NEET-UG Chemistry Sample Paper-19

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. The number of moles of oxygen atoms in 44 g of CO_2 is:

(A) 1

(B) 2

(C) 3

(D) 4

Q2. The energy of electron in first Bohr orbit of hydrogen is E_1. The energy in fourth orbit is:

(A) $\frac{E_1}{4}$

(B) $\frac{E_1}{8}$

(C) $\frac{E_1}{16}$

(D) $16E_1$

Q3. Total number of orbitals in n = 3 shell is:

(A) 3

(B) 6

(C) 9

(D) 18

Q4. Which has lone pair–lone pair repulsion highest?

(A) NH_3

(B) H_2O

(C) CH_4

(D) BF_3

Q5. Hybridization of central atom in SF_6 is:

(A) sp^3

(B) sp^3d

(C) sp^3d^2

(D) sp^2

Q6. Bond order of N_2 is:

(A) 1

(B) 2

(C) 3

(D) 4

Q7. Which molecule is polar?

(A) CO_2

(B) BF_3

(C) NH_3

(D) CCl_4

Q8. For a spontaneous reaction at all temperatures, the condition is:

(A) $\Delta H > 0, \Delta S > 0$

(B) $\Delta H < 0, \Delta S > 0$

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

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

Q9. At equilibrium, the value of equilibrium constant depends on:

(A) Concentration

(B) Temperature

(C) Pressure

(D) Catalyst

Q10. Which pair shows ideal solution behavior?

(A) Benzene + toluene

(B) Ethanol + water

(C) Acetone + chloroform

(D) Water + HCl

Q11. Van't Hoff factor for NaCl (complete dissociation) is:

(A) 1

(B) 2

(C) 3

(D) 4

Q12. Addition of inert gas at constant volume affects equilibrium by:

(A) Shifting right

(B) Shifting left

(C) No change

(D) Increasing rate

Q13. pH of 0.01 M HCl solution is:

(A) 1

(B) 2

(C) 3

(D) 4

Q14. Cell potential is related to Gibbs energy by:

(A) $\Delta G = nFE$

(B) $\Delta G = -nFE$

(C) $\Delta G = \frac{E}{nF}$

(D) $\Delta G = nF/E$

Q15. Which metal is strongest reducing agent?

(A) Cu

(B) Zn

(C) Ag

(D) Au

Q16. For zero order reaction, rate is:

(A) Independent of concentration

(B) Directly proportional

(C) Inversely proportional

(D) Depends on pressure

Q17. Half-life of zero order reaction depends on:

(A) Initial concentration

(B) Temperature

(C) Pressure

(D) Catalyst

Q18. Atomic size increases down the group due to:

(A) Increase in nuclear charge

(B) Increase in shells

(C) Decrease in shielding

(D) Increase in ionization energy

Q19. Which is most acidic oxide?

(A) Na_2O

(B) MgO

(C) SO_3

(D) Al_2O_3

Q20. Shape of XeF_2 is:

(A) Linear

(B) Bent

(C) T-shaped

(D) Trigonal planar

Q21. Which element shows maximum oxidation state +6?

(A) Cr

(B) Fe

(C) Co

(D) Ni

Q22. Which lanthanide shows +4 oxidation state?

(A) Ce

(B) La

(C) Nd

(D) Sm

Q23. Which ion is diamagnetic?

(A) Fe^{2+}

(B) Mn^{2+}

(C) Zn^{2+}

(D) Cu^{2+}

Q24. Coordination number in $[Co(NH_3)_6]^{3+}$ is:

(A) 4

(B) 6

(C) 2

(D) 8

Q25. Which shows linkage isomerism?

(A) NO_2^-

(B) NH_3

(C) Cl^-

(D) H_2O

Q26. Weak field ligand is:

(A) CN^-

(B) CO

(C) NH_3

(D) I^-

Q27. Which method separates solids from liquids?

(A) Filtration

(B) Sublimation

(C) Distillation

(D) Chromatography

Q28. Stability of free radicals is highest in:

(A) 1°

(B) 2°

(C) 3°

(D) Methyl

Q29. Which shows +M effect?

(A) $-NO_2$

(B) $-CN$

(C) $-OH$

(D) $-COOH$

Q30. Nucleophile is:

(A) Electron acceptor

(B) Electron donor

(C) Radical

(D) Neutral species

Q31. Anti-Markovnikov addition occurs in presence of:

(A) Acid

(B) Base

(C) Peroxide

(D) Catalyst

Q32. Benzene reacts with Br_2 in presence of:

(A) UV light

(B) $FeBr_3$

(C) Heat

(D) Pressure

Q33. Which is anti-aromatic?

(A) Benzene

(B) Cyclobutadiene

(C) Cyclopentane

(D) Naphthalene

Q34. SN2 reaction involves:

(A) Two steps

(B) One step

(C) Carbocation

(D) Rearrangement

Q35. Reactivity order of halides is:

(A) F > Cl > Br > I

(B) I > Br > Cl > F

(C) Cl > Br > I > F

(D) Br > I > Cl > F

Q36. Ketones give which test?

(A) Tollen's

(B) Fehling's

(C) Iodoform

(D) Both A and B

Q37. Alcohols form hydrogen bonding due to:

(A) Oxygen electronegativity

(B) Size

(C) Shape

(D) Mass

Q38. Which has lowest boiling point?

(A) Alcohol

(B) Ether

(C) Carboxylic acid

(D) Amine

Q39. Secondary alcohol oxidation gives:

(A) Acid

(B) Aldehyde

(C) Ketone

(D) Ester

Q40. Which amine is most basic?

(A) NH_3

(B) CH_3NH_2

(C) $(CH_3)_2NH$

(D) $(CH_3)_3N$

Q41. Aniline is less basic due to:

(A) Inductive effect

(B) Resonance

(C) Hybridization

(D) Size

Q42. Fructose is:

(A) Aldose

(B) Ketose

(C) Acid

(D) Ester

Q43. DNA contains sugar:

(A) Ribose

(B) Deoxyribose

(C) Glucose

(D) Fructose

Q44. Which indicator is used in acid-base titration?

(A) Phenolphthalein

(B) $KMnO_4$

(C) $K_2Cr_2O_7$

(D) Iodine

Q45. The pH of a 10^{-3} M solution of a strong monoprotic acid is:

(A) 1

(B) 2

(C) 3

(D) 4

Detailed Solutions

Q1.

Solution

Concept: The mole is the standard unit for the amount of a substance, defined as containing exactly 6.022×10^{23} elementary entities (Avogadro's number). The molar mass of a compound is the mass of one mole of that substance, calculated by summing the atomic masses of its constituent atoms. Stoichiometry allows us to relate the amount of a compound to the amounts of its constituent elements.

Solution:

(a) **Identify the Chemical Formula and Given Mass:** The compound is carbon dioxide (CO_2), and the given mass is 44 g.

(b) **Calculate the Molar Mass of CO_2:**

- Atomic mass of Carbon (C) $\approx$ 12 g/mol
- Atomic mass of Oxygen (O) $\approx$ 16 g/mol
- Molar Mass of CO_2 = (1 × Atomic mass of C) + (2 × Atomic mass of O)
- Molar Mass of CO_2 = $(1 \times 12) + (2 \times 16) = 12 + 32 = 44$ g/mol.

(c) **Calculate the Number of Moles of CO_2:** The number of moles is calculated by the formula:

$$\text{Moles} = \frac{\text{Given Mass}}{\text{Molar Mass}}$$

$$\text{Moles of } CO_2 = \frac{44 \text{ g}}{44 \text{ g/mol}} = 1 \text{ mole}$$

(d) **Determine the Moles of Oxygen Atoms:** The chemical formula CO_2 indicates that one molecule of carbon dioxide contains 2 atoms of oxygen. By extension, one mole of CO_2 contains 2 moles of oxygen atoms.

$$\text{Moles of O atoms} = (\text{Moles of } CO_2) \times (\text{Number of O atoms per molecule})$$

$$\text{Moles of O atoms} = 1 \text{ mole} \times 2 = 2 \text{ moles}$$

Final Answer : "2"

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

Q2.

