WBJEE Chemistry Sample Paper-3

Duration: 60 Minutes **Maximum Marks: 50**

Instructions

- This paper contains **40** Multiple Choice Questions divided into **3 Sections**.
- **Section A (Q1–Q30):** Each correct answer carries **+1 mark**. Incorrect answer: **−0.25** marks. Only **one** correct option.
- **Section B (Q31–Q35):** Each correct answer carries **+2 marks**. Incorrect answer: **−0.5** marks. Only **one** correct option.
- **Section C (Q36–Q40):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Section–A — 30 Questions × 1 Mark Each
(Negative Marking: −0.25) [Single Correct]

Q1. An organic hydrocarbon contains 85.7% carbon and 14.3% hydrogen by mass. If its vapor density is 21, what is the true molecular mass of this gaseous hydrocarbon?

(A) 28 g/mol

(B) 42 g/mol

(C) 56 g/mol

(D) 84 g/mol

Q2. A 20.0 mL sample of an aqueous oxalic acid ($H_2C_2O_4$) solution requires exactly 15.0 mL of a 0.05 M acidified $KMnO_4$ solution for complete oxidation. What is the molarity of the oxalic acid solution?

(A) 0.0938 M

(B) 0.0469 M

(C) 0.1875 M

(D) 0.0125 M

Q3. An electron is moving with a kinetic energy of 4.55×10^{-25} J. What is its de Broglie wavelength? (Given: mass of electron $m_e = 9.1 \times 10^{-31}$ kg, $h = 6.626 \times 10^{-34}$ J · s)

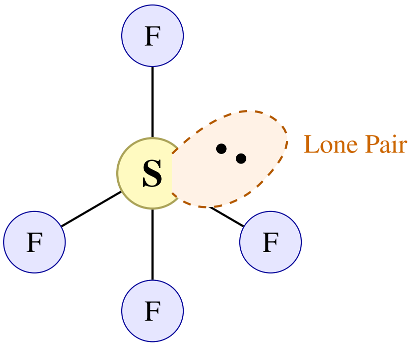
(A) 7.28×10^{-7} m

(B) 2.42×10^{-6} m

(C) 1.65×10^{-7} m

(D) 3.31×10^{-6} m

Q4. According to VSEPR theory, what is the spatial molecular geometry and the number of lone pairs on the central sulfur atom in sulfur tetrafluoride (SF_4)?



(A) See-saw geometry, 1 lone pair

(B) Square planar geometry, 2 lone pairs

(C) Tetrahedral geometry, 0 lone pairs

(D) Trigonal bipyramidal geometry, 2 lone pairs

Q5. A real gas obeys the van der Waals equation of state. Under what specific thermodynamic conditions do the physical properties of this real gas approach those of an ideal gas?

(A) High pressure and low temperature

(B) Low pressure and high temperature

(C) High pressure and high temperature

(D) Low pressure and low temperature

Q6. Two moles of an ideal gas undergo an isothermal reversible expansion at 300 K from an initial volume of 10 L to a final volume of 100 L. What are the values of the internal energy change (ΔU) and the work done (w) by the system respectively? (Given: $R = 8.314$ J/mol · K)

(A) $\Delta U = 0$ J, $w = -11.48$ kJ

(B) $\Delta U = 11.48$ kJ, $w = 0$ J

(C) $\Delta U = 0$ J, $w = -5.74$ kJ

(D) $\Delta U = -11.48$ kJ, $w = +11.48$ kJ

Q7. The solubility product (K_{sp}) of silver chromate (Ag_2CrO_4) in pure water at a specific temperature is $1.1{\times}10^{-12}$. What is its molar solubility in a 0.1 M $AgNO_3$ solution due to the common ion effect?

(A) 1.1×10^{-10} M

(B) 1.1×10^{-11} M

(C) 5.5×10^{-5} M

(D) 1.1×10^{-14} M

Q8. For a certain first-order reaction, a straight line graph is obtained by plotting $\ln[A]_t$ on the y-axis against time (t) on the x-axis, where $[A]_t$ represents the remaining reactant concentration. What do the slope and the y-intercept of this linear plot represent?

(A) Slope = k, Intercept = $[A]_0$

(B) Slope = $-k$, Intercept = $\ln[A]_0$

(C) Slope = $-k/2.303$, Intercept = $\log[A]_0$

(D) Slope = k, Intercept = $1/[A]_0$

Q9. Given the standard reduction potentials: $E^\circ(Zn^{2+}/Zn) = -0.76$ V, $E^\circ(Fe^{2+}/Fe) = -0.44$ V, and $E^\circ(Cu^{2+}/Cu) = +0.34$ V. Which of the following represents the correct decreasing sequence of reducing power for these neutral metallic elements?

(A) $Cu > Fe > Zn$

(B) $Zn > Cu > Fe$

(C) $Zn > Fe > Cu$

(D) $Fe > Zn > Cu$

Q10. When metallic lithium is heated directly under a clean stream of dry pure nitrogen gas, it reacts uniquely among all alkali metals to form a solid binary compound. What is the correct empirical formula of this compound?

(A) LiN

(B) LiN_3

(C) Li_3N

(D) Li_2N_3

Q11. The thermal stability of alkaline earth metal carbonates increases significantly as you descend Group 2. Which of the following arrangements correctly displays these carbonates in sequence of **decreasing** thermal stability?

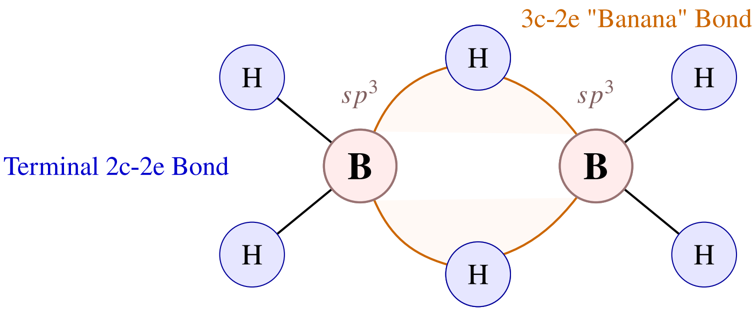
(A) $MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$

(B) $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$

(C) $CaCO_3 > MgCO_3 > BaCO_3 > SrCO_3$

(D) $BaCO_3 > CaCO_3 > SrCO_3 > MgCO_3$

Q12. Diborane (B_2H_6) is a classic electron-deficient molecule. Which description accurately depicts the nature of its bridging bonds and the hybridization state of its central boron atoms?



(A) Two 3-center-2-electron bonds; sp^3 hybridized boron

(B) Two 3-center-4-electron bonds; sp^2 hybridized boron

(C) Four 2-center-2-electron bonds; sp^3 hybridized boron

(D) Two 3-center-2-electron bonds; sp^2 hybridized boron

Q13. Consider the phosphorus oxoacids: orthophosphoric acid (H_3PO_4) and phosphorous acid (H_3PO_3). What are their true protic acidic basicities in aqueous environments?

(A) Both are triprotic acids

(B) H_3PO_4 is triprotic and H_3PO_3 is diprotic

(C) H_3PO_4 is diprotic and H_3PO_3 is monoprotic

(D) H_3PO_4 is triprotic and H_3PO_3 is monoprotic

Q14. The spin-only magnetic moment (μ) of transition metal ions depends on the number of unpaired d-electrons. Which of the following tripositive first-row transition metal aqua-ions possesses the **highest** spin-only magnetic moment value?

(A) Cr^{3+}

(B) Mn^{3+}

(C) Fe^{3+}

(D) Co^{3+}

Q15. According to Crystal Field Theory, what is the electronic configuration and magnetic nature of the central metal core within the low-spin octahedral coordination complex ion $[Co(NH_3)_6]^{3+}$?

