NEET-UG Chemistry Sample Paper-14

Duration: 1 Hour **Maximum Marks: 180**

Instructions

- This paper contains a total of **45** Multiple Choice Questions.
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries **-1 mark**.
- No negative marking for unattempted questions.

Q1. An element has a face-centered cubic (fcc) structure with a cell edge of 200 pm. The atomic radius is:

(A) $100\sqrt{2}$ pm

(B) $50\sqrt{2}$ pm

(C) 100 pm

(D) $200/\sqrt{2}$ pm

Q2. Which of the following aqueous solutions will have the highest boiling point?

(A) 1.0 M KNO_3

(B) 1.0 M Na_2SO_4

(C) 1.0 M Glucose

(D) 1.0 M $AlCl_3$

Q3. The standard reduction potentials of three metals A, B, and C are +0.5 V, -3.0 V, and -1.2 V respectively. The reducing power of these metals are in the order:

(A) A > B > C

(B) C > B > A

(C) A > C > B

(D) B > C > A

Q4. For a zero-order reaction, the plot of concentration of reactant [R] vs time (t) is a straight line with:

(A) Slope = k and intercept = $[R]_0$

(B) Slope = -k and intercept = $[R]_0$

(C) Slope = -k/2.303 and intercept = log $[R]_0$

(D) Slope = k and intercept = 0

Q5. Which of the following is an example of an associated colloid?

(A) Protein in water

(B) Soap in water above CMC

(C) Rubber in benzene

(D) As_2S_3 sol

Q6. The correct order of increasing bond angle in the following is:

(A) $NH_3 < PH_3 < AsH_3 < SbH_3$

(B) $SbH_3 < AsH_3 < PH_3 < NH_3$

(C) $PH_3 < NH_3 < SbH_3 < AsH_3$

(D) $NH_3 < SbH_3 < AsH_3 < PH_3$

Q7. The hybridization of the central metal ion in $[Co(NH_3)_6]^{3+}$ is:

(A) sp^3d^2

(B) d^2sp^3

(C) dsp^2

(D) sp^3d

Q8. Which of the following is most reactive towards S_N1 reaction?

(A) CH_3CH_2Cl

(B) $C_6H_5CH_2Cl$

(C) C_6H_5Cl

(D) $(C_6H_5)_3CCl$

Q9. Which of the following is a non-reducing sugar?

(A) Lactose

(B) Glucose

(C) Sucrose

(D) Maltose

Q10. In the extraction of copper from its sulfide ore, the metal is formed by the reduction of Cu_2O with:

(A) FeS

(B) CO

(C) Cu_2S

(D) SO_2

Q11. The number of angular nodes and radial nodes of a 4d orbital, respectively, are:

(A) 2, 1

(B) 1, 2

(C) 3, 0

(D) 2, 2

Q12. Which of the following species contains three bond pairs and one lone pair around the central atom?

(A) H_2O

(B) BF_3

(C) NH_2^-

(D) PCl_3

Q13. For the reaction $C(s) + O_2(g) \rightarrow CO_2(g)$, ΔH is equal to:

(A) $\Delta U + RT$

(B) $\Delta U - RT$

(C) ΔU

(D) $\Delta U + 0.5RT$

Q14. The pK_a of a weak acid (HA) is 4.5. The pOH of an aqueous buffered solution of HA in which 50% of the acid is ionized is:

(A) 4.5

(B) 9.5

(C) 2.25

(D) 7.0

Q15. In the reaction $3Br_2 + 6OH^- \rightarrow 5Br^- + BrO_3^- + 3H_2O$, bromine is:

(A) Oxidized only

(B) Reduced only

(C) Both oxidized and reduced

(D) Neither oxidized nor reduced

Q16. Temporary hardness of water is due to the presence of:

(A) Magnesium bicarbonate

(B) Calcium chloride

(C) Magnesium sulfate

(D) Calcium sulfate

Q17. Which of the following alkaline earth metal sulfates has the highest solubility in water?

(A) $BaSO_4$

(B) $MgSO_4$

(C) $CaSO_4$

(D) $SrSO_4$

Q18. Boric acid is a polymer because of:

(A) Its acidic nature

(B) The presence of hydrogen bonds

(C) Its monobasic nature

(D) Its geometry

Q19. The IUPAC name of $CH_3 - CH(OH) - CH_2 - CHO$ is:

(A) 3-hydroxybutanal

(B) 2-hydroxybutanal

(C) 3-oxobutanol

(D) 2-oxobutanol

Q20. Which of the following will give a precipitate with ammoniacal silver nitrate?

(A) Ethane

(B) Ethene

(C) Ethyne

(D) Propene

Q21. The gas responsible for the "Blue Baby Syndrome" is:

(A) Sulfate

(B) Fluoride

(C) Nitrate

(D) Chloride

Q22. The rate of a first-order reaction is 0.04 mol $L^{-1}s^{-1}$ at 10 seconds and 0.03 mol $L^{-1}s^{-1}$ at 20 seconds after initiation of the reaction. The half-life of the reaction is:

(A) 44.1 s

(B) 54.1 s

(C) 24.1 s

(D) 34.1 s

Q23. Which of the following is a condensation polymer?

(A) Nylon-6,6

(B) Teflon

(C) Buna-S

(D) Neoprene

Q24. Which of the following is used as an "Antacid"?

(A) Omeprazole

(B) Chloramphenicol

(C) Penicillin

(D) Morphine

Q25. Which of the following ions is colorless in aqueous solution?

(A) Ti^{3+}

(B) Cu^{2+}

(C) Sc^{3+}

(D) Fe^{2+}

Q26. The entropy change for the fusion of 1 mole of ice at 273 K (latent heat of fusion = 6.0 kJ/mol) is:

(A) 21.98 $JK^{-1}mol^{-1}$

(B) 2.198 $JK^{-1}mol^{-1}$

(C) 219.8 $JK^{-1}mol^{-1}$

(D) 0.2198 $JK^{-1}mol^{-1}$

Q27. Which of the following does not give a positive Cannizzaro reaction?

(A) Formaldehyde

(B) Benzaldehyde

(C) Acetaldehyde

(D) Trimethylacetaldehyde

Q28. The strongest acid among the following is:

(A) CH_3COOH

(B) $ClCH_2COOH$

(C) FCH_2COOH

(D) $BrCH_2COOH$

Q29. Aniline on reaction with $NaNO_2$ and HCl at 0-5°C followed by treatment with $CuCN$ gives:

(A) Nitrobenzene

(B) Benzonitrile

(C) Benzylamine

(D) Chlorobenzene

Q30. For the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, the degree of dissociation (α) is related to the total pressure (P) and equilibrium constant (K_p) as:

(A) $\alpha = \sqrt{\frac{K_p}{P+K_p}}$

(B) $\alpha = \sqrt{\frac{K_p}{P}}$

(C) $\alpha = \frac{K_p}{P}$

(D) $\alpha = \sqrt{\frac{P}{K_p}}$

Q31. Which of the following represents the correct order of electron gain enthalpy (most negative first)?

(A) F > Cl > Br > I

(B) Cl > F > Br > I

(C) I > Br > F > Cl

(D) Cl > F > I > Br

Q32. The number of geometrical isomers possible for $[Pt(NH_3)_2Cl_2]$ is:

(A) 1

(B) 2

(C) 3

(D) 4

Q33. An ideal solution is formed when its components:

(A) Have no volume change on mixing

(B) Have no enthalpy change on mixing

(C) Obey Raoult's Law

(D) All of the above

Q34. What is the oxidation state of Phosphorus in $Ba(H_2PO_2)_2$?

(A) +3

(B) +1

(C) +5

(D) -1

Q35. The dehydration of alcohols to form alkenes follows the order:

(A) Primary > Secondary > Tertiary

(B) Tertiary > Secondary > Primary

(C) Secondary > Primary > Tertiary

(D) All have the same rate

Q36. The hydration enthalpy of alkali metal ions follows the order:

(A) $Li^+ > Na^+ > K^+ > Rb^+$

(B) $Rb^+ > K^+ > Na^+ > Li^+$

(C) $Li^+ > K^+ > Na^+ > Rb^+$

(D) $Na^+ > Li^+ > K^+ > Rb^+$

Q37. In a Schottky defect:

(A) An ion occupies an interstitial site

(B) Equal number of cations and anions are missing

(C) Only cations are missing

(D) The density of the crystal increases

Q38. Aspirin is chemically:

(A) Methyl salicylate

(B) Ethyl salicylate

(C) Acetylsalicylic acid

(D) o-hydroxybenzoic acid

Q39. Which vitamin is water-soluble?

