UPCATET Chemistry Sample Paper-2

Duration: 45 Minutes **Maximum Marks: 200**

Instructions

- This paper contains **50** Multiple Choice Questions.
- Each correct answer carries **+4** mark. Incorrect answer: **−1** marks. Only **one** correct option.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. The major product obtained when ethyl bromide reacts with alcoholic KOH is:

(A) Ethanol

(B) Ethene

(C) Diethyl ether

(D) Ethane

Q2. Which of the following carbohydrates reduces Tollen's reagent but does not undergo mutarotation?

(A) α-D-Glucose

(B) β-D-Fructose

(C) Sucrose

(D) None of the above (All reducing sugars undergo mutarotation)

Q3. Consider the following organic transformation path scheme:

$$\boxed{\text{Aniline}} \xrightarrow[0-5^\circ\text{C}]{\text{NaNO}_2 + \text{HCl}} \boxed{\text{Compound X}} \xrightarrow{\text{HBF}_4,\ \Delta} \boxed{\text{Fluorobenzene}}$$

Identify the structural intermediate denoted as Compound X in this sequence:

(A) Chlorobenzene

(B) Benzene diazonium chloride

(C) Nitrobenzene

(D) Benzene diazonium fluoroborate

Q4. The standard reaction of an aldehyde lacking α-hydrogens with concentrated NaOH to produce an alcohol and a carboxylic acid salt is known as:

(A) Aldol Condensation

(B) Cannizzaro Reaction

(C) Rosenmund Reduction

(D) Clemmensen Reduction

Q5. Arrange the following in increasing order of their acidic strength: Phenol (I), Ethanol (II), p-Nitrophenol (III), o-Cresol (IV).

(A) II < IV < I < III

(B) II < I < IV < III

(C) III < I < IV < II

(D) IV < II < I < III

Q6. The conversion of acetone into propane can be efficiently carried out using which reaction?

(A) Wolff-Kishner reduction

(B) Kolbe's electrolytic synthesis

(C) Wurtz reaction

(D) Reimer-Tiemann reaction

Q7. Which functional group is formed when a primary amine reacts with chloroform in the presence of ethanolic KOH?

(A) Cyanide

(B) Isocyanide

(C) Nitro

(D) Amide

Q8. What is the monomeric structural building unit of natural rubber?

(A) Chloroprene

(B) Isoprene

(C) Neoprene

(D) Styrene

Q9. The secondary structure of proteins, such as α-helix and β-pleated sheets, is stabilized predominantly by:

(A) Covalent peptide bonds

(B) Ionic interactions

(C) Hydrogen bonds

(D) Van der Waals forces

Q10. Which type of mechanism is preferred when tert-butyl bromide undergoes substitution with water?

(A) S_N1 with carbocation intermediate

(B) S_N2 with single transition state

(C) E1 elimination

(D) E2 elimination

Q11. Lucas reagent is a solution consisting of:

(A) Dilute HCl and anhydrous $AlCl_3$

(B) Concentrated HCl and anhydrous $ZnCl_2$

(C) Concentrated HNO_3 and H_2SO_4

(D) $Pd/BaSO_4$ in quinoline

Q12. When phenol reacts with bromine water in excess, the precipitate formed is:

(A) o-Bromophenol

(B) p-Bromophenol

(C) 2,4,6-Tribromophenol

(D) 2,4-Dibromophenol

Q13. The standard test used to differentiate between benzaldehyde and acetaldehyde is:

(A) Tollen's reagent test

(B) Fehling's solution test

(C) 2,4-DNP test

(D) Schiffs reagent test

Q14. Identify the final major product Z in the following synthetic sequence:

$$\boxed{\text{Calcium Acetate}} \xrightarrow{\text{Dry Distillation}} \boxed{\text{Product Y}} \xrightarrow{I_2 + \text{NaOH}} \boxed{\text{Product Z}}$$

(A) Chloroform

(B) Iodoform

(C) Acetic acid

(D) Ethanol

Q15. The total number of atoms present in 4.4 grams of CO_2 gas is: (Given: $N_A = 6.02 \times 10^{23}$)

(A) 6.02×10^{22}

(B) 1.81×10^{23}

(C) 6.02×10^{23}

(D) 1.81×10^{24}

Q16. What is the molality of a solution containing 20 grams of NaOH dissolved in 500 grams of water?

(A) 0.5 m

(B) 1.0 m

(C) 2.0 m

(D) 0.25 m

Q17. For a first-order chemical reaction, if the rate constant is $k = 0.0693 \text{ min}^{-1}$, the time required for 50% completion of the reaction is:

(A) 10 minutes

(B) 100 minutes

(C) 5 minutes

(D) 20 minutes

Q18. At a specific temperature, the solubility product (K_{sp}) of a salt AB_2 is 3.2×10^{-11}. Its molar solubility in pure water is:

(A) 2×10^{-4} M

(B) 4×10^{-4} M

(C) 1.6×10^{-4} M

(D) 1×10^{-4} M

Q19. The quantity of electricity required to deposit 27 grams of Al from an aqueous solution containing Al^{3+} ions is: (Atomic mass of Al = 27)

(A) 1 Faraday

(B) 2 Faradays

(C) 3 Faradays

(D) 0.33 Faraday

Q20. If the elevation in boiling point of a 0.1 m aqueous solution of a non-electrolyte solute is 0.052°C, the molal boiling point elevation constant (K_b) of water is:

(A) $0.52 \text{ K kg mol}^{-1}$

(B) 0.052 K kg mol^{-1}

(C) 5.2 K kg mol^{-1}

(D) 0.26 K kg mol^{-1}

Q21. For the gas-phase equilibrium reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, the mathematical relation between K_p and K_c is:

(A) $K_p = K_c$

(B) $K_p = K_c(RT)$

(C) $K_p = K_c(RT)^{-1}$

(D) $K_p = K_c(RT)^2$

Q22. If the pH of a solution decreases from 5 to 2, the hydrogen ion concentration $[H^+]$ increases by a factor of:

(A) 3

(B) 30

(C) 100

(D) 1000

Q23. The standard reduction potentials of three metals A, B, and C are +0.5 V, −2.0 V, and −0.4 V respectively. The correct reducing power order of these metals is:

(A) A > C > B

(B) B > C > A

(C) C > B > A

(D) B > A > C

Q24. When the initial concentration of a reactant in a zero-order reaction is doubled, the half-life period ($t_{1/2}$) of the reaction will:

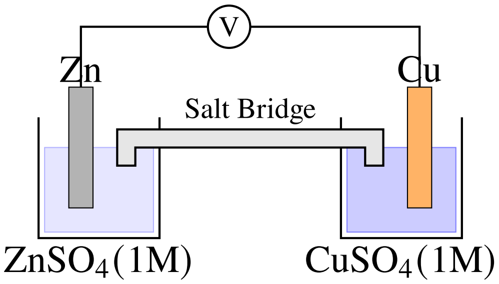
(A) Remain unchanged

(B) Be halved

(C) Be doubled

(D) Become four times

Q25. A structural schematic representation of a standard galvanic cell setup is shown below:



Given that $E^\circ_{Zn^{2+}/Zn} = -0.76$ V and $E^\circ_{Cu^{2+}/Cu} = +0.34$ V, the standard EMF (E°_{cell}) is:

(A) +1.10 V

(B) −1.10 V

(C) +0.42 V

(D) −0.42 V

Q26. The rate of a reaction increases by 2 times for every 10°C rise in temperature. If the temperature is raised from 20°C to 60°C, the overall rate increases by:

(A) 4 times

(B) 8 times

(C) 16 times

(D) 32 times

Q27. According to Raoult's Law, the relative lowering of vapor pressure for a solution containing a non-volatile solute is equal to:

(A) Mole fraction of the solvent

(B) Mole fraction of the solute

(C) Molarity of the solution

(D) Molality of the solution

Q28. Which of the following noble gases exhibits the highest chemical reactivity and forms a well-characterized range of stable fluorides?

(A) Helium

(B) Neon

(C) Argon

(D) Xenon

Q29. The composition of Mond process slag or the specific commercial refinement technique involves volatile complexes. Which metal is purified via the Mond process?