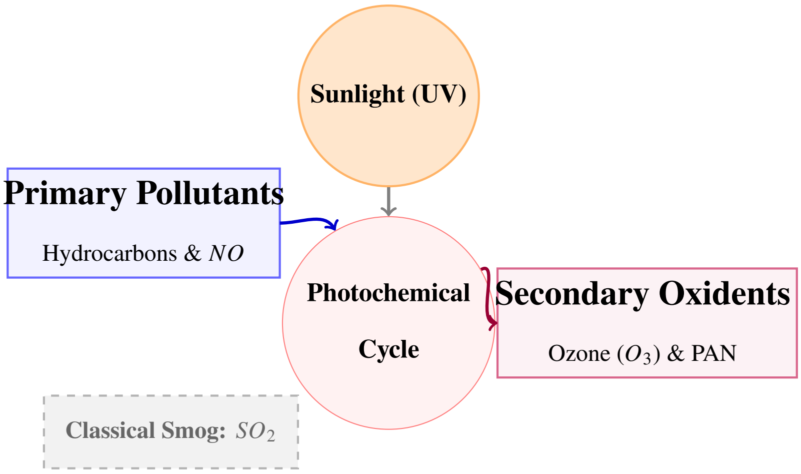
(A) $t_{2g}^4 e_g^2$, paramagnetic

(B) $t_{2g}^6 e_g^0$, diamagnetic

(C) $t_{2g}^5 e_g^1$, paramagnetic

(D) $t_{2g}^6 e_g^0$, paramagnetic

Q16. Photochemical smog is a modern atmospheric issue forming in warm, sunny urban regions. Which of the following chemical species is **NOT** a typical primary or secondary component involved in the cyclic pathways of photochemical smog?



(A) O_3

(B) NO_2

(C) Peroxyacetyl nitrate (PAN)

(D) SO_2

Q17. What is the correct systematic IUPAC name for the polyfunctional organic structural framework shown below?

$$CH_3 - CH(OH) - CH_2 - C(CH_3)_2 - COOH$$

(A) 2,2-Dimethyl-4-hydroxypentanoic acid

(B) 4-Hydroxy-2,2-dimethylpentanoic acid

(C) 4-Hydroxy-2-methylhexanoic acid

(D) 1-Carboxy-3,3-dimethylbutan-2-ol

Q18. When elemental bromine (Br_2) undergoes electrophilic anti-addition across the carbon-carbon double bond of a symmetric alkene, the geometric nature of the reactant dictates the stereochemical outcome. Which alkene yields a **racemic mixture** of enantiomers upon bromination?

(A) Ethene

(B) trans-But-2-ene

(C) cis-But-2-ene

(D) Propene

Q19. An optically active alkyl halide undergoes nucleophilic substitution via a pure unimolecular (S_N1) pathway. What is the fundamental kinetic and stereochemical outcome observed at the reaction center?

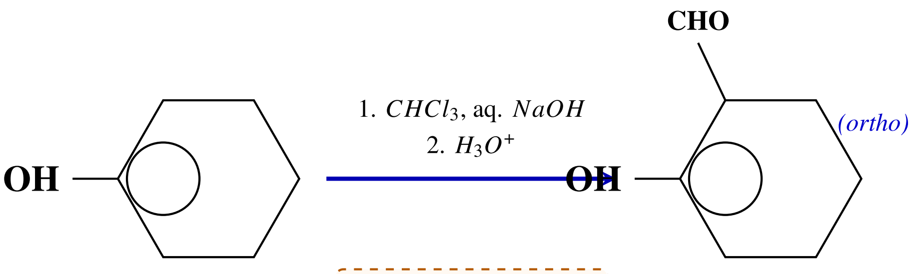
(A) Second-order kinetics accompanied by complete stereochemical inversion

(B) First-order kinetics accompanied by complete stereochemical inversion

(C) Second-order kinetics accompanied by partial stereochemical retention

(D) First-order kinetics accompanied by complete or partial racemization

Q20. When phenol is heated with chloroform ($CHCl_3$) in the presence of an aqueous sodium hydroxide medium followed by acidic workup, an ortho-formylation occurs. What is the principal organic product of this Reimer-Tiemann transformation?



Reactive Intermediate:
Electrophilic Dichlorocarbene ($:CCl_2$)

(A) Salicylic acid

(B) Salicylaldehyde

(C) Acetophenone

(D) Catechol

Q21. An unknown organic compound with the molecular formula C_3H_6O forms a bright orange-yellow precipitate when treated with 2,4-DNP reagent. However, it does not reduce Tollens' or Fehling's reagents. It forms a yellow crystalline solid when warmed with I_2 and $NaOH$. What is the identity of this compound?

(A) Propanal

(B) Allyl alcohol

(C) Acetone

(D) Methyl vinyl ether

Q22. Which of the following primary or secondary amino compounds reacts cleanly with cold nitrous acid (HNO_2) at 273–278 K to produce an aromatic diazonium salt solution that remains stable below 5°C?

(A) Ethylamine

(B) N-Methylaniline

(C) Triethylamine

(D) Aniline

Q23. The double-helical structure of DNA is stabilized by specific inter-strand non-covalent interactions. Which of the following accurately describes the precise hydrogen bonding patterns between complementary heterocyclic bases across the two strands?

(A) Adenine pairs with Uracil via two hydrogen bonds

(B) Guanine pairs with Cytosine via two hydrogen bonds

(C) Adenine pairs with Thymine via two hydrogen bonds, and Guanine pairs with Cytosine via three hydrogen bonds

(D) Adenine pairs with Cytosine via three hydrogen bonds

Q24. Synthetic polymers are classified based on their chain propagation steps. Which of the following commercial polymers is synthesized via a **condensation (step-growth) polymerization** mechanism?

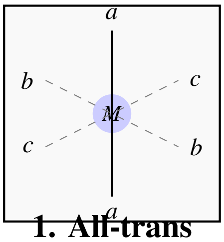
(A) Polyvinyl chloride (PVC)

(B) Teflon

(C) Nylon-6,6

(D) Polystyrene

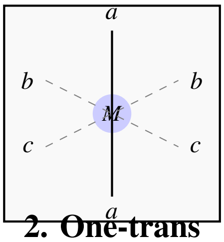
Q25. For an octahedral coordination complex configuration represented general-form as $[Ma_2b_2c_2]$ (where M is the central metal ion and a, b, c are distinct monodentate ligands), what is the total maximum number of stereoisomers (geometric + optical forms) possible?



1. All-trans

$(aa)(bb)(cc)$

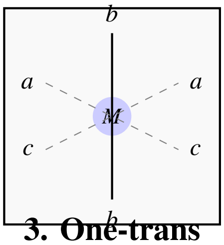
(Ach



2. One-trans

$(aa)(bc)(bc)$

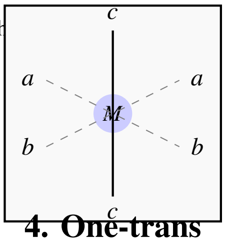
(Achiral)



3. One-trans

$(bb)(ac)(ac)$

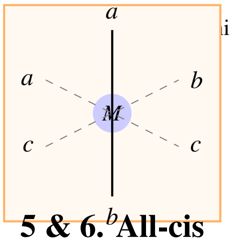
iral)



4. One-trans

$(cc)(ab)(ab)$

(Achiral)



5 & 6. All-cis

$(ab)(bc)(ac)$

(**Chiral: d + l forms**)

(A) 3

(B) 4

(C) 5

(D) 6

Q26. An aqueous solution of a non-volatile non-electrolyte solute exhibits a freezing point depression of 0.186°C. If 0.1 mol of magnesium chloride ($MgCl_2$) is dissolved in 1000 g of water instead, assuming complete ionic dissociation, what will be the observed freezing point depression? (Given: K_f for water = 1.86 K · kg/mol)

(A) 0.186°C

(B) 0.372°C

(C) 0.558°C

(D) 0.744°C

Q27. According to the principles of quantum mechanics, each orbital state is defined by a unique set of quantum values. Which of the following sets of quantum numbers represents an **impossible** physical orbital state?

