planar molecular geometry.

Final Answer: The geometric shape of Xenon Tetrafluoride is square planar.

Answer: (B)

Go Back to Question 30

Q31.

Solution

Concept: The Arrhenius equation describes how chemical reaction rates depend on temperature. Converting the exponential formula into its logarithmic form creates a linear equation that allows the experimental determination of activation energy.

Solution:

(a) The exponential Arrhenius expression is given by the formula $k = Ae^{-E_a/RT}$.

(b) Taking the natural logarithm of both sides of this expression yields the linear equation: $\ln k = \ln A - \frac{E_a}{RT}$.

(c) This mathematical relationship can be rearranged into standard straight-line form ($y = mx+b$) by writing: $\ln k = \left(-\frac{E_a}{R}\right)\left(\frac{1}{T}\right) + \ln A$.

(d) Plotting the natural logarithm of the rate constant ($\ln k$) on the vertical y-axis against the reciprocal of absolute temperature ($\frac{1}{T}$) on the horizontal x-axis produces a straight line.

(e) Comparing the coefficients shows that the slope (m) of this linear plot is equal to $-\frac{E_a}{R}$, while the vertical y-intercept is equal to $\ln A$.

Final Answer: The slope of the linear plot is mathematically equal to $-E_a/R$.

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept: The Wurtz reaction is a classic organic coupling reaction used to prepare symmetrical alkanes. It involves reacting alkyl halides with metallic sodium in an anhydrous non-polar solvent.

Solution:

(a) In a Wurtz reaction mixture, two moles of an alkyl halide react with two atoms of elemental sodium metal.

(b) The starting material specified in this process is methyl iodide, which has the chemical formula CH_3I.

(c) Sodium atoms act as reducing agents, abstracting iodine atoms from the methyl groups to form stable sodium iodide (NaI) precipitates.

(d) This abstraction generates highly reactive methyl free radicals ($\cdot CH_3$) or transient organosodium intermediates in the solution.

(e) Two of these single-carbon methyl fragments rapidly undergo a dimerization coupling step, joining together to form a symmetrical two-carbon alkane known as ethane ($CH_3 - CH_3$).

Final Answer: The hydrocarbon produced by the reaction is Ethane.

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept: Faraday's laws of electrolysis state that the mass of a substance altered at an electrode is directly proportional to the quantity of electric charge passed through the solution. One mole of electrons carries a total charge of approximately 96,500 Coulombs (1 Faraday).

Solution:

(a) Aqueous copper sulfate ($CuSO_4$) dissociates to release divalent copper cations (Cu^{2+}) into the electrolytic solution.

(b) At the cathode, these divalent copper ions undergo a reduction half-reaction given by the equation: $Cu^{2+} + 2e^- \rightarrow Cu(s)$.

(c) According to this stoichiometry, depositing one mole of solid copper metal requires exactly two moles of electrons (2 Faradays).

(d) The total electric charge delivered to the system is exactly 96,500 Coulombs, which corresponds to one mole of electrons (1 Faraday).

(e) Since two Faradays deposit one full mole of copper (63.5 g), passing one Faraday deposits exactly half a mole of copper: $\frac{63.5}{2} = 31.75$ g.

Final Answer: The mass of copper metal deposited is 31.75 g.

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept: The acidity of simple hydrocarbons depends on the hybridization state of the carbon atom bonded to the hydrogen. Increasing the s-character of an orbital pulls electron density closer to the carbon nucleus, stabilizing the resulting conjugate base.

Solution:

(a) Ethane ($CH_3 - CH_3$) features sp^3 hybridized carbon atoms with 25% s-character, making it exceptionally weak at stabilizing a negative charge.

(b) Ethene ($CH_2 = CH_2$) features sp^2 hybridized carbon atoms with 33.3% s-character, holding electrons more tightly than an sp^3 orbital.

(c) Ethyne ($CH \equiv CH$) features sp hybridized carbon atoms with 50% s-character, which exhibits the highest electronegativity.

(d) The high electronegativity of sp orbitals stabilizes the lone pair on the conjugate acetylide anion formed after deprotonation.

(e) Consequently, the ease of losing a proton increases with higher s-character, following the trend: Ethane $<$ Ethene $<$ Ethyne.

Final Answer: The increasing order of acidic character is Ethane $<$ Ethene $<$ Ethyne.

Answer: (A)

Go Back to Question 34

Q35.

Solution

Concept: An electron orbital is completely described by four quantum numbers. Each parameter defines a specific physical characteristic of the orbital space or the electron spin state within the atom.

Solution:

(a) The Principal Quantum Number is designated by the letter n and takes positive integer values starting from 1.

(b) This number identifies the main electron shell or principal energy level where the electron is located.

(c) As the value of n increases, the electron spends more time further from the nucleus, which scales the physical size of the orbital.

(d) In contrast, the Azimuthal Quantum Number (l) determines the three-dimensional geometric shape of the subshell.

(e) The Magnetic Quantum Number (m_l) specifies the spatial orientation of the orbital, while the Spin Quantum Number (m_s) tracks the electron spin.

Final Answer: The Principal Quantum Number determines the size and principal energy level of the orbital.

Answer: (C)

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Q36.

Solution

Concept: Solutions differ in how they respond to chemical additions. Buffer solutions contain a conjugate acid-base pair that acts as a chemical sink, neutralizing small amounts of added hydronium or hydroxide ions to maintain a stable pH.

