Rajasthan JET Chemistry Sample Paper-1

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. The ratio of the de Broglie wavelength of an α-particle and a proton accelerated through the same potential difference V is:

(A) $1 : 2$

(B) $1 : 2\sqrt{2}$

(C) $2\sqrt{2} : 1$

(D) $1 : 4$

Q2. Which type of soil colloid exhibits the highest Cation Exchange Capacity (CEC) among the following options under normal neutral soil conditions?

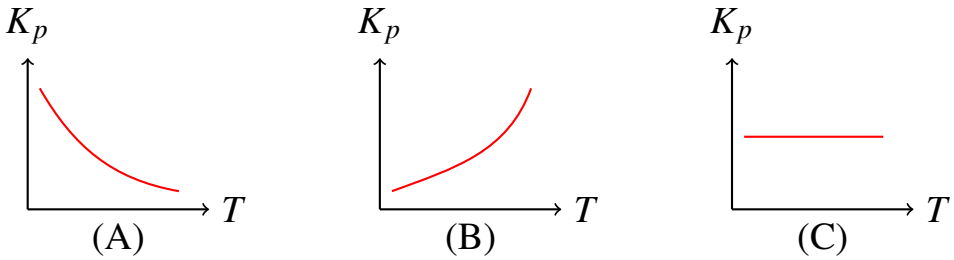
(A) Kaolinite

(B) Illite

(C) Montmorillonite

(D) Humus

Q3. For a reversible exothermic reaction $A + B \rightleftharpoons C$, which of the following diagrams correctly describes the variation of the equilibrium constant K_p with absolute temperature T?



(A) Diagram (A)

(B) Diagram (B)

(C) Diagram (C)

(D) None of these curves are applicable to an exothermic process

Q4. The IUPAC name of the compound given by the structure $CH_3 - CH(OH) - CH_2 - CO - CH_3$ is:

(A) 4-Hydroxypentan-2-one

(B) 2-Hydroxypentan-4-one

(C) 4-Oxopentan-2-ol

(D) 2-Oxopentan-4-ol

Q5. Which of the following elements possesses the highest second ionization enthalpy (IE_2)?

(A) Na

(B) Mg

(C) O

(D) F

Q6. During the electrolysis of an aqueous solution of $CuSO_4$ using inert platinum electrodes, the products liberated at the cathode and anode respectively are:

(A) $H_2(g)$ and $O_2(g)$

(B) Cu(s) and $O_2(g)$

(C) Cu(s) and $SO_2(g)$

(D) $H_2(g)$ and Cu(s)

Q7. The spin-only magnetic moment value of the coordination complex $[Fe(H_2O)_6]^{2+}$ is approximately:

(A) 1.73 BM

(B) 2.83 BM

(C) 4.90 BM

(D) 5.92 BM

Q8. Biuret content in agricultural urea fertilizer should strictly not exceed what percentage by weight according to Indian Fertilizer Control Order regulations to prevent phytotoxicity?

(A) 1.5%

(B) 3.0%

(C) 0.5%

(D) 5.0%

Q9. In the balanced chemical equation: $x\text{MnO}_4^- + y\text{C}_2\text{O}_4^{2-} + z\text{H}^+ \rightarrow x\text{Mn}^{2+} + 2y\text{CO}_2 + \frac{z}{2}\text{H}_2\text{O}$, the stoichiometric coefficients x, y, and z are respectively:

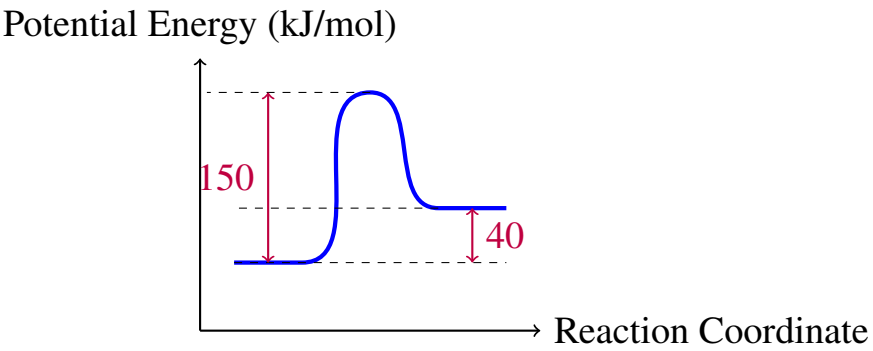
(A) 2, 5, 16

(B) 5, 2, 16

(C) 2, 10, 8

(D) 5, 2, 8

Q10. The following potential energy profile represents an elementary chemical reaction. What is the activation energy (E_a) for the reverse reaction?



(A) 150 kJ/mol

(B) 110 kJ/mol

(C) 190 kJ/mol

(D) 40 kJ/mol

Q11. When calcium carbide (CaC_2) undergoes complete hydrolysis with water, the major gaseous hydrocarbon produced is:

(A) Methane

(B) Ethane

(C) Ethylene

(D) Acetylene

Q12. The molecular geometry and the total number of lone pairs on the central atom of the XeF_4 molecule are respectively:

(A) Tetrahedral, 0

(B) Square planar, 2

(C) See-saw, 1

(D) Square pyramidal, 1

Q13. Which of the following aqueous solutions will exhibit the lowest freezing point temperature?

(A) 0.1 M NaCl

(B) 0.1 M $BaCl_2$

(C) 0.1 M Glucose

(D) 0.1 M $Al_2(SO_4)_3$

Q14. Which amendment is most scientifically suitable and economically recommended for correcting sodic (alkali) soils prevalent in arid regions of Rajasthan?

(A) Calcium carbonate (Lime)

(B) Calcium sulfate dihydrate (Gypsum)

(C) Aluminum sulfate

(D) Ammonium sulfate

Q15. The total number of molecules present in 4.4 grams of CO_2 gas at standard conditions is approximately:

(A) 6.022×10^{23}

(B) 6.022×10^{22}

(C) 3.011×10^{22}

(D) 1.204×10^{23}

Q16. For a spontaneous process at all temperatures, the conditions for the thermodynamic parameters must be:

(A) $\Delta H < 0$ and $\Delta S > 0$

(B) $\Delta H > 0$ and $\Delta S > 0$

(C) $\Delta H < 0$ and $\Delta S < 0$

(D) $\Delta H > 0$ and $\Delta S < 0$

Q17. Ozonolysis of 2-Methylbut-2-ene followed by reduction with Zn/H_2O yields which of the following products mixture?

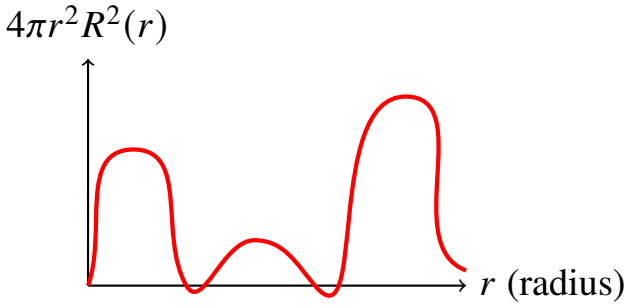
(A) Two molecules of Acetaldehyde

(B) Acetone and Methanal

(C) Acetone and Ethanal

(D) Propanal and Ethanal

Q18. Identify the specific atomic orbital characterized by the radial probability distribution function graph plotted below:



(A) $1s$

(B) $2s$

(C) $3s$

(D) $2p$

Q19. The solubility product (K_{sp}) of a sparingly soluble salt AB_2 in water is 4×10^{-12}. Its molar solubility (S) in pure water is:

(A) 1×10^{-4} M

(B) 2×10^{-6} M

(C) 1×10^{-6} M

(D) 4×10^{-4} M

Q20. According to Crystal Field Theory, the correct electronic configuration for a d^5 transition metal ion forming an octahedral complex with a strong field ligand is:

(A) $t_{2g}^3 e_g^2$

(B) $t_{2g}^5 e_g^0$

(C) $t_{2g}^4 e_g^1$

(D) $t_{2g}^0 e_g^5$

Q21. Which of the following elements is classified as an essential macronutrient for plants, structural constituent of chlorophyll, and involved in enzymatic activation?