(A) $n = 4, l = 0, m_l = 0, m_s = -1/2$

(B) $n = 3, l = 3, m_l = 0, m_s = +1/2$

(C) $n = 2, l = 1, m_l = -1, m_s = +1/2$

(D) $n = 3, l = 2, m_l = +2, m_s = -1/2$

Q28. According to Fajans' rules, the degree of covalent character within predominantly ionic chemical lattices increases under certain conditions. Which of the following halide salts exhibits the **greatest** amount of covalent character?

(A) $NaCl$

(B) $MgCl_2$

(C) $CaCl_2$

(D) $AlCl_3$

Q29. The rate constant (k) of a specific chemical reaction doubles when the ambient experimental temperature is increased from 300 K to 310 K. What is the approximate activation energy (E_a) of this reaction? (Given: $R = 8.314$ J/mol·K, $\ln 2 \approx 0.693$)

(A) 26.8 kJ/mol

(B) 53.6 kJ/mol

(C) 107.2 kJ/mol

(D) 44.3 kJ/mol

Q30. Consider the following dynamic gaseous chemical equilibrium system established inside a rigid container:

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

If the total pressure of this container is suddenly increased at a constant temperature by decreasing the volume, how will the equilibrium respond according to Le Chatelier's principle?

(A) Shift to the right to produce more PCl_3 and Cl_2

(B) Remain completely unaffected

(C) Shift to the left to increase the concentration of PCl_5

(D) K_p will increase

Section–B — 5 Questions × 2 Marks Each
(Negative Marking: -0.5) [Single Correct]

Q31. Chemical oxides are categorized based on their acid-base behavior. Which of the following oxides shows purely amphoteric behavior, dissolving readily in both strong aqueous acids and strong operational alkaline media?

(A) CaO

(B) Al_2O_3

(C) CO_2

(D) SO_3

Q32. In the classical systematic qualitative analysis framework, passing H_2S gas through an acidic sample solution precipitates both cupric ions (Cu^{2+}) and bismuth ions (Bi^{3+}) as their corresponding dark sulfides. Which chemical reagent can be used to selectively separate these two Group II metallic cations?

(A) Dilute HCl

(B) Hydrogen sulfide gas in basic medium

(C) Sodium chloride solution

(D) Excess aqueous ammonia solution

Q33. When bromobenzene is subjected to a classic aromatic nitration reaction using a mixture of concentrated nitric acid (HNO_3) and concentrated sulfuric acid (H_2SO_4), what is the dominant orientation behavior observed for the incoming nitro group?

(A) Exclusively forms meta-nitrobromobenzene

(B) Forms a mixture with meta-nitrobromobenzene as the major product

(C) Forms a mixture of ortho- and para-nitrobromobenzene with the para isomer dominating

(D) No reaction takes place due to full ring deactivation

Q34. Alkyl halides undergo base-induced bimolecular elimination ($E2$) reactions. Which of the following alkyl halide substrates will react most rapidly via an $E2$ pathway when treated with a hot concentrated solution of sodium ethoxide ($NaOCH_2CH_3$)?

(A) 1-Bromobutane

(B) 2-Bromobutane

(C) Bromomethane

(D) 2-Bromo-2-methylpropane

Q35. When benzaldehyde (C_6H_5CHO) is warmed in a concentrated (50%) aqueous solution of sodium hydroxide, it undergoes a self-disproportionation redox reaction because it lacks alpha-hydrogens. What primary organic product mixture is obtained from this Cannizzaro transformation?

(A) Benzoic acid and Benzene

(B) Benzyl alcohol and Benzoquinone

(C) Benzyl alcohol and Sodium benzoate

(D) Acetophenone and Sodium benzoate

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

Q36. Which of the following organic amino structures will yield a positive carbylamine test, forming a distinct, foul-smelling isocyanide compound when treated with chloroform and ethanolic potassium hydroxide?

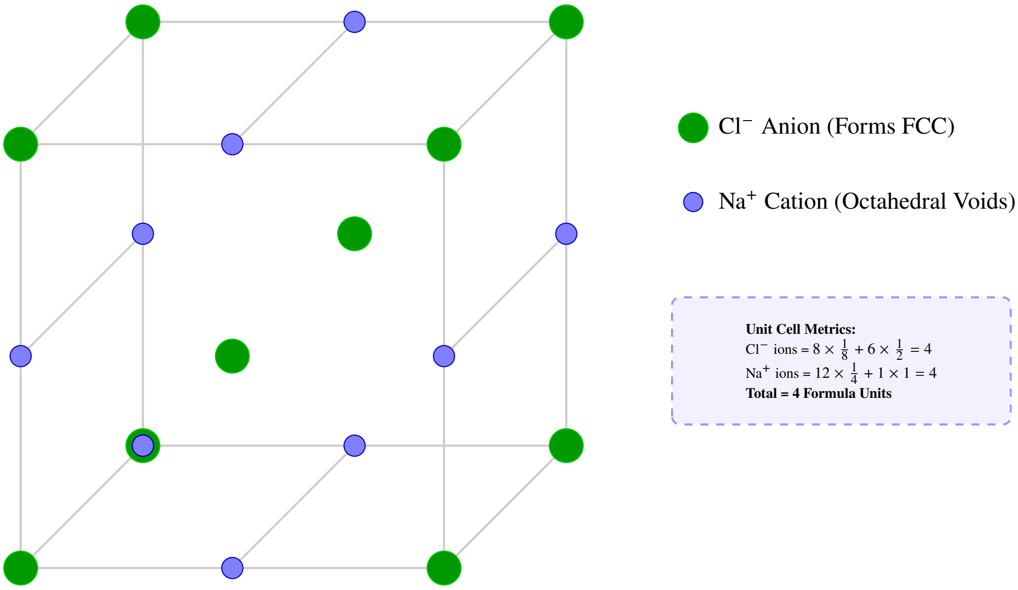
(A) N-Methylaniline

(B) Aniline

(C) N,N-Dimethylaniline

(D) Ethylamine

Q37. The solid-state crystal structure of sodium chloride ($NaCl$) features a face-centered cubic (fcc) arrangement of anions. Which of the following statements are structurally correct regarding this specific unit lattice configuration?



Unit Cell Metrics:
Cl^- ions = $8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$
Na^+ ions = $12 \times \frac{1}{4} + 1 \times 1 = 4$
Total = 4 Formula Units

(A) The coordination number of the Na^+ ion is 6, and that of the Cl^- ion is 6.

(B) Na^+ cations occupy all the tetrahedral voids within the lattice.

(C) Na^+ cations occupy all the octahedral voids within the lattice.

(D) The operational unit cell contains exactly 4 formula units of $NaCl$.

Q38. An ideal solution is prepared by mixing two volatile liquid components, benzene and toluene, which possess similar molecular structures. Which of the following thermodynamic parameters are strictly correct for this ideal mixing process?

(A) $\Delta H_{\text{mix}} = 0$

(B) $\Delta V_{\text{mix}} = 0$

(C) $\Delta S_{\text{mix}} > 0$

(D) $\Delta G_{\text{mix}} < 0$

Q39. Which of the following functional structural groups act as strong or moderate ortho/para-directing activators when attached directly to a benzene ring during an electrophilic aromatic substitution reaction?

(A) $-\text{NH}_2$

(B) $-\text{NO}_2$

(C) $-\text{OH}$

(D) $-\text{CH}_3$

Q40. When D-glucose is treated with an excess of phenylhydrazine ($C_6H_5NHNH_2$) under warm conditions, it yields a yellow crystalline derivative. Which of the following statements are correct regarding this carbohydrate process?

(A) Exactly three equivalents of phenylhydrazine are consumed per molecule of glucose.

(B) D-Fructose reacts with excess phenylhydrazine to form the exact same osazone product.

(C) The underlying chemical reaction modifies all six carbon centers of the sugar molecule.

(D) The final crystalline product obtained from this reaction is called glucosazone.