Solution

Concept: According to Bohr's model for the hydrogen atom, electrons can only exist in specific, quantized energy levels or orbits. The energy of an electron in the n-th orbit (E_n) is inversely proportional to the square of the principal quantum number (n).

Solution: The energy of an electron in the n-th orbit of a hydrogen atom is given by the formula:

$$E_n = -\frac{R_H}{n^2}$$

where R_H is the Rydberg constant and n is the principal quantum number (n = 1, 2, 3, ...).
The energy of the electron in the first Bohr orbit (ground state, n=1) is given as E_1. Using the formula for n=1:

$$E_1 = -\frac{R_H}{1^2} = -R_H$$

Now, we can express the energy of any orbit, E_n, in terms of E_1:

$$E_n = -\frac{R_H}{n^2} = \frac{E_1}{n^2}$$

The question asks for the energy in the fourth orbit, which means n=4. Substituting n=4 into this relationship:

$$E_4 = \frac{E_1}{4^2} = \frac{E_1}{16}$$

Thus, the energy of the electron in the fourth orbit is one-sixteenth of the energy in the first orbit.
Final Answer : "$\frac{E_1}{16}$"

Answer: (C)

Q3.

Solution

Concept: In quantum mechanics, the structure of an atom is described by shells, subshells, and orbitals. A principal energy shell (n) contains n subshells (l = 0 to n-1). Each subshell contains a specific number of orbitals (2l+1). The total number of orbitals in a given shell 'n' can be calculated by the formula n^2.

Solution: We need to find the total number of orbitals in the principal shell n = 3.
Method 1: Using the formula The total number of orbitals in a shell with principal quantum number 'n' is given by n^2. For n = 3, the total number of orbitals is $3^2 = 9$.
Method 2: Summing orbitals in subshells For a given shell 'n', the possible values of the azimuthal quantum number 'l' are 0, 1, 2, ..., (n-1). For each value of 'l', the number of orbitals is (2l+1). For n = 3, the possible values of l are 0, 1, and 2.

- For l = 0 (the s subshell): Number of orbitals = 2(0) + 1 = 1 orbital (the 3s orbital).
- For l = 1 (the p subshell): Number of orbitals = 2(1) + 1 = 3 orbitals (the $3p_x$, $3p_y$, $3p_z$ orbitals).
- For l = 2 (the d subshell): Number of orbitals = 2(2) + 1 = 5 orbitals (the 3d orbitals).

Total number of orbitals = (orbitals in s) + (orbitals in p) + (orbitals in d) = 1 + 3 + 5 = 9. Both methods confirm that there are 9 orbitals in the n=3 shell.
Final Answer : "9"

Answer: (C)

Q4.

Solution

Concept: The Valence Shell Electron Pair Repulsion (VSEPR) theory predicts the geometry of molecules based on minimizing the electrostatic repulsion between electron pairs in the valence shell of the central atom. The strength of repulsion follows the order:
Lone pair–lone pair (lp-lp) > Lone pair–bond pair (lp-bp) > Bond pair–bond pair (bp-bp). The greatest repulsion occurs in molecules where the central atom has multiple lone pairs.

Solution: To find the molecule with the highest lone pair–lone pair repulsion, we must identify the number of lone pairs on the central atom of each molecule.

(a) **NH_3 (Ammonia):** The central atom is Nitrogen (N), which is in Group 15 and has 5 valence electrons. It forms 3 single bonds with Hydrogen atoms (3 bonding pairs). Number of lone pairs = $\frac{1}{2}(5-3) = 1$ lone pair. It has lp-bp repulsion, but no lp-lp repulsion.

(b) **H_2O (Water):** The central atom is Oxygen (O), which is in Group 16 and has 6 valence electrons. It forms 2 single bonds with Hydrogen atoms (2 bonding pairs). Number of lone pairs = $\frac{1}{2}(6-2) = 2$ lone pairs. With two lone pairs, it experiences strong lone pair–lone pair repulsion, which compresses the H-O-H bond angle to 104.5°.

(c) **CH_4 (Methane):** The central atom is Carbon (C), which is in Group 14 and has 4 valence electrons. It forms 4 single bonds with Hydrogen atoms (4 bonding pairs). Number of lone pairs = $\frac{1}{2}(4-4) = 0$ lone pairs. It only has bp-bp repulsion.

(d) **BF_3 (Boron Trifluoride):** The central atom is Boron (B), which is in Group 13 and has 3 valence electrons. It forms 3 single bonds with Fluorine atoms (3 bonding pairs). Number of lone pairs = $\frac{1}{2}(3-3) = 0$ lone pairs. It only has bp-bp repulsion.

Comparing the molecules, H_2O is the only one with two lone pairs on its central atom, leading to the presence of the strongest type of repulsion: lone pair–lone pair repulsion.
Final Answer : "H_2O"

Answer: (B)

Q5.

Solution

Concept: Hybridization is the concept of mixing atomic orbitals to form a new set of equivalent hybrid orbitals. The type of hybridization is determined by the steric number of the central atom, which is the sum of the number of atoms bonded to it (sigma bonds) and the number of lone pairs it has.

Solution: We need to determine the hybridization of the central atom, Sulfur (S), in the SF_6 molecule.

(a) **Identify the central atom:** Sulfur (S).

(b) **Count valence electrons of the central atom:** Sulfur is in Group 16, so it has 6 valence electrons.

(c) **Count the number of bonded atoms and lone pairs:**

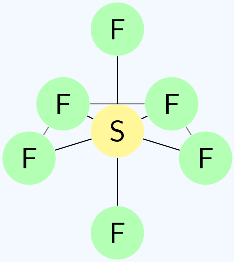
- Sulfur is bonded to 6 Fluorine atoms.
- Number of lone pairs on S = $\frac{1}{2}$ (Valence e^- on S - Number of bonds) = $\frac{1}{2}(6-6) = 0$.

(d) **Calculate the steric number:** Steric Number = (Number of bonded atoms) + (Number of lone pairs) = 6 + 0 = 6.

(e) **Determine the hybridization:** The steric number corresponds to the number of hybrid orbitals required.

- Steric number 2 $\longrightarrow$ sp
- Steric number 3 $\longrightarrow$ sp^2
- Steric number 4 $\longrightarrow$ sp^3
- Steric number 5 $\longrightarrow$ sp^3d
- Steric number 6 $\longrightarrow$ sp^3d^2

Since the steric number is 6, the hybridization of sulfur in SF_6 is $\mathbf{sp^3d^2}$. This hybridization results in an octahedral geometry.



Final Answer : "sp^3d^2"

Answer: (C)

Q6.

Solution

Concept: Molecular Orbital Theory (MOT) describes chemical bonding by combining atomic orbitals to form molecular orbitals (bonding and anti-bonding). The bond order is a measure of the number of chemical bonds between two atoms and is calculated as half the difference between the number of electrons in bonding molecular orbitals (N_b) and anti-bonding molecular orbitals (N_a).

Solution: To find the bond order of the dinitrogen molecule (N_2), we follow these steps:

(a) **Count the total valence electrons:** A nitrogen atom (N) has 5 valence electrons. For the N_2 molecule, the total number of valence electrons is $2 \times 5 = 10$.

(b) **Write the Molecular Orbital (MO) configuration for the valence electrons:** For N_2, which has fewer than 15 electrons, the energy order of orbitals is: $\sigma(2s) < \sigma^*(2s) < \pi(2p_y) = \pi(2p_z) < \sigma(2p_x) < \dots$

(c) **Fill the MOs with the 10 valence electrons:**

- $\sigma(2s)^2$ (2 electrons)
- $\sigma^*(2s)^2$ (2 electrons)
- $\pi(2p_y)^2$ (2 electrons)
- $\pi(2p_z)^2$ (2 electrons)
- $\sigma(2p_x)^2$ (2 electrons)

The complete configuration is: $\sigma(2s)^2\sigma^*(2s)^2\pi(2p_y)^2\pi(2p_z)^2\sigma(2p_x)^2$.