(A) Zinc (Zn)

(B) Iron (Fe)

(C) Magnesium (Mg)

(D) Manganese (Mn)

Q22. Which of the following molecular chemical species is paramagnetic in nature according to Molecular Orbital Theory (MOT)?

(A) N_2

(B) O_2

(C) C_2

(D) F_2

Q23. The half-life period ($t_{1/2}$) of a certain chemical reaction is found to be independent of the initial concentration of the reactants. The order of this reaction is:

(A) Zero order

(B) First order

(C) Second order

(D) Third order

Q24. Among the following carbocations, which one is stabilized maximum by the phenomenon of hyperconjugation and inductive effect?

(A) $^{+}CH_3$

(B) $CH_3CH_2^{+}$

(C) $(CH_3)_2CH^{+}$

(D) $(CH_3)_3C^{+}$

Q25. What volume of 0.5 M HCl solution is precisely required to completely neutralize 20 mL of 0.2 M NaOH solution?

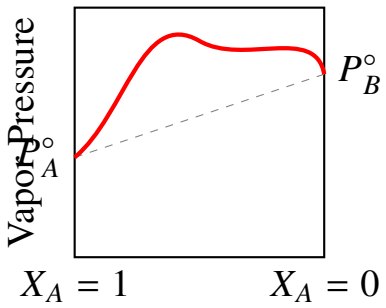
(A) 8 mL

(B) 10 mL

(C) 50 mL

(D) 20 mL

Q26. The following vapor pressure vs. composition phase diagram corresponds to which type of binary liquid system mixture?



(A) Ideal solution obeying Raoult's law

(B) Non-ideal solution showing positive deviation from Raoult's law

(C) Non-ideal solution showing negative deviation from Raoult's law

(D) Completely immiscible binary liquid pair

Q27. The major product obtained when propene reacts with hydrogen bromide (HBr) in the presence of organic peroxides is:

(A) 2-Bromopropane

(B) 1-Bromopropane

(C) 1,2-Dibromopropane

(D) 2-Bromopropan-2-ol

Q28. Which group of microorganisms plays the principal biochemical role in transforming toxic ammonia into nitrite (NO_2^-) during biological nitrification in soil?

(A) Nitrobacter

(B) Azotobacter

(C) Nitrosomonas

(D) Rhizobium

Q29. The correct descending order of atomic radii for the isoelectronic series species S^{2-}, Cl^{-}, K^{+}, and Ca^{2+} is:

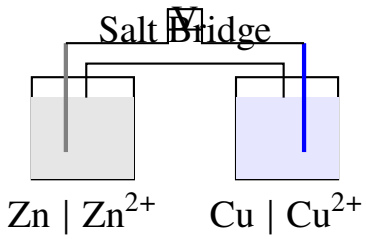
(A) $Ca^{2+} > K^{+} > Cl^{-} > S^{2-}$

(B) $S^{2-} > Cl^{-} > K^{+} > Ca^{2+}$

(C) $Cl^{-} > S^{2-} > Ca^{2+} > K^{+}$

(D) $K^{+} > Ca^{2+} > S^{2-} > Cl^{-}$

Q30. Consider the chemical galvanic setup shown below. Which equation correctly calculates the cell potential (E_{cell}) at 298 K?



(A) $E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{2} \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$

(B) $E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{2} \log \frac{[Cu^{2+}]}{[Zn^{2+}]}$

(C) $E_{cell} = E^{\circ}_{cell} + \frac{0.0591}{2} \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$

(D) $E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{1} \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$

Q31. The spatial relationship and isomerism exhibited between Pentan-2-one and Pentan-3-one is termed as:

(A) Chain isomerism

(B) Functional isomerism

(C) Position isomerism

(D) Metamerism

Q32. The type of atomic orbital hybridization shown by the central boron atom in a molecule of diborane (B_2H_6) is:

(A) sp

(B) sp^2

(C) sp^3

(D) sp^3d

Q33. The heat change accompanying a chemical reaction taking place under constant volume condition (q_v) is exactly equivalent to which thermodynamic parameter change?

(A) Enthalpy change (ΔH)

(B) Entropy change (ΔS)

(C) Internal energy change (ΔU)

(D) Gibbs free energy change (ΔG)

Q34. The coordination number and the oxidation state of the central metal atom in the complex compound $K_3[Fe(C_2O_4)_3]$ are respectively:

(A) 3, +3

(B) 6, +3

(C) 6, +2

(D) 3, +2

Q35. The composition of the widely used agrochemical insecticide "Bordeaux mixture" consists of an aqueous solution containing combination of:

(A) Copper sulfate and Calcium hydroxide (Lime)

(B) Zinc sulfate and Sodium carbonate

(C) Ferrous sulfate and Ammonium chloride

(D) Copper sulfate and Sodium hydroxide

Q36. Identify the chemical species acting as the reducing agent in the following chemical redox reaction: $CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$.

(A) CuO

(B) H_2

(C) Cu

(D) H_2O

Q37. What will be the immediate impact on the position of chemical equilibrium for the synthesis reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{Heat}$ if the total operational pressure is increased at equilibrium?

(A) Shifts in the backward direction

(B) Shifts in the forward direction

(C) Remains totally unaffected

(D) Equilibrium constant increases

Q38. Which of the following organic reaction mechanisms describes the classic nucleophilic substitution reaction of a tertiary alkyl halide such as *tert*-butyl chloride with aqueous KOH?

(A) S_N2 mechanism via a single step transition state

(B) S_N1 mechanism via a stable carbocation intermediate

(C) E1 elimination mechanism

(D) Electrophilic substitution mechanism

Q39. The empirical formula of an organic compound containing 40% Carbon, 6.67% Hydrogen, and 53.33% Oxygen by weight weight is:

(A) CHO

(B) CH_2O

(C) CHO_2

(D) C_2H_4O

Q40. According to Henry's law, the solubility of a gas in a given liquid solvent at a constant ambient temperature is directly proportional to:

(A) The volume of the liquid solvent taken

(B) The partial pressure of the gas above the liquid surface

(C) The critical temperature threshold of the gas

(D) The density of the liquid solvent phase

Detailed Solutions

Q1.

Solution

Concept:

The de Broglie wavelength describes the wave-particle duality of matter. When a charged particle is accelerated through an electric potential difference, it gains kinetic energy equivalent to the product of its electric charge and the potential difference. This kinetic energy can then be used to calculate its momentum and corresponding de Broglie wavelength.

Solution:

(a) The de Broglie wavelength equation is given by the relation where wavelength equals Planck constant divided by momentum. For a particle of mass m and kinetic energy K, the momentum can be written as the square root of two times mass times kinetic energy.