Detailed Solutions

Q1.

Solution

Concept:

The molecular mass of a volatile gas can be deduced from its vapor density using the relationship: Molecular Mass = 2 × Vapor Density. Once the molecular weight is known, the true molecular formula is calculated from the empirical mass ratio.

Solution:

(a) Calculate the total molecular mass of the compound: Molecular Mass $= 2 \times 21 = 42$ g/mol.

(b) Convert the mass percentages to atomic ratios by dividing each by its atomic mass:

- Carbon: $85.7/12 = 7.14$
- Hydrogen: $14.3/1 = 14.3$

(c) Divide each value by the smallest ratio (7.14) to find the simplest empirical integer step: C = 1, H = 2. The empirical formula is thus CH_2.

(d) Calculate the empirical unit formula mass: $12 + (2 \times 1) = 14$ g/mol.

(e) Determine the scaling multiplier n: $n = 42/14 = 3$. Multiplying the empirical formula by 3 yields C_3H_6, which has a true molecular mass of 42 g/mol.

Final Answer: The true molecular mass of this gaseous hydrocarbon is 42 g/mol.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept:

In redox volumetric titrations, the total chemical equivalents of the reducing agent must exactly equal the total equivalents of the oxidizing agent at the stoichiometric endpoint: $N_1V_1 = N_2V_2$.

Solution:

(a) Identify the electron exchange parameter (n-factor) for the chemical species in acidic solution:

- Permanganate (MnO_4^-) is reduced from +7 to +2, so $n_1 = 5$.
- Oxalic acid ($H_2C_2O_4$) is oxidized to CO_2, losing two electrons per molecule, so $n_2 = 2$.

(b) Apply the equivalence balance relation: $n_1 \times M_1 \times V_1 = n_2 \times M_2 \times V_2$.

(c) Substitute the known parameters into the equation: $5 \times 0.05\text{ M} \times 15.0\text{ mL} = 2 \times M_{\text{oxalic}} \times 20.0\text{ mL}$.

(d) Simplify the expression: $3.75 = 40 \times M_{\text{oxalic}}$.

(e) Solve for M_{oxalic}: $M_{\text{oxalic}} = 3.75/40 = 0.09375\text{ M} \approx 0.0938\text{ M}$.

Final Answer: The molarity of the oxalic acid solution is 0.0938 M.

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept:

The wave-particle duality of matter establishes that a moving particle possesses a de Broglie wavelength derived from its momentum: $\lambda = h/p = h/\sqrt{2m \cdot KE}$.

Solution:

(a) Write down the given values: $m_e = 9.1 \times 10^{-31}$ kg, $KE = 4.55 \times 10^{-25}$ J, and $h = 6.626 \times 10^{-34}$ J · s.

(b) Compute the momentum term inside the square root: $2 \cdot m_e \cdot KE = 2 \times (9.1 \times 10^{-31}) \times (4.55 \times 10^{-25}) = 82.81 \times 10^{-56}$.

(c) Take the square root to calculate the momentum value p: $p = \sqrt{82.81 \times 10^{-56}} = 9.1 \times 10^{-28}$ kg · m/s.

(d) Complete the division to find the wavelength λ: $\lambda = (6.626 \times 10^{-34})/(9.1 \times 10^{-28}) = 7.28 \times 10^{-7}$ m.

Final Answer: The de Broglie wavelength is 7.28×10^{-7} m.

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept:
VSEPR theory uses the steric number (number of bonded atoms + lone pairs on the central atom) to predict spatial molecular configurations and minimize electron cloud repulsion.
Solution:

(a) Determine the total valence electron count for the central sulfur atom (Group 16): 6 valence electrons.

(b) Sulfur forms 4 single covalent bonds to the four fluorine atoms, consuming 4 valence electrons.

(c) The remaining 2 valence electrons form exactly 1 lone pair on the sulfur atom.

(d) The total steric number is 4 bonds + 1 lone pair = 5. This maps to a trigonal bipyramidal electron geometry framework.

(e) Placing the lone pair in the roomier equatorial position to minimize lone pair-bonding pair repulsion gives a **see-saw** shape.

Final Answer: The geometry and lone pairs are See-saw geometry, 1 lone pair.

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept:
The van der Waals equation incorporates correction terms for intermolecular attractive forces (a) and finite molecular volume (b). Real gases approach ideal behavior when these correction factors become negligible.
Solution:

(a) At exceptionally low pressures, the volume occupied by the gas becomes very large, making the finite volume of the molecules (b) negligible compared to the total volume of the container.

(b) At high temperatures, the gas molecules possess high kinetic energy, allowing them to easily overcome intermolecular attractive forces (a) during collisions.

(c) Under these combined conditions, the correction terms approach zero, and the van der Waals equation simplifies directly to the ideal gas law ($PV = nRT$).

Final Answer: The specific thermodynamic conditions are Low pressure and high temperature.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept:

For an ideal gas, internal energy depends solely on temperature ($\Delta U = nC_v\Delta T$). During an isothermal process ($\Delta T = 0$), internal energy remains constant. The work done during a reversible expansion is given by: $w = -2.303\, nRT \log(V_f/V_i)$.

Solution:

(a) Since the system expands at a constant temperature of 300 K, $\Delta T = 0$, which means the internal energy change $\Delta U = 0$ J.

(b) Apply the work equation for a reversible isothermal expansion: $w = -2.303 \times 2\ \text{mol} \times 8.314\ \text{J/mol} \cdot \text{K} \times 300\ \text{K} \times \log(100/10)$.

(c) Simplify the logarithm term: $\log(10) = 1$.

(d) Complete the multiplication: $w = -2.303 \times 2 \times 8.314 \times 300 \times 1 = -11478\ \text{J} = -11.48\ \text{kJ}$.

Final Answer: The values are $\Delta U = 0$ J, $w = -11.48$ kJ.

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

Go Back to Question 6

Q7.

Solution

Concept:

The common ion effect suppresses the dissociation of a sparingly soluble salt when a soluble salt containing a shared ion is added, shifting the equilibrium position according to Le Chatelier's principle.

Solution:

(a) Write the solubility equilibrium for silver chromate: $Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq)$.

(b) Let S be the molar solubility of Ag_2CrO_4 in the solution. The concentration of chromate ions is $[CrO_4^{2-}] = S$.

(c) The total silver ion concentration comes from both salts: $[Ag^+] = (2S + 0.1)$ M. Since K_{sp} is exceptionally small, $2S \ll 0.1$, so $[Ag^+] \approx 0.1$ M.

(d) Set up the solubility product expression: $K_{sp} = [Ag^+]^2[CrO_4^{2-}] \implies 1.1 \times 10^{-12} = (0.1)^2 \times S$.

(e) Solve for S: $S = (1.1 \times 10^{-12})/0.01 = 1.1 \times 10^{-10}$ M.

Final Answer: The molar solubility is 1.1×10^{-10} M.

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept:

The integrated rate law for a first-order chemical reaction is given by $\ln[A]_t = -kt + \ln[A]_0$. This matches the equation of a straight line, $y = mx + c$.

Solution:

(a) Compare the first-order integrated rate expression $\ln[A]_t = -kt + \ln[A]_0$ to the standard linear equation $y = mx + c$.

(b) The variable plotted on the y-axis (y) is $\ln[A]_t$, and the variable on the x-axis (x) is time (t).

(c) The slope (m) corresponds to the multiplier of t, which is $-k$.

(d) The y-intercept (c) corresponds to the constant term, which is $\ln[A]_0$.

Final Answer: The slope and intercept represent Slope $= -k$, Intercept $= \ln[A]_0$.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept:
The standard reduction potential measures an ion's tendency to gain electrons. A more negative standard reduction potential indicates a weaker tendency to be reduced, meaning the neutral metal loses electrons more easily and acts as a stronger reducing agent.
Solution:

(a) Compare the given reduction potentials: $E°(Zn^{2+}/Zn) = -0.76$ V, $E°(Fe^{2+}/Fe) = -0.44$ V, and $E°(Cu^{2+}/Cu) = +0.34$ V.