(A) Vitamin A

(B) Vitamin D

(C) Vitamin C

(D) Vitamin K

Q40. Prussian blue color in the Lassaigne's test for nitrogen is due to the formation of:

(A) $Fe_4[Fe(CN)_6]_3$

(B) $Fe_3[Fe(CN)_6]_2$

(C) $Fe[Fe(CN)_6]$

(D) $Na_3[Fe(CN)_6]$

Q41. Which of the following is most stable?

(A) 1-butene

(B) cis-2-butene

(C) trans-2-butene

(D) 2-methyl-2-butene

Q42. Which of the following is the strongest oxidizing agent?

(A) F_2

(B) Cl_2

(C) Br_2

(D) I_2

Q43. The energy of an electron in the nth orbit of Hydrogen is given by $E_n = -13.6/n^2$ eV. The energy required to excite an electron from ground state to the first excited state is:

(A) 3.4 eV

(B) 10.2 eV

(C) 13.6 eV

(D) 1.51 eV

Q44. The bond order of O_2^- ion is:

(A) 2

(B) 1

(C) 1.5

(D) 2.5

Q45. The unit of cell constant is:

(A) $ohm^{-1}cm^{-1}$

(B) $ohmcm$

(C) cm^{-1}

(D) cm

Detailed Solutions

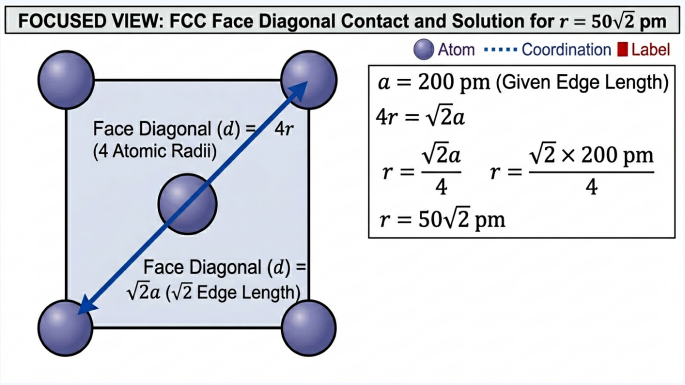
Q1.

Solution

Concept: In a Face-Centered Cubic (FCC) unit cell: - Atoms are present at the corners and the centers of each face. - The atoms touch each other along the face diagonal. - Relationship between edge length (a) and atomic radius (r):

$$\text{Face Diagonal} = \sqrt{2}a = 4r$$

$$r = \frac{\sqrt{2}a}{4} = \frac{a}{2\sqrt{2}}$$



Solution: Given edge length (a) = 200 pm. Using the FCC relationship:

$$r = \frac{\sqrt{2} \times 200}{4}$$

$$r = \frac{200}{2\sqrt{2}}$$

To simplify to match the options:

$$r = \frac{100}{\sqrt{2}}$$

Multiply numerator and denominator by $\sqrt{2}$:

$$r = \frac{100\sqrt{2}}{2}$$

$$r = 50\sqrt{2} \text{ pm}$$

Comparing with the given options, the atomic radius is $50\sqrt{2}$ pm.

Answer: (B)

Q2.

Solution

Concept: The boiling point of a solution is a colligative property, meaning it depends on the number of solute particles in the solution. The elevation in boiling point (ΔT_b) is given by:

$$\Delta T_b = i \cdot K_b \cdot m$$

where: - i is the van't Hoff factor (number of particles the solute dissociates into). - K_b is the ebullioscopic constant of the solvent. - m is the molality (assumed proportional to Molarity here). For solutions with the same concentration, the one with the highest **van't Hoff factor (i)** will have the highest boiling point.

Solution: We analyze the dissociation of each solute in aqueous solution:

1. **KNO_3**: Dissociates into two ions (K^+ and NO_3^-).

$$i = 2$$

2. **Na_2SO_4**: Dissociates into three ions ($2Na^+$ and SO_4^{2-}).

$$i = 3$$

3. **Glucose**: It is a non-electrolyte and does not dissociate.

$$i = 1$$

4. **$AlCl_3$**: Dissociates into four ions (Al^{3+} and $3Cl^-$).

$$i = 4$$

Comparing the values of i: - KNO_3: $i = 2$ - Na_2SO_4: $i = 3$ - Glucose: $i = 1$ - $AlCl_3$: $i = 4$ Since $AlCl_3$ produces the maximum number of particles ($i = 4$), it will result in the maximum elevation of the boiling point.

Final Answer: 1.0 M $AlCl_3$ will have the highest boiling point.

Answer: (D)

Q3.

Solution

Concept: Reducing power refers to the ability of a substance to reduce others by losing its own electrons (undergoing oxidation). In terms of electrochemical potentials: * A **lower (more negative) standard reduction potential** indicates a greater tendency to lose electrons. * Therefore, the **more negative** the reduction potential, the **stronger** the reducing agent (higher reducing power).

Solution: We are given the standard reduction potentials (E°) for the three metals: 1. **Metal A:** +0.5 V 2. **Metal B:** −3.0 V 3. **Metal C:** −1.2 V

To determine the order of reducing power, we arrange them from the most negative potential to the most positive potential: * **Metal B (−3.0 V):** Most negative value; it has the highest tendency to get oxidized and thus is the strongest reducing agent. * **Metal C (−1.2 V):** Intermediate value; its reducing power is less than B but greater than A. * **Metal A (+0.5 V):** Most positive value; it has the least tendency to lose electrons and thus is the weakest reducing agent.

The decreasing order of reducing power is: **B > C > A**.

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

Answer: (D)

Q4.

Solution

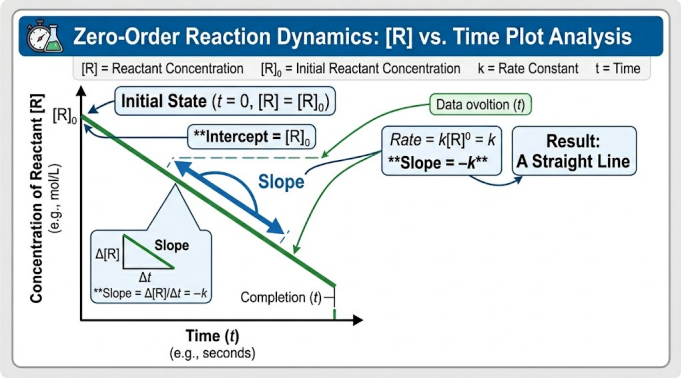
Concept: For a zero-order reaction, the rate of reaction is independent of the concentration of the reactants. The differential rate equation is:

$$-\frac{d[R]}{dt} = k[R]^0 = k$$

Integrating this from $t = 0$ (where $[R] = [R]_0$) to time t gives the integrated rate equation:

$$[R] = -kt + [R]_0$$

This equation follows the form of a straight line, $y = mx + c$.



Solution: 1. Compare the integrated rate equation $[R] = -kt + [R]_0$ to the linear equation $y = mx + c$: - y-axis: Concentration of reactant $[R]$ - x-axis: Time t - Slope (m): $-k$ - Intercept (c): Initial concentration $[R]_0$ 2. Thus, a plot of $[R]$ vs t yields a straight line with a negative slope equal to the rate constant k.

Final Answer: Slope = $-k$ and intercept = $[R]_0$.

Answer: (B)

Q5.

Solution

Concept: Colloids are classified based on the nature of the particles of the dispersed phase: * **Multimolecular colloids:** Aggregates of a large number of atoms or smaller molecules (e.g., Gold sol, S_8 molecules). * **Macromolecular colloids:** Large molecules that form solutions in the colloidal range (e.g., proteins, starch, rubber). * **Associated colloids (Micelles):** Substances that behave as normal strong electrolytes at low concentrations but exhibit colloidal behavior at higher concentrations (above the Critical Micelle Concentration or CMC) due to the formation of aggregates.

Solution: 1. **Protein in water:** This is a macromolecular colloid because proteins are naturally large molecules. 2. **Soap in water above CMC:** Soap molecules (sodium stearate) aggregate at concentrations above the CMC to form micelles. These are the classic example of associated colloids. 3. **Rubber in benzene:** This is a macromolecular colloid. 4. **As_2S_3 sol:** This is a multimolecular colloid formed by the aggregation of many arsenic sulfide molecules.