(b) When a particle carrying an electric charge q is accelerated from rest through a potential difference V, its gained kinetic energy is equal to qV. Substituting this value into the momentum relation gives a wavelength expression inversely proportional to the square root of the product of mass and charge.

(c) A proton has a mass m and a positive charge q. An alpha particle consists of two protons and two neutrons, meaning its mass is approximately four times the mass of a proton, and its net positive charge is exactly twice the charge of a proton.

(d) Taking the ratio of their wavelengths under identical accelerating voltage eliminates the Planck constant and the potential term from the equation. The resulting ratio is equal to the square root of the mass and charge of the proton over those of the alpha particle.

(e) Substituting the relative values yields the square root of one over eight, which simplifies algebraically to one divided by two times the square root of two.

Final Answer: The ratio is $1 : 2\sqrt{2}$.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept:

Cation Exchange Capacity is a crucial chemical property of soil that measures its total capacity to hold and exchange exchangeable cations. This capacity depends directly on the surface area and the net negative surface charge density carried by different types of inorganic mineral clay crystals and organic soil colloids.

Solution:

(a) Soil colloids are categorized into crystalline silicate clays, non-crystalline silicate clays, iron or aluminum oxides, and organic matter. Each group possesses different amounts of negative charges arising from isomorphous substitution or pH-dependent functional groups.

(b) Kaolinite is a one-to-one type non-expanding clay mineral with a low specific surface area and minimal substitution, resulting in a very low exchange capacity ranging between three and fifteen centimoles per kilogram.

(c) Illite is a two-to-one non-expanding clay where potassium ions occupy the interlayer spaces, limiting surface exposure and yielding a moderate exchange capacity between twenty and forty centimoles per kilogram.

(d) Montmorillonite belongs to the two-to-one expanding smectite group, featuring high internal surface exposure due to water intrusion, leading to a high exchange capacity between eighty and one hundred fifty centimoles per kilogram.

(e) Humus is the decomposed amorphous organic component of soil. It contains numerous active carboxylic and phenolic functional groups that dissociate under neutral conditions, producing an exceptionally high exchange capacity often exceeding two hundred centimoles per kilogram.

Final Answer: The colloid is Humus.

Answer: (D)

Go Back to Question 2

Q3.

Solution

Concept:

The temperature dependence of the chemical equilibrium constant is quantitatively described by the thermodynamic van 't Hoff equation. This mathematical relationship connects the differential log change of the equilibrium constant with respect to absolute temperature to the standard enthalpy change of the chemical process.

Solution:

(a) The van 't Hoff equation states that the derivative of the natural logarithm of the equilibrium constant with respect to temperature equals the standard enthalpy change divided by the universal gas constant times the square of absolute temperature.

(b) For a reversible reaction characterized as exothermic, heat is liberated during the forward process, meaning the standard enthalpy change possesses a negative numerical sign.

(c) Inserting a negative enthalpy value into the mathematical relationship dictates that the derivative of the equilibrium constant with respect to temperature must be less than zero across all temperature ranges.

(d) From a physical standpoint, this negative derivative implies that increasing the thermal energy of the system shifts the equilibrium position toward the reactants according to Le Chatelier principle, causing the equilibrium constant to drop continuously.

(e) Looking at the given graphical illustrations, the plot labeled as curve A depicts a non-linear decay behavior where the value of the constant falls steadily as temperature increases, matching the theoretical prediction perfectly.

Final Answer: The correct plot is Diagram (A).

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept:

The nomenclature of multifunctional organic compounds follows structured priority guidelines established by the International Union of Pure and Applied Chemistry. When an organic skeleton contains more than one principal functional group, a single group is selected as the primary suffix while all other remaining groups are designated as prefix substituents.

Solution:

(a) The given molecular structure contains both a hydroxyl functional group characteristic of alcohols and a carbonyl functional group characteristic of ketones embedded within a five-carbon saturated chain.

(b) According to the chemical priority sequence rules established by nomenclature standards, a carbonyl group possesses a higher priority ranking for suffix designation than a hydroxyl group. Therefore, the compound is classified primarily as a ketone.

(c) The continuous carbon backbone contains five distinct carbon atoms, which establishes the root word as pentane. The primary suffix for the ketone group transforms this root name into pentanone.

(d) Numbering the main carbon chain must begin from the direction that grants the highest priority principal functional group the lowest possible locant index. Counting from right to left assigns position two to the ketone group and position four to the hydroxyl group.

(e) The hydroxyl group at the fourth position is treated as a substituent prefix. Combining the substituent location with the parent chain name produces the final systematic name.

Final Answer: The name is 4-Hydroxypentan-2-one.

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept:

Ionization enthalpy represents the minimum amount of energy required to remove an electron from an isolated gaseous atom or ion in its ground electronic state. Successive ionization enthalpies increase sequentially due to the increasing net positive nuclear charge acting on the remaining bound electrons.

Solution:

(a) The first ionization process removes an electron from a neutral atom, while the second ionization process removes a subsequent electron from a univalent positive cation.

(b) Sodium belongs to group one and has a neutral configuration of neon core followed by a single electron in the three-s orbital. Removing this outer valence electron leaves behind a stable sodium cation.

(c) This univalent sodium cation possesses a stable closed-shell electronic configuration identical to the noble gas neon. Breaking into this stable octet configuration to remove a second electron requires an immense input of energy.

(d) Magnesium has two valence electrons. Removing its second electron generates a stable closed-shell ion, making its second ionization enthalpy relatively small.

(e) Oxygen and fluorine are p-block elements whose valence configurations do not change from a stable octet during the first ionization. Consequently, their second ionization values are significantly lower than that of the sodium cation.

Final Answer: The element is Na.

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept:

The product distribution resulting from the electrolysis of an aqueous electrolyte depends heavily on the standard reduction potentials of all competing chemical species present at the electrode interfaces, as well as the chemical nature of the electrodes.

Solution:

(a) An aqueous solution of copper sulfate contains dissolved copper cations, sulfate anions, hydrogen ions, and hydroxide ions from the partial dissociation of the amphiprotic water solvent molecules.

(b) At the negative cathode interface, competition occurs between the reduction of copper cations and the reduction of hydronium ions. The standard reduction potential of copper ions is positive zero point thirty-four volts, which is higher than that of hydrogen.

(c) Because copper cations undergo reduction much more readily than water molecules, metallic copper deposits directly onto the cathode surface, depleting the surrounding blue solution of its copper ions.

(d) At the positive anode interface, competition occurs between the oxidation of sulfate anions and water molecules. Sulfate ions are highly stable and require very high potentials to oxidize due to the high oxidation state of sulfur.

(e) Water molecules undergo preferential oxidation at the anode interface, liberating gaseous molecular oxygen and releasing hydrogen ions into the medium, turning the electrolyte increasingly acidic.

Final Answer: The products are Cu(s) and $O_2(g)$.

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept:

The magnetic properties of transition metal coordination complexes can be evaluated using the spin-only magnetic moment formula derived from crystal field theory. This property depends directly on the total number of unpaired d-electrons present on the central metal ion after accounting for ligand field splitting.

Solution:

(a) In the hexaaquairon coordination complex, the central iron atom exhibits an oxidation state of positive two after balancing charges. The neutral iron atom loses its two valence s-electrons to form a d-six transition ion.