(A) Iron

(B) Nickel

(C) Copper

(D) Zinc

Q30. The coordination number and the oxidation state of Cobalt in the complex ion $[Co(en)_3]^{3+}$ are respectively:

(A) 3 and +3

(B) 6 and +3

(C) 6 and +6

(D) 3 and +6

Q31. The exceptional magnetic behavior of inner transition series can be analyzed via uncoupled shells. The correct electronic configuration of Gadolinium (Gd, Z = 64) is:

(A) $[Xe]4f^7 5d^1 6s^2$

(B) $[Xe]4f^8 6s^2$

(C) $[Xe]4f^7 5d^2 6s^1$

(D) $[Xe]5d^3 6s^2$

Q32. Which p-block oxoacid contains a direct, distinctive peroxide $(O-O)$ covalent linkage?

(A) $H_2S_2O_7$

(B) $H_2S_2O_8$

(C) $H_2S_2O_6$

(D) H_2SO_3

Q33. The intense purple-red coloration of potassium permanganate ($KMnO_4$) crystals originates due to:

(A) d-d electronic transitions

(B) Ligand-to-Metal Charge Transfer (LMCT)

(C) Metal-to-Ligand Charge Transfer (MLCT)

(D) f-d atomic transitions

Q34. The mineral ore known as "Calamine" is chemically represented as:

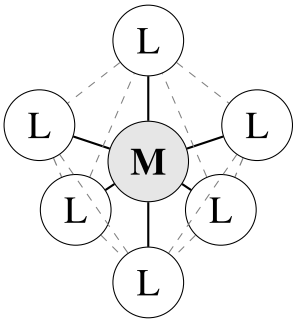
(A) $ZnCO_3$

(B) ZnO

(C) ZnS

(D) $CuCO_3 \cdot Cu(OH)_2$

Q35. Which structural arrangement type corresponds to the coordination complex geometry showcased below?



(A) Square Planar

(B) Tetrahedral

(C) Octahedral

(D) Trigonal Bipyramidal

Q36. The ligand that is classified as an ambidentate coordination partner is:

(A) NH_3

(B) H_2O

(C) SCN^-

(D) ox^{2-} (oxalate)

Q37. The dramatic contraction in ionic radii observed across the lanthanide series is principally driven by:

(A) Perfect shielding of nuclear charge by 4f electrons

(B) Poor shielding of nuclear charge by 4f electrons

(C) Incremental shielding by 5d electrons

(D) Severe inter-electronic repulsions in the 6s shell

Q38. When copper pyrites ore is roasted in a reverberatory furnace, the chemical composition of the obtained "matte" is:

(A) Cu_2S and FeS

(B) CuS and FeO

(C) Cu_2O and FeS

(D) Cu_2S and CuO

Q39. The maximum total number of electrons that can be accommodated in a subshell with orbital angular momentum quantum number $l = 3$ is:

(A) 6

(B) 10

(C) 14

(D) 18

Q40. According to Molecular Orbital Theory, which of the following homonuclear diatomic molecular species is expected to show diamagnetic behavior?

(A) O_2

(B) B_2

(C) C_2

(D) O_2^-

Q41. The hybridization state of the central atom and the definitive spatial shape of the SF_4 molecule are:

(A) sp^3, Tetrahedral

(B) sp^3d, See-saw

(C) sp^3d, Trigonal Bipyramidal

(D) sp^3d^2, Square Planar

Q42. Arrange the following elements in terms of increasing order of their first ionization enthalpy: Na, Mg, Al, Si.

(A) Na < Mg < Al < Si

(B) Na < Al < Mg < Si

(C) Na < Al < Si < Mg

(D) Al < Na < Mg < Si

Q43. Which electronic transition in the atomic spectrum of a Hydrogen atom corresponds to the first line of the Balmer series?

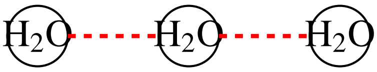
(A) $n = 2 \longrightarrow n = 1$

(B) $n = 3 \longrightarrow n = 2$

(C) $n = 4 \longrightarrow n = 2$

(D) $n = 3 \rightarrow n = 1$

Q44. Which type of intermolecular attractive forces dominate between the individual chemical units of the system shown below?



(A) London dispersion forces

(B) Dipole-induced dipole forces

(C) Hydrogen bonding

(D) Covalent networking

Q45. The correct increasing order of bond angles among the following molecular species is:

(A) $H_2O < NH_3 < CH_4$

(B) $CH_4 < NH_3 < H_2O$

(C) $NH_3 < H_2O < CH_4$

(D) $H_2O < CH_4 < NH_3$

Q46. The property of chemical elements that shows a steady decrease down a vertical group in the periodic table is:

(A) Atomic Radius

(B) Electronegativity

(C) Metallic Character

(D) Principal Quantum Number

Q47. Which of the following properties is an optical manifestation unique to colloidal dispersions?

(A) Brownian movement

(B) Tyndall Effect

(C) Electrophoresis

(D) Coagulation

Q48. According to the Freundlich adsorption isotherm equation, the parameter value of the exponent slope ($1/n$) typically lies between:

(A) 0 and 1

(B) 1 and 10

(C) -1 and 0

(D) Always exactly 1.0

Q49. The atmospheric trace gas mainly responsible for causing the long-term degradation of the stratospheric ozone layer is:

(A) Carbon dioxide

(B) Chlorofluorocarbons (CFCs)

(C) Sulfur dioxide

(D) Methane

Q50. Which practice alternative reflects an implementation of green chemical strategies in routine modern industrial works?

(A) Maximizing toxic organic solvent use

(B) Using liquid CO_2 or H_2O_2 as benign bleaching alternatives

(C) Utilizing non-biodegradable polymer packaging

(D) Running open-loop raw industrial discharge pipelines

Detailed Solutions

Q1.

Solution

Concept: The reaction deals with the elimination mechanism of haloalkanes. When a primary alkyl halide like ethyl bromide (CH_3CH_2Br) is treated with a strong, bulky base dissolved in a protic or non-polar alcoholic solvent (such as alcoholic KOH containing ethoxide ions), elimination dominates over substitution. This specific reaction proceeds via a concerted, single-step bimolecular elimination path.

Solution:

(a) The hydroxide ion (OH^-) reacts with ethanol to form the ethoxide ion ($CH_3CH_2O^-$), which is a much stronger and harsher base than the aqueous hydroxide counterpart.

(b) This strong base attacks one of the acidic β-hydrogens on the methyl carbon of ethyl bromide instead of acting as a nucleophile at the α-carbon.

(c) Concurrently, the $C-H$ bond breaks, a carbon-carbon π-bond forms, and the bromide ion leaves as a stable conjugate base leaving group.

(d) This synchronized, single-step elimination sequence (E2) effectively converts the saturated alkyl halide into an unsaturated hydrocarbon.

(e) Therefore, ethyl bromide loses a molecule of hydrogen bromide (HBr) in a process known as dehydrohalogenation, yielding ethene gas as the predominant organic product.

Final Answer: The product is Ethene.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: This question tests the structural features of carbohydrates, specifically reducing properties and mutarotation. All monosaccharides and reducing disaccharides switch between their cyclic α, β anomers and open-chain structures in solution, causing mutarotation. However, a sugar that is trapped or lacks an equilibrium cannot exhibit this dynamic optical mutation.

Solution:

(a) Tollen's reagent reduction requires a free or potentially free carbonyl group (hemiacetal or hemiketal) that can open up into a free aldehyde form in an alkaline medium.

(b) Both α-D-Glucose and β-D-Fructose possess free hemiacetal/hemiketal groups, allowing them to open up, reduce Tollen's reagent, and naturally undergo mutarotation.

(c) Sucrose is a non-reducing sugar because the anomeric carbons of both glucose and fructose are tied up in a glycosidic bond, meaning it cannot reduce Tollen's reagent.

(d) If a sugar reduces Tollen's reagent, it generally must open its ring, which inherently makes it capable of anomerization and mutarotation in an aqueous solvent.

(e) Thus, there is no common carbohydrate that acts as a reducing sugar while simultaneously failing to exhibit mutarotation. Every standard reducing sugar undergoes mutarotation.

Final Answer: None of the above.

Answer: (D)

Go Back to Question 2

Q3.

Solution

Concept: The problem outlines the two-step synthesis of fluorobenzene from a primary aromatic amine via the Schiemann reaction (also called the Balz-Schiemann reaction). Primary aromatic amines react with nitrous acid at freezing temperatures to yield stable aromatic diazonium salts, which serve as highly versatile intermediates for aryl functionalization.