Final Answer: Soap in water above CMC is an example of an associated colloid.

Answer: (B)

Q6.

Solution

Concept: The bond angle in hydrides of Group 15 elements (NH_3, PH_3, AsH_3, SbH_3) is determined by the electronegativity of the central atom and the size of the atom. According to VSEPR theory and Drago's rule: * As the electronegativity of the central atom decreases, the bond pair-bond pair repulsion decreases. * As the size of the central atom increases, the bond pairs are further away from each other, allowing the lone pair to compress the bond angle more effectively.

Solution: 1. In NH_3, Nitrogen is highly electronegative. The bond pairs are pulled closer to the Nitrogen atom, resulting in strong bond pair-bond pair repulsion, which keeps the bond angle large (approx. 107°). 2. Down the group ($N \rightarrow P \rightarrow As \rightarrow Sb$), the electronegativity of the central atom decreases and its size increases. 3. The bond pairs shift further away from the central atom, reducing the repulsion between them. This allows the lone pair to push the bond pairs closer together. 4. For PH_3, AsH_3, and SbH_3, the bond angles drop significantly (approaching 90°) as the orbitals used for bonding have more p-character (Drago's Rule). 5. The correct increasing order of bond angle is: $SbH_3 < AsH_3 < PH_3 < NH_3$.

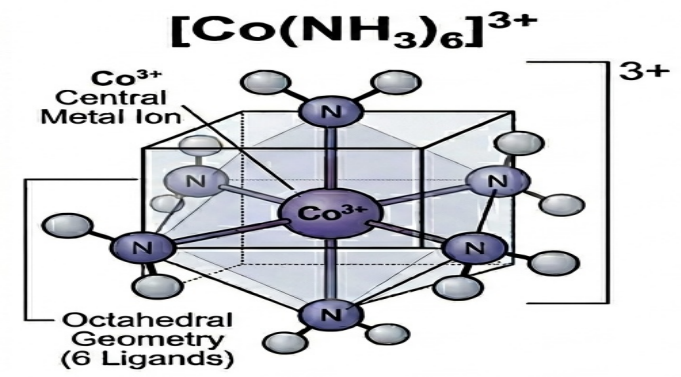
Final Answer: The correct order is $SbH_3 < AsH_3 < PH_3 < NH_3$.

Answer: (B)

Q7.

Solution

Concept: The hybridization of a coordination complex depends on the coordination number, the oxidation state of the metal, and the strength of the ligand (Crystal Field Theory). * Ammonia (NH_3) acts as a **strong field ligand** when complexed with Co^{3+}. * Strong field ligands cause the pairing of electrons in the d-orbitals (low spin complex).



Solution: 1. **Oxidation State:** In $[Co(NH_3)_6]^{3+}$, let x be the oxidation state of Cobalt. $x + 6(0) = +3 \Rightarrow x = +3$. 2. **Electronic Configuration:** Atomic number of Co is 27 ($[Ar]3d^7 4s^2$). Co^{3+} configuration is $[Ar]3d^6 4s^0$. 3. **Ligand Effect:** NH_3 is a strong field ligand for Co^{3+}. It forces the 6 electrons in the $3d$ orbital to pair up in the t_{2g} orbitals. 4. **Orbital Availability:** After pairing, two $3d$ orbitals become empty. These two $3d$, one $4s$, and three $4p$ orbitals hybridize to form six d^2sp^3 hybrid orbitals. 5. This results in an **inner orbital octahedral complex**.

Final Answer: The hybridization is d^2sp^3.

Answer: (B)

Q8.

Solution

Concept: The S_N1 reaction (Substitution Nucleophilic Unimolecular) proceeds via the formation of a **carbocation intermediate**. The rate of the reaction is directly proportional to the stability of the carbocation formed in the rate-determining step. Carbocation stability follows the general order:

$$\text{Benzilic/Allylic (with resonance)} > 3^\circ > 2^\circ > 1^\circ > \text{Methyl}$$

Solution: We analyze the stability of the carbocation formed after the departure of the chloride ion (Cl^-) for each option:
1. **CH_3CH_2Cl**: Forms an ethyl carbocation ($CH_3CH_2^+$), which is a 1° carbocation. It is very unstable. 2. **$C_6H_5CH_2Cl$**: Forms a benzyl carbocation ($C_6H_5CH_2^+$). It is stabilized by resonance with one benzene ring. 3. **C_6H_5Cl**: The Cl is attached to an sp^2 carbon. Phenyl carbocations are extremely unstable, and the $C-Cl$ bond has partial double bond character due to resonance, making it nearly inert to S_N1. 4. **$(C_6H_5)_3CCl$**: Forms a triphenylmethyl carbocation ($(C_6H_5)_3C^+$). This carbocation is exceptionally stable because the positive charge is delocalized over **three** phenyl rings via resonance.
Since $(C_6H_5)_3C^+$ is the most stable intermediate, the parent compound is the most reactive towards S_N1.
Final Answer: $(C_6H_5)_3CCl$ is most reactive.

Answer: (D)

Q9.

Solution

Concept: A **reducing sugar** is a carbohydrate that contains a free aldehyde or ketone group (or a hemiacetal/hemiketal group in its cyclic form) that can act as a reducing agent toward Tollen's or Fehling's reagents. If the anomeric carbons of the monosaccharide units are involved in a glycosidic linkage, the sugar becomes **non-reducing**.
Solution: 1. **Glucose**: A monosaccharide with a free aldehyde group at C_1. (Reducing). 2. **Lactose**: A disaccharide where the C_1 of galactose is linked to C_4 of glucose. The anomeric carbon of glucose (C_1) remains free. (Reducing). 3. **Maltose**: A disaccharide where two glucose units are linked by an $\alpha(1 \rightarrow 4)$ bond. One anomeric carbon remains free. (Reducing). 4. **Sucrose**: A disaccharide composed of glucose and fructose. The linkage occurs between the anomeric C_1 of α-glucose and the anomeric C_2 of β-fructose.
Because both reducing groups (anomeric carbons) are "locked" in the glycosidic bond, sucrose cannot revert to an open-chain form with a free carbonyl group. Thus, it is a non-reducing sugar.
Final Answer: Sucrose is a non-reducing sugar.

Answer: (C)

Q10.

Solution

Concept: In the metallurgy of copper, specifically during the smelting and bessemerization of sulfide ores (like copper pyrites), a process called **self-reduction** (or auto-reduction) occurs. In this process, no external reducing agent (like Carbon or Carbon Monoxide) is required. Instead, the partially oxidized ore reacts with the remaining unreacted sulfide ore to produce the metal.

Solution: 1. During the roasting process, copper(I) sulfide (Cu_2S) is partially oxidized to copper(I) oxide (Cu_2O):

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2$$

2. The copper(I) oxide formed then reacts with the remaining unreacted copper(I) sulfide in the furnace (Bessemer converter) to reduce the copper ions into metallic copper:

$$2Cu_2O + Cu_2S \rightarrow 6Cu + SO_2$$

3. This is known as the self-reduction process because the sulfide itself acts as the reducing agent for the oxide. 4. The sulfur dioxide (SO_2) gas escapes, leaving behind "blister copper" named so because of the bubbles formed by the escaping gas.

Final Answer: The metal is formed by the reduction of Cu_2O with Cu_2S.

Answer: (C)

Q11.

Solution

Concept: The number of nodes in an atomic orbital provides information about the regions where the probability of finding an electron is zero. * **Angular Nodes (Nodal Planes):** These are determined solely by the azimuthal quantum number (l).

$$\text{Number of Angular Nodes} = l$$

* **Radial Nodes (Spherical Nodes):** These are determined by the principal quantum number (n) and the azimuthal quantum number (l).

$$\text{Number of Radial Nodes} = n - l - 1$$

Solution: For a **4d orbital**: 1. Principal quantum number **$n = 4$**. 2. Azimuthal quantum number **$l = 2$** (since $s = 0, p = 1, d = 2, f = 3$). 3. **Calculate Angular Nodes:**

$$\text{Angular Nodes} = l = 2$$

4. **Calculate Radial Nodes:**

$$\text{Radial Nodes} = n - l - 1 = 4 - 2 - 1 = 1$$

5. Therefore, the number of angular and radial nodes are 2 and 1 respectively.
Final Answer: The number of nodes are 2 (angular) and 1 (radial).