(b) Water functions as a weak-field aqua ligand according to the spectrochemical series. This weak field strength is insufficient to overcome the electron pairing energy within the d-orbitals of the iron cation.

(c) The five degenerate d-orbitals split into a lower energy set of three t-two-g orbitals and a higher energy set of two e-g orbitals under an octahedral coordination geometry.

(d) Following Hund rule of maximum multiplicity for a weak field, five electrons occupy individual orbitals with parallel spins before the sixth electron pairs up in the lowest t-two-g orbital.

(e) This distribution leaves exactly four unpaired electrons. Substituting this value into the spin-only formula yields a value equal to the square root of twenty-four, which calculates to four point nine Bohr magnetons.

Final Answer: The value is approximately 4.90 BM.

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept:

Urea is a widely used nitrogenous fertilizer in agriculture. During the industrial manufacturing process of manufacturing urea via the condensation of ammonia and carbon dioxide at high temperatures, a thermal decomposition side reaction can occur, producing a toxic dimeric byproduct called biuret.

Solution:

(a) When two individual molecules of urea combine under high temperature conditions, they eliminate a molecule of ammonia gas to form a single molecule of carbamyl urea, commonly known as biuret.

(b) Biuret is highly phytotoxic to crops. When applied to agricultural soils or sprayed via foliar application, it interferes with normal plant protein synthesis and damages cellular structures, causing leaf chlorosis and growth retardation.

(c) To safeguard crop health, the Indian Fertilizer Control Order establishes strict legal regulations governing the composition of synthetic fertilizers distributed to farmers across the agricultural market.

(d) For standard prilled or granulated urea intended for general soil application, regulations dictate that the total biuret contaminant concentration must never exceed one point five percent by total weight.

(e) For specialized foliar spray applications where the fertilizer directly contacts sensitive crop foliage, even lower thresholds are recommended to eliminate the risk of burning leaf tissues.

Final Answer: The percentage limit is 1.5

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept:

Balancing a redox chemical equation requires matching both the total number of atoms of each element and the net chemical charge on both the reactant and product sides. This conservation can be systematically achieved using the ion-electron half-reaction method.

Solution:

(a) The given chemical process involves the reduction of permanganate anions to manganese cations and the concurrent oxidation of oxalate anions into carbon dioxide gas in an acidic medium.

(b) In the oxidation half-reaction, one oxalate ion containing two carbon atoms loses two electrons to generate two molecules of carbon dioxide gas, establishing an electron change of two.

(c) In the reduction half-reaction, the manganese atom shifts its oxidation state from positive seven in the permanganate ion to positive two as a free ion, which requires the gain of five electrons.

(d) To balance the total number of electrons exchanged in the overall reaction, the oxidation half-reaction is multiplied by five, and the reduction half-reaction is multiplied by two, making the total electron transfer equal to ten.

(e) Combining these coefficients results in two permanganate ions and five oxalate ions. Balancing the oxygen atoms requires adding eight water molecules to the products, which demands sixteen hydrogen ions on the reactant side.

Final Answer: The coefficients are 2, 5, 16.

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept:

The activation energy of a chemical reaction represents the minimum potential energy barrier that reactant molecules must overcome to transition into products. The energy profile shows a direct mathematical relationship between the activation energy of the forward reaction, the activation energy of the reverse reaction, and the net enthalpy change.

Solution:

(a) In a potential energy diagram, the reactants occupy an initial stable energy level baseline, and the products settle at a final energy level baseline upon completion of the elementary step.

(b) The peak of the potential curve represents the high-energy activated complex or transition state. The forward activation energy is the vertical energy difference measured between this transition state peak and the initial reactant level.

(c) The diagram explicitly states that this forward activation barrier equals one hundred fifty kilojoules per mole, marking the energy climb required for the forward conversion.

(d) The net enthalpy change of the reaction represents the total vertical gap between the reactant baseline and the product baseline, given here as positive forty kilojoules per mole.

(e) The reverse activation energy measures the energy barrier that products must climb to return back to reactants, which is the difference between the peak and the product level. Subtracting forty from one hundred fifty yields one hundred ten kilojoules per mole.

Final Answer: The energy is 110 kJ/mol.

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept:

The hydrolysis of metallic carbides serves as a fundamental method for preparing various gaseous hydrocarbons in industrial and laboratory environments. The type of organic hydrocarbon gas liberated depends directly on the crystalline lattice structure, the nature of the carbide anion, and the specific ionic bonding properties present within the initial inorganic salt compound.

Solution:

(a) Calcium carbide is an ionic crystalline solid where calcium cations are ionically bound to acetylide dicarbide anions, which are composed of two carbon atoms linked together through a covalent triple bond.

(b) When water molecules are added to solid calcium carbide at room temperature, a vigorous exothermic double displacement reaction takes place at the solid liquid interface.

(c) The water molecules dissociate to provide proton donors that attack the highly reactive carbon centers of the acetylide structure, while the remaining hydroxide anions combine with calcium.

(d) This protonation process completely breaks the ionic bond assembly, transforming the dicarbide structure into a volatile, unsaturated organic gas containing a triple bond while forming solid calcium hydroxide as a byproduct.

(e) The resulting gaseous stream consists entirely of ethyne, which is traditionally known by its common name acetylene, a highly flammable fuel gas widely utilized across engineering and welding workshops.

Final Answer: The hydrocarbon is Acetylene.

Answer: (D)

Go Back to Question 11

Q12.

Solution

Concept:

The spatial three dimensional arrangement of atoms within a coordination molecule can be accurately determined using the Valence Shell Electron Pair Repulsion theory. This theoretical model states that the geometry around a central chemical atom is dictated entirely by minimizing the electrostatic repulsion forces operating between all valence electron pairs.

Solution:

(a) Xenon belongs to the noble gas family and contains eight valence electrons in its outermost shell. In a molecule of xenon tetrafluoride, the central atom forms four single covalent bonds with four individual fluorine atoms.

(b) Forming these four localized sigma bonds requires sharing four of the valence electrons of xenon, leaving behind four unshared valence electrons localized around the central core.

(c) These four remaining unshared valence electrons arrange themselves into two distinct non-bonding lone pairs. The steric number is calculated by adding the four bonding pairs and the two lone pairs, yielding a value of six.

(d) A steric number of six demands an octahedral coordination geometry orientation for the electron pairs, which corresponds to a hybrid orbital assignment of s-p-three-d-two.

(e) To minimize the strong repulsion forces operating between lone pairs, the two non-bonding pairs position themselves exactly opposite to one another along the vertical axis, forcing the four fluorine atoms into a stable flat square planar geometry configuration.

Final Answer: The geometry and lone pairs are Square planar, 2.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:

The freezing point of a solution is a colligative property, meaning it depends exclusively on the total concentration of individual solute particles present in the liquid phase rather than the chemical identity of the solute. Dissolving a non-volatile substance disrupts the thermodynamic equilibrium, lowering the freezing temperature.

Solution:

(a) The absolute depression in freezing point is calculated mathematically by multiplying the molal freezing point depression constant of the solvent by the molality of the solution and the dimensionless van 't Hoff factor.

(b) The van 't Hoff factor accounts for the dissociation behavior of electrolyte solutes in water, representing the true number of ions or particles liberated per formula unit upon dissolution.

(c) Glucose is a covalent organic carbohydrate that does not undergo ionic dissociation in aqueous environments, remaining as a single molecule with a van 't Hoff factor equal to one.