(d) **Calculate the bond order:** Bond Order $= \frac{1}{2}(N_b - N_a)$

- Bonding electrons (N_b): Electrons in orbitals without an asterisk. $N_b = 2(\text{from } \sigma 2s) + 2(\text{from } \pi 2p_y) + 2(\text{from } \pi 2p_z) + 2(\text{from } \sigma 2p_x) = 8$.
- Anti-bonding electrons (N_a): Electrons in orbitals with an asterisk. $N_a = 2(\text{from } \sigma^* 2s) = 2$.

Bond Order $= \frac{1}{2}(8 - 2) = \frac{6}{2} = 3$.

A bond order of 3 indicates a triple bond between the two nitrogen atoms (N≡N), which is consistent with its Lewis structure and high bond dissociation energy.

Final Answer : "3"

Answer: (C)

Q7.

Solution

Concept: A molecule is considered polar if it possesses a net permanent dipole moment. This requires two conditions to be met:

(a) The molecule must contain polar covalent bonds, which occur between atoms with a significant difference in electronegativity.

(b) The molecular geometry must be asymmetrical, such that the individual bond dipoles do not cancel each other out through vector addition.

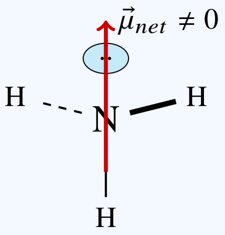
Solution: Let's analyze the polarity of each given molecule by considering its bond polarity and molecular geometry:

(a) **CO_2 (Carbon Dioxide):** The C=O bonds are polar because oxygen is more electronegative than carbon. However, the molecule has a linear geometry (O=C=O). The two bond dipoles are equal in magnitude and point in opposite directions, so they cancel each other out. The net dipole moment is zero. Thus, CO_2 is a non-polar molecule.

(b) **BF_3 (Boron Trifluoride):** The B-F bonds are highly polar. The molecule has a trigonal planar geometry, with the three B-F bonds arranged symmetrically at 120° angles. The vector sum of these three bond dipoles is zero. Thus, BF_3 is a non-polar molecule.

(c) **NH_3 (Ammonia):** The N-H bonds are polar because nitrogen is more electronegative than hydrogen. Due to the presence of a lone pair on the central nitrogen atom, the molecule has a trigonal pyramidal geometry. This asymmetrical shape prevents the bond dipoles from canceling. The three N-H bond dipoles and the dipole contribution from the lone pair add up vectorially to create a significant net dipole moment. Thus, NH_3 is a polar molecule.

(d) **CCl_4 (Carbon Tetrachloride):** The C-Cl bonds are polar. The molecule has a perfectly symmetrical tetrahedral geometry. The four C-Cl bond dipoles are oriented such that their vector sum is zero. Thus, CCl_4 is a non-polar molecule.



Final Answer : "NH_3"

Answer: (C)

Q8.

Solution

Concept: The spontaneity of a chemical reaction is determined by the change in Gibbs Free Energy (ΔG). A reaction is spontaneous if $\Delta G < 0$, non-spontaneous if $\Delta G > 0$, and at equilibrium if $\Delta G = 0$. The Gibbs-Helmholtz equation relates ΔG to enthalpy change (ΔH) and entropy change (ΔS):

$$\Delta G = \Delta H - T\Delta S$$

where T is the absolute temperature in Kelvin, which is always a positive value.

Solution: For a reaction to be spontaneous at **all** temperatures, the value of ΔG must be negative regardless of the value of T. Let's analyze the signs of the terms in the equation for each condition:

- **(A)** $\Delta H > 0, \Delta S > 0$**:** $\Delta G = (\text{positive}) - T(\text{positive})$. For ΔG to be negative, the $T\Delta S$ term must be larger than the ΔH term. This only occurs at high temperatures. Not spontaneous at all temperatures.
- **(B)** $\Delta H < 0, \Delta S > 0$**:** $\Delta G = (\text{negative}) - T(\text{positive})$. In this case, the ΔH term is negative, and the $-T\Delta S$ term is also always negative (since T and ΔS are positive). The sum of two negative numbers is always negative. Therefore, ΔG will be less than zero at any temperature. This is the condition for spontaneity at all temperatures.
- **(C)** $\Delta H < 0, \Delta S < 0$**:** $\Delta G = (\text{negative}) - T(\text{negative}) = (\text{negative}) + (\text{positive})$. For ΔG to be negative, the negative ΔH term must be larger in magnitude than the positive $T\Delta S$ term. This only occurs at low temperatures. Not spontaneous at all temperatures.
- **(D)** $\Delta H > 0, \Delta S < 0$**:** $\Delta G = (\text{positive}) - T(\text{negative}) = (\text{positive}) + (\text{positive})$. Both terms are positive, so their sum, ΔG, will always be positive. The reaction is never spontaneous under any temperature.

Final Answer : "$\Delta H < 0, \Delta S > 0$"

Answer: (B)

Q9.

Solution

Concept: The equilibrium constant (K) represents the ratio of product concentrations to reactant concentrations (each raised to the power of its stoichiometric coefficient) when a reversible reaction has reached equilibrium. Le Chatelier's principle states that if a change of condition is applied to a system in equilibrium, the system will shift in a direction that relieves the stress. While several factors can shift the *position* of an equilibrium, only one changes the *value* of the equilibrium constant itself.

Solution: Let's examine the effect of each factor on the equilibrium constant, K:

- **Concentration:** Changing the concentration of a reactant or product will cause the equilibrium to shift (according to Le Chatelier's principle) to re-establish the equilibrium ratio. However, the value of K at that specific temperature does not change.
- **Pressure:** For reactions involving gases, changing the pressure shifts the equilibrium position to favor the side with fewer or more moles of gas. Like concentration, this changes the individual equilibrium partial pressures but does not change the value of the equilibrium constant (K_p or K_c).
- **Catalyst:** A catalyst increases the rate of both the forward and reverse reactions equally. It allows the system to reach equilibrium faster but has no effect on the position of the equilibrium or the value of K.
- **Temperature:** Temperature is the only factor that changes the intrinsic value of the equilibrium constant. The relationship is described by the van 't Hoff equation. For an endothermic reaction ($\Delta H > 0$), K increases as temperature increases. For an exothermic reaction ($\Delta H < 0$), K decreases as temperature increases.

Therefore, the value of the equilibrium constant is dependent on temperature.

Final Answer : "Temperature"

Answer: (B)

Q10.

Solution

Concept: An ideal solution is a mixture in which the molecules of different species are completely interchangeable. According to Raoult's Law, this means the vapor pressure of each component above the solution is proportional to its mole fraction. Microscopically, ideal behavior occurs when the intermolecular forces of attraction between unlike molecules (A-B) are identical to the forces between like molecules (A-A and B-B). This is best approximated by mixing components that are very similar in size, structure, and polarity.

Solution: Let's analyze the intermolecular forces in each pair:

(a) **Benzene + toluene:** Both benzene (C_6H_6) and toluene ($C_6H_5CH_3$) are non-polar, aromatic hydrocarbons. They have very similar structures, sizes, and their primary intermolecular forces are London dispersion forces. The A-A, B-B, and A-B interactions are nearly identical, making this pair a classic example of a nearly ideal solution.

(b) **Ethanol + water:** Both are polar and exhibit strong hydrogen bonding. However, when mixed, the structure of the hydrogen-bonding network is altered. The interactions are strong, but not identical to those in the pure components, leading to non-ideal behavior (negative deviation from Raoult's Law).

(c) **Acetone + chloroform:** In pure chloroform ($CHCl_3$), there are dipole-dipole interactions. In pure acetone (CH_3COCH_3), there are also dipole-dipole interactions. When mixed, a new, stronger hydrogen bond forms between the hydrogen atom of chloroform and the oxygen atom of acetone. Since the A-B interaction is stronger than the A-A and B-B interactions, this pair shows a significant negative deviation from ideality.

(d) **Water + HCl:** This is not a simple physical mixture. Hydrogen chloride (HCl) is a strong acid that ionizes completely in water to form hydronium (H_3O^+) and chloride (Cl^-) ions. This chemical reaction results in a highly non-ideal solution.