Answer: (A)

Q12.

Solution

Concept: To determine the number of bond pairs (bp) and lone pairs (lp), we use the Valence Shell Electron Pair Repulsion (VSEPR) theory. The total number of electron pairs (steric number) is calculated as:

$$\text{Steric Number} = \frac{1}{2}\left[V + M - C + A\right]$$

where V is valence electrons of the central atom, M is number of monovalent atoms, C is cationic charge, and A is anionic charge.
Solution: We evaluate each species: 1. **H_2O**: Central atom O ($V = 6$). $S.N. = \frac{1}{2}(6 + 2) = 4$. It has 2 bp ($H$) and 2 lp. 2. **$BF_3$**: Central atom B ($V = 3$). $S.N. = \frac{1}{2}(3 + 3) = 3$. It has 3 bp ($F$) and 0 lp. 3. **$NH_2^-$**: Central atom N ($V = 5$). $S.N. = \frac{1}{2}(5 + 2 + 1) = 4$. It has 2 bp ($H$) and 2 lp. 4. **$PCl_3$**: Central atom P ($V = 5$). $S.N. = \frac{1}{2}(5 + 3) = 4$. It has 3 bond pairs (with Cl atoms) and $4 - 3 = 1$ lone pair.
Final Answer: PCl_3 contains three bond pairs and one lone pair.

Answer: (D)

Q13.

Solution

Concept: The relationship between enthalpy change (ΔH) and internal energy change (ΔU) for a chemical reaction is given by the formula:

$$\Delta H = \Delta U + \Delta n_g RT$$

where Δn_g is the change in the number of moles of **gaseous** products and reactants:

$$\Delta n_g = \sum n_g(\text{products}) - \sum n_g(\text{reactants})$$

Solution: 1. Write the balanced chemical equation:

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

2. Identify the phases of each species: - $C(s)$ is solid (not included in Δn_g). - $O_2(g)$ is gas (1 mole). - $CO_2(g)$ is gas (1 mole). 3. Calculate Δn_g:

$$\Delta n_g = 1(\text{for } CO_2) - 1(\text{for } O_2) = 0$$

4. Substitute $\Delta n_g = 0$ into the enthalpy-internal energy relation:

$$\Delta H = \Delta U + (0)RT$$

$$\Delta H = \Delta U$$

Final Answer: For this reaction, ΔH is equal to ΔU.

Answer: (C)

Q14.

Solution

Concept: For a buffer solution consisting of a weak acid (HA) and its conjugate base (A^-), the pH is calculated using the **Henderson-Hasselbalch equation**:

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

The relationship between pH and pOH at 298 K is:

$$pH + pOH = 14$$

Solution: 1. **Analyze ionization:** The problem states that 50% of the acid is ionized. This means the concentration of the ionized form ($[A^-]$) is equal to the concentration of the unionized form ($[HA]$).

$$[A^-] = [HA] \implies \frac{[A^-]}{[HA]} = 1$$

2. **Calculate pH:**

$$pH = pK_a + \log(1)$$

Since $\log(1) = 0$:

$$pH = pK_a = 4.5$$

3. **Calculate pOH:**

$$pOH = 14 - pH$$

$$pOH = 14 - 4.5 = 9.5$$

Final Answer: The pOH of the solution is 9.5.

Answer: (B)

Q15.

Solution

Concept: A reaction in which the same substance is both oxidized and reduced is called a **disproportionation reaction**. - **Oxidation:** Increase in oxidation number. - **Reduction:** Decrease in oxidation number.

Solution: Analyze the oxidation states of Bromine in the given reaction:

$$3\overset{0}{Br_2} + 6OH^- \rightarrow 5\overset{-1}{Br^-} + \overset{+5}{BrO_3^-} + 3H_2O$$

1. **Reactant side:** Bromine (Br_2) is in its elemental state, so its oxidation state is **0**. 2. **Product side (Bromide ion):** In Br^-, the oxidation state is **-1**. - Change from $0 \rightarrow -1$ is a **reduction**. 3. **Product side (Bromate ion):** In BrO_3^-, let the oxidation state of Br be x.

$$x + 3(-2) = -1 \implies x - 6 = -1 \implies x = +5$$

- Change from $0 \rightarrow +5$ is an **oxidation**.

Since Bromine is simultaneously converted to a lower oxidation state (-1) and a higher oxidation state ($+5$), it is both oxidized and reduced.

Final Answer: Bromine is both oxidized and reduced.

Answer: (C)

Q16.

Solution

Concept: Hardness of water is classified into two types based on the minerals present: * **Temporary Hardness:** Caused by the presence of dissolved bicarbonate salts of calcium and magnesium ($Ca(HCO_3)_2$ and $Mg(HCO_3)_2$). It can be easily removed by boiling. * **Permanent Hardness:** Caused by the presence of chlorides and sulfates of calcium and magnesium ($CaCl_2, MgCl_2, CaSO_4, MgSO_4$). This cannot be removed by boiling.

Solution: 1. **Magnesium bicarbonate ($Mg(HCO_3)_2$):** This is a bicarbonate salt. Upon boiling, it decomposes to form insoluble magnesium hydroxide, thereby removing the hardness. Hence, it causes temporary hardness. 2. **Calcium chloride ($CaCl_2$):** This is a chloride salt, which causes permanent hardness. 3. **Magnesium sulfate ($MgSO_4$):** This is a sulfate salt, which causes permanent hardness. 4. **Calcium sulfate ($CaSO_4$):** This is a sulfate salt, which causes permanent hardness.

Final Answer: Temporary hardness is due to Magnesium bicarbonate.

Answer: (A)

Q17.

Solution

Concept: The solubility of alkaline earth metal sulfates ($BeSO_4$ to $BaSO_4$) depends on the balance between **Lattice Enthalpy** and **Hydration Enthalpy**. * **Lattice Enthalpy:** Energy required to break the crystal lattice. It decreases as the size of the cation increases. * **Hydration Enthalpy:** Energy released when ions are solvated by water. It decreases rapidly as the size of the cation increases.

Solution: 1. In the case of sulfates, the sulfate ion (SO_4^{2-}) is very large compared to the cations ($Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}$). 2. Because the anion is so large, the change in lattice enthalpy down the group is relatively small. 3. However, the hydration enthalpy of the cations decreases significantly as we move from Mg^{2+} to Ba^{2+} due to the increase in ionic size. 4. For $MgSO_4$, the high hydration enthalpy of the small Mg^{2+} ion overcomes the lattice enthalpy, making it highly soluble. 5. As we move down the group to $BaSO_4$, the hydration enthalpy drops so much that it can no longer overcome the lattice energy, leading to very low solubility (insolubility). 6. Therefore, the solubility order is: $MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$.

Final Answer: $MgSO_4$ has the highest solubility among the given options.

Answer: (B)

Q18.

Solution

Concept: Boric acid (H_3BO_3) exists as a white crystalline solid. In its solid state, the $B(OH)_3$ units are linked together in a specific structural arrangement. While it is a weak monobasic acid, its physical state and "polymeric" nature are determined by its secondary bonding.

Solution: 1. Each orthoboric acid unit has a planar triangular geometry. 2. These planar units are joined together by **hydrogen bonds** to form a two-dimensional layered structure. 3. In this network, each oxygen atom of a $-OH$ group forms a hydrogen bond with a hydrogen atom of an adjacent molecule. 4. This extensive hydrogen bonding creates a large, sheet-like polymeric network, which is why the layers can easily slide over each other, giving boric acid a soapy or slippery touch.

Final Answer: Boric acid is considered a polymer due to the presence of hydrogen bonds.

Answer: (B)

Q19.

Solution

Concept: According to IUPAC nomenclature rules for polyfunctional organic compounds: * Identify the principal functional group based on the priority order. * The priority order for common groups is: $-COOH > -SO_3H > -CHO > >C=O > -OH > -NH_2$. * The principal group gets the lowest locant (number) and provides the suffix. * Other groups are treated as substituents and named as prefixes.