(d) Sodium chloride dissociates completely into one sodium cation and one chloride anion, giving a factor of two, while barium chloride splits into three distinct ions, giving a factor of three.

(e) Aluminum sulfate dissociates into two aluminum cations and three sulfate anions, liberating five ions per formula unit. This high particle count creates the greatest colligative effect and the lowest freezing point.

Final Answer: The solution is 0.1 M $Al_2(SO_4)_3$.

Answer: (D)

Go Back to Question 13

Q14.

Solution

Concept:

Sodic soils are agricultural soils characterized by an excessive accumulation of exchangeable sodium ions bound to clay surfaces, leading to soil structure dispersion, poor water infiltration, and high pH conditions. Correcting these degraded soils requires adding chemical amendments that can replace sodium with calcium.

Solution:

(a) Sodic soil conditions cause clay platelets to swell and disperse, sealing the soil pores and preventing normal root aeration and crop development across arid agricultural fields.

(b) Applying calcium carbonate is ineffective in these regions because lime is virtually insoluble under the elevated alkaline pH conditions typical of sodic soils, failing to release sufficient calcium ions.

(c) Agricultural gypsum, chemically identified as calcium sulfate dihydrate, is highly recommended due to its moderate solubility and ability to provide a steady supply of divalent calcium cations to the soil solution.

(d) When applied to the field, the dissolved calcium ions displace the monovalent sodium ions from the clay exchange complex through a competitive cation exchange process.

(e) The displaced sodium ions combine with the remaining sulfate anions to form highly soluble sodium sulfate, which can then be easily leached down out of the root zone with proper irrigation water.

Final Answer: The amendment is Calcium sulfate dihydrate (Gypsum).

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept:

The mole concept provides a bridge between the macroscopic mass of a substance and the submicroscopic number of constituent particles it contains. One mole of any chemically pure substance contains a fixed number of particles, a constant defined internationally as Avogadro number.

Solution:

(a) The molecular mass of a carbon dioxide molecule is calculated by summing the atomic masses of its component atoms, adding twelve for carbon and thirty-two for the two oxygen atoms to equal forty-four grams per mole.

(b) The total number of moles present in a given mass of gas is determined by dividing the mass of the sample by the molar mass of the chemical compound.

(c) For a sample containing four point four grams of carbon dioxide gas, dividing this value by forty-four grams per mole yields exactly zero point one moles of gas.

(d) According to fundamental chemistry principles, one full mole of any ideal gas contains six point zero two two times ten to the power of twenty-three individual molecules.

(e) Multiplying the calculated zero point one moles by Avogadro constant shifts the decimal place, giving a total value of six point zero two two times ten to the power of twenty-two molecules.

Final Answer: The number of molecules is 6.022×10^{22}.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:

The absolute criterion governing the thermodynamic spontaneity of a chemical process under conditions of constant temperature and pressure is dictated by the net change in Gibbs free energy. A process can only occur spontaneously if it leads to a net decrease in the free energy of the system.

Solution:

(a) The fundamental thermodynamic relationship defines the change in Gibbs free energy as the change in enthalpy minus the product of the absolute temperature and the change in system entropy.

(b) For a process to be spontaneous, the calculated change in Gibbs free energy must maintain a negative mathematical sign less than zero at the designated conditions.

(c) If a chemical reaction is exothermic, its enthalpy change is negative. If the process simultaneously increases molecular disorder, its entropy change is positive.

(d) Substituting a negative enthalpy value and a positive entropy value into the equation ensures that the mathematical term remains negative regardless of the magnitude of the absolute temperature variable.

(e) Therefore, an exothermic reaction that increases molecular disorder will always be thermodynamically spontaneous, meaning it can proceed without requiring an external driving force across all thermal ranges.

Final Answer: The conditions are $\Delta H < 0 and \Delta S > 0$.

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept:

Ozonolysis is an organic chemical reaction that involves breaking the unsaturated carbon-carbon double bond of an alkene using ozone. This process forms an intermediate ozonide ring structure, which can then undergo reductive cleavage to yield specific carbonyl compounds.

Solution:

(a) The starting material is 2-methylbut-2-ene, an asymmetric alkene where the double bond connects a carbon atom holding two methyl groups to a carbon atom holding one methyl group and one hydrogen atom.

(b) Passing ozone gas through this alkene solution induces an electrophilic addition reaction across the double bond, forming a highly unstable malozonide that rapidly rearranges into a stable ozonide structure.

(c) Adding zinc dust and water initiates a reductive cleavage of the ozonide ring, breaking both the carbon-carbon sigma bond and the adjacent oxygen-oxygen bonds.

(d) This reductive cleavage transforms each alkene carbon atom into a distinct carbonyl group while preventing over-oxidation of the products to carboxylic acids.

(e) Cleaving the highly substituted carbon atom yields a three-carbon ketone known as acetone, while cleaving the less substituted carbon atom generates a two-carbon aldehyde known as ethanal.

Final Answer: The products are Acetone and Ethanal.

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept:

The radial probability distribution function describes the total probability of finding an electron within a spherical shell of infinitesimal thickness at a given distance from the atomic nucleus, a behavior derived from the electronic wave functions of quantum mechanics.

Solution:

(a) The mathematical expression for the radial probability function contains a distance term multiplied by the square of the radial wave function component, which determines the overall shape of the distribution curve.

(b) The positions where the radial probability function drops completely to zero are called radial nodes. The total number of radial nodes for any given atomic orbital is calculated using the formula principal quantum number minus azimuthal quantum number minus one.

(c) Analyzing the provided graph shows that the curve starts at the origin, rises to a small peak, drops to zero, rises to a second peak, drops to zero again, and finally reaches a third maximum.

(d) Counting these zero points reveals exactly two radial nodes present within the electronic structure of the orbital.

(e) Evaluating an s-orbital where the azimuthal quantum number is zero indicates that a principal quantum number of three yields exactly two radial nodes, confirming the graph represents a three-s atomic orbital.

Final Answer: The orbital is 3s.

Answer: (C)

Go Back to Question 18

Q19.

Solution

Concept:

The solubility product constant represents a temperature-dependent thermodynamic equilibrium constant that governs the dissolution of a sparingly soluble ionic salt in water, defining the equilibrium point between the solid phase and its dissolved ions.

Solution:

(a) When a sparingly soluble salt with the formula AB_2 is dissolved in water, it establishes a heterogeneous equilibrium with its constituent ions.

(b) Each formula unit of the dissolving salt dissociates to liberate exactly one univalent or divalent metal cation and two corresponding univalent anions into the surrounding solution.

(c) If the molar solubility of the salt at equilibrium is represented by the variable S, the equilibrium concentration of the metal cation will equal S, and the concentration of the anion will equal two times S.

(d) Writing the equilibrium expression for the solubility product yields the cation concentration multiplied by the square of the anion concentration, which simplifies algebraically to four times the cube of the molar solubility.

(e) Equating this expression to the given value of four times ten to the power of negative twelve and solving for S yields a molar solubility value of one times ten to the power of negative four moles per liter.

Final Answer: The solubility is $1 \times 10^{-4} M$.

Answer: (A)

Go Back to Question 19

Q20.

Solution

Concept:

Crystal field theory describes the electronic structure of transition metal complexes by considering how the electrostatic fields of surrounding ligands remove the energy degeneracy of the central d-orbitals, splitting them into distinct energy levels based on the complex geometry.

