BITSAT Chemistry Sample Paper-19

Duration: 40 Minutes **Maximum Marks: 90**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries: **−1** marks. Unattempted questions carry **0** marks.
- Only one option is correct for each question.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Q1. In the reaction of an aldehyde with Tollens' reagent (ammoniacal $AgNO_3$), the aldehyde is:

(A) Reduced to alcohol

(B) Oxidised to carboxylic acid

(C) Condensed with ammonia

(D) Not reacted

Q2. The Bohr model correctly predicts the energy levels of:

(A) Multi-electron atoms like oxygen

(B) Hydrogen-like ions only

(C) All atoms

(D) Alkali metal cations

Q3. In the molecular orbital diagram for O_2, the order of orbital filling (from lowest to highest energy) includes:

(A) $\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \pi_{2p} < \sigma_{2p}$

(B) $\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \pi_{2p} < \sigma^*_{2s} < \sigma_{2p}$

(C) $\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \pi_{2p} < \pi^*_{2p}$

(D) $\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \sigma_{2p} < \pi_{2p}$

Q4. Ethyl acetate ($CH_3COOC_2H_5$) is an ester. Its molecular formula is:

(A) $C_3H_6O_2$

(B) $C_4H_8O_2$

(C) $C_5H_{10}O_2$

(D) $C_6H_{12}O_2$

Q5. For an exothermic reaction, the enthalpy of products is:

(A) Equal to enthalpy of reactants

(B) Less than enthalpy of reactants

(C) Greater than enthalpy of reactants

(D) Zero

Q6. Which of the following oxides of nitrogen is coloured?

(A) N_2O (colourless)

(B) NO (colourless)

(C) NO_2 (brown)

(D) N_2O_5 (colourless)

Q7. At constant temperature, when pressure is applied to the equilibrium $PCl_5 \rightleftharpoons PCl_3 + Cl_2$, the equilibrium shifts:

(A) Towards products (right)

(B) Towards reactants (left)

(C) No shift

(D) Cannot determine

Q8. Amphoteric compounds can act as both acids and bases. Which of the following is amphoteric?

(A) HCl

(B) NaOH

(C) H_2O

(D) HNO_3

Q9. In the electrolysis of aqueous $CuSO_4$ using Cu electrodes, the cathode reaction is:

(A) $Cu \rightarrow Cu^{2+} + 2e^-$

(B) $Cu^{2+} + 2e^- \rightarrow Cu$

(C) $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

(D) $SO_4^{2-} \rightarrow S + O_2$

Q10. In an SN2 mechanism, the rate-determining step involves:

(A) Formation of a carbocation

(B) Concerted backside attack by nucleophile and C–X bond breaking

(C) Formation of an intermediate

(D) Loss of a proton

Q11. Toluene (methylbenzene) undergoes substitution mainly at:

(A) Meta position (3-position)

(B) Ortho and para positions (2,6,4-positions)

(C) All positions equally

(D) Only para position

Q12. The standard enthalpy of formation (ΔH_f°) of an element in its standard state is:

(A) Zero

(B) Positive

(C) Negative

(D) Depends on temperature

Q13. In the hydrolysis of an alkyl bromide in water, a secondary bromide reacts via:

(A) SN1 mechanism predominantly

(B) SN2 mechanism exclusively

(C) E1 elimination only

(D) Neither substitution nor elimination

Q14. The geometry of $[Pt(NH_3)_4]^{2+}$ is:

(A) Tetrahedral

(B) Square planar

(C) Octahedral

(D) Linear

Q15. In the crystal structure of NaCl, each Na^+ ion is surrounded by:

(A) 4 Cl^- ions

(B) 6 Cl^- ions

(C) 8 Cl^- ions

(D) 12 Cl^- ions

Q16. Primary alcohols are oxidised to carboxylic acids using:

(A) Mild oxidising agent like PCC

(B) Strong oxidising agent like $KMnO_4$ or $K_2Cr_2O_7$

(C) Reducing agents

(D) Acid catalysts only

Q17. Sucrose is composed of glucose and:

(A) Galactose

(B) Fructose

(C) Mannose

(D) Ribose

Q18. Transition metals often exhibit variable oxidation states because:

(A) Electrons can be removed from both $(n-1)d$ and ns orbitals

(B) They have stable half-filled d orbitals

(C) They are always paramagnetic

(D) They form ionic bonds only

Q19. Amides are:

(A) Stronger bases than amines

(B) Weaker bases than amines

(C) Non-basic

(D) Acidic in nature

Q20. Vapour pressure of a liquid increases with:

(A) Increase in pressure

(B) Decrease in temperature

(C) Increase in temperature

(D) Increase in volume

Q21. Dimethyl ether (CH_3OCH_3) and ethanol (CH_3CH_2OH) have:

(A) The same molar mass but different boiling points

(B) Different molar masses but same boiling points

(C) Same molar mass and same boiling points

(D) Different molar masses and different boiling points

Q22. Natural rubber is a polymer of:

(A) Styrene

(B) Isoprene (2-methylbuta-1,3-diene)

(C) Butadiene

(D) Chloroprene

Q23. An amphoteric oxide is:

(A) Na_2O (basic oxide)

(B) CO_2 (acidic oxide)

(C) Al_2O_3 (amphoteric oxide)