Solution: 1. **Identify groups:** The molecule $CH_3 - CH(OH) - CH_2 - CHO$ contains an aldehyde group ($-CHO$) and a hydroxyl group ($-OH$). 2. **Determine priority:** Aldehyde has higher priority than alcohol. Therefore, the suffix will be "-anal" and the $-OH$ group will be named as the prefix "hydroxy". 3. **Numbering the chain:** Start numbering from the aldehyde carbon to give it the lowest number (C_1): - C_1: CHO - C_2: CH_2 - C_3: $CH(OH)$ - C_4: CH_3 4. **Assemble the name:** - The parent chain has 4 carbons (butane). - The hydroxy group is at position 3. - The name is **3-hydroxybutanal**.

Final Answer: The IUPAC name is 3-hydroxybutanal.

Answer: (A)

Q20.

Solution

Concept: Ammoniacal silver nitrate, also known as **Tollen's Reagent**, is used to distinguish between terminal alkynes and other hydrocarbons. Terminal alkynes (alkynes with a triple bond at the end of the carbon chain) possess an **acidic hydrogen** atom attached to the sp-hybridized carbon. This hydrogen can be replaced by silver ions (Ag^+) to form a solid silver acetylide.

Solution: 1. **Ethane ($CH_3 - CH_3$):** An alkane. It does not have acidic hydrogens or a triple bond. No reaction. 2. **Ethene ($CH_2 = CH_2$):** An alkene. It does not have sufficiently acidic hydrogens. No reaction. 3. **Ethyne ($HC \equiv CH$):** A terminal alkyne. It has two acidic hydrogens. When reacted with $[Ag(NH_3)_2]^+$, it forms a **white precipitate** of silver acetylide:

$$HC \equiv CH + 2[Ag(NH_3)_2]OH \rightarrow AgC \equiv CAg \downarrow +4NH_3 + 2H_2O$$

4. **Propene ($CH_3 - CH = CH_2$):** An alkene. No reaction.

Final Answer: Ethyne will give a white precipitate with ammoniacal silver nitrate.

Answer: (C)

Q21.

Solution

Concept: Blue Baby Syndrome, medically known as **methemoglobinemia**, is a condition that affects the oxygen-carrying capacity of hemoglobin in the blood. It primarily affects infants who consume water containing high levels of certain contaminants.

Solution: 1. **Contaminant:** The syndrome is caused by the presence of excess **nitrates (NO_3^-)** in drinking water. 2. **Mechanism:** In the body, particularly in the digestive system of infants, nitrates are reduced to **nitrites (NO_2^-)**. 3. **Blood Interaction:** These nitrites react with the hemoglobin in the blood to form **methemoglobin**. 4. **Oxygen Transport:** Unlike normal hemoglobin, methemoglobin cannot bind and release oxygen effectively. This leads to a decrease in the oxygen supply to the body's tissues. 5. **Symptoms:** Due to the lack of oxygen, the skin of the infant takes on a bluish or purplish tint, hence the name "Blue Baby Syndrome". 6. **Regulatory Limits:** The World Health Organization and other regulatory bodies set a maximum limit of 50 mg/L (50 ppm) for nitrate in drinking water to prevent this condition.

Final Answer: The gas (ion) responsible for Blue Baby Syndrome is Nitrate.

Answer: (C)

Q22.

Solution

Concept: For a first-order reaction, the rate is proportional to the concentration of the reactant: Rate $= k[R]$. The relationship between concentrations (or rates) at two different times t_1 and t_2 is given by:

$$k = \frac{2.303}{t_2 - t_1} \log\left(\frac{\text{Rate}_1}{\text{Rate}_2}\right)$$

The half-life ($t_{1/2}$) for a first-order reaction is calculated as:

$$t_{1/2} = \frac{0.693}{k}$$

Solution: 1. **Given Data:** - $\text{Rate}_1 = 0.04$ mol L^{-1} s^{-1} at $t_1 = 10$ s - $\text{Rate}_2 = 0.03$ mol L^{-1} s^{-1} at $t_2 = 20$ s 2. **Calculate Rate Constant (k):**

$$k = \frac{2.303}{20 - 10} \log\left(\frac{0.04}{0.03}\right)$$

$$k = \frac{2.303}{10} \log(1.333)$$

Using $\log(1.333) \approx 0.1249$:

$$k = 0.2303 \times 0.1249 \approx 0.02877 \text{ s}^{-1}$$

3. **Calculate Half-life ($t_{1/2}$):**

$$t_{1/2} = \frac{0.693}{0.02877} \approx 24.08 \text{ s}$$

4. Rounding to the nearest option gives approximately 24.1 s.

Final Answer: The half-life of the reaction is 24.1 s.

Answer: (C)

Q23.

Solution

Concept: Polymers are classified into two main types based on the mode of polymerization: * **Addition Polymers:** Formed by the repeated addition of monomer molecules possessing double or triple bonds without the loss of any small molecules (e.g., polythene, Teflon, Buna-S). * **Condensation Polymers:** Formed by the repeated condensation reaction between two different bi-functional or tri-functional monomeric units, usually with the elimination of small molecules such as water, alcohol, or hydrogen chloride.

Solution: 1. **Nylon-6,6:** Formed by the condensation of hexamethylenediamine and adipic acid with the elimination of water molecules. Since a small molecule (H_2O) is removed, it is a condensation polymer. 2. **Teflon:** Formed by the addition polymerization of tetrafluoroethene ($CF_2 = CF_2$). 3. **Buna-S:** An addition copolymer of 1,3-butadiene and styrene. 4. **Neoprene:** Formed by the addition polymerization of chloroprene.

Final Answer: Nylon-6,6 is a condensation polymer.

Answer: (A)

Q24.

Solution

Concept: Antacids are chemical substances used to neutralize excess hydrochloric acid in the stomach and raise the pH to an appropriate level. They are used to treat conditions like acidity, heartburn, and gastric ulcers. Modern antacids or "anti-hyperacidity" drugs often work by inhibiting the secretion of acid from the gastric glands.

Solution: 1. **Omeprazole:** It is a proton pump inhibitor (PPI). It works by decreasing the amount of acid produced in the stomach. It is widely used to treat gastroesophageal reflux disease (GERD) and peptic ulcers. Thus, it is used as an antacid/anti-acid drug. 2. **Chloramphenicol:** It is a broad-spectrum antibiotic used to treat bacterial infections like typhoid. 3. **Penicillin:** It is a narrow-spectrum antibiotic used for various bacterial infections. 4. **Morphine:** It is a potent analgesic (painkiller) and a narcotic drug.

Final Answer: Omeprazole is used as an antacid.

Answer: (A)

Q25.

Solution

Concept: The color of transition metal ions in aqueous solution is generally due to **d-d transitions**. * For d-d transitions to occur, the metal ion must have a partially filled d-orbital (i.e., d^1 to d^9). * Ions with a completely empty d-orbital (d^0) or a completely filled d-orbital (d^{10}) are **colorless** because no d-d transitions are possible.

Solution: We examine the electronic configurations of the given ions: 1. **Ti^{3+}:** Atomic number of Ti is 22 ($[Ar]3d^2 4s^2$). Ti^{3+} is $[Ar]3d^1$. It has one unpaired electron; therefore, it is colored (purple). 2. **Cu^{2+}:** Atomic number of Cu is 29 ($[Ar]3d^{10}4s^1$). Cu^{2+} is $[Ar]3d^9$. It has one unpaired electron; therefore, it is colored (blue). 3. **Sc^{3+}:** Atomic number of Sc is 21 ($[Ar]3d^1 4s^2$). Sc^{3+} is $[Ar]3d^0$. It has no electrons in the d-orbital. No d-d transition is possible. Thus, it is **colorless**. 4. **Fe^{2+}:** Atomic number of Fe is 26 ($[Ar]3d^6 4s^2$). Fe^{2+} is $[Ar]3d^6$. It has unpaired electrons; therefore, it is colored (light green).

Final Answer: Sc^{3+} is colorless in aqueous solution.

Answer: (C)

Q26.

Solution

Concept: Entropy change (ΔS) for a phase transition at constant temperature and pressure is calculated using the formula:

$$\Delta S = \frac{\Delta H_{rev}}{T}$$

where: - ΔH_{rev} is the enthalpy change (latent heat) of the process. - T is the absolute temperature in Kelvin at which the transition occurs.