Solution:

(a) When aniline ($C_6H_5NH_2$) is treated with nitrous acid (generated in situ from sodium nitrite and hydrochloric acid) at $0-5°C$, it undergoes diazotization.

(b) In this initial step, the primary amino group is converted into a diazonium group, yielding benzene diazonium chloride ($C_6H_5N_2^+Cl^-$) as a stable intermediate in solution.

(c) When benzene diazonium chloride is treated with fluoroboric acid (HBF_4), precipitate intermediate benzene diazonium fluoroborate forms, which decomposes upon heating (Δ) to give fluorobenzene.

(d) Compound X, being the immediate product after the first reaction block, must be the ionic diazonium salt formed before fluoroboric acid addition.

(e) Therefore, Compound X corresponds precisely to benzene diazonium chloride, which is isolated or maintained at cold temperatures to prevent decomposition into phenol.

Final Answer: The compound is Benzene diazonium chloride.

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

Go Back to Question 3

Q4.

Solution

Concept: The question relates to the redox transformations of carbonyl compounds. Aldehydes that lack α-hydrogens cannot form an enolate ion under basic conditions. When treated with concentrated alkali, they undergo a self-redox reaction where one molecule is oxidized and another is reduced.

Solution:

(a) Aldehydes containing α-hydrogens undergo aldol condensation when exposed to base due to the ease of abstracting the acidic protons next to the carbonyl carbon.

(b) Substrates like formaldehyde (HCHO) or benzaldehyde (C_6H_5CHO) completely lack these α-hydrogens, making enolization impossible.

(c) Upon addition of concentrated caustic alkali (NaOH), a nucleophilic attack occurs at the carbonyl center of one aldehyde molecule, triggering a hydride transfer to a second molecule.

(d) This intermolecular hydride transfer results in the simultaneous oxidation of one molecule to a carboxylic acid and the reduction of the other to a primary alcohol.

(e) This specific disproportionation reaction of non-enolizable aldehydes is known as the Cannizzaro reaction, distinguishing it from alternative reduction paths.

Final Answer: The reaction is Cannizzaro Reaction.

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: The acid strength of hydroxyl compounds depends on the stability of their conjugate bases (phenoxide or alkoxide ions). Substituents on the aromatic ring alter this stability through resonance, inductive effects, or hyperconjugation.

Solution:

(a) Ethanol (II) is an aliphatic alcohol. Its conjugate base, the ethoxide ion, is destabilized by the electron-donating inductive effect (+I) of the ethyl group, making it the least acidic.

(b) Phenol (I) is substantially more acidic than ethanol because its conjugate base, the phenoxide ion, is stabilized by the resonance delocalization of the negative charge into the aromatic ring.

(c) In p-nitrophenol (III), the strongly electron-withdrawing nitro group ($-R$ and $-I$) stabilizes the phenoxide ion by withdrawing charge density from the para position.

(d) In o-cresol (IV), the methyl group exerts an electron-donating effect via inductive properties and hyperconjugation, which destabilizes the phenoxide ion relative to unsubstituted phenol.

(e) Combining these factors gives the clear order: ethanol (II) is weakest, followed by o-cresol (IV), then phenol (I), with p-nitrophenol (III) being the strongest acid.

Final Answer: The order is II < IV < I < III.

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept: The conversion of a carbonyl group ($C = O$) into a methylene group (CH_2) is a fundamental deoxygenation reduction. For ketones like acetone (CH_3COCH_3), this transformation directly yields the corresponding alkane, propane ($CH_3CH_2CH_3$).

Solution:

(a) Acetone contains a central carbonyl group that can be reduced to a hydrocarbon using either acidic or basic deoxygenation methods.

(b) The Wolff-Kishner reduction utilizes hydrazine (NH_2NH_2) and a strong base like KOH in a high-boiling glycol solvent to convert carbonyl groups into alkanes.

(c) Alternatively, the Clemmensen reduction uses zinc amalgam and concentrated hydrochloric acid to achieve the same chemical conversion for acid-stable molecules.

(d) Out of the given multiple-choice options, the Wolff-Kishner reduction is the only option listed that accomplishes this deoxygenation conversion.

(e) Other listed processes like the Wurtz or Kolbe reactions serve to extend carbon chains rather than directly reducing individual ketone molecules into matching alkanes.

Final Answer: The reaction is Wolff-Kishner reduction.

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept: This question addresses the diagnostic test for primary amines known as the carbylamine reaction or Hofmann's isocyanide test. Secondary and tertiary amines do not undergo this transformation, making it highly specific for identifying primary amino groups.

Solution:

(a) When a primary aliphatic or aromatic amine reacts with chloroform ($CHCl_3$) in an alkaline medium containing ethanolic potassium hydroxide, it undergoes an alpha-elimination.

(b) Chloroform reacts with the strong base to generate a highly reactive dichlorocarbene intermediate ($:CCl_2$).

(c) The nucleophilic nitrogen atom of the primary amine attacks this electrophilic dichlorocarbene intermediate.

(d) Subsequent base-mediated elimination of three molecules of HCl leads to the formation of an isocyanide or carbylamine compound ($-N \equiv C$).

(e) These isocyanide products are characterized by an extremely foul, repulsive odor, providing a positive visual and olfactory confirmation of a primary amine.

Final Answer: The functional group is Isocyanide.

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: This question focuses on polymer chemistry and the composition of natural elastomers. Natural rubber is a high-molecular-weight addition polymer derived from diene monomers found in the latex of certain plants.

Solution:

(a) Natural rubber is a linear polymer made of repeating five-carbon diene units arranged in a regular, stereospecific orientation.

(b) The IUPAC name for this monomer building block is 2-methylbuta-1,3-diene, which is commonly known as isoprene.

(c) Polymerization of isoprene occurs via a 1,4-addition mechanism, preserving a cis configuration at every double bond throughout the polymer chain.

(d) This all-cis configuration prevents tight packing, imparting the characteristic elasticity and flexibility to natural rubber.

(e) Chloroprene is the monomer for synthetic neoprene rubber, whereas styrene yields polystyrene, leaving isoprene as the correct monomer for natural rubber.

Final Answer: The monomeric unit is Isoprene.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: The structural organization of proteins is categorized into primary, secondary, tertiary, and quaternary levels. While the primary structure is defined by covalent peptide bonds, higher-order folding relies on weaker, non-covalent interactions.

Solution:

(a) The secondary structure refers to the localized folding or spatial arrangement of the polypeptide backbone into regular geometric patterns.

(b) The two most common secondary structural configurations are the rigid α-helix conformation and the extended β-pleated sheet arrangement.

(c) These patterns are stabilized by hydrogen bonds forming between the carbonyl oxygen $(\mathrm{C=O})$ of one peptide bond and the amide hydrogen $(\mathrm{N-H})$ of another.

(d) In an α-helix, these hydrogen bonds are intramolecular, whereas in β-pleated sheets, they can form between adjacent polypeptide strands.

(e) Although covalent, ionic, and van der Waals forces contribute to other structural levels, hydrogen bonding is the primary stabilizing force for secondary structures.

Final Answer: The secondary structure is stabilized by Hydrogen bonds.

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

Go Back to Question 9

Q10.

Solution

Concept: Nucleophilic substitution reactions of alkyl halides typically proceed via either a bimolecular (S_N2) or a unimolecular (S_N1) path. The preferred mechanism depends heavily on steric hindrance, carbocation stability, and the strength of the nucleophile.

Solution:

(a) Tert-butyl bromide is a tertiary alkyl halide, meaning the central carbon is bonded to three bulky methyl groups.

(b) This high steric hindrance shields the backside of the carbon atom, preventing a direct, simultaneous nucleophilic attack via an S_N2 transition state.

(c) Water (H_2O) is a weak, neutral nucleophile and a highly protic solvent, which favors heterolytic cleavage of the carbon-halogen bond.

(d) The leaving group (Br^-) departs first, forming a stable tertiary carbocation intermediate, $(CH_3)_3C^+$, which is stabilized by inductive effects and hyperconjugation.

(e) This two-step process involving a distinct carbocation intermediate is the classic path for an S_N1 substitution mechanism.

Final Answer: The preferred mechanism is S_N1.