(D) SiO_2 (acidic oxide)

Q24. In a colloidal solution, the particle size is typically in the range:

(A) 1 μm to 100 μm

(B) 1 nm to 1 μm

(C) 1 pm to 1 nm

(D) 100 μm to 1 mm

Q25. Benzoic acid (C_6H_5COOH) is extracted from aqueous solution using:

(A) Water

(B) Polar solvent

(C) Non-polar organic solvent (e.g., ether, chloroform)

(D) Aqueous NaOH

Q26. In the compound $K_2Cr_2O_7$, the oxidation state of Cr is:

(A) +2

(B) +3

(C) +6

(D) +7

Q27. EDTA (ethylenediaminetetraacetic acid) is a powerful chelating agent because:

(A) It is a monodentate ligand

(B) It is a hexadentate ligand with multiple donor atoms

(C) It has no lone pairs

(D) It is aromatic

Q28. Cyclohexane adopts a chair conformation because:

(A) It minimises ring strain and steric hindrance

(B) It is planar

(C) It has sp^2 hybridised carbons

(D) It maximises angle strain

Q29. The oxidation state of carbon in formaldehyde (HCHO) is:

(A) 0

(B) +1

(C) +2

(D) +4

Q30. The Nernst equation accounts for the effect of:

(A) Temperature only

(B) Concentration only

(C) Both temperature and concentration

(D) Pressure only

Detailed Solutions

Q1.

Solution

Concept: Tollens' reagent (ammoniacal $AgNO_3$) is a mild oxidising agent specific to aldehydes. It oxidises aldehydes to carboxylic acids while $AgNO_3$ is reduced to Ag metal (silver mirror test).

Step 1: Reaction: Aldehyde + Tollens' reagent $\rightarrow$ carboxylic acid (or carboxylate anion) + Ag(s) (silver precipitate).

Step 2: The aldehyde's H (on the CHO carbon) is removed and replaced with an additional O bond, forming COOH. This is oxidation of the aldehyde.

Step 3: Simultaneously, Ag^+ is reduced: $Ag^+ + e^- \rightarrow Ag(s)$. The black/white precipitate is metallic silver.

Note: Tollens' test is a characteristic test for aldehydes. Ketones do not react with Tollens' reagent (no oxidising attack on ketone carbonyls in mild conditions).
Final Answer: Aldehyde is oxidised to carboxylic acid $\Rightarrow$ B

Answer: (B)
Go Back to Q1

Q2.

Solution

Concept: The Bohr model successfully predicts energy levels only for hydrogen-like species (one electron). For multi-electron atoms, electron-electron repulsion and shielding complicate the model.

Step 1: Bohr's assumptions: (1) electron moves in circular orbits; (2) angular momentum = $n\hbar$; (3)$no radiation loss. These work for hydrogen (H) and hydrogen-like ions (He^+$, Li^{2+}, etc.).

Step 2: For oxygen (O) with 8 electrons, the Bohr model fails because it ignores electron-electron interactions. Each electron "sees" a nuclear charge reduced by the other electrons (shielding effect).

Step 3: Quantum mechanics (Schrödinger equation) is required for multi-electron atoms. The Bohr model is historically important but limited to hydrogen-like systems.

Note: The Bohr model predicts the Rydberg formula correctly for H, but energies for He^+, Li^{2+} follow $E_n = -13.6Z^2/n^2$ eV.
Final Answer: Bohr model applies to hydrogen-like ions only $\Rightarrow$ B

Answer: (B)
Go Back to Q2

Q3.

Solution

Concept:

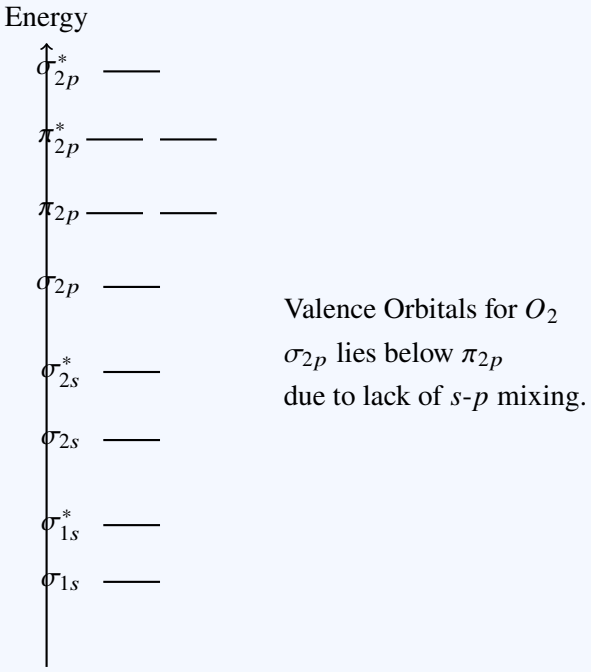
The spatial arrangement and energetic stabilization of homonuclear diatomic molecules are explained using Molecular Orbital (MO) theory. For oxygen (O_2), the filling of molecular orbitals follows specific energy ordering rules that govern its unique paramagnetic properties and chemical bond stability.

Solution:

(a) In O_2, the core $1s$ orbitals combine to yield low-energy bonding σ_{1s} and higher-energy antibonding σ^*_{1s} molecular orbitals. This baseline distribution patterns identically for the valence $2s$ subshells, yielding σ_{2s} followed by σ^*_{2s}.