Solution: 1. **Identify given values:** - Latent heat of fusion (ΔH_{fus}) = 6.0 kJ/mol = 6000 J/mol. - Temperature (T) = 273 K. 2. **Calculate ΔS:**

$$\Delta S_{fus} = \frac{\Delta H_{fus}}{T}$$

$$\Delta S_{fus} = \frac{6000 \text{ J/mol}}{273 \text{ K}}$$

3. **Computation:**

$$\Delta S_{fus} \approx 21.978 \text{ J K}^{-1} \text{ mol}^{-1}$$

Rounding to two decimal places, we get 21.98 J K^{-1} mol^{-1}.

Final Answer: The entropy change is 21.98 $JK^{-1}mol^{-1}$.

Answer: (A)

Q27.

Solution

Concept: The **Cannizzaro reaction** is a self-redox (disproportionation) reaction undergone by aldehydes that **do not have an α-hydrogen atom**. - Aldehydes with α-hydrogen atoms undergo Aldol condensation instead when treated with a dilute base. - Aldehydes without α-hydrogen atoms, when treated with concentrated alkali, produce one molecule of alcohol (reduction) and one molecule of carboxylic acid salt (oxidation).

Solution: We examine the structure of each aldehyde: 1. **Formaldehyde ($HCHO$):** No α-carbon, therefore no α-hydrogen. Gives positive Cannizzaro. 2. **Benzaldehyde (C_6H_5CHO):** The carbon adjacent to the $-CHO$ group is part of the benzene ring and has no hydrogen attached. Gives positive Cannizzaro. 3. **Acetaldehyde (CH_3CHO):** The α-carbon is a methyl group containing **three α-hydrogen atoms**. Therefore, it undergoes Aldol condensation and **does not** give the Cannizzaro reaction. 4. **Trimethylacetaldehyde ($(CH_3)_3CCHO$):** The α-carbon is quaternary and has no hydrogens attached. Gives positive Cannizzaro.

Final Answer: Acetaldehyde does not give a positive Cannizzaro reaction.

Answer: (C)

Q28.

Solution

Concept: The acidity of carboxylic acids is influenced by the **inductive effect** ($-I$ effect) of the substituents attached to the α-carbon. * Electron-withdrawing groups (EWGs) stabilize the carboxylate anion by dispersing the negative charge, thereby increasing the acidity. * The strength of the $-I$ effect depends on the electronegativity of the halogen: $F > Cl > Br > I$.

Solution: 1. **CH_3COOH:** The methyl group has a $+I$ effect, which destabilizes the conjugate base. This is the weakest acid in the set. 2. **$ClCH_2COOH$, FCH_2COOH, and $BrCH_2COOH$:** All contain an electron-withdrawing halogen atom. 3. Comparing the electronegativity of the halogens: - Fluorine (F): 4.0 - Chlorine (Cl): 3.0 - Bromine (Br): 2.8 4. Since Fluorine is the most electronegative element, it exerts the strongest $-I$ effect. This makes FCH_2COOH the most effective at stabilizing the carboxylate ion (FCH_2COO^-). 5. Therefore, **Fluoroacetic acid (FCH_2COOH)** is the strongest acid.

Final Answer: FCH_2COOH is the strongest acid.

Answer: (C)

Q29.

Solution

Concept: This is a two-step sequence involving the formation of a diazonium salt followed by a **Sandmeyer reaction**. * **Step 1 (Diazotization):** Primary aromatic amines react with nitrous acid (generated in situ from $NaNO_2$ and HCl) at low temperatures to form benzene diazonium chloride. * **Step 2 (Sandmeyer Reaction):** The diazonium group is replaced by a nucleophile (like $-CN$, $-Cl$, or $-Br$) using the corresponding cuprous salt.

Solution: 1. **First Reaction:** Aniline ($C_6H_5NH_2$) reacts with $NaNO_2/HCl$ at 0–5°C to form **Benzene diazonium chloride** ($C_6H_5N_2^+Cl^-$).

$$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{273-278K} C_6H_5N_2^+Cl^- + NaCl + 2H_2O$$

2. **Second Reaction:** When benzene diazonium chloride is treated with **Cuprous cyanide ($CuCN$)**, the diazonium group is replaced by the nitrile ($-CN$) group.

$$C_6H_5N_2^+Cl^- \xrightarrow{CuCN/KCN} C_6H_5CN + N_2 \uparrow$$

3. The resulting product is **Benzonitirle** (also known as Phenyl cyanide).

Final Answer: The final product is Benzonitrile.

Answer: (B)

Q30.

Solution

Concept: For a gaseous dissociation reaction, the equilibrium constant K_p is expressed in terms of the partial pressures of the reactants and products. The partial pressure of a gas is given by its mole fraction multiplied by the total pressure (P).

Solution: 1. Consider the dissociation of PCl_5:

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

2. Let the initial moles of PCl_5 be 1 and the degree of dissociation be α. At equilibrium: * Moles of $PCl_5 = 1 - \alpha$ * Moles of $PCl_3 = \alpha$ * Moles of $Cl_2 = \alpha$ 3. **Total moles at equilibrium:** $(1 - \alpha) + \alpha + \alpha = 1 + \alpha$. 4. **Partial Pressures:** * $p_{PCl_5} = \left(\frac{1-\alpha}{1+\alpha}\right) P$ * $p_{PCl_3} = \left(\frac{\alpha}{1+\alpha}\right) P$ * $p_{Cl_2} = \left(\frac{\alpha}{1+\alpha}\right) P$ 5. **Substitute into K_p expression:**

$$K_p = \frac{p_{PCl_3} \cdot p_{Cl_2}}{p_{PCl_5}} = \frac{\left[\frac{\alpha P}{1+\alpha}\right] \cdot \left[\frac{\alpha P}{1+\alpha}\right]}{\left[\frac{(1-\alpha)P}{1+\alpha}\right]}$$

$$K_p = \frac{\alpha^2 P^2}{(1+\alpha)^2} \cdot \frac{1+\alpha}{(1-\alpha)P} = \frac{\alpha^2 P}{1-\alpha^2}$$

6. **Solve for α:**

$$K_p - K_p\alpha^2 = \alpha^2 P \implies K_p = \alpha^2(P + K_p)$$

$$\alpha^2 = \frac{K_p}{P + K_p} \implies \alpha = \sqrt{\frac{K_p}{P + K_p}}$$

Final Answer: The relationship is $\alpha = \sqrt{\frac{K_p}{P+K_p}}$.

Answer: (A)

Q31.

Solution

Concept: Electron gain enthalpy ($\Delta_{eg}H$) is the energy change when an electron is added to a neutral gaseous atom. Generally, it becomes more negative across a period and less negative down a group. However, a significant exception occurs in **Group 17 (Halogens)** between the second and third-period elements.

Solution: 1. **The Exception:** One might expect Fluorine (F) to have the most negative electron gain enthalpy because it is at the top of the group. However, Fluorine is a very small atom. 2. **Inter-electronic Repulsion:** In Fluorine, the added electron goes into the $n = 2$ quantum level, which is already crowded with electrons. The strong inter-electronic repulsions in the small $2p$ subshell of Fluorine offset the attractive force of the nucleus. 3. **Chlorine (Cl):** In Chlorine, the electron is added to the larger $n = 3$ quantum level. The repulsions are significantly lower, allowing the nucleus to attract the incoming electron more effectively. Consequently, Chlorine has a more negative electron gain enthalpy than Fluorine. 4. **Down the Group:** From Chlorine to Bromine to Iodine, the size of the atom increases significantly. The increased distance between the nucleus and the incoming electron decreases the nuclear attraction, making the electron gain enthalpy less negative. 5. **The Order:** The values are approximately: * Cl : -349 kJ/mol * F : -328 kJ/mol * Br : -325 kJ/mol * I : -295 kJ/mol

The correct order (most negative first) is: **Cl > F > Br > I**.

Final Answer: The correct order is Cl > F > Br > I.

Answer: (B)

Q32.

Solution

Concept: The complex $[Pt(NH_3)_2Cl_2]$ is a **square planar** complex of the type $[Ma_2b_2]$. In square planar geometry, geometrical isomerism arises because the ligands can be arranged differently in space relative to one another (adjacent vs. opposite).

Solution: 1. **Cis-isomer:** The two similar ligands (e.g., the two Cl^- ions or the two NH_3 molecules) are adjacent to each other (at a 90° angle). This specific isomer is famously known as **cis-platin**, a powerful anti-cancer drug. 2. **Trans-isomer:** The two similar ligands are situated opposite to each other (at a 180° angle). This isomer is called **trans-platin**.