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept: The question focuses on the composition of Lucas reagent, which is utilized to distinguish between primary, secondary, and tertiary aliphatic alcohols based on their rate of reaction. The reagent works via a nucleophilic substitution mechanism where the hydroxyl group of the alcohol is replaced by a chloride ion, leading to the formation of an insoluble alkyl chloride.

Solution:

(a) Lucas reagent is prepared by mixing concentrated hydrochloric acid (HCl) with anhydrous zinc chloride ($ZnCl_2$) in an equimolar ratio.

(b) In this solution, anhydrous zinc chloride acts as a Lewis acid catalyst that coordinates with the oxygen atom of the alcohol group.

(c) This coordination weakens the carbon-oxygen bond, making the hydroxyl group a better leaving group and facilitating carbocation generation.

(d) Tertiary alcohols form highly stable carbocations and react almost instantly, creating an immediate cloudy turbidity or separation of layers.

(e) Secondary alcohols react within five minutes upon mild warming, whereas primary alcohols do not produce any visible turbidity at room temperature.

Final Answer: The solution consists of Concentrated HCl and anhydrous $ZnCl_2$.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: The reaction illustrates the electrophilic aromatic substitution of phenol under highly activating conditions. The hydroxyl group bonded to the benzene ring is a powerful ortho and para director due to the resonance contribution of the lone pairs on the oxygen atom into the aromatic aromatic system.

Solution:

(a) When phenol is treated with bromine water (Br_2/H_2O), the highly polar solvent molecule helps to ionize phenol into a phenoxide ion.

(b) The phenoxide ion possesses a full negative charge on oxygen, which increases its electron-donating resonance power compared to neutral phenol.

(c) This massive increase in electron density activates all available ortho and para positions of the aromatic ring toward electrophilic attack.

(d) Consequently, bromine electrophiles (Br^+) substitute the hydrogen atoms at positions 2, 4, and 6 simultaneously during the reaction.

(e) The poly-halogenated product undergoes symmetric crystallization, yielding a characteristic white precipitate of 2,4,6-tribromophenol in the solution.

Final Answer: The precipitate formed is 2,4,6-Tribromophenol.

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: This chemical problem focuses on distinguishing between aromatic and aliphatic aldehydes using mild oxidizing agents. While both categories can reduce Tollen's silver mirror reagent, they exhibit completely different behaviors when exposed to copper-based alkaline test solutions.

Solution:

(a) Acetaldehyde (CH_3CHO) is an aliphatic aldehyde containing reactive α-hydrogens that easily transitions into an enol form in basic media.

(b) Benzaldehyde (C_6H_5CHO) is an aromatic aldehyde where the carbonyl carbon is directly attached to the electron-delocalized sp2 carbon of a benzene ring.

(c) Fehling's solution contains a copper sulfate complex stabilized by sodium potassium tartrate in a highly alkaline sodium hydroxide matrix.

(d) Aliphatic aldehydes easily reduce the blue copper complexes into a distinct red-brown precipitate of copper(I) oxide (Cu_2O) upon heating.

(e) Aromatic aldehydes like benzaldehyde lack the necessary reducing power for this specific copper reagent, allowing clear differentiation between them.

Final Answer: The standard test used is Fehling's solution test.

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

Go Back to Question 13

Q14.

Solution

Concept: The problem presents a multi-step sequence involving the dry thermal decomposition of a calcium carboxylate followed by a haloform reaction. This sequence tests the synthesis of symmetrical ketones and their oxidation behavior with halogens in basic media.

Solution:

(a) The dry distillation of calcium acetate, $(CH_3COO)_2Ca$, involves thermal decomposition where calcium carbonate ($CaCO_3$) leaves the solid crystal lattice.

(b) This pyrolysis step couples the remaining methyl and acetyl radicals, yielding volatile liquid acetone (CH_3COCH_3) as Product Y.

(c) Product Y contains three reactive α-hydrogens on a methyl group directly adjacent to the central electrophilic carbonyl function.

(d) Treating acetone with iodine (I_2) and sodium hydroxide (NaOH) initiates successive halogenations to form a triiodoacetone molecule.

(e) Hydroxide cleavage of this intermediate yields sodium acetate and a bright yellow precipitate of iodoform (CHI_3) as Product Z.

Final Answer: The final major product Z is Iodoform.

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: This question requires applying stoichiometric mole relationships to determine microscopic atomic values from a macroscopic mass. It involves calculating molar quantities and using Avogadro's constant to count individual constituent particles.

Solution:

(a) The molecular formula of carbon dioxide is CO_2, which means its total molar mass equals $12 + (2 \times 16) = 44$ g/mol.

(b) Dividing the given sample mass by its molar weight gives the total moles: $4.4 \text{ grams}/44 \text{ g/mol} = 0.1$ mole.

(c) One mole of any gas contains exactly Avogadro's number of distinct molecular units, which is 6.02×10^{23} molecules.

(d) Therefore, 0.1 mole of carbon dioxide gas contains $0.1 \times 6.02 \times 10^{23} = 6.02 \times 10^{22}$ separate CO_2 molecules.

(e) Since each individual molecule contains three atoms (one carbon and two oxygens), the total atom count is $3 \times 6.02 \times 10^{22} = 1.81 \times 10^{23}$.

Final Answer: The total number of atoms is 1.81×10^{23}.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: This calculation deals with concentration expressions in solution chemistry. Molality (m) measures solution concentration independently of temperature variations because it relies purely on mass ratios rather than volumetric measurements.

Solution:

(a) Molality is defined mathematically as the total chemical moles of solute dissolved per one kilogram of pure solvent material.

(b) The given solute is sodium hydroxide (NaOH), which has a molar mass of 23 + 16 + 1 = 40 grams per mole.

(c) Calculating solute moles from the given mass yields: $20\text{ grams}/40\text{ g/mol} = 0.5$ mole of NaOH.

(d) The mass of the solvent (water) is given as 500 grams, which converts directly to 0.5 kilograms of solvent.

(e) Dividing the calculated solute moles by the solvent mass in kilograms gives: $0.5\text{ mole}/0.5\text{ kg} = 1.0\text{ mol/kg}$ or 1.0 m.

Final Answer: The molality of the solution is 1.0 m.

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: This kinetics problem relates the first-order rate constant (k) to the reaction half-life ($t_{1/2}$). First-order reactions have a unique property where the time needed to consume half of the reactant is independent of its initial starting concentration.

Solution:

(a) The integrated rate equation for a first-order chemical process defines the relationship between time, remaining concentration, and the specific velocity constant.

(b) Deriving this integrated equation for exactly 50% reactant completion provides the standard half-life mathematical expression: $t_{1/2} = \ln(2)/k$.

(c) Substituting the numerical value of the natural logarithm of 2 gives the simplified working formula: $t_{1/2} = 0.693/k$.

(d) Plugging the given rate constant into this formula yields: $t_{1/2} = 0.693/0.0693\ \text{min}^{-1}$.

(e) Solving this simple division shows that the reaction requires exactly 10 minutes to reach half-completion.

Final Answer: The time required is 10 minutes.

Answer: (A)

Go Back to Question 17

Q18.

Solution

Concept: This equilibrium problem requires determining molar solubility (S) from the solubility product constant (K_{sp}) for an asymmetric ionic salt. The calculation depends on the stoichiometry of the dissociation reaction in an aqueous medium.

Solution:

(a) The sparse dissolution of a solid salt AB_2 in water produces dissolved ions according to the equilibrium equation: $\mathrm{AB_2}(s) \rightleftharpoons \mathrm{A}^{2+}(aq) + 2\mathrm{B}^-(aq)$.

(b) If the overall molar solubility of the salt is denoted as S, then the equilibrium concentration of A^{2+} is S, and B^- is $2S$.

(c) Writing out the solubility product expression gives: $K_{sp} = [\mathrm{A}^{2+}][\mathrm{B}^-]^2 = (S)\cdot(2S)^2 = 4S^3$.

(d) Equating this expression to the given numerical value yields: $4S^3 = 3.2 \times 10^{-11}$, which simplifies to $S^3 = 8 \times 10^{-12}$.

(e) Taking the cube root of both sides gives the final molar solubility value: $S = 2 \times 10^{-4}$ M.

Final Answer: The molar solubility is 2×10^{-4} M.

