CUET UG (Chemistry)

15 May 2024

Question 1

The increasing order of acidity of the following compounds based on pKa values is

(A) $BrCH_2COOH$

(B) $ClCH_2COOH$

(C) FCH_2COOH

(D) HCOOH

Choose the correct answer from the options given below:

Options:

A. (D)<(A)<(B)<(C)

B. (A)<(D)<(C) <(B)

C. (B) <(A) <(D) <(C)

D. (C) <(B) <(D) <(A)

Answer: A

Solution:

CONCEPT:

Acidity and pKa Values

- The acidity of a compound is inversely related to its pKa value. A lower pKa value indicates a stronger acid.
- The presence of electronegative substituents (such as halogens) near the carboxyl group increases the acidity of carboxylic acids by stabilizing the conjugate base through the inductive effect.

EXPLANATION:

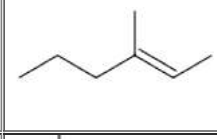
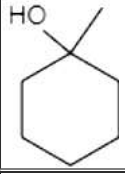
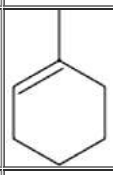
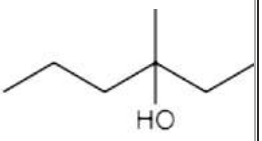
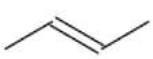
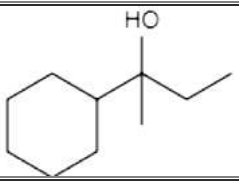
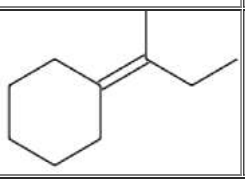
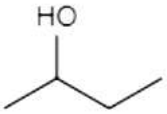
- The electronegativity of the halogens decreases in the order: F > Cl > Br.
- The stronger the electron-withdrawing effect, the more stable the conjugate base, and the stronger the acid (lower pKa).
- Therefore, the order of acidity based on the inductive effect will be:
  - FCH_2COOH (C) > $ClCH_2COOH$ (B) > $BrCH_2COOH$ (A) > HCOOH (D)

Therefore, the correct increasing order of acidity based on pKa values is (D) < (A) < (B) < (C)

Question 2

In the following table, match the reactants given in List-I with the correct product in List-II as per the reaction of hydration of alkene under acidic condition.

	List-I (Reactants)		List-II (Products)

(A)		(I)	
(B)		(II)	
(C)		(III)	
(D)		(IV)	

Choose the correct answer from the options given below:

Options:

A. (A) - (I), (B) - (II), (C) - (III), (D) - (IV)

B. (A) - (I), (B) - (III), (C) - (II), (D) - (IV)

C. (A) - (II), (B) - (I), (C) - (IV), (D) - (III)

D. (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Answer: C

Solution:

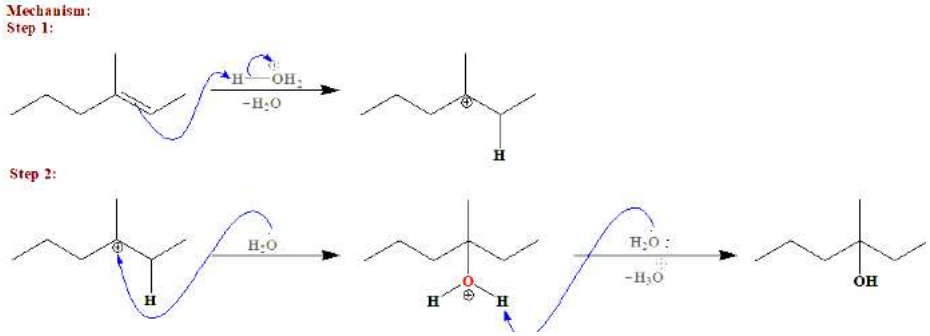
CONCEPT:

Hydration of Alkenes under Acidic Conditions

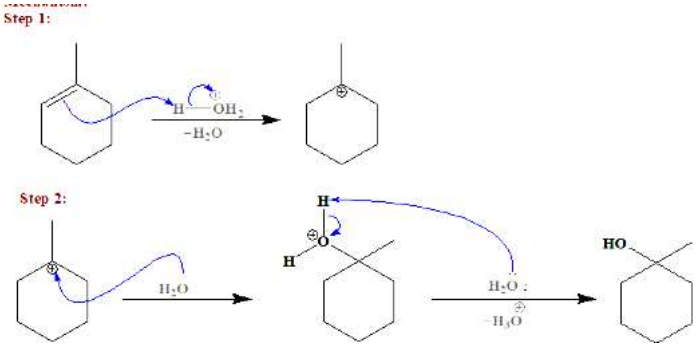
- Hydration of alkenes in the presence of an acid (H^+) follows Markovnikov's rule, where the hydroxyl group (-OH) attaches to the more substituted carbon (the carbon with fewer hydrogen atoms).
- The mechanism involves:
  1. Protonation of the alkene to form the most stable carbocation intermediate.
  2. Nucleophilic attack by water (H_2O) on the carbocation.
  3. Deprotonation to yield the final alcohol product.
- The key step is the formation of the most stable carbocation, which determines the regioselectivity of the product.

EXPLANATION:

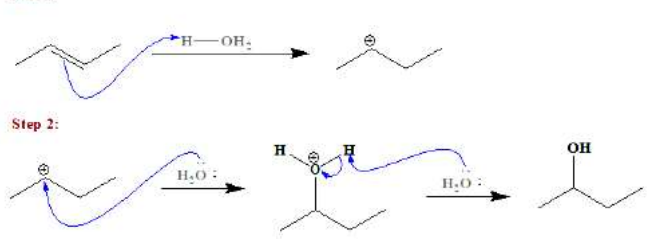
- **Matching Reactants with Products:**
  - **(A)** The given alkene undergoes hydration where the -OH group attaches to the more substituted carbon, leading to product (I).



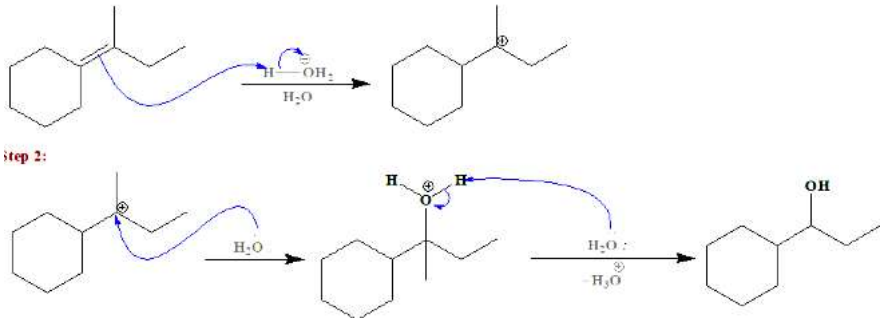
  - **(B)** Hydration of the cycloalkene with a methyl substituent leads to the formation of the product (I) due to Markovnikov addition and carbocation stability.



- **(C)** Ethene on hydration gives ethanol, corresponding to product (IV).



- **(D)** The given substituted cycloalkene undergoes hydration resulting in product (III) due to the formation of a more stable carbocation intermediate.



Therefore, the correct answer is(A) - (I), (B) - (I), (C) - (IV), (D) - (III)

Question 3

Which among the following is not an Analgesic?

Options:

A. Morphene

B. Heroin

C. Codeine

D. Ranitidine

Answer: D

Solution:

CONCEPT:

Analgesics

- Analgesics are drugs that are used to relieve pain. They act on the central or peripheral nervous system.
- There are two main types of analgesics: non-narcotic analgesics and narcotic analgesics.
- Narcotic analgesics (such as morphine and codeine) are used for severe pain and non-narcotic analgesics (such as ibuprofen and aspirin) are used for mild to moderate pain.

EXPLANATION:

- In the given options:
  - Morphine is a potent narcotic analgesic.

- Heroin (derived from morphine) is a narcotic analgesic used (legally) for severe pain relief.
- Codeine is a weaker narcotic analgesic that is used for mild to moderate pain relief.
- Ranitidine, however, is not an analgesic. It is a medication used to reduce stomach acid production, and is commonly used for the treatment of peptic ulcers and gastroesophageal reflux disease (GERD).

Therefore, the correct answer is 4) Ranitidine.