(b) For elements with higher atomic numbers ($Z \geq 8$), the effective nuclear charge significantly suppresses the $2s$ subshell energy. This wide separation eliminates s-p orbital mixing, positioning the bonding σ_{2p} orbital below the degenerate bonding π_{2p} orbitals.

(c) Consequently, the specific sequence of orbital energy filling from lowest to highest follows the definitive progression: $\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \sigma_{2p} < \pi_{2p}$.



Final Answer: The correct filling sequence includes $\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \sigma_{2p} < \pi_{2p}$.

Answer: (C)

Go Back to Question 3

Q4.

Solution

Concept: Molecular formula is determined by counting all atoms: C, H, O. Structural formula ($CH_3COOC_2H_5$) shows the connectivity; molecular formula shows only atom counts.

Step 1: Ethyl acetate: $CH_3COOC_2H_5$. Write out fully: CH_3–CO–O–CH_2–CH_3.

Step 2: Count atoms: C: 1 (from CH_3) + 1 (from CO) + 2 (from C_2H_5) = 4 carbons. H: 3 + 0 + 5 = 8 hydrogens. O: 2 (from CO and O bridge) = 2 oxygens.

Step 3: Molecular formula: $C_4H_8O_2$.

Check: General formula for esters: R–COO–R′. Here R = CH_3 (C_1H_3) and R′ = C_2H_5 (C_2H_5). Total: $C_{1+2}H_{3+5}O_2 = C_4H_8O_2$.

Final Answer: $C_4H_8O_2 \Rightarrow$ B

Answer: (B)

Go Back to Q4

Q5.

Solution

Concept:

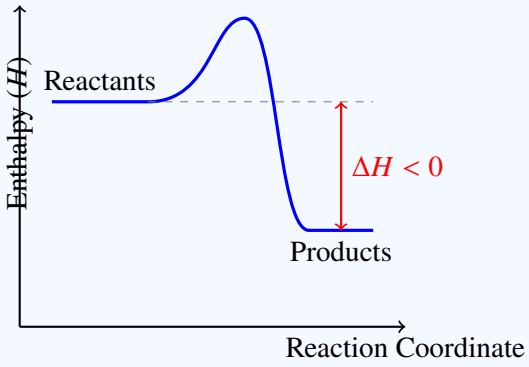
Chemical thermodynamics uses changes in system enthalpy to classify reactions based on net energy transmission. An exothermic transition is structurally defined by an overall release of heat to the surroundings due to energy alterations involved in breaking and forming bonds.

Solution:

(a) System enthalpy change (ΔH) represents the absolute heat content difference calculated precisely as $\Delta H = H_{\text{products}} - H_{\text{reactants}}$.

(b) In any exothermic process, energy release occurs because chemical bonds formed within the final products are thermodynamically more stable and lower in potential energy than the original bonds of the starting reactants.

(c) Because the chemical network sheds heat during this conversion, the final change in enthalpy evaluates to a negative value ($\Delta H < 0$). This mathematical inequality directly requires that the absolute enthalpy profile value of the products remains less than the enthalpy profile value of the reactants.



Final Answer: The enthalpy of products is less than the enthalpy of reactants.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Colour in gases arises from electronic absorption. Molecules with available electronic transitions in the visible spectrum absorb light and appear coloured.

Step 1: Nitrogen oxides: N_2O (colourless), NO (colourless), NO_2 (brown), N_2O_5 (white solid/colourless in gas).

Step 2: NO_2 has an unpaired electron (free radical, $\bullet NO_2$). This unpaired electron can transition to excited states by absorbing visible light (red-orange region). The absorption gives the brown colour.

Step 3: Other oxides lack unpaired electrons or have transitions only in UV range, so they appear colourless in visible light.

Note: NO is colourless but reacts with O_2 to form NO_2 (brown): $2NO + O_2 \rightarrow 2NO_2$. This is why air pollution appears brown.

Final Answer: NO_2 is brown (unpaired electron) $\Rightarrow$ C

Answer: (C)

Go Back to Q6

Q7.

Solution

Concept:

Chemical equilibrium networks respond dynamically to external perturbations according to Le Chatelier principle. When a dynamic equilibrium system at a constant temperature experiences a modification in external pressure or volume, the positions of the interacting chemical species adjust to counteract that explicit stress by shifting toward the direction containing fewer or more total moles of gas.

Solution:

(a) The given reversible gaseous reaction describes the thermal dissociation of phosphorus pentachloride into phosphorus trichloride and chlorine gas, which is represented by the chemical equation $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$.

(b) Evaluating the stoichiometric coefficients on both sides of the reaction allows for the determination of total gaseous moles. The reactant side contains exactly one mole of gas, while the product side contains two independent moles of gas.

(c) When external pressure is applied to this system at a constant temperature, the total volume decreases, increasing the overall concentration and partial pressures of all individual gaseous components inside the containment vessel.

(d) According to Le Chatelier principle, the system will naturally attempt to decrease this increased pressure stress. It achieves this stabilization by favoring the specific pathway that leads to a reduction in the total number of gaseous molecules.

(e) Because the reactant side possesses fewer total moles of gas compared to the product side, the position of the equilibrium shifts backward or toward the left, increasing the net production of PCl_5.