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept: This question applies Faraday's laws of electrolysis to calculate the quantity of electricity needed for electrodeposition. The mass of an element discharged at an electrode is directly proportional to the total electric charge passed through the electrolyte.

Solution:

(a) The reduction reaction for depositing aluminum metal from trivalent aluminum ions at the cathode is written as: $\mathrm{Al}^{3+} + 3\mathrm{e}^- \rightarrow \mathrm{Al}(s)$.

(b) This stoichiometry shows that depositing one mole of elemental aluminum requires exactly three moles of electrons.

(c) One Faraday (1 F) represents the total electric charge carried by one mole of individual electrons.

(d) Therefore, depositing one mole of aluminum (27 grams) requires passing exactly 3 Faradays of electric charge.

(e) Since the mass specified in the problem is exactly 27 grams, the required quantity of electricity is exactly 3 Faradays.

Final Answer: The quantity of electricity is 3 Faradays.

Answer: (C)

Go Back to Question 19

Q20.

Solution

Concept: The problem evaluates colligative properties, specifically the elevation of boiling point (ΔT_b). Colligative effects depend solely on the total number of solute particles present in the solution, regardless of their chemical identity.

Solution:

(a) The mathematical relationship for boiling point elevation is given by the formula: $\Delta T_b = i \cdot K_b \cdot m$.

(b) For a non-electrolyte solute, the molecules do not dissociate or associate in solution, meaning the van 't Hoff factor (i) equals 1.

(c) The formula can therefore be simplified to: $\Delta T_b = K_b \cdot m$, where m is the molality of the solution.

(d) Rearranging the variables to isolate the molal boiling point elevation constant gives: $K_b = \Delta T_b / m$.

(e) Substituting the values from the prompt yields: $K_b = 0.052°\text{C}/0.1 \text{ m} = 0.52 \text{ K kg mol}^{-1}$.

Final Answer: The boiling point elevation constant is $0.52 \text{ K kg mol}^{-1}$.

Answer: (A)

Go Back to Question 20

Q21.

Solution

Concept: This question deals with the thermodynamic relationship connecting the two equilibrium constants, K_p and K_c, for a chemical reaction involving an ideal gas mixture. The factor connecting them arises directly from the ideal gas equation and depends on the net change in the stoichiometry of gaseous molecules between the products and reactants.

Solution:

(a) The mathematical formula establishing the link between the pressure-based and concentration-based equilibrium constants is written as $K_p = K_c(RT)^{\Delta n_g}$.

(b) In this thermodynamic relation, R represents the universal gas constant, T denotes the absolute temperature in Kelvin, and Δn_g is the change in moles of gas.

(c) For the specific dissociation process given, $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, we calculate the molar difference using the balanced coefficients.

(d) The total number of product gas moles is $1 + 1 = 2$, while the total number of reactant gas moles is 1.

(e) Subtracting the reactant value from the product value gives $\Delta n_g = 2 - 1 = 1$. Substituting this back into our original formula yields $K_p = K_c(RT)^1$.

Final Answer: The mathematical relation is $K_p = K_c(RT)$.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: This problem involves the definition of pH and its logarithmic relationship with the molar concentration of hydrogen ions ($[H^+]$) in an aqueous solution. Because pH is scaled logarithmically, small integer changes in its value correspond to order-of-magnitude exponential shifts in acidity.

Solution:

(a) The mathematical definition of pH is given by the negative base-10 logarithm of the hydrogen ion concentration, which is expressed as $\text{pH} = -\log_{10}[H^+]$.

(b) Rearranging this logarithmic formula to solve directly for the ion concentration yields the exponential relationship $[H^+] = 10^{-\text{pH}}$.

(c) For the initial state where the solution has a pH of 5, the corresponding concentration is calculated as $[H^+]_1 = 10^{-5}$ M.

(d) For the final state where the solution drops to a pH of 2, the new concentration is calculated as $[H^+]_2 = 10^{-2}$ M.

(e) To find the scaling factor, divide the final concentration by the initial concentration: $10^{-2}/10^{-3} = 10^3 = 1000$. This indicates a thousand-fold increase.

Final Answer: The hydrogen ion concentration increases by a factor of 1000.

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

Go Back to Question 22

Q23.

Solution

Concept: This problem evaluates the correlation between the standard reduction potential ($E°$) of a metal and its intrinsic chemical reducing power. The standard reduction potential measures how readily a species gains electrons, meaning lower potentials signify a greater tendency to lose electrons and act as reducing agents.

Solution:

(a) A negative standard reduction potential indicates that a metal is easily oxidized, meaning it readily sheds electrons to reduce other substances.

(b) Consequently, the lower or more negative the standard reduction potential of an element, the stronger its capability to act as a reducing agent.

(c) The given reduction potentials for the three metal elements are +0.5 V for A, −2.0 V for B, and −0.4 V for C.

(d) Comparing these values shows that metal B possesses the lowest reduction potential, followed next by metal C, while metal A has the highest value.

(e) Arranging them in decreasing order of ease of oxidation yields the relative reducing strength series, which is correctly represented as B > C > A.

Final Answer: The correct reducing power order is B > C > A.

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: This chemical kinetics problem addresses how initial reactant concentrations affect the half-life period ($t_{1/2}$) of a zero-order reaction. In zero-order kinetics, the rate of transformation remains completely constant and is independent of concentration shifts.

Solution:

(a) The integrated rate equation for a zero-order chemical process is written as $[A]_t = [A]_0 - kt$, where k represents the rate constant.

(b) The half-life is defined as the time required for the initial reactant concentration to drop by exactly half, meaning $[A]_t = [A]_0/2$.

(c) Substituting this parameter into the integrated equation yields the direct relationship for the half-life period: $t_{1/2} = [A]_0/(2k)$.

(d) This mathematical expression shows that the half-life of a zero-order reaction is directly proportional to its initial concentration $[A]_0$.

(e) Therefore, if the initial concentration of the starting material is doubled, the time required to consume half of it will also double.

Final Answer: The half-life period of the reaction will be doubled.

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept: This electrochemistry question requires calculating the standard electromotive force (E°_{cell}) of a standard galvanic cell using reduction potentials. The total cell potential is determined by subtracting the anode potential from the cathode potential.

Solution:

(a) In the standard zinc-copper galvanic setup shown, oxidation occurs at the zinc electrode (anode), while reduction takes place at the copper electrode (cathode).

(b) The standard formula used to compute the total voltage output of an electrochemical cell is $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$.

(c) Both reference values must be expressed as standard reduction potentials to ensure mathematical consistency when utilizing this standard algebraic formula.

(d) The given standard values are $E^\circ_{\text{Cu}^{2+}/\text{Cu}} = +0.34$ V for the cathode and $E^\circ_{\text{Zn}^{2+}/\text{Zn}} = -0.76$ V for the anode.

(e) Substituting these values into the equation yields: $+0.34 \text{ V} - (-0.76 \text{ V}) = +0.34 \text{ V} + 0.76 \text{ V} = +1.10 \text{ V}$.

Final Answer: The standard EMF is +1.10 V.

Answer: (A)

Go Back to Question 25

Q26.

Solution

Concept: This question focuses on the temperature coefficient (μ) of a reaction, which describes how the kinetic rate scales with temperature. For many common reactions, the rate increases exponentially with regular incremental increases in temperature.

Solution:

(a) The temperature coefficient (μ) expresses the ratio of rate constants when the reaction temperature is raised by exactly 10°C.

(b) The problem states that the reaction rate doubles for each increment, meaning the temperature coefficient value is equal to 2.

(c) The overall temperature shift for this process is calculated by subtracting the initial value from the final value: $60°\text{C} - 20°\text{C} = 40°\text{C}$.

(d) Dividing this total shift by the standard interval gives the number of increments: $n = 40°\text{C}/10°\text{C} = 4$.

(e) The final rate acceleration factor is determined exponentially using the formula $\mu^n = 2^4 = 16$. This shows the rate increases sixteen-fold.

Final Answer: The overall rate increases by 16 times.

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept: This question explores Raoult's Law as it applies to ideal solutions containing non-volatile solutes. The addition of a non-volatile solute restricts solvent molecules from escaping into the gas phase, lowering the total vapor pressure.

Solution:

(a) Raoult's Law states that the partial vapor pressure of a volatile solvent above a solution is directly proportional to its mole fraction.