Solution:

(a) In an octahedral coordination field, the five d-orbitals split into a lower energy triply degenerate t-2-g set and a higher energy doubly degenerate e-g set.

(b) The electronic configuration of a iron-three cation contains five valence electrons in its outer d-shell. How these five electrons occupy the split orbitals depends on the field strength of the surrounding ligands.

(c) Strong-field ligands, such as cyanide or carbonyl groups, create a large energy separation between the t-2-g and e-g sets that exceeds the energy required for electron pairing.

(d) Because of this large energy gap, the valence electrons will pair up completely within the lower energy t-2-g orbitals before any electrons can gain enough energy to occupy the higher e-g level.

(e) Distributing the five d-electrons sequentially following this low-spin pairing requirement fills the t-2-g level with five electrons and leaves the e-g level empty, giving a final electronic configuration written as t-2-g-five e-g-zero.

Final Answer: The configuration is $t_{2g}^5 e_g^0$.

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept:

Plant physiology establishes specific criteria for classifying chemical elements as essential macronutrients based on their abundance inside plant tissues and their direct involvement in vital metabolic processes, structural synthesis, or complex enzymatic activation systems.

Solution:

(a) Essential nutrients are divided into macronutrients and micronutrients depending on the absolute quantity required by the plant for healthy reproductive and vegetative development.

(b) Zinc, iron, and manganese are classified as essential micronutrients because they are required in minute quantities, functioning primarily as catalytic cofactors within specific enzymatic pathways.

(c) Magnesium is a key macronutrient absorbed extensively from the soil solution as a divalent cation, playing a fundamental role in maintaining the structural integrity of cellular components.

(d) From a structural standpoint, a single magnesium atom occupies the absolute center of the complex porphyrin ring head group of a chlorophyll molecule, making it indispensable for light harvesting during photosynthesis.

(e) Beyond its primary structural role, magnesium serves as an essential enzymatic activator that triggers major physiological enzymes, including ribulose bisphosphate carboxylase oxygenase and phosphoenolpyruvate carboxylase, which drive carbon fixation.

Final Answer: The element is Magnesium (Mg).

Answer: (C)

Go Back to Question 21

Q22.

Solution

Concept:

Molecular orbital theory describes the electronic structure of homonuclear diatomic molecules by linear combination of atomic orbitals, mapping electrons into bonding and antibonding molecular orbitals to predict magnetic behavior and bond properties accurately.

Solution:

(a) A chemical species exhibits paramagnetism if its completed molecular orbital diagram contains one or more unpaired electrons, which generate a net magnetic moment interacting with external fields.

(b) Gaseous nitrogen contains fourteen total electrons that fill the bonding and antibonding sigma and pi molecular orbitals up to the highest occupied level in pairs, leaving zero unpaired spins.

(c) Gaseous carbon and fluorine contain twelve and eighteen total electrons respectively, both of which fill their molecular orbitals completely in paired arrangements, resulting in a diamagnetic nature.

(d) Molecular oxygen possesses sixteen total electrons. Following the orbital filling sequence, fourteen electrons fill the lower energy levels completely, leaving two remaining valence electrons to distribute.

(e) According to Hund rule, these final two valence electrons must occupy the degenerate doubly degenerate antibonding pi-two-p-x and pi-two-p-y orbitals individually with parallel spins, rendering the oxygen molecule highly paramagnetic.

Final Answer: The species is O_2.

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept:

The kinetics of a chemical reaction are mathematically defined by its differential and integrated rate laws, which express how the consumption rate of reactants depends directly on their current concentrations raised to an experimental power called the reaction order.

Solution:

(a) The half-life period represents the total time required for the initial concentration of a reactant to decrease to exactly half of its starting baseline value.

(b) For a generic reaction of order n, calculus shows that the half-life period is inversely proportional to the initial reactant concentration raised to the power of the reaction order minus one.

(c) In a zero-order reaction, the half-life is directly proportional to the starting concentration, meaning a higher initial amount linearly extends the time needed to consume half the material.

(d) In a second-order process, the half-life is inversely proportional to the initial concentration, meaning that doubling the starting concentration cuts the half-life duration exactly in half.

(e) For a first-order chemical reaction, the integrated rate equation yields a half-life expression equal to the natural logarithm of two divided by the rate constant. This mathematical formula contains no concentration parameters, confirming perfect independence.

Final Answer: The order is First order.

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept:

The relative thermodynamic stability of reactive carbocation intermediates is governed by electronic displacement effects, specifically the inductive effect and hyperconjugation, which delocalize the positive charge away from the trivalent carbon center.

Solution:

(a) A carbocation features a positively charged trivalent carbon atom with an empty p-orbital, making it highly electron-deficient and unstable unless stabilized by neighboring groups.

(b) The inductive effect involves the permanent displacement of sigma electrons through a chain, where electron-donating alkyl groups push electron density toward the positive carbon center to reduce its net charge.

(c) Hyperconjugation involves the stabilizing overlap between the sigma C-H bonds of adjacent alpha carbons and the vacant unhybridized p-orbital of the positively charged carbon atom.

(d) The magnitude of hyperconjugation is directly proportional to the total number of alpha hydrogen atoms available for non-bond resonance delocalization within the molecular structure.

(e) The tertiary butyl carbocation contains three methyl groups bound to the central carbon, providing nine alpha hydrogens and a strong combined inductive push, achieving maximum stabilization among the options.

Final Answer: The carbocation is $((CH)_3)_3C^+$.

Answer: (D)

Go Back to Question 24

Q25.

Solution

Concept:

A chemical neutralization process involving a strong monoprotic acid and a strong monoacidic base proceeds to completion when the total chemical equivalents of hydronium ions delivered by the acid match the equivalents of hydroxide ions supplied by the base.

Solution:

(a) Hydrochloric acid dissociates completely in water to release one mole of hydronium ions per formula unit, meaning its molarity is exactly equal to its normality.

(b) Sodium hydroxide functions as a strong Arrhenius base, releasing a single mole of hydroxide ions per formula unit upon dissolution, which makes its molarity equal to its normality.

(c) The volumetric equivalence relationship states that the product of the normality and volume of the acid must equal the product of the normality and volume of the base.

(d) Substituting the given values into the equation relates the unknown volume of acid multiplied by zero point five molar to twenty milliliters of base multiplied by zero point two molar.

(e) Solving this linear algebraic equation isolates the volume variable, yielding a precise requirement of eight milliliters of hydrochloric acid solution to achieve a neutral endpoint.

Final Answer: The volume is 8 mL.

Answer: (A)

Go Back to Question 25

Q26.

Solution

Concept:

The vapor pressure behavior of homogeneous binary liquid mixtures can be analyzed using Raoult's law. Deviations from ideal linear behavior arise due to differences in the relative strength of intermolecular adhesive forces versus cohesive forces between molecules.

Solution:

(a) An ideal liquid solution obeys Raoult's law perfectly across all configurations, displaying a linear change in total vapor pressure represented by a straight dashed line connecting the pure component pressures.

(b) When the adhesive attractive forces between different molecules are weaker than the cohesive forces within pure components, the molecules escape into the vapor phase more readily.

(c) This increased tendency to vaporize causes the experimental vapor pressure of the mixture to rise significantly above the theoretical ideal baseline at every composition point.

(d) The provided graph illustrates a distinct non-linear red curve that bows upward, reaching a maximum point that exceeds the vapor pressure of either pure component.