(b) Zinc has the most negative potential (-0.76 V), making it the strongest reducing agent because it oxidizes most readily.

(c) Copper has a positive reduction potential ($+0.34$ V), meaning it strongly resists oxidation and is the weakest reducing agent among the three.

(d) Rank the neutral elements in order of decreasing reducing power: $Zn > Fe > Cu$.

Final Answer: The correct sequence of reducing power is $Zn > Fe > Cu$.

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept:
Lithium has a very small ionic radius, giving it a high lattice energy that stabilizes crystals with small, highly charged anions like the nitride ion (N^{3-}).
Solution:

(a) When heated under a clean stream of nitrogen gas, lithium reacts directly to form a stable ionic nitride salt, a property unique among alkali metals.

(b) Balance the ionic charges: Lithium forms a +1 cation (Li^{+}), while nitrogen forms a -3 nitride anion (N^{3-}).

(c) Combine the ions in a neutral ratio: Three Li^{+} ions balance one N^{3-} ion to achieve chemical neutrality, giving the empirical formula Li_3N.

Final Answer: The correct empirical formula is Li_3N.

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept:

The thermal stability of Group 2 carbonates depends on the charge density of the metal cation. High charge density distorts the large carbonate anion, weakening its bonds and lowering the decomposition temperature.

Solution:

(a) Down Group 2, the ionic radius increases while the ionic charge remains constant at +2: $Mg^{2+} < Ca^{2+} < Sr^{2+} < Ba^{2+}$.

(b) The small Mg^{2+} ion has the highest charge density, strongly polarizing the carbonate ion and making $MgCO_3$ thermally unstable.

(c) The large Ba^{2+} ion has the lowest charge density, causing minimal distortion and making $BaCO_3$ highly stable against heat.

(d) Therefore, thermal stability increases down the group, meaning the sequence of decreasing thermal stability is $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$.

Final Answer: The arrangement in sequence of decreasing thermal stability is $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept:

Diborane (B_2H_6) lacks enough valence electrons to form conventional two-electron covalent bonds between all its atoms, forming multicenter bonds instead.

Solution:

(a) Diborane contains 12 valence electrons in total. Four terminal B-H bonds consume 8 electrons in standard 2-center-2-electron (2c-2e) bonds.

(b) The remaining 4 electrons form two bridging B-H-B bonds. Each bridge involves three atoms sharing two electrons, forming a 3-center-2-electron (3c-2e) "banana bond".

(c) To accommodate these four localized orbital overlaps in a tetrahedral geometry, each central boron atom undergoes sp^3 hybridization.

Final Answer: The structure is defined by Two 3-center-2-electron bonds; sp^3 hybridized boron.

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept:

The basicity of a phosphorus oxoacid depends on the number of hydrogen atoms bonded to highly electronegative oxygen atoms (P-O-H groups), which can ionize in water. Hydrogen atoms bonded directly to phosphorus (P-H groups) are non-acidic.

Solution:

(a) Examine orthophosphoric acid (H_3PO_4): The central phosphorus atom is bonded to one oxygen via a double bond ($P = O$) and to three hydroxyl groups ($-OH$). All three hydrogens can ionize, making it a triprotic acid.

(b) Examine phosphorous acid (H_3PO_3): The central phosphorus is bonded to one $P = O$ oxygen, two $-OH$ hydroxyl groups, and one hydrogen atom directly ($P - H$). Only the two hydroxyl hydrogens can ionize in water, making it a diprotic acid.

Final Answer: The acid protic basicities are H_3PO_4 is triprotic and H_3PO_3 is diprotic.

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept:

The spin-only magnetic moment is calculated using the formula $\mu = \sqrt{n(n+2)}$ BM, where n is the number of unpaired electrons. A higher number of unpaired electrons yields a larger magnetic moment.

Solution:

(a) Determine the d-electron configuration for each tripositive transition metal ion:

- Cr^{3+}: Neutral Cr is $[Ar]3d^5 4s^1 \implies Cr^{3+}$ is $3d^3$, giving $n = 3$ unpaired electrons.
- Mn^{3+}: Neutral Mn is $[Ar]3d^5 4s^2 \implies Mn^{3+}$ is $3d^4$, giving $n = 4$ unpaired electrons.
- Fe^{3+}: Neutral Fe is $[Ar]3d^6 4s^2 \implies Fe^{3+}$ is $3d^5$, giving a half-filled subshell with $n = 5$ unpaired electrons.
- Co^{3+}: Neutral Co is $[Ar]3d^7 4s^2 \implies Co^{3+}$ is $3d^6$, giving $n = 4$ unpaired electrons.

(b) Since Fe^{3+} possesses the maximum possible number of unpaired d-electrons ($n = 5$), it exhibits the highest spin-only magnetic moment (≈ 5.92 BM).

Final Answer: The ion with the highest magnetic moment value is Fe^{3+}.

Answer: (C)

Go Back to Question 14

Q15.

Solution

Concept:

Under octahedral ligand fields, d-orbitals split into lower-energy t_{2g} and higher-energy e_g levels. Strong-field ligands force electrons to pair up in the lower levels, forming a low-spin configuration.

Solution:

(a) In the complex ion $[Co(NH_3)_6]^{3+}$, ammonia is a neutral ligand, which places cobalt in the +3 oxidation state, corresponding to a $3d^6$ configuration.

(b) Ammonia (NH_3) acts as a strong-field ligand with trivalent Co^{3+}, creating a large crystal field splitting energy (Δ_o) that exceeds the electron pairing energy (P).

(c) This large splitting forces all six d-electrons to pair up completely within the lower-energy t_{2g} orbitals, leaving the e_g orbitals empty.

(d) The resulting electronic configuration is $t_{2g}^6 e_g^0$. Because all electrons are paired up, the complex ion is diamagnetic.

Final Answer: The configuration and magnetic nature are $t_{2g}^6 e_g^0$, diamagnetic.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:

Photochemical smog is an oxidizing smog formed by the action of sunlight on unsaturated hydrocarbons and nitrogen oxides. Classical smog, by contrast, is a reducing smog containing sulfur dioxide (SO_2) that forms in cool, humid climates.

Solution:

(a) Photochemical smog begins primarily with the atmospheric emission of nitric oxide (NO) and volatile hydrocarbons from internal combustion engines.

(b) Solar photolysis of NO_2 generates free oxygen radicals that react with ambient O_2 to form ozone (O_3).

(c) Ozone then reacts with hydrocarbons to produce toxic secondary pollutants such as peroxyacetyl nitrate (PAN).

(d) Sulfur dioxide (SO_2) comes from burning sulfur-rich fossil fuels like coal and is the primary hallmark component of classical smog, not photochemical smog.

Final Answer: The chemical species that is not a component is SO_2.

Answer: (D)

Go Back to Question 16

Q17.

Solution

Concept:
IUPAC nomenclature ranks functional groups by priority. The principal group forms the suffix and defines carbon-1, while lower-priority groups are treated as prefixes arranged alphabetically.
Solution:

(a) Identify the functional groups present: a principal carboxylic acid group ($-COOH$) and a secondary hydroxyl alcohol group ($-OH$). Carboxylic acids hold the highest priority, so the suffix is "-anoic acid".

(b) Locate the longest continuous carbon chain containing the principal functional group: a five-carbon chain, making the root name pentanoic acid.

(c) Number the carbon chain starting directly from the carboxylic acid carbon as carbon-1.

(d) Identify the substituents along the numbered chain: Two methyl groups are located on carbon-2, and one hydroxyl group is located on carbon-4.

(e) Arrange the prefixes alphabetically ("hydroxy" comes before "methyl"): 4-Hydroxy-2,2-dimethylpentanoic acid.