Question 4

For $S_N2$reaction, the increasing order of the reactivity of the following alkyl halides is:

(A)$CH_3CH_2CH_2CH_2Br$

(B)$CH_3CH_2CH(Br)CH_3$

(C)$(CH_3)_3CBr$

(D)$(CH_3)_2CHCH_2Br$

Choose the correct answer from the options given below :

Options:

A. (A)<(B)<(C)<(D)

B. (A)<(C)<(B)<(D)

C. (B)<(A)<(D)<(C)

D. (C)<(B)<(D)<(A)

Answer: D

Solution:

CONCEPT:

SN2 Reaction

- SN2 (Substitution Nucleophilic Bimolecular) reactions involve a backside attack by the nucleophile, leading to a one-step mechanism where the bond formation and bond breaking occur simultaneously.
- The rate of SN2 reactions is highly dependent on the steric hindrance around the carbon atom undergoing substitution. Less steric hindrance results in a faster SN2 reaction.

EXPLANATION:

- We need to arrange them in increasing order of reactivity towards SN2 reaction:
  - (C) (CH3)3CBr: **Tertiary alkyl halide,** highest steric hindrance, least reactive.
  - (B) CH3CH2CH(Br)CH3: **Secondary alkyl halide, moderate** steric hindrance.
  - (D) (CH3)2CHCH2Br: **Primary alkyl halide** but with some steric hindrance due to branching.
  - (A) CH3CH2CH2CH2Br: Primary alkyl halide, least steric hindrance, most reactive.
- Therefore, the increasing order of reactivity is:
  - (C) < (B) < (D) < (A)

Therefore, the correct answer is option 4.

Question 5

The number of moles of hydrogen oxidised is:

The number of moles of hydrogen oxidised is:

Options:

A. 0.33 moles

B. 33.3 moles

C. 3.0 moles

D. 1.33 moles

Answer: C

Solution:

CONCEPT:

Moles and Volume of a Gas at STP

- At standard temperature and pressure (STP), one mole of an ideal gas occupies 22.4 liters of volume.
- Therefore, we can use the volume of gas to calculate the number of moles of the gas present using the formula:

  Number of moles = Volume of gas at STP / Molar volume at STP

  Molar volume at STP = 22.4 L

EXPLANATION:

- Given:
  - Volume of hydrogen (H_2) at STP = 67.2 L
- Using the formula for number of moles:

  Number of moles of H_2 = Volume of H_2 at STP / Molar volume at STP

  = 67.2 L / 22.4 L

  = 3 moles

Therefore, the number of moles of hydrogen oxidised is 3.0 moles, and the correct answer is 3) 3.0 moles.

Question 6

The number of moles of electrons produced in the oxidation of 67.2 L of H_2 at STP is:

The number of moles of electrons produced in the oxidation of 67.2 L of H_2 at STP is:

Options:

A. 2 moles

B. 4 moles

C. 1 mole

D. 6 moles

Answer: D

Solution:

CONCEPT:

Oxidation Reaction and Moles of Electrons

- In a redox reaction, the number of moles of electrons involved can be determined from the stoichiometry of the half-reactions.
- The anode reaction provided is:

  $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$

- This indicates that for each mole of H_2 gas oxidized, 2 moles of electrons are produced.
- We have already calculated that the number of moles of H_2 in 67.2 L at STP is 3 moles.

EXPLANATION:

- Using the stoichiometry of the anode reaction:

  1 mole of H_2 → 2 moles of electrons

  Therefore, 3 moles of H_2 will produce:

  3 moles of H_2 → 3 x 2 = 6 moles of electrons

Therefore, the number of moles of electrons produced in the oxidation of 67.2 L of H_2 at STP is 6 moles, and the correct answer is 6 moles.