Final Answer: The equilibrium shifts towards reactants (left).

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept:

Chemical substances are grouped into acidic, basic, or amphoteric categories based on their capacity to donate or receive protons under Brønsted-Lowry parameters. An amphoteric compound possess a dual molecular nature, functioning as a proton donor when encountering strong bases or behaving as a proton acceptor in the presence of strong acids.

Solution:

(a) Evaluating the options reveals that hydrogen chloride (HCl) and nitric acid (HNO_3) operate exclusively as strong proton donors in aqueous solutions, qualifying them structurally as classic Brønsted-Lowry acids.

(b) Sodium hydroxide (NaOH) dissociates completely in water to yield hydroxide ions, which act as powerful proton acceptors, classifying this compound explicitly as a strong Arrhenius and Brønsted-Lowry base.

(c) Water (H_2O) exhibits autoionization and can uniquely display both behaviors depending on the chemical environment. When reacting with an acid like HCl, water accepts a proton to form a hydronium ion (H_3O^+), thereby acting as a base.

(d) Conversely, when reacting with a base like ammonia (NH_3), water donates a proton to form a hydroxide ion (OH^-), thereby functioning as an acid. This remarkable dual reactivity confirms its identity as a classic amphoteric substance.

Final Answer: The amphoteric compound is H_2O.

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept:

Electrochemical cells force non-spontaneous chemical reactions to occur via the application of external electrical currents through liquid electrolytes. During electrolysis, the negatively charged electrode is designated as the cathode, which serves as the physical site for reduction transformations where migrating chemical species actively gain valence electrons.

Solution:

(a) In the electrolysis of an aqueous copper sulfate solution using active copper electrodes, the ionic mixture contains mobile copper cations (Cu^{2+}), sulfate anions (SO_4^{2-}), hydrogen ions (H^+), and hydroxide ions (OH^-). at (0,0) [anchor=center] ;

(b) When an external voltage is applied, competing reduction reactions are possible at the cathode between the water molecules and the attracted copper cations. Copper possesses a significantly higher standard reduction potential compared to water.

(c) Due to this favorable standard reduction potential, copper ions are preferentially reduced at the cathode interface. The copper ions extract electrons directly from the electrode surface, converting into solid copper metal.

(d) Concurrently, the active copper anode undergoes an oxidation reaction where copper atoms dissolve back into the solution as cations. This dual action leads to the continuous transfer of copper from the anode to the cathode plate.

Final Answer: The cathode reaction is $Cu^{2+} + 2e^- \rightarrow Cu$.

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept:

Nucleophilic substitution mechanisms describe how electron-rich chemical species displace leaving groups attached to saturated tetrahedral carbon centers. The bimolecular substitution pathways follow a single energetic transition state where molecular bond construction and breaking transpire simultaneously without forming stable reaction intermediate configurations.

Solution:

(a) The term SN2 signifies a nucleophilic substitution reaction that exhibits second-order bimolecular kinetics. This kinetic profile implies that the absolute rate-determining step depends on the concentrations of both the attacking nucleophile and the substrate.

(b) The process occurs via a concerted single-step mechanism. The incoming nucleophile approaches the central carbon atom from the exact opposite side of the leaving group to minimize electron repulsion with the negative leaving group.

(c) This backside approach triggers a simultaneous transition state where the new covalent bond with the nucleophile begins to form while the existing carbon-halogen bond stretches and breaks.

(d) The entire transformation involves no discrete intermediates like carbocations. The simultaneous combination of nucleophilic attack and leaving group departure constitutes the lone transition barrier and dictates the rate-determining step of the entire sequence.

Final Answer: The rate-determining step involves a concerted backside attack by the nucleophile and C–X bond breaking.

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept:

Electrophilic aromatic substitution profiles are heavily modified by structural attachments already present on a benzene ring system. Functional groups influence both the total rate of reaction and the specific spatial positions where incoming chemical electrophiles connect to the conjugated aromatic network.

Solution:

(a) Toluene consists of a benzene ring bonded to a methyl substituent group. The attached methyl group modifies the underlying electron distribution of the aromatic pi cloud via inductive effects and hyperconjugation.

(b) Through hyperconjugation, the C-H sigma bonds of the methyl group donate electron density into the conjugated ring system. This donation increases the electron density across the aromatic ring, activating it toward electrophilic attack.

(c) Resonance structures demonstrate that this electron density increase is concentrated at the ortho and para positions relative to the methyl group. The meta positions receive no significant resonance stabilization.

(d) Because the ortho and para carbons are more electron-rich, they act as superior nucleophilic sites. Electrophiles selectively attack these positions due to the stable, low-energy sigma complexes formed during the intermediate steps.

Final Answer: Toluene undergoes substitution mainly at the ortho and para positions.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Standard enthalpy of formation (H_f°) is the enthalpy change when 1 mole of a compound is formed from its elements in their standard states.

Step 1: For an element in its standard state (e.g., $O_2(g)$, C(s), Fe(s)), H_f° is defined as zero by convention. No reaction occurs—the element is already in its standard form.

Step 2: This is a reference point used to calculate H_{rxn} for any reaction: $H_{rxn} = H_f^\circ$ (products) – H_f° (reactants).