Solution:

(a) Adding a strong acid to pure water or an unbuffered solution dramatically increases the free hydronium ion concentration, dropping the pH.

(b) A buffer solution resists these sudden shifts by utilizing a mixture of a weak acid and its conjugate base, or a weak base and its conjugate acid.

(c) When extra hydronium ions (H_3O^+) enter the system, the weak conjugate base reacts with them, preventing them from altering the pH.

(d) When hydroxide ions (OH^-) are added, the weak acid component neutralizes them to minimize changes in alkalinity.

(e) This ability to minimize shifts in hydronium ion concentration makes buffer solutions vital for maintaining stable pH levels in biological and chemical systems.

Final Answer: An aqueous solution that resists pH changes is designated as a Buffer solution.

Answer: (B)

Go Back to Question 36

Q37.

Solution

Concept: Ligands are molecules or ions that donate electron pairs to a central metal atom. While most ligands coordinate through a single dedicated atom, certain structures possess multiple potential donor sites that can bind one at a time.

Solution:

(a) Ambidentate ligands are monodentate species that contain two or more different potential donor atoms but coordinate through only one site during complex formation.

(b) Neutral molecules like ammonia (NH_3) and water (H_2O) are simple monodentate ligands that bind exclusively through their nitrogen and oxygen lone pairs, respectively.

(c) Ethylenediamine (en) features two nitrogen donor atoms that bind to the metal center simultaneously, classifying it as a didentate chelate ligand.

(d) The thiocyanate ion (SCN^-) possesses two distinct donor sites: the sulfur atom and the nitrogen atom.

(e) It can coordinate either as $M - SCN$ (thiocyanato) or $M - NCS$ (isothiocyanato), making it a classic illustration of an ambidentate ligand.

Final Answer: The classic illustration of an ambidentate ligand is SCN^-.

Answer: (C)

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Q38.

Solution

Concept: Catalysts alter reaction rates by interacting with the chemical intermediates along the reaction coordinate. A positive catalyst accelerates a reaction without changing the thermodynamic properties of the reactants or products.

Solution:

(a) A positive catalyst increases the rate of a chemical reaction by introducing an alternative reaction mechanism.

(b) This new pathway features a significantly lower activation energy barrier (E_a) than the original uncatalyzed pathway.

(c) Lowering this energy barrier allows a larger fraction of reactant molecules to possess the kinetic energy needed for successful collisions.

(d) Crucially, a catalyst lowers the activation energy barriers for both the forward and reverse reactions by the exact same amount.

(e) Because the relative energy levels of the initial reactants and final products remain unchanged, parameters like enthalpy (ΔH) and the equilibrium constant (K_{eq}) are unaltered.

Final Answer: A positive catalyst modifies the speed of the reaction by altering the activation energy pathway.

Answer: (C)

Go Back to Question 38

Q39.

Solution

Concept: The reactivity and properties of organic molecules are influenced by electron displacement effects. These effects are categorized as permanent or temporary based on whether they require an external reagent to manifest.

Solution:

(a) The inductive effect is a permanent electron displacement that occurs when atoms of differing electronegative values are linked within a molecule.

(b) This electronegativity difference creates an unsymmetrical distribution of shared electron density along a chain of single bonds.

(c) This polarization is transmitted strictly through localized σ-bonding electrons, decaying rapidly as the distance from the electronegative atom increases.

(d) In contrast, the electromeric effect involves a temporary shift of shared π-bonding electrons, occurring only when an attacking reagent is present.

(e) Resonance effects involve the delocalization of π-bonding pairs or non-bonding lone pairs across a conjugated system, rather than a simple inductive shift.

Final Answer: The inductive displacement effect involves the permanent shift of sigma-bonding electrons.

Answer: (A)

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Q40.

Solution

Concept: Cation Exchange Capacity (CEC) measures the total exchangeable cations that a soil colloid can retain on its negatively charged surfaces. This capacity depends on the surface area and the density of negative charges on the colloid.

Solution:

(a) Kaolinite is a 1:1 non-expanding aluminosilicate clay with a low surface area, resulting in a minimal CEC value ($3 - 15$ cmol$_c$ kg^{-1}).

(b) Illite is a 2:1 non-expanding clay where interlayer potassium ions restrict swelling, keeping its CEC moderate ($20 - 40$ cmol$_c$ kg^{-1}).

(c) Montmorillonite is a 2:1 expanding silicate clay with extensive internal surfaces, giving it a high CEC ($80 - 150$ cmol$_c$ kg^{-1}).

(d) Humus is an organic colloid containing numerous oxygen-bearing functional groups, such as carboxyl ($-COOH$) and phenolic ($-OH$) groups.

(e) These groups deprotonate under typical soil pH conditions, generating an exceptionally high density of negative charges ($150 - 300$ cmol$_c$ kg^{-1}).

Final Answer: Humus exhibits the highest Cation Exchange Capacity value.

Answer: (D)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	A	4	B	5	D
6	C	7	A	8	B	9	A	10	A
11	B	12	B	13	B	14	A	15	C
16	B	17	C	18	B	19	B	20	D
21	A	22	B	23	D	24	B	25	B
26	C	27	B	28	C	29	C	30	B
31	A	32	B	33	B	34	A	35	C
36	B	37	C	38	C	39	A	40	D