Question 7

The quantity of electricity produced in the oxidation of 67.2 L of H_2 at STP is:

The quantity of electricity produced in the oxidation of 67.2 L of H_2 at STP is:

Options:

A. 96500 C

B. 579000 C

C. 193000 C

D. 48250 C

Answer: B

Solution:

CONCEPT:

Faraday's Laws of Electrolysis

- Faraday's first law of electrolysis states that the amount of substance deposited or liberated at an electrode during electrolysis is directly proportional to the quantity of electricity passed through the electrolyte.
- The quantity of electricity (Q) is given by the equation:

  $Q = n \times F$

  where,

  n is the number of moles of electrons

  F is Faraday's constant (96500 C/mol)

EXPLANATION:

- Given:

  Volume of H_2 at STP = 67.2 L

- At STP, 1 mole of any gas occupies 22.4 L. Therefore,

  Number of moles of H_2 = (67.2 L) / (22.4 L/mol) = 3 mol

- The oxidation of H_2 involves 2 electrons per molecule of H_2:

  $H_2 \rightarrow 2H^+ + 2e^-$

- Therefore, the number of moles of electrons (n) is:

  n = 3 mol H_2 × 2 mol e^-/mol H_2 = 6 mol e^-

- Using Faraday's constant (F = 96500 C/mol), the quantity of electricity (Q) is:

  Q = n × F = 6 mol e^- × 96500 C/mol = 579000 C

Therefore, the quantity of electricity produced in the oxidation of 67.2 L of H_2 at STP is 579000 C.

Question 8

If the entire current produced is used for the electrodeposition of Silver (at.wt. 108 g mol^{-1}) from Silver (I) solution, the amount of silver deposited will be:

If the entire current produced is used for the electrodeposition of Silver (at.wt. 108 g mol^{-1}) from Silver (I) solution, the amount of silver deposited will be:

Options:

A. 324 g

B. 648 g

C. 108 g

D. 216 g

Answer: B

Solution:

CONCEPT:

Electrodeposition and Amount of Substance Deposited

- The amount of a substance deposited or liberated during electrolysis is directly proportional to the quantity of electricity passed through the solution.
- According to Faraday's laws, the mass (m) of a substance deposited at an electrode is given by:

  m = (Q * M) / (n * F)

  where m = mass of the substance deposited, Q = quantity of electricity in coulombs, M = molar mass of the substance (g/mol), n = number of moles of electrons required to deposit 1 mole of the substance, and F = Faraday's constant (approximately 96500 C/mol).

- For silver (Ag), the reduction half-reaction is:

  $Ag^{+} + e^{-} \rightarrow Ag$

  This indicates that 1 mole of electrons deposits 1 mole of silver (n = 1).

- We previously calculated the quantity of electricity (Q) to be 579000 C.

EXPLANATION:

- Given:
  - Quantity of electricity (Q) = 579000 C
  - Molar mass of silver (M) = 108 g/mol
  - Number of moles of electrons (n) = 1 mole
  - Faraday's constant (F) = 96500 C/mol
- Using the formula:

  m = (Q * M) / (n * F)

  = (579000 C * 108 g/mol) / (1 * 96500 C/mol)

  = 579000 * 108 / 96500

  = 648 g

Therefore, the amount of silver deposited will be 648 g.

Question 9

The source of electrical energy on the Apollo moon flight was:

The source of electrical energy on the Apollo moon flight was:

Options:

A. Lead storage battery

B. A generator set

C. Ni-Cd cells

D. H_2-O_2Fuel cell

Answer: D

Solution:

CONCEPT:

H_2-O_2 Fuel Cell

- A fuel cell is a device that converts chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent.
- Hydrogen-oxygen (H_2-O_2) fuel cells are a type of fuel cell that uses hydrogen as the fuel and oxygen as the oxidant.
- In an H_2-O_2 fuel cell, hydrogen and oxygen react to produce water, electricity, and heat.

EXPLANATION:

- The Apollo moon missions used H_2-O_2 fuel cells as the primary source of electrical energy.
- This choice was made due to several advantages:
  - High energy density: Fuel cells can store and produce a large amount of energy compared to other power sources of the same size and weight.
  - Water production: The by-product of the H_2-O_2 reaction is water, which was used by astronauts for drinking.
  - Efficiency: Fuel cells are highly efficient at converting chemical energy directly into electrical energy.
- The reaction in the fuel cell is:

  $2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(l) + \text{Energy (electricity + heat)}$

Therefore, the source of electrical energy on the Apollo moon flight was the H_2-O_2 fuel cell.

Question 10

Identify the incorrect statement.

Identify the incorrect statement.