(e) This specific visual profile represents a non-ideal binary solution exhibiting positive deviation from ideal behavior, typical of mixtures like ethanol and cyclohexane where molecular interactions are disrupted.

Final Answer: The mixture is Non-ideal solution showing positive deviation from Raoult's law.

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept:

The addition of hydrogen halides across asymmetric alkenes typically follows Markovnikov rule. However, introducing organic peroxides completely changes the reaction pathway, diverting the mechanism from an ionic addition to a free-radical chain process.

Solution:

(a) In the absence of peroxides, propene reacts with hydrogen bromide via an electrophilic addition mechanism, generating a stable secondary carbocation that yields two-bromopropane as the major product.

(b) When organic peroxides are added, thermal homolysis splits the weak peroxide oxygen-oxygen bond, generating highly reactive alkoxy radicals that react with hydrogen bromide to form a bromine radical.

(c) The bromine radical attacks the pi-bond of propene, choosing a position that generates the most stable carbon-centered radical intermediate.

(d) Attacking the terminal primary carbon produces a highly stable secondary radical, whereas attacking the central carbon would generate a less stable primary radical.

(e) This secondary radical rapidly abstracts a hydrogen atom from a fresh hydrogen bromide molecule, completing the anti-Markovnikov addition and producing one-bromopropane as the major product.

Final Answer: The product is 1-Bromopropane.

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept:

Biological nitrification is a two-step aerobic biochemical process driven by specialized soil chemoautotrophic bacteria. This pathway converts reduced nitrogen forms into highly oxidized nitrate anions that are readily accessible for crop uptake.

Solution:

(a) The nitrogen cycle in soil relies on distinct groups of microbes to execute sequential chemical transformations, preventing the accumulation of toxic compounds in the rhizosphere.

(b) Rhizobium bacteria form symbiotic root nodules with legumes to fix atmospheric nitrogen gas into ammonia, but they do not oxidize ammonia directly within the bulk soil matrix.

(c) Azotobacter functions as a free-living non-symbiotic nitrogen-fixing microbe that enriches the soil with organic nitrogen compounds rather than driving the nitrification cascade.

(d) The nitrification pathway begins with the biochemical oxidation of toxic ammonia or ammonium ions into intermediate nitrite anions, a step requiring specific obligate autotrophs.

(e) Genus Nitrosomonas drives this initial conversion step, whereas genus Nitrobacter operates in the subsequent step, oxidizing the resulting nitrite anions into stable nitrate fertilizer.

Final Answer: The group is Nitrosomonas.

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept:

An isoelectronic series consists of distinct atoms or ions that share an identical total number of electrons. The relative structural size or radius of these species is determined by the net positive nuclear charge acting on the electron cloud.

Solution:

(a) The chemical species sulfide, chloride, potassium, and calcium all contain exactly eighteen electrons, organizing themselves into identical core and valence electronic configurations.

(b) Although the total number of shielding electrons remains constant, the number of protons residing within the atomic nucleus increases sequentially across the series.

(c) The sulfur nucleus contains sixteen protons, chlorine contains seventeen, potassium contains nineteen, and the calcium nucleus contains exactly twenty protons.

(d) An increasing nuclear charge exerts a stronger electrostatic pull on the shared electron cloud, drawing the orbitals inward and contracting the ionic radius.

(e) Consequently, the species with the lowest atomic number retains the largest electron cloud, establishing a descending size order from sulfide to chloride, potassium, and calcium.

Final Answer: The order is $S^{2-} > Cl^{-} > K^{+} > Ca^{2+}$.

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept:

The quantitative relationship connecting the electromotive force of an electrochemical galvanic cell to the concentrations of the participating chemical species is given by the Nernst equation, derived from classic thermodynamic principles.

Solution:

(a) The provided diagram depicts a standard zinc-copper Daniel cell, where metallic zinc undergoes oxidation at the anode and copper ions undergo reduction at the cathode.

(b) The net balanced redox reaction shows that solid zinc reacts with copper cations to produce zinc cations and deposited metallic copper, involving a net two-electron transfer.

(c) The general Nernst equation at standard temperature subtracts a factor of zero point zero five nine one divided by n times the logarithm of the reaction quotient from the standard cell potential.

(d) The reaction quotient for this process is written as the concentration of the products divided by the reactants, which simplifies to zinc ion concentration over copper ion concentration.

(e) Substituting the electron count of two into this relationship yields an expression that matches option A, allowing accurate calculation of cell potential under non-standard concentrations.

Final Answer: The equation is $E_{cell} = E^{\circ}_{cell} - \frac{0.0591}{2} \log \frac{[Zn^{2+}]}{[Cu^{2+}]}$.

Answer: (A)

Go Back to Question 30

Q31.

Solution

Concept:

Constitutional isomerism in organic molecules describes compounds that share an identical molecular formula but possess different connectivity patterns among their constituent atoms, leading to unique physical and chemical characteristics.

Solution:

(a) Pentan-two-one and pentan-three-one both contain exactly five carbon atoms, ten hydrogen atoms, and one oxygen atom, which translates to a shared molecular formula of C-five-H-ten-O.

(b) Both organic molecules possess the exact same linear open-chain skeletal carbon structure, which eliminates chain isomerism since the principal carbon frame remains completely unaltered.

(c) Both chemical entities belong to the same homologous series of ketones and share an identical carbonyl functional group, which means they do not exhibit functional group isomerism.

(d) The structural difference arises entirely from the specific position of the double-bonded oxygen atom along the continuous five-carbon backbone of the parent hydrocarbon chain.

(e) In pentan-two-one, the carbonyl functional group is located at the second carbon position, whereas in pentan-three-one, it is positioned at the third carbon, classifying them directly as position isomers.

Final Answer: The isomerism is Position isomerism.

Answer: (C)

Go Back to Question 31

Q32.

Solution

Concept:

The structural geometry and bonding properties of electron-deficient boron compounds can be elucidated through valence shell orbital hybridization models, which explain how atomic orbitals mix to form non-traditional multicenter bonds.

Solution:

(a) A neutral boron atom features a ground state valence electron configuration of two-s-two two-p-one, providing three available outer electrons to participate in covalent bond formation.

(b) In a molecule of diborane, each individual boron atom is surrounded by a total of four distinct hydrogen atoms, requiring four spatial hybrid bonding pathways.

(c) To accommodate these four surrounding hydrogen atoms, the single two-s orbital and all three two-p orbitals of each boron atom undergo hybrid mixing.

(d) This mixing process generates four equivalent hybrid orbitals arranged in a tetrahedral spatial distribution around each central atom, corresponding to s-p-three orbital hybridization.

(e) Two hybrid orbitals on each boron form standard terminal bonds, while the remaining two participate in unique three-center two-electron banana bonds that bridge the two boron nuclei.

Final Answer: The hybridization is sp^3.

Answer: (C)

Go Back to Question 32

Q33.

Solution

Concept:

The first law of thermodynamics states that the total energy change of a closed system during a process is equal to the net heat exchanged plus the mechanical work performed on or by the surroundings.

Solution:

(a) The mathematical expression for the first law of thermodynamics relates the change in internal energy to the heat added to the system minus the pressure-volume expansion work.

(b) Mechanical expansion work is defined as the external opposing pressure multiplied by the net change in the total volume occupied by the thermodynamic system.