Final Answer: The systematic IUPAC name is 4-Hydroxy-2,2-dimethylpentanoic acid.

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept:
Electrophilic bromination of an alkene proceeds via a cyclic bromonium ion intermediate, which blocks cis attack and forces anti-addition across the double bond.
Solution:

(a) Anti-addition across a planar alkene center is highly stereospecific.

(b) Halogenation of a symmetric *trans* alkene via anti-addition yields a single, optically inactive **meso** compound because the product has an internal plane of symmetry.

(c) Halogenation of a symmetric *cis* alkene (such as cis-but-2-ene) via anti-addition yields an equimolar mixture of non-superimposable mirror images. This forms a **racemic mixture** because the front and back attacks occur at equal rates.

Final Answer: The alkene that yields a racemic mixture is cis-But-2-ene.

Answer: (C)

Go Back to Question 18

Q19.

Solution

Concept:
The S_N1 mechanism involves a slow, rate-determining step where the leaving group departs to form a planar carbocation intermediate. This flat geometry allows the nucleophile to attack from either side with equal probability.

Solution:

(a) The rate-determining step depends entirely on the concentration of the alkyl halide alone, following first-order kinetics: Rate $= k[\text{R-X}]$.

(b) The departure of the leaving group creates a planar, sp^2 hybridized carbocation intermediate with a vacant p-orbital.

(c) The incoming nucleophile can attack this flat intermediate from either the front side or the back side with equal probability.

(d) This non-stereospecific dual-sided attack results in a mixture of retention and inversion, leading to complete or partial **racemization** at an initially optically active center.

Final Answer: The kinetic and stereochemical outcome is First-order kinetics accompanied by complete or partial racemization.

Answer: (D)

Go Back to Question 19

Q20.

Solution

Concept:
The Reimer-Tiemann reaction is an organic substitution process that introduces a formyl group ($-CHO$) onto an electron-rich aromatic ring, typically targeting the position ortho to a phenolic hydroxyl group.

Solution:

(a) Phenol reacts with sodium hydroxide to form a highly reactive phenoxide ion.

(b) Hydroxide ions deprotonate chloroform ($CHCl_3$) to generate a neutral, electrophilic dichlorocarbene intermediate ($: CCl_2$) via alpha-elimination.

(c) The highly reactive dichlorocarbene attacks the electron-rich ortho position of the phenoxide ring, forming a dichloromethyl intermediate.

(d) Alkaline hydrolysis replaces the chlorine atoms with hydroxyl groups, creating an unstable geminal diol that spontaneously loses water to yield an aldehyde group.

(e) Final acidic workup restores the phenol group, yielding 2-hydroxybenzaldehyde, commonly known as **salicylaldehyde**.

Final Answer: The principal product of this transformation is Salicylaldehyde.

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept:
Carbonyl compounds react with 2,4-DNP to form hydrazone precipitates. Aldehydes reduce Tollens' and Fehling's reagents, whereas ketones do not. Carbonyl compounds with a methyl ketone group ($CH_3 - C = O$) undergo the iodoform reaction.
Solution:

(a) The positive 2,4-DNP test confirms the presence of a carbonyl group ($C = O$), narrowing the possibilities for C_3H_6O to propanal or acetone.

(b) The negative Tollens' and Fehling's tests show that the compound resists mild oxidation, ruling out the aldehyde (propanal). This identifies it as a ketone (acetone).

(c) Acetone ($CH_3-CO-CH_3$) contains the required methyl ketone structure. When treated with I_2 and $NaOH$, it undergoes the haloform reaction to yield a yellow crystalline precipitate of iodoform (CHI_3), confirming its identity.

Final Answer: The identity of this compound is Acetone.

Answer: (C)

Go Back to Question 21

Q22.

Solution

Concept:
Primary aromatic amines react with nitrous acid at low temperatures (0–5°C) to form diazonium salts. These salts are stabilized by resonance delocalization of the positive charge into the aromatic ring.
Solution:

(a) Primary aliphatic amines like ethylamine form highly unstable diazonium salts that decompose immediately, even below 5°C, to evolve nitrogen gas.

(b) Secondary amines like N-methylaniline react with nitrous acid to form oily yellow N-nitroso compounds rather than diazonium salts.

(c) Aniline ($C_6H_5NH_2$) is a primary aromatic amine. At 273–278 K (0–5°C), it reacts cleanly with nitrous acid to form benzenediazonium chloride, which remains remarkably stable in solution below 5°C due to resonance stabilization with the phenyl ring.

Final Answer: The compound that produces a stable diazonium salt solution is Aniline.

Answer: (D)

Go Back to Question 22

Q23.

Solution

Concept:

The DNA double helix is stabilized by hydrogen bonding between complementary purine and pyrimidine bases on opposite strands. This pairing maintains a constant distance between the strands to prevent distortion.

Solution:

(a) DNA utilizes four primary heterocyclic bases: adenine (A), thymine (T), guanine (G), and cytosine (C). Uracil is used in RNA instead of thymine.

(b) To maintain a uniform double-helical diameter, a large two-ring purine base must always pair with a smaller single-ring pyrimidine base.

(c) Adenine pairs exclusively with thymine, forming **two hydrogen bonds**.

(d) Guanine pairs exclusively with cytosine, forming **three hydrogen bonds** due to the optimal spatial alignment of their respective carbonyl and amino groups.

Final Answer: The correct description is Adenine pairs with Thymine via two hydrogen bonds, and Guanine pairs with Cytosine via three hydrogen bonds.

Answer: (C)

Go Back to Question 23

Q24.

Solution

Concept:

Addition polymerization links unsaturated monomers without losing any atoms. Condensation polymerization combines polyfunctional monomers with the simultaneous elimination of small molecules like water or alcohol.

Solution:

(a) Polyvinyl chloride (PVC), Teflon, and polystyrene are synthesized via addition polymerization pathways, where the double bonds of vinyl chloride, tetrafluoroethene, and styrene open up to link monomers together without losing any byproducts.

(b) Nylon-6,6 is synthesized by reacting equimolar amounts of hexamethylenediamine and adipic acid.

(c) The amine groups react with the carboxylic acid groups to form strong amide linkages, eliminating a molecule of water with each step-growth coupling, which classifies it as a condensation polymer.

Final Answer: The commercial polymer synthesized via condensation is Nylon-6,6.

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept:
The total number of stereoisomers for a coordination complex is the sum of its geometrically distinct arrangements and any non-superimposable mirror images (enantiomers).

Solution:

(a) An octahedral complex of the form $[Ma_2b_2c_2]$ can form **5 geometric isomers** based on the spatial distribution of the ligand pairs:

- All-trans: $trans(a, a), trans(b, b), trans(c, c)$
- One pair trans, two pairs cis: three distinct arrangements depending on which specific pair is trans (a, b, or c).
- All-cis: $cis(a, a), cis(b, b), cis(c, c)$.

(b) The first four geometric isomers contain planes of symmetry and are optically inactive (achiral).

(c) The all-cis isomer completely lacks a plane of symmetry, making it chiral. It exists as a pair of non-superimposable optical enantiomers (dextro and levo forms).

(d) Summing the 5 geometric configurations plus the 1 additional optical enantiomer yields a total of **6 stereoisomers**.

Final Answer: The total maximum number of stereoisomers possible is 6.

Answer: (D)

Go Back to Question 25

Q26.

Solution

Concept:
Freezing point depression is a colligative property given by $\Delta T_f = i \cdot K_f \cdot m$. For electrolytic solutes, the van 't Hoff factor (i) accounts for the dissociation of the solute into multiple particles.
Solution:

(a) For the first solution, the non-electrolyte solute does not dissociate in water, so $i = 1$. The observed depression is $\Delta T_{f1} = 1 \cdot K_f \cdot m = 0.186°\text{C}$.

(b) Magnesium chloride ($MgCl_2$) is a strong electrolyte that dissociates completely in water: $MgCl_2(aq) \rightarrow Mg^{2+}(aq) + 2Cl^-(aq)$. One formula unit yields 3 distinct ions, so $i = 3$.