Final Answer : "Benzene + toluene"

Answer: (A)

Q11.

Solution

Concept: The Van't Hoff factor (i) is a measure of the effect of a solute on colligative properties (such as boiling point elevation, freezing point depression, and osmotic pressure). It is defined as the ratio of the actual number of particles (ions or molecules) in a solution after dissociation to the number of formula units initially dissolved.

$$i = \frac{\text{moles of particles in solution}}{\text{moles of solute dissolved}}$$

Solution: We need to find the Van't Hoff factor for Sodium Chloride (NaCl) assuming complete dissociation. NaCl is a strong electrolyte, meaning it dissociates completely into its constituent ions when dissolved in a polar solvent like water.

(a) **Write the dissociation equation:** The dissociation of one formula unit of NaCl in water is:

$$\text{NaCl (s)} \xrightarrow{\text{water}} \text{Na}^+\text{(aq)} + \text{Cl}^-\text{(aq)}$$

(b) **Count the particles produced:** For each one formula unit of NaCl that dissolves, it produces:

- 1 sodium ion (Na^+)
- 1 chloride ion (Cl^-)

This results in a total of $1 + 1 = 2$ particles (ions) in the solution.

(c) **Calculate the Van't Hoff factor (i):**

$$i = \frac{\text{1 mole of Na}^+ + \text{1 mole of Cl}^-}{\text{1 mole of NaCl}} = \frac{\text{2 moles of particles}}{\text{1 mole of solute}} = 2$$

Therefore, for complete dissociation, the Van't Hoff factor for NaCl is 2.

Final Answer : "2"

Answer: (B)

Q12.

Solution

Concept: Le Chatelier's Principle states that if a change of condition (stress) is applied to a system in equilibrium, the system will shift in a direction that counteracts the stress. The effect of adding an inert gas depends critically on whether the addition occurs at constant volume or constant pressure.

Solution: The condition specified is the addition of an inert gas at **constant volume**. Let's analyze the consequences of this action on the system at equilibrium.

(a) **Definition of an Inert Gas:** An inert gas (like Helium or Argon) is one that does not participate in the chemical reaction. It does not react with any of the reactants or products.

(b) **Effect on Moles and Volume:**

- The number of moles of each reacting gas (reactants and products) remains unchanged at the moment of addition.
- The volume of the container is held constant as per the problem statement.

(c) **Effect on Concentrations and Partial Pressures:**

- **Concentration:** Concentration is defined as moles per unit volume ($C = n/V$). Since both the number of moles (n) of each reacting species and the volume (V) of the container are constant, the concentrations of all reactants and products **do not change**.
- **Partial Pressure:** The partial pressure of a reacting gas 'A' is given by $P_A = C_A \times RT$. Since the concentration (C_A) and temperature (T) are unchanged, the partial pressures of all reactants and products also **do not change**.

(d) **Effect on Total Pressure:** While the partial pressures of the reacting gases remain constant, the addition of the inert gas increases the total number of moles of gas in the container. This leads to an increase in the total pressure of the system. However, the equilibrium position does not depend on the total pressure, but on the partial pressures (or concentrations) of the reacting substances.

(e) **Conclusion based on Equilibrium Condition:** The equilibrium constant, K (either K_c or K_p), is a function of the concentrations or partial pressures of the reacting species. Since these values have not changed, the reaction quotient (Q) remains equal to the equilibrium constant (K). As Q = K, the system is still at equilibrium, and there is no net shift in either the forward or reverse direction.

Therefore, the addition of an inert gas at constant volume has no effect on the position of the equilibrium.

Final Answer : "No change"

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

Q13.

Solution

Concept: The pH of a solution is a measure of its acidity or alkalinity, defined as the negative logarithm (base 10) of the hydrogen ion concentration, $[H^+]$. Hydrochloric acid (HCl) is a strong acid, which means it dissociates completely in water.

Solution:

(a) **Dissociation of HCl:** Since HCl is a strong acid, it completely ionizes in water according to the equation:

$$\text{HCl (aq)} \rightarrow \text{H}^+\text{(aq)} + \text{Cl}^-\text{(aq)}$$

(b) **Determine Hydrogen Ion Concentration:** Due to complete dissociation, the concentration of hydrogen ions $[H^+]$ is equal to the initial molar concentration of the HCl solution.

$$[\text{H}^+] = [\text{HCl}] = 0.01 \text{ M}$$

(c) **Calculate pH:** The pH is calculated using the formula:

$$\text{pH} = -\log_{10}[\text{H}^+]$$

We can express the concentration in scientific notation: $0.01 \text{ M} = 1 \times 10^{-2} \text{ M}$.

$$\text{pH} = -\log_{10}(10^{-2})$$

Using the logarithm property $\log(10^x) = x$:

$$\text{pH} = -(-2) = 2$$

Final Answer : "2"

Answer: (B)

Q14.

Solution

Concept: The relationship between electrochemistry and thermodynamics is fundamental. The change in Gibbs free energy (ΔG) for a reaction represents the maximum amount of non-expansion work that can be extracted from a system. In an electrochemical cell, this work is the electrical work done by moving a charge through a potential difference.

Solution:

(a) **Electrical Work:** The electrical work done by a cell is the product of the total charge transferred and the cell potential (E).

$$W_{\text{elec}} = \text{Total Charge} \times \text{Cell Potential}$$

(b) **Total Charge:** The total charge transferred depends on the number of moles of electrons (n) that pass through the circuit for the balanced redox reaction. The charge of one mole of electrons is the Faraday constant ($F \approx 96485$ C/mol).

$$\text{Total Charge} = n \times F$$

(c) **Relating Work to Gibbs Energy:** For a reversible, spontaneous process, the decrease in Gibbs free energy ($-\Delta G$) is equal to the maximum work the system can do.

$$-\Delta G = W_{\text{max}} = W_{\text{elec}}$$

(d) **Combining the Equations:**

$$-\Delta G = (n \times F) \times E$$

Rearranging the equation gives the standard relationship:

$$\Delta G = -nFE$$

This equation shows that a positive cell potential ($E > 0$), which indicates a spontaneous reaction, corresponds to a negative Gibbs free energy change ($\Delta G < 0$).

Final Answer : "$\Delta G = -nFE$"

Answer: (B)

Q15.

Solution

Concept: The strength of a reducing agent is its ability to donate electrons, i.e., to be oxidized. In electrochemistry, this is quantified by the standard electrode potential (E°). A substance with a more negative (or less positive) standard reduction potential is more easily oxidized and is therefore a stronger reducing agent.

Solution: We compare the standard reduction potentials (E°) for the given metals. The half-reactions are written as reductions:

- Ag^+ (aq) + e^- $\longrightarrow$ Ag (s) $\quad E^\circ = +0.80$ V
- Cu^{2+} (aq) + $2e^-$ $\longrightarrow$ Cu (s) $\quad E^\circ = +0.34$ V
- Zn^{2+} (aq) + $2e^-$ $\longrightarrow$ Zn (s) $\quad E^\circ = -0.76$ V
- Au^{3+} (aq) + $3e^-$ $\longrightarrow$ Au (s) $\quad E^\circ = +1.50$ V

A more negative E° value indicates a greater tendency for the reverse reaction (oxidation) to occur. Comparing the values: Zn has the most negative standard reduction potential (−0.76 V). This means that the oxidation of Zn to Zn^{2+} is the most favorable among the given options, making metallic Zinc (Zn) the strongest reducing agent. The order of reducing strength is Zn > Cu > Ag > Au.

Final Answer : "Zn"

Answer: (B)

Q16.

Solution

Concept: Chemical kinetics deals with the rates of chemical reactions. The rate law for a reaction expresses the relationship between the rate of reaction and the concentration of reactants. For a generic reaction A → Products, the rate law is given by Rate = k[A]^x, where 'x' is the order of the reaction with respect to reactant A.