(c) When a chemical reaction is restricted to run inside a rigid, sealed vessel under constant volume conditions, the volume change parameter becomes zero.

(d) Because the volume change is zero, the pressure-volume work term drops out of the equation completely, meaning the system performs no mechanical work on its surroundings.

(e) Under these strict constant volume constraints, the total quantity of heat absorbed or released is equivalent to the absolute change in the internal energy parameter.

Final Answer: The parameter is Internal energy change (ΔU).

Answer: (C)

Go Back to Question 33

Q34.

Solution

Concept:

In coordination chemistry, the total coordination number represents the number of ligand donor atoms bound directly to the central metal ion, while the oxidation state represents the net charge remaining after removing all ligands.

Solution:

(a) The coordination compound features three potassium counter-cations balanced against a single complex anion containing a central iron atom bound to three oxalate ligand structures.

(b) Each individual oxalate ion acts as a bidentate chelating ligand, delivering two separate oxygen donor atoms simultaneously to form two coordinate bonds with the metal center.

(c) Because three bidentate oxalate ligands are bound to the iron center, the total number of coordinate bonds formed equals six, establishing a coordination number of six.

(d) Each oxalate ligand carries a net charge of negative two, meaning the three ligands contribute a combined negative charge of six to the coordination sphere.

(e) To balance the three positive potassium ions and the negative six charge from the oxalates, the central iron atom must possess an oxidation state of positive three.

Final Answer: The values are 6, +3.

Answer: (B)

Go Back to Question 34

Q35.

Solution

Concept:

Agricultural chemistry utilizes specialized inorganic salt formulations as traditional fungicides and bactericides to protect commercial crops from devastating fungal blights, downy mildews, and surface pathogens.

Solution:

(a) Bordeaux mixture was originally formulated in the nineteenth century in France as an effective agricultural treatment to combat fungal infestations in commercial grape vineyards.

(b) The primary active ingredient responsible for killing fungal spores is copper sulfate, which releases copper ions that disrupt essential enzymes within the pathogen.

(c) Dissolving copper sulfate alone in water creates an acidic solution that causes severe chemical burns and phytotoxicity on green plant foliage.

(d) To neutralize this acidity, slaked lime, chemically known as calcium hydroxide, is added to the aqueous mixture to form a stable suspension.

(e) The resulting blend forms a precipitate of copper hydroxide and calcium sulfate that adheres effectively to leaf surfaces, providing long-lasting protection against agricultural diseases.

Final Answer: The composition is Copper sulfate and Calcium hydroxide (Lime).

Answer: (A)

Go Back to Question 35

Q36.

Solution

Concept:

A redox reaction involves the simultaneous transfer of electrons between chemical species, where one component undergoes oxidation by losing electrons and another undergoes reduction by gaining electrons.

Solution:

(a) The reducing agent is the specific reactant that drives the reduction of another substance by donating electrons, undergoing oxidation itself in the process.

(b) In the provided reaction, copper inside the solid copper oxide reactant starts with a positive two formal oxidation state bound to oxygen.

(c) As the chemical reaction proceeds, copper oxide loses its oxygen atom and is converted into neutral metallic copper with an oxidation state of zero.

(d) Gaseous hydrogen starts as a pure elemental reactant with a formal oxidation state of zero before reacting with the displaced oxygen.

(e) During the reaction, hydrogen gains oxygen to form water, increasing its oxidation state to positive one, which confirms it acts as the reducing agent.

Final Answer: The reducing agent is H_2.

Answer: (B)

Go Back to Question 36

Q37.

Solution

Concept:

Le Chatelier principle states that if a chemical system at equilibrium experiences a change in temperature, pressure, or concentration, the position of equilibrium will shift to counteract the imposed disturbance.

Solution:

(a) The industrial synthesis of ammonia from hydrogen and nitrogen gases is a reversible exothermic process that involves a net decrease in total gas volume.

(b) The reactant side contains one mole of nitrogen gas and three moles of hydrogen gas, combining for a total of four moles of gaseous material.

(c) The product side contains exactly two moles of gaseous ammonia, meaning the forward reaction path reduces the total number of gas molecules.

(d) Increasing the total operational pressure forces the system to respond by shifting in the direction that minimizes the total gas volume and relieves pressure.

(e) Therefore, the equilibrium shifts in the forward direction to produce more ammonia, though the equilibrium constant itself remains completely unchanged since it depends solely on temperature.

Final Answer: The impact is Shifts in the forward direction.

Answer: (B)

Go Back to Question 37

Q38.

Solution

Concept: Nucleophilic aliphatic substitution reactions operate via two primary mechanistic pathways, denoted as S_N1 and S_N2, which depend on the structural configuration of the alkyl halide substrate.

Solution:

(a) Tertiary alkyl halides, such as tert-butyl chloride, feature a central carbon atom that is heavily crowded by three bulky, electron-donating methyl groups.

(b) This significant steric crowding blocks incoming nucleophiles from attacking the back lobe of the carbon–chlorine bond directly, preventing a single-step substitution pathway.

(c) When treated with an aqueous base, the reaction proceeds via a two-step S_N1 mechanism that begins with the slow, rate-determining departure of the chloride leaving group.

(d) The loss of the leaving group generates a planar, tertiary carbocation intermediate that is stabilized by the inductive and hyperconjugative effects of the surrounding methyl groups.

(e) In the fast second step, a hydroxide nucleophile attacks the flat carbocation intermediate from either side, completing the substitution to form tert-butyl alcohol.

Final Answer: The mechanism is S_N1 mechanism via a stable carbocation intermediate.

Answer: (B)

Go Back to Question 38

Q39.

Solution

Concept:

The empirical formula represents the simplest whole-number ratio of the various atoms present within a chemical compound, calculated using the mass percentages of each constituent element.

Solution:

(a) To find the atomic ratio, assume a sample size of exactly one hundred grams, converting the given element mass percentages directly into corresponding mass values.

(b) This sample contains forty grams of carbon, six point sixseven grams of hydrogen, and fifty-three point three-three grams of oxygen.

(c) Divide the mass of each element by its respective molar mass to determine the relative number of moles of each atom present.

(d) This calculation yields three point three-three moles of carbon, six point six-seven moles of hydrogen, and three point three-three moles of oxygen.

(e) Divide each value by the smallest mole value to find the simplest whole-number ratio, which yields one carbon, two hydrogens, and one oxygen atom.

Final Answer: The empirical formula is CH_2O.

Answer: (B)

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Q40.

Solution

Concept:

Henry's law describes the physical behavior of gas-liquid solutions at equilibrium, establishing a quantitative relationship that governs how gases dissolve into liquid solvents under varying external pressures.

Solution:

(a) Dissolving a gas into a liquid phase depends on the frequency of collisions between the gaseous molecules and the exposed surface of the liquid solvent.

(b) Henry's law states that at a constant temperature, the mass or molar solubility of a gas is directly proportional to its pressure above the solution.

(c) Increasing the partial pressure of a gas forces more gas molecules to collide with the liquid surface, accelerating the rate of dissolution.

(d) This relationship is expressed mathematically by multiplying a temperature-dependent Henry's law constant by the partial pressure of the gas to calculate its equilibrium concentration.

(e) The law explains why carbonated beverages remain bubbly when sealed under high pressure, but rapidly lose dissolved gas once opened to ambient conditions.

Final Answer: The solubility is directly proportional to The partial pressure of the gas above the liquid surface.

Answer: (B)

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Answer Key

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