(c) The molality of the $MgCl_2$ solution (0.1 mol in 1000 g of water) is identical to that of the first solution (0.1 mol/kg).

(d) Since K_f and m are constant, the freezing point depression is directly proportional to the van 't Hoff factor: $\Delta T_{f2} = 3 \times \Delta T_{f1} = 3 \times 0.186°\text{C} = 0.558°\text{C}$.

Final Answer: The observed freezing point depression will be 0.558°C.

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept:
Quantum numbers must obey strict rules derived from the wave equation: the principal number n must be a positive integer; the azimuthal number l ranges from 0 to $n - 1$; and the magnetic number m_l ranges from $-l$ to $+l$.
Solution:

(a) Test option (A): $n = 4, l = 0, m_l = 0, m_s = -1/2$ is valid, describing an electron in a 4s orbital.

(b) Test option (B): $n = 3, l = 3$ violates the absolute quantum restriction that the azimuthal number l must be strictly less than n ($l \leq n - 1$). For the third energy shell ($n = 3$), the maximum allowed value for l is 2 (d-orbital). An l value of 3 represents an f-orbital, which does not exist for $n = 3$.

(c) Test options (C) and (D): Both sets perfectly satisfy all constraints, describing valid 2p and 3d orbitals respectively.

Final Answer: The impossible physical orbital state is $n = 3, l = 3, m_l = 0, m_s = +1/2$.

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept:
Fajans' rules state that covalent character increases with high polarization of the anion electron cloud. This is favored by small cation size, high cation charge, and large anion size.

Solution:

(a) All four compounds share the exact same chloride anion (Cl^-), so the relative differences depend entirely on the nature of the metal cation.

(b) Compare the charges of the cations: Na^+, Mg^{2+}, Ca^{2+}, and Al^{3+}. Aluminum carries the highest positive charge (+3).

(c) Compare their relative ionic sizes: Moving across the period from sodium to aluminum, the increasing effective nuclear charge pulls the outer electron shells closer, making Al^{3+} the smallest ion.

(d) Because the Al^{3+} cation possesses both the highest charge and the smallest radius, it has an exceptionally high charge density. This allows it to strongly polarize the chloride electron cloud, inducing the greatest amount of covalent character.

Final Answer: The halide salt with the greatest covalent character is $AlCl_3$.

Answer: (D)

Go Back to Question 28

Q29.

Solution

Concept:

The temperature dependence of a reaction rate constant is modeled by the linear Arrhenius equation: $\ln(k_2/k_1) = (E_a/R) \cdot [(1/T_1) - (1/T_2)]$.

Solution:

(a) Set up the parameters given: The rate constant doubles, so $k_2/k_1 = 2$. The initial and final absolute temperatures are $T_1 = 300$ K and $T_2 = 310$ K.

(b) Substitute these values into the Arrhenius expression: $\ln(2) = (E_a/8.314) \times [(1/300) - (1/310)]$.

(c) Simplify the temperature bracket: $(310 - 300)/(300 \times 310) = 10/93000 = 1/9300$.

(d) Substitute $\ln(2) \approx 0.693$ and rearrange to isolate the activation energy term: $0.693 = (E_a/8.314) \times (1/9300) \implies E_a = 0.693 \times 8.314 \times 9300$.

(e) Complete the multiplication: $E_a \approx 53583$ J/mol ≈ 53.6 kJ/mol.

Final Answer: The approximate activation energy is 53.6 kJ/mol.

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept:
Le Chatelier's principle states that increasing the total pressure of a gaseous system at equilibrium shifts the reaction in the direction that reduces the total number of gas moles, minimizing the pressure stress.

Solution:

(a) Count the moles of gas on each side of the balanced chemical equation:

- Reactant side: 1 mole of $PCl_5(g)$.
- Product side: 1 mole of $PCl_3(g)$ + 1 mole of $Cl_2(g)$ = 2 moles of gas.

(b) Increasing the total pressure by reducing the volume squeezes the gas particles closer together, increasing molecular stress.

(c) To relieve this pressure stress, the system shifts toward the side with fewer total moles of gas.

(d) Since 1 mole of reactant gas is less than 2 moles of product gas, the equilibrium shifts to the left, increasing the concentration of PCl_5.

Final Answer: The equilibrium will Shift to the left to increase the concentration of PCl_5.

Answer: (C)

Go Back to Question 30

Q31.

Solution

Concept:
Amphoteric oxides exhibit both acidic and basic properties. They react with strong acids to form salts and water, and with strong bases to form soluble complex coordination compounds.
Solution:

(a) Calcium oxide (CaO) is a metal oxide from an electropositive alkaline earth metal, making it purely basic.

(b) Carbon dioxide (CO_2) and sulfur trioxide (SO_3) are non-metal oxides that readily react with water to form carbonic and sulfuric acids, making them purely acidic.

(c) Aluminum oxide (Al_2O_3) lies near the metal-nonmetal boundary line, giving it intermediate amphoteric properties.

(d) It reacts cleanly with strong acids to form aluminum salts: $Al_2O_3+6HCl \rightarrow 2AlCl_3+3H_2O$.

(e) It also dissolves in strong basic media to form soluble aluminate complex coordinates: $Al_2O_3 + 2NaOH + 3H_2O \rightarrow 2Na[Al(OH)_4]$, confirming its amphoteric behavior.

Final Answer: The oxide showing purely amphoteric behavior is Al_2O_3.

Answer: (B)

Go Back to Question 31

Q32.

Solution

Concept:
Cation separation in qualitative analysis exploits differences in coordination chemistry. When excess ammonia is added, one metal ion forms a soluble coordination complex while the other precipitates as an insoluble hydroxide.
Solution:
1. Both Cu^{2+} and Bi^{3+} precipitate as sulfides (CuS and Bi_2S_3) in acidic H_2S, so options (A), (B), and (C) fail to separate them. 2. Adding excess aqueous ammonia differentiates the two ions through their coordination behavior. 3. Bismuth ions do not form stable amine complexes. Instead, they undergo basic hydrolysis to form a white, gelatinous precipitate of bismuth hydroxide, $Bi(OH)_3$, which remains insoluble. 4. Copper ions react readily with excess ammonia to form a stable, water-soluble coordination complex, $[Cu(NH_3)_4]^{2+}$, which turns the solution a deep blue. Filtration easily separates the solid bismuth hydroxide from the soluble copper complex.
Final Answer: Excess aqueous ammonia solution

Answer: (D)

Go Back to Question 32

Q33.

Solution

Concept:

The directing effect of a substituent depends on the balance between its inductive and resonance effects. Activators increase electron density on the ring and direct incoming electrophiles to the ortho and para positions.

Solution:

1. In bromobenzene, the bromine atom exerts two opposing electronic forces: a strong electron-withdrawing inductive effect ($-I$) due to its electronegativity, and a weak electron-donating resonance effect ($+M$) via its lone pairs. 2. The inductive effect reduces the overall electron density of the ring, making bromobenzene less reactive than benzene. 3. However, the resonance donation stabilizes the positive charge of the arenium intermediate specifically at the ortho and para positions during an attack. 4. Because resonance controls the orientation, the incoming nitro group attacks the ortho and para positions. 5. The ortho position experiences steric hindrance from the bulky bromine atom, which shifts the product distribution in favor of the unhindered para position. This yields a mixture dominated by para-nitrobromobenzene.

Final Answer: Forms a mixture of ortho- and para-nitrobromobenzene with the para isomer dominating

Answer: (C)

Go Back to Question 33

Q34.

Solution

Concept:

The $E2$ mechanism is a concerted, single-step elimination reaction where a base abstracts a proton as the leaving group departs. The transition state develops alkene character, so factors that stabilize the resulting alkene lower the activation energy.