(b) Mathematically, this relation is expressed as $P = P^\circ \cdot X_{\text{solvent}}$, where P° represents the vapor pressure of the pure solvent.

(c) The lowering of vapor pressure is given by $P^\circ - P = P^\circ - (P^\circ \cdot X_{\text{solvent}}) = P^\circ(1 - X_{\text{solvent}})$.

(d) In a binary solution mixture, the sum of mole fractions is $X_{\text{solvent}} + X_{\text{solute}} = 1$, which means that $1 - X_{\text{solvent}} = X_{\text{solute}}$.

(e) Substituting this back into the expression yields $(P^\circ - P)/P^\circ = X_{\text{solute}}$. This confirms the ratio equals the mole fraction of the solute.

Final Answer: The relative lowering of vapor pressure is equal to the mole fraction of the solute.

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept: This question tests the periodic trends and chemical reactivity of Group 18 elements (the noble gases). While initially considered completely inert, the heavier noble gases can form stable compounds with highly electronegative elements.

Solution:

(a) Moving down Group 18, the atomic radius increases, which structurally distances the outermost valence electrons from the positive nucleus.

(b) This expansion causes a significant decrease in ionization enthalpy, making it easier to share or manipulate electron density.

(c) Among the options listed, Xenon (Xe) has a lower ionization enthalpy that closely matches the ionization energy of oxygen molecules.

(d) Because of this favorable energy threshold, Xenon reacts directly with highly oxidizing fluorine gas under varying thermal conditions.

(e) These reactions yield a well-characterized range of stable isolation fluorides, including XeF_2, XeF_4, and XeF_6, whereas lighter noble gases remain inert.

Final Answer: The noble gas is Xenon.

Answer: (D)

Go Back to Question 28

Q29.

Solution

Concept: This inorganic metallurgy question relates to the chemical vapor transport method used to purify specific transition metals. The Mond process relies on the reversible formation of a volatile coordination complex with a common gaseous ligand.

Solution:

(a) Vapor-phase refining requires a metal to react with a volatile reagent to form a compound that decomposes easily at higher temperatures.

(b) In the Mond process, impure nickel metal is heated in a stream of carbon monoxide (CO) gas at a moderate temperature of $330 - 350$ K.

(c) This reaction forms a volatile coordination complex known as nickel tetracarbonyl, $Ni(CO)_4$, leaving impurities behind as solid residue. $Ni + 4CO \rightarrow Ni(CO)_4$

(c) The gaseous nickel tetracarbonyl is then transported to a separate chamber and heated to a higher temperature of $450 - 470$ K.

(d) At this temperature, the complex decomposes to yield pure solid nickel metal, while regenerating carbon monoxide gas to be reused in the process.

Final Answer: The metal purified is Nickel.

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: This problem evaluates coordination chemistry concepts, specifically determining the coordination number and oxidation state of a central metal ion. These values depend on the total number of donor atoms and the net charge of the ligands.

Solution:

(a) The ligand ethylenediamine, abbreviated as "en", is a neutral bidentate ligand that possesses two nitrogen donor atoms capable of coordinating with a metal center.

(b) Since the complex ion contains three ethylenediamine ligands, the total number of coordinate bonds formed is $3 \times 2 = 6$.

(c) The coordination number is defined as the total number of ligand donor atoms bonded directly to the metal, which equals 6.

(d) To find the oxidation state of Cobalt (x), set up a charge balance equation: $x + 3 \times (\text{charge of en}) = \text{total ionic charge}$.

(e) Substituting the values gives $x + 3 \times (0) = +3$, which simplifies to $x = +3$. This confirms the metal has an oxidation state of +3.

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

Answer: (B)

Go Back to Question 30

Q31.

Solution

Concept: This question focuses on the anomalies in ground-state electronic structures observed among the inner transition elements (lanthanides). The filling of the 4f subshell follows Hund's rule of maximum multiplicity, which favors configurations that achieve extra structural stability through completely filled or symmetrically half-filled subshells.

Solution:

(a) Gadolinium is located within the 4f inner transition block and possesses an atomic number (Z) of 64.

(b) The nearest preceding noble gas core configuration belongs to Xenon, which accounts for the first 54 electrons.

(c) Following standard Aufbau principles, the next electrons would normally fill the 6s orbital and then populate the internal 4f sublevel.

(d) This expected regular sequence would lead to an unrefined valence configuration represented as $4f^8 6s^2$.

(e) However, shifting one electron from the 4f orbital over into the empty 5d subshell generates a highly symmetric $4f^7$ system.

(f) This unique arrangement contains a perfectly half-filled f-shell that yields significant exchange energy and structural stability, giving the actual configuration $[Xe]4f^7 5d^1 6s^2$.

Final Answer: The correct electronic configuration of Gadolinium is $[Xe]4f^7 5d^1 6s^2$.

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept: This question requires identifying specific covalent connectivity patterns within p-block oxoacids, specifically looking for a peroxide linkage. A peroxide bond involves two oxygen atoms bonded directly to each other, which fundamentally alters the characteristic oxidation states of those oxygen centers.

Solution:

(a) Peroxodisulfuric acid, traditionally known as Marshall's acid, is represented by the formula $H_2S_2O_8$.

(b) The molecule features two central sulfur atoms that each achieve a stable hexavalent oxidation state through oxygen coordination.

(c) Each sulfur atom binds directly to a terminal hydroxyl group and forms two coordinate or double bonds with terminal oxygen atoms.

(d) The two remaining internal oxygen atoms connect the two separate symmetrical sulfur centers together, forming a bridge.

(e) This internal bridging arrangement creates a distinct, linear peroxide covalent linkage $(O - O)$ right at the center of the structural skeleton.

(f) Other sulfur oxoacids like pyrosulfuric acid ($H_2S_2O_7$) instead possess a simple ether-like sulfur-oxygen-sulfur $(S - O - S)$ link lacking peroxide properties.

Final Answer: The p-block oxoacid containing a direct peroxide linkage is $H_2S_2O_8$.

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept: This problem explores the origin of color in transition metal complexes, specifically focusing on systems where standard d-d electronic transitions are impossible. The absorption of visible light can instead be driven by charge-transfer transitions between the metal and its coordinating ligands.

Solution:

(a) In a potassium permanganate crystal matrix ($KMnO_4$), manganese exists in its highest possible oxidation state of +7.

(b) The electronic configuration of a Mn^{7+} ion is completely empty of d-electrons, matching the closed shell of Argon.

(c) Because there are no valence electrons present in the 3d levels, normal d-d electronic transitions cannot happen.

(d) The intense purple-red color arises from an optical transition where an electron shifts from the surrounding oxo ligands to the metal.

(e) Specifically, an electron absorbs a photon to jump from a filled oxygen p-orbital into an empty manganese d-orbital.

(f) This process is called a Ligand-to-Metal Charge Transfer (LMCT) transition, and its high probability causes intense light absorption.

Final Answer: The coloration originates due to Ligand-to-Metal Charge Transfer.

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept: This question evaluates knowledge of metallurgy and industrial mineral resources. Economic extraction requires identifying the mineral ores that correspond to different commercial metals, along with their precise chemical compositions.

Solution:

(a) Calamine is an essential carbonate mineral ore that serves as a common resource for extracting zinc metal.

(b) Chemically, the pure form of this mineral ore is composed of zinc carbonate, represented as $ZnCO_3$.

(c) Other zinc minerals include zinc blende, which is a sulfide form (ZnS), and zincite, which is an oxide (ZnO).

(d) The mineral formula listed as $CuCO_3 \cdot Cu(OH)_2$ corresponds to malachite, which is a basic copper carbonate ore.

(e) In industrial processing, calamine ore undergoes a thermal calcination step to drive off carbon dioxide gas, leaving behind zinc oxide.

(f) This resulting zinc oxide intermediate is then easily reduced with carbon in a smelting furnace to yield pure zinc metal.

Final Answer: The mineral ore known as Calamine is chemically represented as $ZnCO_3$.

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

Go Back to Question 34

Q35.

Solution

Concept: This question focuses on the structural spatial geometry of coordination compounds. The arrangement shown involves a central metal atom surrounded by six independent ligands, which defines a specific polyhedral geometry.

Solution:

(a) The structural schematic diagram illustrates a single central metal atom, denoted as **M**, located at the origin.

(b) Surrounding this central metal atom are six separate, identical coordinating ligand units, each labeled as L.