Solution: A zero-order reaction is one where the rate of the reaction does not depend on the concentration of the reactant(s). For a zero-order reaction A → Products, the rate law is written as:

$$\text{Rate} = k[\text{A}]^0$$

According to the rules of exponents, any non-zero value raised to the power of 0 is equal to 1.

$$[\text{A}]^0 = 1$$

Therefore, the rate law simplifies to:

$$\text{Rate} = k \times 1 = k$$

This equation shows that the rate of a zero-order reaction is constant and equal to the rate constant, k. It is completely **independent of the concentration** of the reactant.
Final Answer : "Independent of concentration"

Answer: (A)

Q17.

Solution

Concept: The half-life ($t_{1/2}$) of a reaction is the time required for the concentration of a reactant to decrease to half of its initial value. The formula for the half-life depends on the order of the reaction.

Solution: The integrated rate law for a zero-order reaction (A → Products) is:

$$[\mathrm{A}]_t = -kt + [\mathrm{A}]_0$$

where $[\mathrm{A}]_t$ is the concentration at time t, k is the rate constant, and $[\mathrm{A}]_0$ is the initial concentration. By definition, at the half-life ($t = t_{1/2}$), the concentration of the reactant is half of its initial value:

$$[\mathrm{A}]_t = \frac{[\mathrm{A}]_0}{2}$$

Substituting this into the integrated rate law:

$$\frac{[\mathrm{A}]_0}{2} = -kt_{1/2} + [\mathrm{A}]_0$$

Now, we rearrange the equation to solve for $t_{1/2}$:

$$kt_{1/2} = [\mathrm{A}]_0 - \frac{[\mathrm{A}]_0}{2}$$

$$kt_{1/2} = \frac{[\mathrm{A}]_0}{2}$$

$$t_{1/2} = \frac{[\mathrm{A}]_0}{2k}$$

This final expression clearly shows that the half-life of a zero-order reaction is directly proportional to the **initial concentration** ($[\mathrm{A}]_0$) and inversely proportional to the rate constant (k).

Final Answer : "Initial concentration"

Answer: (A)

Q18.

Solution

Concept: Atomic size (or atomic radius) is a periodic property that describes the size of an atom. Several factors influence atomic size, including nuclear charge, the number of electron shells, and the shielding effect of inner electrons.

Solution: When moving down a group in the periodic table, two main effects occur simultaneously:

(a) **Increase in Nuclear Charge:** The number of protons in the nucleus increases, which tends to pull the electrons closer to the nucleus, decreasing the size.

(b) **Increase in Number of Shells:** The principal quantum number (n) of the outermost electrons increases. This means a new electron shell is added for each period you move down. Each new shell is located further from the nucleus than the previous one.

The effect of adding a new, larger electron shell is the dominant factor. This substantial increase in distance from the nucleus far outweighs the increased pull from the higher nuclear charge. The inner electron shells also provide a "shielding" effect, which partially cancels the pull of the nucleus on the outermost electrons. Therefore, the primary reason for the increase in atomic size down a group is the **increase in the number of electron shells**.

Final Answer : “Increase in shells”

Answer: (B)

Q19.

Solution

Concept: The acidic or basic nature of oxides is a periodic trend. In general, metallic oxides are basic, non-metallic oxides are acidic, and metalloid oxides are amphoteric (can act as both). Acidity increases across a period (as elements become more non-metallic) and decreases down a group.

Solution: Let's classify each of the given oxides based on the element they contain:

- **Na_2O (Sodium oxide):** Sodium (Na) is a Group 1 alkali metal. Its oxide is strongly basic. It reacts with water to form a strong base, NaOH.
- **MgO (Magnesium oxide):** Magnesium (Mg) is a Group 2 alkaline earth metal. Its oxide is basic.
- **Al_2O_3 (Aluminum oxide):** Aluminum (Al) is a metalloid. Its oxide is amphoteric, meaning it can react with both acids and bases.
- **SO_3 (Sulfur trioxide):** Sulfur (S) is a non-metal located in Group 16. Its oxide is strongly acidic. It is the anhydride of sulfuric acid, reacting vigorously with water to form H_2SO_4, a very strong acid.

Comparing the options, SO_3 is the only oxide of a true non-metal and exhibits the most pronounced acidic character. Therefore, it is the most acidic oxide in the list.
Final Answer : "SO_3"

Answer: (C)

Q20.

Solution

Concept: The molecular shape (geometry) of a molecule can be predicted using the Valence Shell Electron Pair Repulsion (VSEPR) theory. The theory states that electron pairs in the valence shell of a central atom repel each other and will arrange themselves to be as far apart as possible, which determines the molecule's geometry.

Solution:

(a) **Central Atom and Valence Electrons:** The central atom is Xenon (Xe), a noble gas in Group 18. It has 8 valence electrons.

(b) **Bonding and Lone Pairs:**

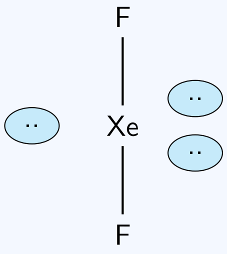
- Xe is bonded to two Fluorine (F) atoms, forming 2 single bonds (2 bonding pairs).
- Number of lone pair electrons = (Total valence e^-) - (Bonding e^-) = 8 - 2 = 6 electrons.
- Number of lone pairs = 6 electrons / 2 = 3 lone pairs.

(c) **Steric Number and Electron Geometry:**

- Steric Number = (Number of bonding pairs) + (Number of lone pairs) = 2 + 3 = 5.
- A steric number of 5 corresponds to a **trigonal bipyramidal** electron geometry.

(d) **Molecular Shape:** In a trigonal bipyramidal arrangement, the lone pairs occupy the positions that maximize separation to minimize repulsion. The three lone pairs will occupy the three equatorial positions, while the two fluorine atoms will occupy the two axial positions. This arrangement places the F-Xe-F atoms in a straight line.

The resulting molecular shape is **Linear**.



Final Answer : "Linear"

Answer: (A)

Q21.

Solution

Concept: The oxidation state of an element represents the degree of oxidation (loss of electrons) of an atom in a chemical compound. For transition metals, the maximum possible oxidation state often corresponds to the total number of valence electrons (ns + (n-1)d electrons).

Solution: Let's examine the electron configurations and maximum possible oxidation states for the given d-block elements:

- **Cr (Chromium):** The electron configuration is [Ar] $3d^5\ 4s^1$. The total number of valence electrons is 5 (from 3d) + 1 (from 4s) = 6. Chromium can lose all 6 of these valence electrons to achieve a maximum oxidation state of **+6**, which is common and stable in compounds like potassium dichromate ($K_2Cr_2O_7$) and chromium trioxide (CrO_3).
- **Fe (Iron):** The electron configuration is [Ar] $3d^6\ 4s^2$. The total number of valence electrons is 6 + 2 = 8. While it has 8 valence electrons, its most common oxidation states are +2 and +3. A +6 state exists but is very rare and unstable (e.g., in the ferrate ion, FeO_4^{2-}).
- **Co (Cobalt):** The electron configuration is [Ar] $3d^7\ 4s^2$. Its most common oxidation states are +2 and +3. Higher states are rare.
- **Ni (Nickel):** The electron configuration is [Ar] $3d^8\ 4s^2$. Its most common oxidation state is +2.

Among the choices provided, Chromium (Cr) is the element that most readily and commonly exhibits the maximum oxidation state of +6.

Final Answer : "Cr"

Answer: (A)

Q22.

Solution

Concept: Lanthanides are the f-block elements from Lanthanum (La) to Lutetium (Lu). Their most common and stable oxidation state is +3. However, some lanthanides can exhibit other oxidation states, such as +2 or +4, if doing so results in a particularly stable electron configuration, such as an empty (f^0), half-filled (f^7), or completely filled (f^{14}) f-subshell.