Solution:

1. According to Zaitsev's rule, highly substituted alkenes are thermodynamically more stable due to hyperconjugation and inductive stabilization from the alkyl groups. 2. Group the substrates by structural class: 1-bromobutane is primary, 2-bromobutane is secondary, bromomethane cannot undergo elimination (no beta-carbon), and 2-bromo-2-methylpropane is tertiary. 3. When the strong base ethoxide reacts with the tertiary substrate, 2-bromo-2-methylpropane, it abstracts a proton from one of the nine equivalent beta-hydrogens. 4. This elimination forms 2-methylpropene, a highly stable branched alkene. Because the transition state leading to this stable product is low in energy, the tertiary alkyl halide reacts most rapidly.

Final Answer: 2-Bromo-2-methylpropane

Answer: (D)

Go Back to Question 34

Q35.

Solution

Concept:

The Cannizzaro reaction is a base-catalyzed redox disproportionation unique to aldehydes that lack alpha-hydrogens. In a concentrated strong base, these aldehydes cannot form an enolate ion to undergo an aldol condensation.

Solution:

1. In benzaldehyde (C_6H_5CHO), the formyl carbon is bonded directly to an sp^2 aromatic carbon that carries no hydrogen atoms, meaning it has zero alpha-hydrogens. 2. Treating it with a concentrated 503. Hydroxide ions attack the carbonyl carbon of one benzaldehyde molecule to form a tetrahedral intermediate. 4. This intermediate collapses and transfers a hydride ion (H^-) to a second benzaldehyde molecule. 5. The molecule that loses the hydride ion is oxidized to benzoic acid, which instantly reacts with the basic medium to form a sodium benzoate salt. The molecule that accepts the hydride ion is reduced to benzyl alcohol, yielding an equimolar mixture of both products.

Final Answer: Enzyl alcohol and Sodium benzoate

Answer: (C)

Go Back to Question 35

Q36.

Solution

Concept:

The carbylamine reaction (Hofmann's isocyanide test) is exclusive to primary amino groups ($-NH_2$). Heating a primary amine with chloroform and a strong base forms an isocyanide, which is easily recognized by its intensely foul odor.

Solution:

1. Identify the structural class of each amine: * N-Methylaniline is a secondary aromatic amine. * N,N-Dimethylaniline is a tertiary aromatic amine. * Aniline ($C_6H_5NH_2$) is a primary aromatic amine. * Ethylamine ($CH_3CH_2NH_2$) is a primary aliphatic amine.

2. Secondary and tertiary amines cannot undergo this reaction because they lack the two protons on the nitrogen atom required to form the carbon-nitrogen triple bond of the isocyanide.

3. Aniline and ethylamine are primary amines. The strong base removes a proton and a chloride ion from chloroform ($CHCl_3$) via alpha-elimination to generate a highly reactive dichlorocarbene intermediate ($: CCl_2$). 4. The nucleophilic nitrogen of the primary amine attacks the dichlorocarbene, undergoing successive eliminations of HCl to form phenyl isocyanide (C_6H_5NC) and ethyl isocyanide (CH_3CH_2NC) respectively, both of which have a characteristic foul odor.

Final Answer: Aniline, Ethylamine

Answer: (B, D)

Go Back to Question 36

Q37.

Solution

Concept:

The rock-salt crystal structure consists of an interlocking network of ions. The larger anions form a close-packed lattice, while the smaller counter-ions occupy the internal voids to maximize electrostatic attraction.

Solution:

1. In the $NaCl$ unit cell, the larger chloride anions (Cl^-) form a face-centered cubic (fcc) lattice. 2. The smaller sodium cations (Na^+) occupy all the available octahedral voids within this framework (located at the body center and along the twelve edges). This configuration gives each ion an octahedral coordination environment, meaning the coordination number for both Na^+ and Cl^- is 6. This confirms statements (A) and (C). 3. Calculate the number of ions per unit cell to verify statement (D): * Chloride ions: 8 corners $\times(1/8)$ + 6 faces $\times(1/2)$ = 4 ions. * Sodium ions: 12 edges $\times(1/4)$ + 1 body center $\times 1$ = 4 ions.

4. The unit cell contains exactly 4 units of $NaCl$. Statement (B) is incorrect because the tetrahedral voids remain completely empty.

Final Answer: The coordination number of the + ion is 6, and that of the ion is 6.

+ cations occupy all the octahedral voids within the lattice.

The operational unit cell contains exactly 4 formula units of .

$\boxed{\textbf{Answer: (A, C, D)}}$

Go Back to Question 37

Q38.

Solution

Concept:

An ideal solution forms when the intermolecular forces between the mixed components match the cohesive forces within the pure liquids. The thermodynamic changes associated with an ideal mixing process reflect these balanced interactions.

Solution:

1. Because the new A-B interactions match the original A-A and B-B interactions in strength, the energy required to break old bonds equals the energy released forming new ones. This results in no net heat change, so $\Delta H_{\text{mix}} = 0$ (Statement A).

2. For the same reason, the molecular spacing does not expand or contract upon mixing. The total volume equals the sum of the individual volumes, meaning $\Delta V_{\text{mix}} = 0$ (Statement B).

3. Intermingling two separate components increases the spatial disorder and the number of available microstates in the system, so the entropy change must be positive: $\Delta S_{\text{mix}} > 0$ (Statement C).

4. Because the mixing process is spontaneous, the Gibbs free energy change ($\Delta G_{\text{mix}} = \Delta H_{\text{mix}} - T\Delta S_{\text{mix}}$) must be negative: $\Delta G_{\text{mix}} < 0$ (Statement D).

Final Answer: A, B, C, D

$\boxed{\textbf{Answer: (A, B, C, D)}}$

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Q39.

Solution

Concept:

Ortho/para-directing activators increase electron density on a benzene ring relative to hydrogen, making it more reactive toward electrophilic attack. This is achieved through resonance donation of lone pairs or inductive/hyperconjugative donation from alkyl groups.

Solution:

1. Examine the amino group ($-NH_2$) and hydroxyl group ($-OH$): The nitrogen and oxygen atoms possess unshared lone pairs positioned directly adjacent to the aromatic pi-system. These atoms donate electron density into the ring through a strong resonance effect ($+M$), activating the ring and directing incoming groups to the ortho and para positions. This confirms statements (A) and (C).

2. Examine the methyl group ($-CH_3$): It lacks lone pairs but donates electron density through a combination of a weaker inductive effect ($+I$) and hyperconjugation, acting as an activator that directs to the ortho and para positions. This confirms statement (D).

3. The nitro group ($-NO_2$) contains a highly positive nitrogen atom bonded to electronegative oxygens, which strongly withdraws electron density from the ring via resonance ($-M$), making it a deactivating meta-director.

Final Answer: A, C, D

Answer: (A, C, D)

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Q40.

Solution

Concept:

Osazone formation involves a sequence of condensation and redox reactions between a reducing sugar and phenylhydrazine. The reaction alters only the first two carbon atoms of the carbohydrate chain.

Solution:

1. Under warm, mildly acidic conditions, one molecule of D-glucose consumes exactly three equivalents of phenylhydrazine to form the final crystalline product, glucosazone. This confirms statements (A) and (D).

2. The first equivalent forms a standard phenylhydrazone at the aldehyde carbon ($C-1$). The second equivalent acts as an oxidizing agent, converting the adjacent secondary alcohol group at carbon-2 ($C-2$) into a ketone while being reduced to aniline and ammonia. The third equivalent condenses with this new ketone group to form the osazone.

3. Because the reaction modifies only $C-1$ and $C-2$, the remaining carbon centers ($C-3$ to $C-6$) are unaltered. Statement (C) is therefore incorrect.

4. D-fructose is a functional isomer of glucose with an identical stereochemical configuration from $C-3$ to $C-6$. Because the reaction removes their structural differences at the first two carbons, both sugars yield the exact same crystalline derivative, glucosazone, confirming statement (B).

Final Answer: A, B, D

Answer: (A, B, D)

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Answer Key

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