Since these are the only two unique spatial arrangements possible for a square planar complex with two pairs of identical ligands, the total number of geometrical isomers is 2.

Final Answer: The number of geometrical isomers is 2.

Answer: (B)

Q33.

Solution

Concept: An **ideal solution** is a solution that behaves exactly like an ideal mixture across the entire range of concentrations. This occurs when the intermolecular forces between the different components ($A - B$ interactions) are identical to those between the pure components ($A - A$ and $B - B$ interactions).

Solution: For a solution to be considered ideal, it must satisfy the following criteria: 1. **Obey Raoult's Law:** The partial vapor pressure of each component is proportional to its mole fraction ($P_i = P_i^0 x_i$) at all temperatures and concentrations. 2. **Enthalpy of Mixing ($\Delta H_{mix} = 0$):** No heat is absorbed or evolved when the components are mixed, meaning the strength of the bonds remains unchanged. 3. **Volume of Mixing ($\Delta V_{mix} = 0$):** The total volume of the solution is exactly equal to the sum of the volumes of the individual components. There is no expansion or contraction upon mixing.

Since all three conditions are defining characteristics of an ideal solution, the correct choice is "All of the above."

Final Answer: The correct choice is (D).

Answer: (D)

Q34.

Solution

Concept: The oxidation state of an element in a compound is calculated by assigning known oxidation states to the other elements and setting the sum of all oxidation states equal to the overall charge of the species. * Alkaline earth metals (Group 2), like Barium (Ba), always have an oxidation state of **+2**. * Hydrogen (H) attached to non-metals is **+1**. * Oxygen (O) is typically **-2**.

Solution: The compound $Ba(H_2PO_2)_2$ is Barium hypophosphite. It dissociates into one Ba^{2+} ion and two $(H_2PO_2)^-$ (hypophosphite) ions. We can find the oxidation state of Phosphorus (P) by analyzing the hypophosphite ion $(H_2PO_2)^-$.

1. Let the oxidation state of Phosphorus be x. 2. In $(H_2PO_2)^-$: * 2 Hydrogen atoms: $2\times(+1) = +2$ * 1 Phosphorus atom: $1 \times x = x$ * 2 Oxygen atoms: $2 \times (-2) = -4$ 3. The sum of these oxidation states must equal the charge of the ion (-1):

$$(+2) + x + (-4) = -1$$

$$x - 2 = -1$$

$$x = +1$$

Alternatively, calculating for the entire neutral molecule $Ba(H_2PO_2)_2$:

$$(+2) + 2[2(+1) + x + 2(-2)] = 0$$

$$2 + 2(x - 2) = 0$$

$$2x - 4 = -2$$

$$2x = 2 \implies x = +1$$

Final Answer: The oxidation state of Phosphorus is +1.

Answer: (B)

Q35.

Solution

Concept: The dehydration of alcohols to alkenes is an acid-catalyzed elimination reaction ($E1$ mechanism). The reaction proceeds through the formation of a **carbocation intermediate**. The rate-determining step is the formation of this carbocation; therefore, the ease of dehydration is directly proportional to the stability of the carbocation formed.

Solution: 1. **Carbocation Stability:** The stability of carbocations follows the order:

$$\text{Tertiary } (3^\circ) > \text{Secondary } (2^\circ) > \text{Primary } (1^\circ)$$

2. **Mechanism:** * **Tertiary alcohols** form a 3° carbocation, which is highly stabilized by inductive effects and hyperconjugation. They dehydrate easily, often requiring only mild conditions (e.g., 20% H_2SO_4 at 358 K). * **Secondary alcohols** form a 2° carbocation and require slightly more vigorous conditions (e.g., 85% H_3PO_4 at 440 K). * **Primary alcohols** form a 1° carbocation, which is the least stable. They are the most difficult to dehydrate and require concentrated acid and high temperatures (e.g., $conc.H_2SO_4$ at 443 K).

3. Consequently, the ease (and rate) of dehydration follows the stability of the intermediate.

Final Answer: The correct order of reactivity is Tertiary > Secondary > Primary.

Answer: (B)

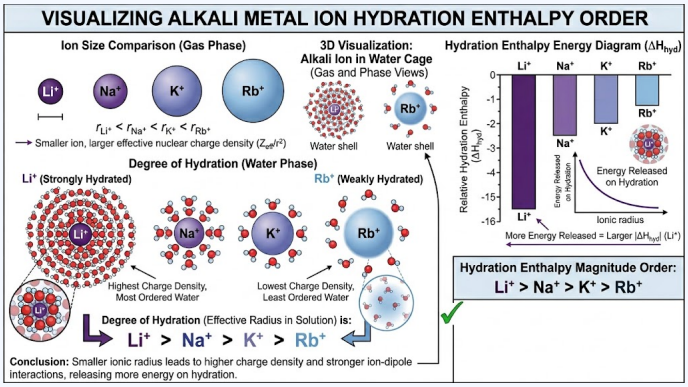
Q36.

Solution

Concept: Hydration enthalpy is the amount of energy released when one mole of gaseous ions is dissolved in water. It depends on the **charge density** of the ion. Charge density is defined as the ratio of the charge to the size (radius) of the ion:

$$\text{Charge Density} \propto \frac{\text{Charge}}{\text{Size}}$$

Since all alkali metal ions carry a +1 charge, the hydration enthalpy is determined solely by the **ionic size**.



Solution: 1. **Size Trend:** In Group 1, the ionic radius increases as we move down the group: $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$. 2. **Hydration Relationship:** Smaller ions have a higher charge density, which allows them to attract water molecules more strongly and extensively. This results in a higher (more negative) hydration enthalpy. 3. **The Order:** Li^+ is the smallest ion in the group and thus has the highest hydration enthalpy. As the size increases down the group, the hydration enthalpy decreases.

4. Therefore, the correct order is: $Li^+ > Na^+ > K^+ > Rb^+$.

Final Answer: The correct order is $Li^+ > Na^+ > K^+ > Rb^+$.

Answer: (A)

Q37.

Solution

Concept: A **Schottky defect** is a type of point defect in ionic solids that occurs when ions leave their lattice sites, creating vacancies. It is typically found in highly ionic compounds where the cation and anion are of similar size (e.g., $NaCl$, KCl).

Solution: 1. **Electrical Neutrality:** To maintain the electrical neutrality of the crystal, the number of missing cations must be equal to the number of missing anions. 2. **Density:** Because atoms are leaving the crystal lattice entirely, the mass of the crystal decreases while the volume remains the same. Consequently, the **density of the crystal decreases**.

3. **Comparison:** This is different from a Frenkel defect, where an ion (usually the smaller cation) simply moves to an interstitial site, leaving the overall density unchanged.

Final Answer: In a Schottky defect, an equal number of cations and anions are missing from the lattice.

Answer: (B)

Q38.

Solution

Concept: Aspirin is one of the most widely used analgesic, antipyretic, and anti-inflammatory drugs. It is synthesized by the **acetylation** of salicylic acid (o-hydroxybenzoic acid) using acetic anhydride in the presence of an acid catalyst.

Solution: 1. **Starting Material:** The reaction begins with salicylic acid, which contains both a carboxylic acid group and a phenolic hydroxyl group. 2. **Reaction:** The hydroxyl group ($-OH$) of salicylic acid reacts with acetic anhydride. During this process, the hydrogen of the hydroxyl group is replaced by an acetyl group (CH_3CO-). 3. **Chemical Name:** This substitution turns salicylic acid into **Acetylsalicylic acid**.

$$C_6H_4(OH)COOH + (CH_3CO)_2O \rightarrow C_6H_4(OCOCH_3)COOH + CH_3COOH$$

4. **Comparison:** * **Methyl salicylate:** Known as oil of wintergreen, formed by esterification of the carboxyl group, not the hydroxyl group. * **o-hydroxybenzoic acid:** This is simply the common name for salicylic acid itself (the precursor).

Final Answer: Aspirin is chemically Acetylsalicylic acid.

Answer: (C)

Q39.

Solution

Concept: Vitamins are classified into two groups based on their solubility: * **Fat-soluble vitamins:** These are soluble in lipids (fats) but insoluble in water. They are stored in the liver and adipose tissues. Examples include Vitamins **A, D, E, and K**. * **Water-soluble vitamins:** These are soluble in water and must be supplied regularly in the diet because they are readily excreted in urine and cannot be stored in the body (except for Vitamin B12). Examples include **Vitamin C** and the **B-complex** vitamins.