Solution: Let's analyze the electron configurations and potential oxidation states of the given lanthanides:

- **Ce (Cerium):** The electron configuration of neutral Cerium is [Xe] $4f^1\ 5d^1\ 6s^2$.
  - To form the common Ce^{3+} ion, it loses the 6s and 5d electrons, leaving a $4f^1$ configuration.
  - To form a Ce^{4+} ion, it can lose all four of its valence electrons (two 6s, one 5d, and one 4f). This results in the electron configuration of the noble gas Xenon ([Xe]), which has an empty f-subshell (f^0). This is a very stable configuration, making the **+4 oxidation state** prominent for Cerium.
- **La (Lanthanum):** The electron configuration is [Xe] $5d^1\ 6s^2$. It exclusively shows the +3 oxidation state by losing all three valence electrons to achieve the stable [Xe] configuration.
- **Nd (Neodymium):** The electron configuration is [Xe] $4f^4\ 6s^2$. It predominantly shows the +3 oxidation state.
- **Sm (Samarium):** The electron configuration is [Xe] $4f^6\ 6s^2$. It shows the +3 state, but can also show a +2 state (Sm^{2+}) to achieve a $4f^6$ configuration, which is close to the stable half-filled $4f^7$ configuration.

Of the options listed, Cerium (Ce) is the well-known example of a lanthanide that readily shows a +4 oxidation state.

Final Answer : "Ce"

Answer: (A)

Q23.

Solution

Concept: Diamagnetic species are those which have no unpaired electrons. Their orbitals are completely filled.

Solution: To determine if an ion is diamagnetic, we check its electronic configuration for unpaired electrons.

- Fe (Z=26): [Ar] 3d 6 6

  4s 2 2

  . So, Fe 2 + 2+

  is [Ar] 3d 6 6

  . It has 4 unpaired electrons.

- Mn (Z=25): [Ar] 3d 5 5

  4s 2 2

  . So, Mn 2 + 2+

  is [Ar] 3d 5 5

  . It has 5 unpaired electrons.

- Zn (Z=30): [Ar] 3d 10 10

  4s 2 2

  . So, Zn 2 + 2+

  is [Ar] 3d 10 10

  . The 3d orbital is completely filled, so it has 0 unpaired electrons.

- Cu (Z=29): [Ar] 3d 10 10

  4s 1 1

  . So, Cu 2 + 2+

  is [Ar] 3d 9 9

  . It has 1 unpaired electron.

Since Zn 2 + 2+
has no unpaired electrons, it is diamagnetic.

”Final Answer : “Zn 2 + 2+
”

Answer: (C)

Q24.

Solution

Concept: The coordination number of a central metal ion in a complex is the number of ligand donor atoms to which the metal is directly bonded.

Solution: In the complex [Co(NH 3 3
) 6 6
] 3 + 3+
, the central metal ion is Cobalt (Co). It is bonded to six ammonia (NH 3 3
) ligands. Since NH 3 3
is a monodentate ligand (it donates one pair of electrons), the total number of bonds formed with the central metal ion is 6. Thus, the coordination number is 6.
Final Answer : "6"

Answer: (B)

Q25.

Solution

Concept: Linkage isomerism arises in a coordination compound containing an ambidentate ligand. An ambidentate ligand is a ligand that can bind to the central metal atom through two or more different atoms.

Solution: Among the given options, the nitrite ion (NO 2 2
) is an ambidentate ligand. It can coordinate to a metal center through the nitrogen atom (M NO
2 2
, nitro isomer) or through one of the oxygen atoms (M ONO, nitrito isomer). NH 3 3
, Cl
, and H 2 2
O are monodentate ligands with only one possible donor atom. Therefore, NO 2 2
can show linkage isomerism.

"**Final Answer : "NO 2 2**
"

Answer: (A)

Q26.

Solution

Concept: Ligands are classified as strong-field or weak-field based on their ability to cause crystal field splitting. The spectrochemical series arranges ligands in order of increasing field strength.

Solution: The spectrochemical series is an empirically determined order of ligands. A simplified version of the series is: I
< Br
< Cl
< F
< H 2 2
O < NH 3 3
< CN
< CO Ligands on the left side of the series, like halide ions (I
), are weak-field ligands. Ligands on the right side, like CN
and CO, are strong-field ligands. Therefore, I
is the weakest field ligand among the choices.

”**Final Answer : “I**
”

Answer: (D)

Q27.

Solution

Concept: Separation techniques are physical methods used to separate components of a mixture based on differences in their physical properties.

Solution: Filtration is a mechanical or physical operation that separates an insoluble solid from a fluid (a liquid or a gas) by interposing a medium through which only the fluid can pass. Sublimation separates a volatile solid from a non-volatile one. Distillation separates liquids with different boiling points. Chromatography separates components based on their distribution between a stationary and a mobile phase. For separating a general solid from a liquid, filtration is the most direct method.
Final Answer : “Filtration”

Answer: (A)

Q28.

Solution

Concept: The stability of free radicals is influenced by hyperconjugation and the inductive effect. Alkyl groups are electron-donating and stabilize the electron-deficient carbon atom of the radical.

Solution: The stability of alkyl free radicals increases with the number of alkyl groups attached to the carbon atom bearing the unpaired electron. This is because alkyl groups stabilize the radical through electron donation (+I effect) and hyperconjugation. The order of stability is: Tertiary (3
) > Secondary (2
) > Primary (1
) > Methyl Therefore, the 3
free radical is the most stable.

”**Final Answer : “3**
”

Answer: (C)

Q29.

Solution

Concept: The positive mesomeric effect (+M effect) occurs when a group donates electrons to a conjugated system, increasing the electron density on the system. This is typically shown by groups with a lone pair of electrons on the atom directly attached to the system.

Solution:

- NO 2 2

  , CN, and COOH are electron-withdrawing groups and exhibit a negative mesomeric effect (-M effect).
- The hydroxyl group (OH) has lone pairs on the oxygen atom which can be delocalized into a conjugated system (like a benzene ring), thereby donating electron density. This is a positive mesomeric effect (+M effect).

Final Answer : “ OH”

Answer: (C)

Q30.

Solution

Concept: A nucleophile ("nucleus loving") is a chemical species that donates an electron pair to an electrophile ("electron loving") to form a chemical bond.

Solution: Nucleophiles are electron-rich species. They possess a lone pair of electrons or a pi-bond that can be used to form a new covalent bond. By definition, a species that donates a pair of electrons is a Lewis base. Therefore, a nucleophile is an electron donor. An electron acceptor is an electrophile.

Final Answer : “Electron donor”

Answer: (B)

Q31.

Solution

Concept: The addition of HBr to unsymmetrical alkenes in the presence of a peroxide follows a free-radical mechanism, leading to the anti-Markovnikov product. This is known as the peroxide effect or Kharasch effect.

Solution: According to Markovnikov’s rule, in the addition of HX to an unsymmetrical alkene, the hydrogen atom adds to the carbon that has more hydrogen atoms. However, in the presence of peroxides (like R-O-O-R), the addition of HBr proceeds via a free-radical mechanism. This mechanism reverses the regioselectivity, causing the bromine atom to add to the less substituted carbon, resulting in the anti-Markovnikov product. This effect is specific to HBr addition in the presence of peroxides.

Final Answer : “Peroxide”

Answer: (C)

Q32.

Solution

Concept: The reaction of benzene with halogens is an electrophilic aromatic substitution. Benzene's aromatic ring is electron-rich but stable, so it requires a strong electrophile to react. A Lewis acid catalyst is used to generate this strong electrophile.

Solution: The bromination of benzene involves substituting a hydrogen atom on the ring with a bromine atom.

- The Br 2 2

  molecule itself is not a strong enough electrophile to attack the stable benzene ring.

- A Lewis acid catalyst, such as FeBr 3 3

  (iron(III) bromide), is required. The FeBr 3 3

  polarizes the Br-Br bond, making one bromine atom strongly electrophilic and susceptible to attack by the benzene ring.

- The reaction mechanism is: Br 2 2

  + FeBr 3 3

  Br + +

  [FeBr 4 4

  ]

  The generated "Br + +

  " (or the polarized complex) is the potent electrophile that attacks the benzene ring.

- **UV light** promotes free-radical substitution, which occurs with alkanes or on the side-chains of alkylbenzenes, not on the aromatic ring itself.

- **Heat** and **Pressure** are reaction conditions but are not the specific agents required to enable this particular reaction. The key is the catalyst.