Step 3: H_f° of compounds (formed from elements) can be positive or negative depending on whether formation is endothermic or exothermic.

Example: $H_f^\circ(O_2) = 0$; $H_f^\circ(O_3) = +143$ kJ/mol (formation of ozone from O_2 is endothermic).
Final Answer: H_f° of elements in standard state = 0 $\Rightarrow$ A

Answer: (A)
Go Back to Q12

Q13.

Solution

Concept: Secondary substrates undergo both SN1 and SN2, with the mechanism depending on conditions (solvent, nucleophile, temperature).

Step 1: Secondary alkyl bromide + water (nucleophile, poor in this context; solvent is protic).

Step 2: Protic aqueous solvent stabilises carbocations via solvation. Secondary carbocations are stable enough to form (E_a for ionisation is moderate). SN1 becomes competitive.

Step 3: In aqueous solution, SN1 mechanism dominates for secondary halides: slow ionisation to carbocation, then fast attack by H_2O forming the alcohol.

Note: With strong nucleophile (e.g., OH^-) in aprotic solvent (e.g., DMSO), SN2 would be preferred even for secondary.
Final Answer: Secondary bromide in water undergoes SN1 predominantly $\Rightarrow$ A

Answer: (A)
Go Back to Q13

Q14.

Solution

Concept:

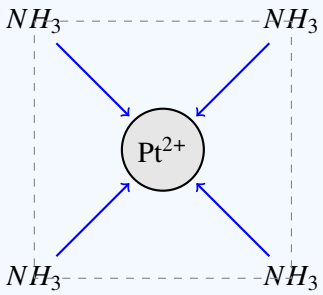
Coordination chemistry uses Crystal Field Theory (CFT) to evaluate geometric structure based on a central metal ion's d-orbital electron distribution. Platinum complexes represent a distinctive group where spatial configurations are strictly guided by large crystal field splitting values from high atomic mass periods.

Solution:

(a) Platinum exists in a +2 oxidation state inside the $[Pt(NH_3)_4]^{2+}$ complex. The underlying electronic configuration of atomic platinum is $[Xe]\,4f^{14}\,5d^9\,6s^1$, which becomes a stable d^8 configuration $[Xe]\,4f^{14}\,5d^8$ upon losing two outer electrons.

(b) Because Pt^{2+} belongs to the heavy $5d$ transition series, its valence electrons experience exceptionally large crystal field splitting energies. This intense interaction forces complete pairing of the $5d$ electrons, leaving one $5d$ orbital completely empty for chemical bonding.

(c) The empty $5d$, one $6s$, and two $6p$ valence orbitals undergo internal dynamic restructuring to yield four equivalent dsp^2 hybrid orbitals directed toward flat coplanar spatial coordinates, constructing a characteristic square planar coordination geometry.



Final Answer: The geometry of the complex is Square planar.

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept:

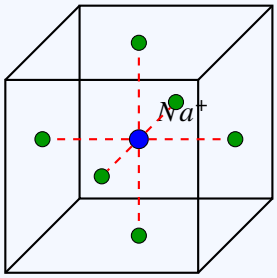
Solid-state crystal structure analysis groups ionic configurations into specific Bravais lattices depending on the relative physical sizes of cations and anions. The foundational rock salt ($NaCl$) layout features intersecting face-centered cubic sublattices that dictate maximum regular structural packing limits.

Solution:

(a) The basic structural morphology of sodium chloride features a closely packed arrangement of larger chloride anions (Cl^-) organizing into a face-centered cubic (FCC) lattice framework. The smaller sodium cations (Na^+) shift neatly into the intermediate octahedral void positions.

(b) Evaluating this structural intersection from a central point reveals that each individual sodium cation rests directly at the core of an identical, symmetric octahedral cage.

(c) This geometry places exactly six equidistant chloride anions around the central sodium ion along three orthogonal coordinate axes. Consequently, the coordination numbers for both ions match symmetrically in a balanced 6:6 crystal architecture.



Final Answer: Each sodium ion is surrounded by 6 chloride ions.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:

Organic oxidation pathways classify reagents based on their energetic capability to insert oxygen or remove hydrogen from organic substrates. The complete oxidation of primary aliphatic alcohols into carboxylic acids requires robust oxidants that can navigate through intermediate aldehyde configurations without stopping at that stage.

Solution:

(a) Primary alcohols undergo oxidation in two sequential stages due to the presence of two alpha hydrogen atoms available for elimination on the functional carbon.

(b) Mild oxidizing reagents, such as pyridinium chlorochromate (PCC) dissolved in anhydrous dichloromethane, facilitate only the first stage of oxidation, selectively transforming primary alcohols into volatile aldehydes.

(c) To complete the conversion directly to carboxylic acids, a powerful reagent is required to oxidize the initially formed aldehyde intermediate rapidly in situ before it can escape.

(d) Strong chemical oxidants, including potassium permanganate ($KMnO_4$) or acidified potassium dichromate ($K_2Cr_2O_7$), supply the necessary chemical potential to drive the primary alcohol completely past the aldehyde phase, terminating exclusively at the carboxylic acid stage.

Final Answer: Strong oxidising agent like $KMnO_4$ or $K_2Cr_2O_7$.