Solution: 1. **Vitamin A, D, and K:** These belong to the fat-soluble category. 2. **Vitamin C (Ascorbic Acid):** This is a highly water-soluble vitamin. It is found in citrus fruits and green leafy vegetables.

Final Answer: Vitamin C is water-soluble.

Answer: (C)

Q40.

Solution

Concept: In Lassaigne's test for the detection of nitrogen in an organic compound, the nitrogen and carbon from the compound react with fused sodium metal to form sodium cyanide ($NaCN$). When this extract is treated with freshly prepared ferrous sulfate ($FeSO_4$) and acidified with concentrated HCl, a characteristic **Prussian blue** color appears.

Solution: 1. **Step 1:** Sodium cyanide reacts with ferrous sulfate to form sodium ferrocyanide.

$$6NaCN + FeSO_4 \rightarrow Na_4[Fe(CN)_6] + Na_2SO_4$$

2. **Step 2:** Upon adding HCl and some $FeCl_3$ (often formed by the oxidation of ferrous ions), the ferrocyanide reacts with ferric ions (Fe^{3+}) to form **ferri-ferrocyanide**.

$$3Na_4[Fe(CN)_6] + 4FeCl_3 \rightarrow Fe_4[Fe(CN)_6]_3 + 12NaCl$$

3. The complex responsible for the deep blue color is **Ferriferrocyanide**, chemically represented as $Fe_4[Fe(CN)_6]_3$.

Final Answer: The Prussian blue color is due to $Fe_4[Fe(CN)_6]_3$.

Answer: (A)

Q41.

Solution

Concept: The stability of alkenes is determined by: 1. **Degree of Substitution:** According to Saytzeff's rule, alkenes with more alkyl groups attached to the sp^2 carbon atoms are more stable due to hyperconjugation and inductive effects. 2. **Steric Hindrance:** In isomers with the same degree of substitution, the *trans* isomer is generally more stable than the *cis* isomer because bulky groups are further apart, minimizing van der Waals strain.

Solution: Let us examine the substitution pattern of each option:

- **1-butene ($CH_2 = CH - CH_2 - CH_3$):** Monosubstituted (one alkyl group).
- **cis-2-butene ($CH_3 - CH = CH - CH_3$):** Disubstituted. Steric repulsion exists between the two methyl groups on the same side.
- **trans-2-butene ($CH_3 - CH = CH - CH_3$):** Disubstituted. More stable than *cis* due to opposite orientation of methyl groups.
- **2-methyl-2-butene ($(CH_3)_2C = CH - CH_3$):** Trisubstituted (three alkyl groups).

Because 2-methyl-2-butene has the highest number of alkyl substituents, it provides the maximum number of hyperconjugative structures, making it the most stable alkene in the list.

Stability Order:

$$\text{2-methyl-2-butene} > \text{trans-2-butene} > \text{cis-2-butene} > \text{1-butene}$$

Answer: (D)

Q42.

Solution

Concept: The strength of an oxidizing agent depends on its **Standard Reduction Potential (E°)**. A higher (more positive) E° value indicates a greater tendency for the substance to gain electrons and undergo reduction. For halogens (X_2), the oxidizing power is determined by: 1. Bond dissociation enthalpy of X_2. 2. Electron gain enthalpy of X. 3. Hydration enthalpy of the resulting X^- ion.

Solution: As we move down Group 17, the oxidizing power decreases:

$$F_2 > Cl_2 > Br_2 > I_2$$

- **Fluorine (F_2):** It has the highest reduction potential (+2.87 V). Despite having a lower electron gain enthalpy than Chlorine, it is the strongest oxidizing agent due to its **very low bond dissociation enthalpy** (small atom, $F - F$ repulsion) and **very high hydration enthalpy** of the small F^- ion.
- **Iodine (I_2):** It has the lowest reduction potential (+0.54 V) among the listed halogens and is the weakest oxidizing agent.

Thus, Fluorine (F_2) is the most powerful oxidizing agent.

Answer: (A)

Q43.

Solution

Concept: The excitation energy is the energy required to move an electron from a lower energy level (initial state) to a higher energy level (final state). It is calculated as the difference between the energies of the two levels:

$$\Delta E = E_{final} - E_{initial}$$

Solution: For a Hydrogen atom, the energy levels are defined as:

- **Ground State:** $n = 1$
- **First Excited State:** $n = 2$

1. Calculate energy of the ground state (E_1):

$$E_1 = -\frac{13.6}{1^2} = -13.6 \text{ eV}$$

2. Calculate energy of the first excited state (E_2):

$$E_2 = -\frac{13.6}{2^2} = -\frac{13.6}{4} = -3.4 \text{ eV}$$

3. Calculate the required excitation energy (ΔE):

$$\Delta E = E_2 - E_1$$

$$\Delta E = -3.4 - (-13.6)$$

$$\Delta E = -3.4 + 13.6 = 10.2 \text{ eV}$$

The energy required to excite the electron is 10.2 eV.

Answer: (B)

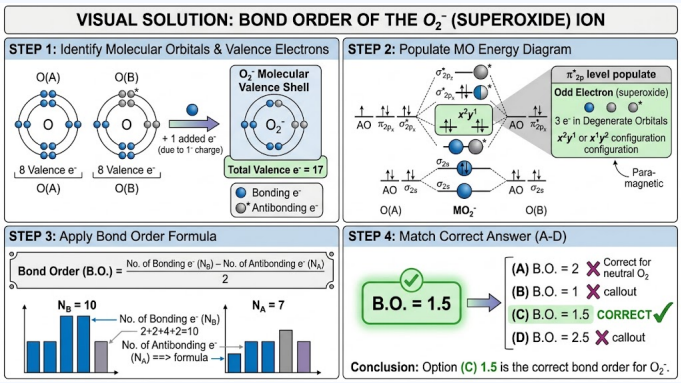
Q44.

Solution

Concept: According to Molecular Orbital (MO) Theory, the bond order of a molecule or ion is calculated using the formula:

$$\text{Bond Order (B.O.)} = \frac{1}{2}(N_b - N_a)$$

where N_b is the number of electrons in bonding molecular orbitals and N_a is the number of electrons in antibonding molecular orbitals.



Solution: 1. **Total electrons in O_2^- (Superoxide ion):** Oxygen atom has 8 electrons. For O_2^-, the total is $(8 \times 2) + 1 = 17$ electrons.

2. **Electronic Configuration (MO Theory):** The distribution of 17 electrons follows the sequence for molecules with $Z > 7$:

$$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, (\pi 2p_x^2 = \pi 2p_y^2), (\pi^* 2p_x^2 = \pi^* 2p_y^1)$$

3. **Count Bonding and Antibonding electrons:**

- **Bonding electrons (N_b):** $2(\sigma 1s) + 2(\sigma 2s) + 2(\sigma 2p_z) + 4(\pi 2p_{x,y}) = 10$
- **Antibonding electrons (N_a):** $2(\sigma^* 1s) + 2(\sigma^* 2s) + 3(\pi^* 2p_{x,y}) = 7$

4. **Calculate Bond Order:**

$$\text{B.O.} = \frac{10 - 7}{2} = \frac{3}{2} = 1.5$$

The bond order of the O_2^- ion is 1.5.

Answer: (C)

Q45.

Solution

Concept: The cell constant (G^*) of a conductivity cell is a characteristic property that depends on the geometry of the electrodes. It is defined as the ratio of the distance between the electrodes (l) to the area of cross-section of the electrodes (A):

$$G^* = \frac{l}{A}$$

Solution: 1. **Identify Units of Measurement:**

- Distance (l) is measured in centimeters (cm).
- Area of cross-section (A) is measured in square centimeters (cm^2).

2. **Derive the Unit:** Substituting the units into the formula for the cell constant:

$$\text{Unit of } G^* = \frac{cm}{cm^2}$$

$$\text{Unit of } G^* = \frac{1}{cm} = cm^{-1}$$

3. **Relationship with Conductivity:** The cell constant also links specific conductance (κ) and observed conductance (G):

$$\kappa = G \times \left(\frac{l}{A}\right) \Rightarrow \kappa = G \times G^*$$

While the SI unit is m^{-1}, the common unit used in laboratory chemistry is cm^{-1}.
Final Answer: The unit of cell constant is cm^{-1}.

Answer: (C)

Answer Key

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