Therefore, benzene reacts with Br 2 2
in the presence of FeBr 3 3
to form bromobenzene.

**”Final Answer : “FeBr 3 3
”**

Answer: (B)

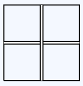
Q33.

Solution

Concept: Aromaticity is determined by Hückel's rules. For a compound to be anti-aromatic, it must be cyclic, planar, fully conjugated, and have a total of 4n -electrons (where n is an integer, n=1, 2, 3...).

Solution: Let's analyze the options based on the criteria for aromaticity and anti-aromaticity.

- **Benzene:** It is cyclic, planar, and fully conjugated. It has 6 -electrons (from three double bonds). This fits the (4n+2) rule for n=1 (4(1)+2 = 6). Benzene is **aromatic**.
- **Cyclobutadiene:** It is cyclic, planar, and fully conjugated. It has 4 -electrons (from two double bonds). This fits the 4n rule for n=1 (4(1) = 4). Cyclobutadiene is **anti-aromatic** and highly unstable.



Cyclobutadiene (4 e)

- **Cyclopentane:** It is cyclic but is not planar (it has an envelope conformation) and is not conjugated. It has no -electrons as it is an alkane. It is **non-aromatic**.
- **Naphthalene:** It is cyclic, planar, and fully conjugated. It has 10 -electrons (from five double bonds). This fits the (4n+2) rule for n=2 (4(2)+2 = 10). Naphthalene is **aromatic**.

Thus, cyclobutadiene is the anti-aromatic compound.

Final Answer : "Cyclobutadiene"

Answer: (B)

Q34.

Solution

Concept: The SN2 (Substitution, Nucleophilic, Bimolecular) reaction is a type of nucleophilic substitution reaction where the rate-determining step involves two components: the substrate and the nucleophile.

Solution: The key features of the SN2 mechanism are:

- **One Step:** The entire reaction occurs in a single, concerted step. The nucleophile attacks the electrophilic carbon at the same time as the leaving group departs. There are no intermediates.
- **Transition State:** The reaction proceeds through a high-energy transition state where the carbon atom is pentacoordinate (partially bonded to both the incoming nucleophile and the outgoing leaving group).
- **Backside Attack:** The nucleophile attacks from the side opposite to the leaving group. This leads to an inversion of stereochemistry at the reaction center (Walden inversion).
- **No Carbocation:** Since there is no intermediate, a carbocation is not formed. This also means that carbocation rearrangements are not possible.
- **Rate Law:** The rate is dependent on the concentration of both the substrate and the nucleophile: Rate = k[Substrate][Nucleophile].

In contrast, the SN1 reaction proceeds in two steps, involves a carbocation intermediate, and can undergo rearrangement. Therefore, the defining characteristic of an SN2 reaction is that it is a one-step process.

Final Answer : "One step"

Answer: (B)

Q35.

Solution

Concept: In nucleophilic substitution reactions, the reactivity of alkyl halides (R-X) depends on the C-X bond strength and the ability of the halide ion (X

) to act as a leaving group. A good leaving group is the conjugate base of a strong acid.

Solution: The halide leaving group ability is inversely related to its basicity. A weaker base is a better leaving group because it is more stable on its own in solution.

(a) **Acidity of HX:** Let's consider the acidity of the hydrohalic acids: HI > HBr > HCl > HF HI is the strongest acid, and HF is the weakest. This is because the H-I bond is the longest and weakest, making it easiest to break.

(b) : The strength of the conjugate base is opposite to the strength of the acid. Therefore, the basicity of the halide ions is: F

> Cl

> Br

> I

Iodide (I

) is the weakest base, and fluoride (F

) is the strongest base.

(c) **Leaving Group Ability:** Since a better leaving group is a weaker base, the order of leaving group ability is: I

> Br

> Cl

> F

(d) **Reactivity Order:** Consequently, the reactivity of alkyl halides in both SN1 and SN2 reactions follows this trend, as the departure of the leaving group is crucial in both mechanisms. R-I > R-Br > R-Cl > R-F

Therefore, the reactivity order of halides is I > Br > Cl > F.

Final Answer : "I > Br > Cl > F"

Answer: (B)

Q36.

Solution

Concept: Different functional groups can be distinguished by specific chemical tests. Aldehydes are easily oxidized, whereas ketones are generally resistant to oxidation by mild oxidizing agents.
Solution: Let's examine the given tests:

- **Tollen's Test (Silver Mirror Test):** Tollen's reagent [Ag(NH 3 3

) 2 2

  ] + +

  is a mild oxidizing agent. It oxidizes aldehydes to carboxylate ions and is itself reduced to metallic silver, which forms a mirror on the test tube. Ketones do not react. This test is used to distinguish aldehydes from ketones.

- **Fehling's Test:** Fehling's solution (containing Cu 2 + 2+

  ions) is another mild oxidizing agent. It oxidizes aliphatic aldehydes, and the Cu 2 + 2+

  is reduced to Cu + +

  which precipitates as red copper(I) oxide (Cu 2 2

  O). Ketones (and aromatic aldehydes) do not react.

- **Iodoform Test:** This test is positive for compounds containing a methyl ketone group (CH 3 3

  -C=O-) or a group that can be oxidized to a methyl ketone (like CH 3 3

  -CH(OH)-). The reagent is iodine in the presence of a base (like NaOH). A positive test is the formation of a yellow precipitate of iodoform (CHI 3 3

). Many ketones, such as acetone (CH 3 3

  COCH 3 3

) and acetophenone (C 6 6

  H 5 5

  COCH 3 3

  ), give a positive iodoform test.

Since ketones do not give positive Tollen's or Fehling's tests but certain ketones (methyl ketones) do give a positive iodoform test, the correct answer is Iodoform test.
Final Answer : "Iodoform"

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

Q37.

Solution

Concept: Hydrogen bonding is a special type of strong dipole-dipole interaction that occurs between a hydrogen atom bonded to a highly electronegative atom (N, O, or F) and another nearby electronegative atom.

Solution: Alcohols have the general formula R-O-H. The key to their ability to form hydrogen bonds lies in the O-H group.

(a) **Electronegativity:** Oxygen is a highly electronegative atom. This means it has a strong attraction for the electrons in the covalent O-H bond.

(b) **Bond Polarity:** Due to oxygen's high electronegativity, the bonding electrons are pulled towards the oxygen atom. This creates a partial negative charge (

) on the oxygen and a partial positive charge (+ +

) on the hydrogen. The O-H bond is therefore highly polar.

(c) **Intermolecular Attraction:** The partially positive hydrogen atom (+ +

) of one alcohol molecule is strongly attracted to the lone pair of electrons on the partially negative oxygen atom (

) of a neighboring alcohol molecule. This strong electrostatic attraction is called a hydrogen bond.

Other factors like size, shape, and mass influence physical properties, but the fundamental reason for hydrogen bonding is the high electronegativity of the oxygen atom, which creates the required bond polarity.

Final Answer : "Oxygen electronegativity"

Answer: (A)

Q38.

Solution

Concept: The boiling point of a substance is determined by the strength of its intermolecular forces. Stronger forces require more energy (higher temperature) to overcome, resulting in a higher boiling point.

Solution: Let's compare the intermolecular forces in the given classes of compounds, assuming similar molecular weights for a fair comparison.

- **Carboxylic acid (R-COOH):** They can form two hydrogen bonds per molecule, creating stable dimers. This results in very strong intermolecular forces and the highest boiling points.
- **Alcohol (R-OH):** They can form hydrogen bonds due to the polar O-H group. These are strong forces, leading to high boiling points.
-): Primary and secondary amines can also form hydrogen bonds via the N-H group. However, since nitrogen is less electronegative than oxygen, these hydrogen bonds are weaker than those in alcohols. Their boiling points are generally between those of alcohols and alkanes.
- **Ether (R-O-R):** Ethers have a polar C-O-C bond, so they exhibit dipole-dipole interactions. However, they lack a hydrogen atom bonded to the oxygen. Therefore, ether molecules **cannot** form hydrogen bonds with each other. Their intermolecular forces are much weaker than those in alcohols and carboxylic acids.