(c) Two of these ligands occupy directly opposing vertical axial positions, one pointing straight up and the other straight down.

(d) The remaining four ligands are distributed horizontally along an equatorial plane, creating a square arrangement around the center.

(e) The dashed lines trace out the outer faces of the coordination polyhedron, showing eight distinct triangular facets.

(f) This geometric shape, featuring six equivalent vertices and eight faces, corresponds to a classic symmetric octahedral arrangement.

Final Answer: The coordination complex geometry is Octahedral.

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

Go Back to Question 35

Q36.

Solution

Concept: This question deals with structural coordination chemistry, specifically identifying an ambidentate ligand partner. Ambidentate ligands possess two or more different donor atoms but can only bind to a central metal ion through one atom at a time.

Solution:

(a) Common ligands like ammonia (NH_3) and water (H_2O) act as monodentate partners that use a single atom to donate electrons.

(b) Oxalate (ox^{2-}) is a bidentate ligand that binds using two oxygen atoms simultaneously to form a stable chelate ring.

(c) The thiocyanate ion (SCN^-) contains two different potential donor atoms: a nitrogen atom and a sulfur atom.

(d) Because both atoms possess lone pairs, the ligand can coordinate in two completely different ways depending on conditions.

(e) It can bind through the sulfur atom ($M-SCN$) or link through the nitrogen atom ($M-NCS$), which forms linkage isomers.

(f) This ability to coordinate through alternative atoms while using only one at a time defines an ambidentate ligand.

Final Answer: The ligand classified as an ambidentate coordination partner is SCN^-.

Answer: (C)

Go Back to Question 36

Q37.

Solution

Concept: This question addresses lanthanide contraction, which describes the steady decrease in atomic and ionic radii observed across the lanthanide series. This trend significantly impacts the chemical behavior and separation chemistry of the heavier transition elements.

Solution:

(a) As you move across the lanthanide series from lanthanum to lutetium, the nuclear charge increases by one unit at each step.

(b) This added positive nuclear charge is balanced by adding electrons to the inner 4f electronic subshell.

(c) The 4f orbitals have a highly diffuse spatial shape, which makes them very ineffective at shielding other electrons.

(d) Specifically, they provide poor shielding against the increasing positive charge of the nucleus for outer valence electrons.

(e) Because of this poor shielding, the outer electron shell experiences an increasing effective nuclear charge.

(f) This stronger electrostatic pull draws the electron cloud closer to the nucleus, causing a steady contraction in size.

Final Answer: The contraction is driven by poor shielding of nuclear charge by 4f electrons.

Answer: (B)

Go Back to Question 37

Q38.

Solution

Concept: This metallurgy question focuses on the chemical composition of intermediate phases during pyrometallurgical copper extraction. Roasting copper pyrites in a reverberatory furnace separates iron impurities from the target copper compounds.

Solution:

(a) Copper pyrites ore ($CuFeS_2$) is heated with a silica flux in a reverberatory furnace during the roasting process.

(b) This roasting step partially oxidizes the iron and copper sulfides present within the complex mineral matrix.

(c) Iron has a higher affinity for oxygen than copper, so it preferentially converts into iron(II) oxide (FeO).

(d) This iron oxide then reacts with the added silica (SiO_2) flux to form a molten iron silicate slag layer ($FeSiO_3$). $FeO + SiO_2 \rightarrow FeSiO_3$

(d) The remaining unoxidized heavy sulfide materials settle at the bottom of the furnace to form a dense liquid layer called matte.

(e) This copper matte intermediate consists primarily of a mixture of copper(I) sulfide (Cu_2S) and iron(II) sulfide (FeS).

Final Answer: The chemical composition of the obtained matte is Cu_2S and FeS.

Answer: (A)

Go Back to Question 38

Q39.

Solution

Concept: This quantum mechanics problem relates quantum numbers to the electron capacity of an atomic subshell. The capacity of any subshell is determined by its orbital angular momentum quantum number (l), which defines its spatial orientation options.

Solution:

(a) The orbital angular momentum quantum number (l) designates the specific subshell type, where $l = 0, 1, 2, 3$ correspond to s, p, d, f subshells.

(b) For a given value of l, the magnetic quantum number (m_l) ranges from $-l$ through 0 to $+l$, defining the number of individual orbitals.

(c) The total number of individual degenerate orbitals contained within any subshell is calculated using the formula $2l + 1$.

(d) Substituting the given value of $l = 3$ into this expression yields: $2 \times (3) + 1 = 6 + 1 = 7$ distinct spatial orbitals.

(e) According to the Pauli exclusion principle, each individual atomic orbital can hold a maximum of two electrons with opposing spins.

(f) Therefore, the total electron capacity of the subshell is calculated as: $2 \times (2l + 1) = 2 \times 7 = 14$ electrons.

Final Answer: The maximum total number of electrons is 14.

Answer: (C)

Go Back to Question 39

Q40.

Solution

Concept: This question applies Molecular Orbital Theory to evaluate the magnetic properties of homonuclear diatomic molecules. Diamagnetic behavior occurs when a molecule has all of its valence electrons paired within its molecular orbitals.

Solution:

(a) We can evaluate each option by filling molecular orbitals based on their total electron counts.

(b) Oxygen (O_2) has 16 valence electrons, which puts two unpaired electrons in its anti-bonding π^*_{2p} orbitals, making it paramagnetic.

(c) The superoxide ion (O_2^-) has 17 electrons, leaving one unpaired electron in its anti-bonding levels, so it is also paramagnetic.

(d) Boron (B_2) contains 10 total electrons, which places two unpaired electrons singly into degenerate π_{2p} orbitals, making it paramagnetic.

(e) Carbon (B_2 configuration modified) or C_2 contains a total of 12 electrons to distribute.

(f) Filling these into the molecular orbital sequence gives: $\sigma^2_{1s}\sigma^{*}_{1s}{}^{2}\sigma^2_{2s}\sigma^{*}_{2s}{}^{2}\pi^2_{2p_x}\pi^2_{2p_y}$.

(g) All 12 electrons are completely paired within these bonding levels, which means C_2 exhibits diamagnetic behavior.

Final Answer: The homonuclear diatomic molecular species expected to show diamagnetic behavior is C_2.

Answer: (C)

Go Back to Question 40

Q41.

Solution

Concept: This question deals with predicting the valence shell electron pair repulsion (VSEPR) geometry and steric properties of a main group fluoride. The layout is determined by counting both bonding pairs and lone pairs surrounding the central atom to find the total steric coordination number.

Solution:

(a) Sulfur serves as the central atom in sulfur tetrafluoride (SF_4) and belongs to Group 16, contributing six valence electrons.

(b) The four surrounding fluorine atoms each form a single covalent σ-bond, consuming four of sulfur's valence electrons.

(c) The remaining two valence electrons reside on the central sulfur atom as a single non-bonding lone pair.

(d) Adding the four bonding pairs to the single lone pair gives a total steric number of five.

(e) A steric number of five corresponds to a fundamental sp^3d orbital hybridization state with a trigonal bipyramidal geometry.

(f) To minimize strong electron repulsions, the lone pair occupies an equatorial site, distorting the spatial shape into a see-saw structure.

Final Answer: The hybridization state and shape are sp^3d and See-saw.

Answer: (B)

Go Back to Question 41

Q42.

Solution

Concept: This problem evaluates periodic trends in first ionization enthalpy across the third row of elements. Ionization enthalpy generally scales with effective nuclear charge, but standard trends can be altered by specific electronic configurations.

Solution:

(a) Moving from left to right across Period 3, the first ionization enthalpy generally increases as atomic radius decreases.

(b) The elements given are sodium (Na), magnesium (Mg), aluminum (Al), and silicon (Si).

(c) Sodium has the lowest nuclear charge and largest radius in this series, giving it the lowest ionization energy.

(d) Magnesium has a stable, fully filled $3s^2$ valence shell configuration ($[Ne]3s^2$).

(e) Aluminum ($[Ne]3s^23p^1$) requires removing an electron from a higher-energy p-orbital, which is easier than breaking magnesium's closed subshell.

(f) This anomaly shifts aluminum below magnesium, while silicon ($[Ne]3s^23p^2$) has a higher nuclear charge and remains the highest.

Final Answer: The increasing order of first ionization enthalpy is Na < Al < Mg < Si.