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept:

Carbohydrate chemistry classifies complex sugars based on their structural composition and the specific monosaccharide subunits liberated during chemical hydrolysis. Disaccharides consist of two individual cyclic monosaccharide rings linked together through a characteristic ether connection known as a glycosidic linkage.

Solution:

(a) Sucrose, commonly recognized as table sugar, is a naturally occurring non-reducing disaccharide that undergoes complete acid-catalyzed or enzymatic hydrolysis to yield equal amounts of two simpler monosaccharide units.

(b) The structural assembly of sucrose involves a condensation reaction between an alpha-D-glucose molecule and a beta-D-fructose molecule, establishing a unique cross-ring chemical bridge.

(c) The specific bond stabilizing this disaccharide framework is an alpha-1,2-glycosidic linkage, which directly joins the anomeric carbon atom one of the glucose ring with the anomeric carbon atom two of the fructose ring.

(d) Because both individual anomeric carbon centers are locked inside this glycosidic bond, sucrose loses the ability to open its ring structure in solution, making it completely non-reactive toward standard Tollens or Fehling test reagents.

Final Answer: Fructose.

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept:

The unique chemical behavior of d-block transition metals originates from their atomic orbital configurations. Unlike main-group elements that lose or share valence electrons exclusively from outer s or p shells, transition metals possess overlapping valence shells that allow deep-seated electrons to participate actively in chemical bonding.

Solution:

(a) Transition metals feature a valence electronic architecture represented generally by the notation $(n-1)d^{1-10}\,ns^{1-2}$, where electrons occupy both outer s and inner d subshells.

(b) The primary factor enabling these elements to display multiple stable oxidation states is the exceptionally small difference in energy levels separating the outer ns orbital from the underlying, penultimate $(n-1)d$ orbital.

(c) When these metals undergo chemical reactions, the electrons residing in the outer ns orbital are invariably stripped away first to generate baseline positive oxidation states.

(d) Because the energetic barrier is minimal, varying numbers of electrons from the adjacent $(n-1)d$ subshell can also be sequentially extracted during bond formation, culminating in a diverse array of stable oxidation states for a single metal.

Final Answer: Electrons can be removed from both $(n-1)d$ and ns orbitals.

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept:

The relative basicity of nitrogen-bearing organic functional groups depends on the localized availability of the unshared lone pair of electrons on the nitrogen atom. Structural features that alter electron density or redistribute this lone pair through resonance significantly reduce a compound capacity to accept protons.

Solution:

(a) Amines are characterized by an alkyl or aryl group attached to a nitrogen center, where the lone pair of electrons remains highly localized on the nitrogen atom, rendering them effective Brønsted-Lowry bases.

(b) Amides possess a nitrogen atom directly bonded to an electron-withdrawing carbonyl group, creating a highly conjugated system that facilitates strong resonance interaction.

(c) This structural resonance involves the delocalization of the nitrogen lone pair into the adjacent pi-system of the carbonyl group, effectively distributing the electron density onto the highly electronegative oxygen atom.

(d) Because this lone pair is involved in resonance stabilization, it becomes unavailable for donation to incoming protons, causing amides to exhibit significantly weaker basic properties compared to typical amines.

Final Answer: Weaker bases than amines.

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept:

The physical phenomenon of liquid vaporization represents a dynamic equilibrium established when molecules possess sufficient kinetic energy to overcome intermolecular cohesive forces and escape into the vapor phase. The rate of escape depends heavily on thermal energy distribution variations.

Solution:

(a) Vapour pressure is defined as the pressure exerted by a vapor in thermodynamic equilibrium with its condensed liquid phase at a specific temperature inside a closed system.

(b) According to kinetic molecular theory, increasing the temperature of a liquid directly expands the average kinetic energy profile of all constituent molecules within the container.

(c) As the thermal energy input rises, a significantly larger fraction of molecules gain sufficient velocity to sever the attractive intermolecular bonds holding them within the bulk liquid phase.

(d) This kinetic shift increases the rate of evaporation, populating the space above the liquid surface with a greater density of gas molecules, which drives up the measured vapour pressure of the system.

Final Answer: Increase in temperature.

Answer: (C)

Go Back to Question 20

Q21.

Solution

Concept:

Organic molecules possessing identical molecular formulas but contrasting structural arrangements are classified as functional isomers. While functional isomers share an identical total molecular mass, their different functional groups give rise to completely distinct intermolecular attractive networks and physical properties.

Solution:

(a) Dimethyl ether (CH_3OCH_3) and ethanol (CH_3CH_2OH) both possess the identical molecular formula C_2H_6O, which mathematically dictates that they exhibit the exact same molar mass of forty-six grams per mole.

(b) Ethanol contains a highly polar hydroxyl group (–OH) capable of forming strong, extensive intermolecular hydrogen bonding networks with neighboring ethanol molecules.

(c) Dimethyl ether lacks a hydrogen atom bonded directly to a highly electronegative element, preventing it from establishing intermolecular hydrogen bonds and leaving it reliant on much weaker dipole-dipole interactions.

(d) Because disrupting hydrogen bonds requires a far greater thermal energy input, ethanol exhibits a significantly higher boiling point than dimethyl ether despite sharing the exact same molecular mass.

Final Answer: The same molar mass but different boiling points.

Answer: (A)

Go Back to Question 21

Q22.