The strength of intermolecular forces is generally: Carboxylic acids > Alcohols > Amines > Ethers > Alkanes. Therefore, for a comparable molecular weight, ethers will have the lowest boiling point among the given options.
Final Answer : "Ether"

Answer: (B)

Q39.

Solution

Concept: Oxidation of alcohols involves removal of hydrogen from both the hydroxyl group (-OH) and the carbon attached to it. The product depends on the degree of the alcohol.

Solution: Alcohols are classified based on the number of alkyl groups attached to the carbon bearing the -OH group.

- **Primary (1°) Alcohol (R-CH$_2$OH):** The carbon has two hydrogen atoms. On oxidation, one hydrogen is removed from -OH and one from carbon to form an aldehyde (R-CHO). With strong oxidizing agents (like KMnO$_4$, K$_2$Cr$_2$O$_7$), the aldehyde is further oxidized to a carboxylic acid (R-COOH).
- **Secondary (2°) Alcohol (R-CH(OH)-R'):** The carbon has one hydrogen atom. Oxidation leads to formation of a carbonyl group (>C=O), producing a ketone. Further oxidation is difficult because it would require breaking a C–C bond.

$$\text{R-CH(OH)-R'} \xrightarrow{[O]} R - C(=O) - R' + H_2\text{O}$$

- **Tertiary (3°) Alcohol (R-C(OH)(R')-R"):** No hydrogen is attached to the carbon bearing -OH. Hence oxidation cannot occur without cleavage of C–C bonds, which requires very harsh conditions. Therefore, they are generally resistant to oxidation.

Thus, oxidation of a secondary alcohol yields a ketone.

Final Answer : "Ketone"

Answer: (C)

Q40.

Solution

Concept: Basicity of amines in aqueous solution depends on three major factors: inductive effect (+I), solvation of the conjugate acid, and steric hindrance.

Solution: Amines act as bases due to the lone pair of electrons on nitrogen which can accept a proton.

- **Inductive Effect (+I):** Alkyl groups donate electron density to nitrogen, increasing availability of the lone pair. Hence, basicity increases:

  $$(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$$

- **Solvation Effect:** In aqueous solution, the conjugate acid formed is stabilized by hydrogen bonding. More hydrogen bonds mean greater stability:

  $$NH_4^+ > RNH_3^+ > R_2NH_2^+ > R_3NH^+$$

  Thus, tertiary amines are least solvated.

- **Steric Hindrance:** Bulky alkyl groups around nitrogen hinder the approach of H$^+$, decreasing basicity of tertiary amines.

Considering all effects together, secondary amines strike the best balance between electron donation and solvation.
Hence, the observed order:

$$(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$$

Final Answer : "(CH$_3$)$_2$NH"

Answer: (C)

Q41.

Solution

Concept: Basicity depends on how easily the lone pair on nitrogen can be donated to a proton. Delocalization of the lone pair reduces its availability.

Solution: Aniline is an aromatic amine in which the -NH_2 group is directly attached to a benzene ring.

- The lone pair on nitrogen participates in resonance with the π-electron system of the benzene ring.
- This leads to delocalization of electron density from nitrogen into the ring.
- As a result, the lone pair is less available for protonation.
- Additionally, the sp^2 hybridized carbon of the benzene ring exerts a slight -I effect, further reducing electron density on nitrogen.

In contrast, in aliphatic amines, the lone pair remains localized and is more available for donation. Hence, aniline is less basic due to resonance stabilization of the lone pair.
Final Answer : "Resonance"

Answer: (B)

Q42.

Solution

Concept: Monosaccharides are classified based on the nature and position of the carbonyl group:
- Aldehyde group → Aldose
- Ketone group → Ketose

Solution: Fructose ($C_6H_{12}O_6$) is a hexose sugar.

- In its open-chain structure, it contains six carbon atoms.
- The carbonyl group is located at the second carbon (C-2).
- A carbonyl group within the carbon chain represents a ketone functional group.
- Therefore, fructose is classified as a ketose.

Since it has six carbons and a ketone group, fructose is specifically called a **ketohexose**.
Final Answer : "Ketose"

Answer: (B)

Q43.

Solution

Concept: Nucleic acids, DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid), are polymers made of nucleotide monomers. Each nucleotide consists of a phosphate group, a pentose sugar, and a nitrogenous base.

Solution: The name of the nucleic acid itself indicates the type of sugar it contains.

- **DNA** stands for **D**eoxyribo**n**ucleic **a**cid. The sugar component is a modified form of ribose called **2-deoxyribose**. In this sugar, the hydroxyl (-OH) group at the 2' position of the ribose ring is replaced by a hydrogen (-H) atom.
- **RNA** stands for **R**ibo**n**ucleic **a**cid. The sugar component is **ribose**.
- **Glucose** and **Fructose** are hexose sugars and are primarily involved in metabolism and energy storage; they are not components of the nucleic acid backbone.

Therefore, the sugar found in the backbone of DNA is deoxyribose.
Final Answer : "Deoxyribose"

Answer: (B)

Q44.

Solution

Concept: An indicator is a substance that undergoes a distinct, observable change (usually a color change) when the conditions in its solution change. In an acid-base titration, the indicator changes color at or near the equivalence point, signaling the end of the titration.

Solution: Let's analyze the roles of the given substances in titrations:

- **Phenolphthalein:** This is a common acid-base indicator. It is a weak acid that is colorless in acidic and neutral solutions ($pH < 8.2$) and turns fuchsia/pink in basic solutions ($pH > 8.2$). Its sharp color change makes it suitable for many acid-base titrations, especially for titrating a strong acid with a strong base or a weak acid with a strong base.

- (Potassium permanganate): This is a strong oxidizing agent used in redox titrations. It has a deep purple color. During the titration, the permanganate ion (MnO 4 4

) is reduced to the nearly colorless Mn 2 + 2+

  ion. At the endpoint, the first drop of excess KMnO 4 4

  imparts a permanent pink/purple color to the solution. It acts as its own indicator (a self-indicator).

- Cr 2 2

  O 7 7

  (Potassium dichromate): This is another strong oxidizing agent used in redox titrations. The orange dichromate ion (Cr 2 2

  O 7 2 7 2

) is reduced to the green chromium(III) ion (Cr 3 + 3+

). It does not act as a self-indicator; an external redox indicator is usually required.

- **Iodine:** Iodine is used in redox titrations (iodometry and iodimetry). The endpoint is typically detected by adding starch indicator, which forms an intense blue-black complex with iodine.

Of the options given, only phenolphthalein is specifically used as an indicator for acid-base titrations.

Final Answer : "Phenolphthalein"

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

Q45.

Solution

Concept: The pH of a solution is a measure of its acidity or alkalinity, defined as the negative base-10 logarithm of the hydrogen ion concentration ($[H^+]$). A strong acid is an acid that dissociates completely in an aqueous solution.

Solution: The problem asks for the pH of a 10^{-3} M solution of a strong monoprotic acid.
Step 1: Understand the properties of a strong monoprotic acid.

- **Strong acid**: This means the acid completely ionizes or dissociates in water. If we represent the acid as HA, the dissociation reaction is: $HA \rightarrow H^+ + A^-$ Since the dissociation is complete, the concentration of hydrogen ions $[H^+]$ produced is equal to the initial concentration of the acid.
- **Monoprotic**: This means each molecule of the acid donates exactly one proton (H^+).

Step 2: Determine the hydrogen ion concentration $[H^+]$. Given the initial concentration of the strong monoprotic acid is 10^{-3} M. Because it dissociates completely, the concentration of H^+ ions will be the same as the initial acid concentration. Therefore, $[H^+] = 10^{-3}$ M.
Step 3: Calculate the pH. The formula for pH is: pH = -log$[H^+]$ Substitute the value of $[H^+]$ into the formula: pH = -log(10^{-3}) Using the logarithmic property log(a^b) = b · log(a): pH = -(-3) · log(10) Since log(10) = 1: pH = -(-3) · 1 pH = 3
Final Answer : The pH of a 10^{-3} M solution of a strong monoprotic acid is 3.

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

Answer Key

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