Answer: (B)

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Q43.

Solution

Concept: This question focuses on the line spectrum of atomic hydrogen described by the Rydberg formula. Spectral series are categorized by their final lower energy level, with individual lines inside a series defined by their starting upper level.

Solution:

(a) The Balmer series consists of electronic transitions that terminate in the second principal quantum shell ($n_{\text{final}} = 2$).

(b) These transitions emit or absorb photons that fall within the visible region of the electromagnetic spectrum.

(c) The individual spectral lines within a series are ordered based on their wavelength or transition energy gaps.

(d) The first line of any series corresponds to the lowest energy transition, originating from the next adjacent orbital level.

(e) For the Balmer series, the transition with the lowest energy gap begins at $n = 3$ and drops down to $n = 2$.

(f) Higher lines like the second line originate from $n = 4$, making $n = 3 \rightarrow n = 2$ the first line.

Final Answer: The first line corresponds to the transition $n = 3 \rightarrow n = 2$.

Answer: (B)

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Q44.

Solution

Concept: This problem looks at intermolecular forces that act between discrete chemical units. The strength and type of these non-covalent interactions depend on molecular polarity and the presence of highly electronegative atoms.

Solution:

(a) The schematic diagram illustrates three independent water (H_2O) molecules aligned horizontally in a matrix.

(b) Water is a highly polar molecule due to the large electronegativity difference between oxygen and hydrogen atoms.

(c) The oxygen atom pulls electron density away from the hydrogen atoms, creating a strong partial negative charge.

(d) This leaves the hydrogen atoms with a strong partial positive charge and a small local concentration of charge.

(e) The red dashed lines represent strong electrostatic attractions between a hydrogen atom and a neighboring oxygen lone pair.

(f) This specific non-covalent interaction between hydrogen and a highly electronegative atom defines hydrogen bonding.

Final Answer: The dominant intermolecular attractive forces are Hydrogen bonding.

Answer: (C)

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Q45.

Solution

Concept: This question compares the interior bond angles of simple hydrides using valence shell electron pair repulsion theory. Variations in bond angles among molecules with similar shell counts are caused by lone pair repulsions.

Solution:

(a) Methane (CH_4), ammonia (NH_3), and water (H_2O) all feature central atoms with four valence electron pairs.

(b) This common steric count gives all three molecules a basic tetrahedral electron-pair geometry.

(c) Methane contains four bonding pairs and zero lone pairs, maintaining an ideal tetrahedral bond angle of 109.5°.

(d) Ammonia contains three bonding pairs and one lone pair, which exerts stronger repulsion and closes the angle to 107°.

(e) Water contains two bonding pairs and two lone pairs, which create even stronger repulsions that reduce the angle further to 104.5°.

(f) Comparing these values gives an increasing trend in bond angles that follows the series $H_2O < NH_3 < CH_4$.

Final Answer: The correct increasing order of bond angles is $H_2O < NH_3 < CH_4$.

Answer: (A)

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Q46.

Solution

Concept: This problem evaluates vertical periodic trends for elemental properties down a group. As you move down a column, adding principal electronic shells changes the atomic structure and influences how strongly the nucleus attracts electrons.

Solution:

(a) Moving down a vertical group, the principal quantum number increases as new electron shells are added.

(b) Adding these shells increases the distance between the valence electrons and the positive nucleus, which expands the atomic radius.

(c) This larger distance screens the valence shell and weakens the electrostatic pull exerted by the nucleus.

(d) Electronegativity measures the relative ability of an atom to attract bonding electrons toward itself.

(e) Because the atomic radius expands down a group, the nucleus cannot attract shared pairs as effectively.

(f) This weaker pull causes a steady decrease in electronegativity values down the column, while metallic character increases.

Final Answer: The property that shows a steady decrease down a vertical group is Electronegativity.

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

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Q47.

Solution

Concept: This surface chemistry question focuses on identifying properties that are unique to colloidal systems. Colloidal dispersions contain particles that are larger than simple molecules but small enough to remain suspended without settling.

Solution:

(a) Colloidal particles range in size from 1 to 1000 nanometers, which allows them to interact uniquely with light waves.

(b) The Tyndall effect is the scattering of a light beam as it passes through a colloidal liquid or mixture.

(c) True solutions contain solute particles that are too small to scatter visible light, leaving the beam invisible.

(d) Colloidal particles have dimensions comparable to visible wavelengths, allowing them to scatter light and make the path visible.

(e) Other properties like Brownian movement are kinetic manifestations, while electrophoresis and coagulation are electrical properties.

(f) Therefore, the Tyndall effect serves as a unique optical manifestation that distinguishes colloids from true solutions.

Final Answer: The unique optical manifestation is the Tyndall Effect.

Answer: (B)

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Q48.

Solution

Concept: This problem looks at the Freundlich adsorption isotherm, which models how gas pressure impacts the mass of gas adsorbed onto a solid surface at a constant temperature. The mathematical parameters reflect surface behavior and saturation.

Solution:

(a) The mathematical expression for the Freundlich adsorption isotherm is written as $x/m = k \cdot P^{1/n}$.

(b) Taking the logarithm of both sides yields the linear equation $\log(x/m) = \log(k) + (1/n)\log(P)$.

(c) The term $1/n$ represents the slope of the isotherm plot and indicates the absorption intensity or surface heterogeneity.

(d) At very low pressures, adsorption is directly proportional to pressure, making the exponent value $1/n$ equal to 1.

(e) At very high pressures, the surface reaches saturation and becomes independent of pressure, shifting $1/n$ to 0.

(f) Under ordinary operating conditions, the value of this exponent parameter ranges smoothly between 0 and 1.

Final Answer: The parameter value of the exponent slope typically lies between 0 and 1.

Answer: (A)

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Q49.

Solution

Concept: This environmental chemistry question addresses the chemical mechanisms behind stratospheric ozone depletion. The long-term stability of certain synthetic trace gases allows them to reach the upper atmosphere and release reactive radicals.

Solution:

(a) Chlorofluorocarbons (CFCs) are highly stable synthetic compounds containing chlorine, fluorine, and carbon atoms.

(b) Their chemical inertness allows them to persist in the lower atmosphere and gradually diffuse up into the stratosphere.

(c) Once in the stratosphere, these molecules encounter intense high-energy ultraviolet radiation.

(d) This UV light breaks the carbon-chlorine bonds, releasing highly reactive free chlorine radicals into the atmosphere.

(e) These free chlorine radicals act as catalysts in a chain reaction that breaks down ozone molecules (O_3) into oxygen (O_2).

(f) A single chlorine radical can destroy thousands of ozone molecules, leading to the long-term degradation of the ozone layer.

Final Answer: The trace gas mainly responsible is Chlorofluorocarbons (CFCs).

Answer: (B)

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Q50.

Solution

Concept: This question focuses on the core principles of green chemistry, which aim to reduce or eliminate the use and generation of hazardous substances. Sustainable industrial manufacturing relies on using renewable feedstock and benign reagents.

Solution:

(a) Green chemistry emphasizes preventing waste, maximizing atom economy, and utilizing non-hazardous chemical alternatives.

(b) Traditional industrial bleaching processes rely heavily on elemental chlorine gas, which generates toxic organochlorine waste.

(c) Modern green strategies replace these hazardous systems with environmentally benign bleaching alternatives.

(d) Supercritical or liquid carbon dioxide (CO_2) serves as an excellent non-toxic solvent for dry cleaning applications.

(e) Hydrogen peroxide (H_2O_2) acts as an eco-friendly bleaching agent because it decomposes purely into water and oxygen gas.

(f) Implementing these clean alternatives eliminates toxic discharge, aligning with sustainable industrial chemistry goals.

Final Answer: The green chemical strategy is using liquid CO_2 or H_2O_2 as benign bleaching alternatives.

Answer: (B)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	D	3	B	4	B	5	A
6	A	7	B	8	B	9	C	10	A
11	B	12	C	13	B	14	B	15	B
16	B	17	A	18	A	19	C	20	A
21	B	22	D	23	B	24	C	25	A
26	C	27	B	28	D	29	B	30	B
31	A	32	B	33	B	34	A	35	C
36	C	37	B	38	A	39	C	40	C
41	B	42	B	43	B	44	C	45	A
46	B	47	B	48	A	49	B	50	B