Solution

Concept:

Polymerization reactions involve the chemical linking of small, repeating molecular units known as monomers into long-chain macromolecular frameworks. The physical characteristics of natural elastomers are governed by the specific spatial geometry and chemical structure of their underlying monomeric subunits.

Solution:

(a) Natural rubber is a biopolymer harvested as latex from specific plant species, exhibiting remarkable elastic properties due to its regular, recurring unsaturated carbon backbone.

(b) Chemical analysis and thermal degradation demonstrate that the structural building block of natural rubber is the conjugated diene monomer commonly known as isoprene.

(c) The IUPAC nomenclature for this specific five-carbon monomeric unit is designated precisely as 2-methylbuta-1,3-diene.

(d) During natural stereospecific addition polymerization, these units connect exclusively in a cis-1,4 configuration, generating cis-polyisoprene, where the regular coiled arrangement allows the polymer chains to stretch and retract smoothly under mechanical stress.

Final Answer: Isoprene (2-methylbuta-1,3-diene).

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept:

Chemical oxides are categorized as acidic, basic, neutral, or amphoteric depending on their behavior when reacting with water, acids, or bases. This chemical behavior is heavily dictated by the ionic or covalent character of the element bonded to oxygen and its position on the periodic table.

Solution:

(a) Sodium oxide (Na_2O) is a highly ionic metal oxide that reacts readily with water to produce a strongly alkaline solution of sodium hydroxide, classifying it as a classic basic oxide.

(b) Carbon dioxide (CO_2) and silicon dioxide (SiO_2) are non-metal covalent oxides that interact with bases or water to yield acidic species or salts, defining them explicitly as acidic oxides.

(c) Aluminum oxide (Al_{2O3}) contains a metal with intermediate electronegativity, which gives the oxide a unique chemical nature capable of neutralizing both strong acids and strong bases.

(d) For example, aluminum oxide dissolves in hydrochloric acid to yield aluminum chloride salt and water, while simultaneously reacting with concentrated sodium hydroxide to generate soluble sodium aluminate, confirming its amphoteric identity.

Final Answer: Al_2O_3 (amphoteric oxide).

Answer: (C)

Go Back to Question 23

Q24.

Solution

Concept:

Mixtures are classified into true solutions, colloidal dispersions, or coarse suspensions based entirely on the average linear dimensions of the distributed solute or disperse phase particles. This specific size threshold determines whether a mixture will undergo gravitational settling or exhibit unique optical behaviors.

Solution:

(a) In a true solution, the solute particles dissolve completely down to the molecular or ionic level, maintaining an average particle diameter strictly below one nanometer.

(b) A suspension represents a heterogeneous mixture containing large particles exceeding one micrometer in size, which causes them to settle out over time under the influence of gravity.

(c) Colloidal solutions represent an intermediate state of matter where the disperse phase particles are larger than molecules but small enough to remain permanently suspended by Brownian motion.

This stable framework operates within a definitive particle size range spanning from one nanometer to one micrometer.

Final Answer: 1 nm to 1 μm.

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept:

The separation and purification of organic compounds from aqueous mixtures rely heavily on the principle of differential solubility. Liquid-liquid extraction utilizes a distribution solvent that is completely immiscible with water, allowing organic solutes to partition preferentially into the phase where they experience greater thermodynamic stability.

Solution:

(a) Benzoic acid contains a polar carboxylic acid group attached to a large, non-polar hydrophobic aromatic benzene ring, making it only sparingly soluble in cold water.

(b) To separate benzoic acid from an aqueous matrix efficiently, an extraction solvent must be introduced that creates a distinct, separate layer while maximizing solute solubility interactions.

(c) According to the principle of like dissolves like, the non-polar aromatic ring of benzoic acid interacts favorably via London dispersion forces with non-polar organic solvents such as diethyl ether or chloroform.

(d) Shifting the mixture inside a separating funnel causes the benzoic acid to migrate out of the highly polar water phase and dissolve preferentially into the non-polar organic solvent layer, which can then be isolated and evaporated.

Final Answer: Non-polar organic solvent (e.g., ether, chloroform).

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept:

The oxidation state of a specific atom within a polyatomic molecule or complex ion represents the hypothetical charge it would carry if all its shared chemical bonds were completely ionic. Determining this value relies on established oxidation number rules, which dictate that alkali metals always exhibit a constant positive charge while oxygen consistently retains a fixed negative charge in standard oxoanions.

Solution:

(a) The neutral chemical compound potassium dichromate is represented by the formula $K_2Cr_2O_7$. Because the entire structure carries no net electrical charge, the summation of the individual oxidation states for all combining constituent atoms must equal zero.

(b) According to periodic properties, potassium is an alkali metal belonging to Group 1, which assigns it a fixed oxidation state of $+1$. Concurrently, oxygen is highly electronegative and displays its standard oxidation state of -2 in this oxoanion network.

(c) Let the unknown oxidation state of a single chromium atom be represented by the variable x. Since the molecule contains two potassium atoms, two chromium atoms, and seven oxygen atoms, these quantities can be arranged into a balanced algebraic expression.

(d) Setting up the equation yields: $2(+1) + 2(x) + 7(-2) = 0$. Simplifying the numerical values results in the expression $2 + 2x - 14 = 0$, which can be further reduced to $2x - 12 = 0$.

(e) Isolating the variable gives $2x = 12$, which simplifies directly to $x = +6$. This calculation demonstrates that each chromium atom sustains a highly oxidized state, sharing six valence electrons across the bridging oxo-framework.

Final Answer: The oxidation state of Cr is +6.

Answer: (C)

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Q27.

Solution

Concept: Chelating ligands have multiple donor atoms that can coordinate to a single metal ion, forming ring structures (chelate rings). EDTA is a powerful chelating agent.

Step 1: EDTA (ethylenediaminetetraacetic acid): Has 6 potential donor sites—2 from the ethylenediamine part (N atoms) and 4 from the carboxylate groups (O atoms via C=O).

Step 2: Denticity: EDTA is hexadentate (binds via 6 atoms). Coordination to a metal ion forms multiple chelate rings (5 and 6-membered rings), greatly stabilising the complex.

Step 3: Chelate effect: Polydentate ligands have higher binding affinity than monodentate ligands of the same type. Entropy increase upon chelation (one ligand displaces multiple water molecules) drives coordination.

Application: EDTA is used in complexometric titrations, water softening (binds Ca^{2+}, Mg^{2+}), and chelation therapy (binding toxic metal ions).

Final Answer: EDTA is hexadentate with multiple donor atoms $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B)

Go Back to Q27

Q28.

Solution

Concept:

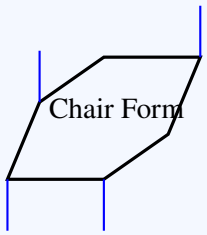
Conformational chemistry addresses structural stability fluctuations resulting from spatial deviations in non-planar saturated rings. For cyclohexane, stability optimization balances angle constraints with non-bonded atomic repulsions across three dimensions.

Solution:

(a) A perfectly flat, planar orientation for cyclohexane would constrain its structural bond angles to a wide 120°. This deviation creates severe angle strain away from the ideal tetrahedral angle of 109.5° required by its sp^3 hybrid carbons.

(b) To eliminate this energetic cost, cyclohexane puckers out of a flat configuration into a highly favorable three-dimensional chair conformation. This movement allows every single internal $C - C - C$ bond angle to expand or contract precisely to 110.9°.

(c) This structure also ensures all adjacent carbon-hydrogen linkages settle into perfectly staggered arrangements. This minimization removes torsional interactions while maximizing spatial separation between axial hydrogen atoms, driving down ring strain and steric hindrance.



Final Answer: It minimizes ring strain and steric hindrance.

Answer: (A)

Go Back to Question 28

Q29.

Solution

Concept: Oxidation state is assigned based on valence rules. For carbon, the typical state is +4 (C in CO_2), and it decreases with more bonding to H or less electronegative elements.

Step 1: Formaldehyde: H–C(=O)–H or HCHO. The C is double-bonded to O.

Step 2: Oxidation state assignment: Each H is –1 (to the C). O is –2. Let C oxidation state = x. For a neutral molecule: x + 2(–1) + (–2) = 0. $x = +4$... [wait, let me recalculate].

Step 3: Correct calculation: $x + 2(+1) + (--2) = 0$ (H contributes +1 to C in terms of oxidation accounting for formaldehyde's H as bonded to C by covalent rules; standard method: C oxidation = x; 2 H atoms contribute –1 each to balance; 1 O contributes –2). $x - 2 - 2 = 0$... [standard method]: Assign O = –2, H = +1: $x + 2(+1) - 2 = 0$, $x = 0$?

[Actually, standard: In HCHO, treat as C bonded to H and O. O is –2; H is +1. $x + 2(+1) + (-2) = 0 \Rightarrow x = 0$? No. Correct: Oxidation state of C in HCHO = +2. Let me use: (H × +1) + (O × –2) + x(C) = 0. $2(+1) + 1(--2) + x = 0$. $x = 0$.

Actually, the standard assignment in formaldehyde: C–O double bond; C is more oxidised than in alkanes (C = 0 in alkanes; C = +2 in aldehydes/ketones). In HCHO: C oxidation state = +2.
Final Answer: Oxidation state of C in HCHO = +2 $\Rightarrow$ C

Answer: (C)

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Q30.

Solution

Concept: The Nernst equation relates the actual cell potential to the standard cell potential and the effects of concentration and temperature.

Nernst Equation:

$$E = E^\circ - \frac{RT}{nF} \ln Q = E^\circ - \frac{0.0592}{n} \log Q$$

where Q is the reaction quotient (concentration-dependent).

Step 1: Standard cell potential (E°): calculated from standard reduction potentials (constant at a given T).

Step 2: Actual cell potential (E): depends on the reaction quotient Q, which changes with concentrations. At equilibrium, $Q = K$ and $E = 0$.

Step 3: Temperature dependence: E also depends on T via the RT/nF term. At different temperatures, the actual potential is different.

Note: The Nernst equation explains why cell voltages drop as a battery discharges (concentrations change, Q increases, E decreases).

Final Answer: Nernst accounts for both temperature and concentration effects $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	C	4	B	5	B
6	C	7	B	8	C	9	B	10	B
11	B	12	A	13	A	14	B	15	B
16	B	17	B	18	A	19	B	20	C
21	A	22	B	23	C	24	B	25	C
26	C	27	B	28	A	29	C	30	C