Options:

A. Second ionisation enthalpy of Ag is greater than second ionisation enthalpy of Pd.

B. Zr and Hf shares almost identical nuclear properties.

C. Melting point of Mn is lower than that of Cr.

D. Interstitial compounds are non-stoichiometric and neither ionic nor covalent in nature.

Answer: B

Solution:

CONCEPT:

Ionisation Enthalpy and Nuclear Properties

- **Ionisation Enthalpy**: The amount of energy required to remove an electron from an isolated atom or ion in its gaseous state.
- **Nuclear Properties**: Elements with similar electron configurations can have similar nuclear properties due to similar shielding and effective nuclear charge.

EXPLANATION:

- Option 1: Second ionisation enthalpy of Ag is greater than that of Pd.

- Ag (Silver) has a filled d^10 configuration after losing one electron, making the removal of a second electron energetically more expensive compared to Pd (Palladium).
- Option 2: Zr and Hf share almost identical nuclear properties.
  - Despite being in different periods, Zr (Zirconium) and Hf (Hafnium) have similar atomic radii and other properties due to the lanthanide contraction, making them chemically and physically similar.
- Option 3: Melting point of Mn is lower than that of Cr.
  - Mn (Manganese) has a melting point of 1246°C, which is indeed lower than Cr (Chromium) with a melting point of 1907°C.
- Option 4: Interstitial compounds are non-stoichiometric and neither ionic nor covalent in nature.
  - Interstitial compounds are formed when small atoms (like hydrogen, carbon, or nitrogen) occupy the interstitial sites in a metal lattice, making them non-stoichiometric and neither purely ionic nor covalent.

Therefore, the correct answer is option 2, as Zr and Hf do indeed share almost identical nuclear properties.

Question 11

Which of the following is the correct order of second ionisation enthalpy?

Which of the following is the correct order of second ionisation enthalpy?

Options:

A. V > Cr > Mn

B. V < Cr < Mn

C. V < Cr > Mn

D. V > Cr < Mn

Answer: C

Solution:

CONCEPT:

Second Ionisation Enthalpy

- The second ionisation enthalpy is the energy required to remove an electron from a singly charged gaseous cation (X^{+}) to form a doubly charged gaseous cation (X^{2+}).
- It is generally higher than the first ionisation enthalpy because it is more difficult to remove an electron from a positively charged ion.

EXPLANATION:

- For the elements V (Vanadium), Cr (Chromium), and Mn (Manganese), the second ionisation enthalpy values are influenced by their electronic configurations:
  - V: [Ar] $3d^3$ $4s^2$
  - Cr: [Ar] $3d^5$ $4s^1$
  - Mn: [Ar] $3d^5$ $4s^2$
- The second ionisation will remove an electron from:
  - V^{2+}: [Ar] $3d^3$
  - Cr^{2+}: [Ar] $3d^4$
  - Mn^{2+}: [Ar] $3d^5$
- The stability of the $3d^5$ configuration in Cr^{2+} and Mn^{2+} makes it harder to remove an electron from Mn^{+}, while Cr has a relatively stable half-filled d-orbital.
  - Therefore, the second ionisation enthalpy order is: V < Cr > Mn.

Therefore, the correct order of second ionization enthalpy is V < Cr > Mn.

Question 12

Which of the following pair of compounds exhibits same colour in aqueous solution?

Which of the following pair of compounds exhibits same colour in aqueous solution?

Options:

A. $FeCl_2$, $CuCl_2$

B. $VOCl_2$, $CuCl_2$

C. VOC_2, $FeCl_2$

D. $VOCl_2$, $MnCl_2$

Answer: B

Solution:

CONCEPT:

Color of Aqueous Solutions of Transition Metal Compounds

- Transition metal ions exhibit characteristic colors in aqueous solutions due to d-d electronic transitions.
- The observed color depends on several factors including the oxidation state of the metal and the ligands attached to it.

EXPLANATION:

- **$FeCl_2$:** Contains Fe^{2+} ions which typically give a pale green color in solution.
- **$CuCl_2$:** Contains Cu^{2+} ions which typically give a blue or blue-green color in solution.
- **$VOCl_2$:** Contains VO^{2+} ions which exhibit a blue color in solution.
- **$MnCl_2$:** Contains Mn^{2+} ions which typically give a pale pink color in solution.

Pairs Analysis:

- **$FeCl_2$, $CuCl_2$:** Pale green and blue/blue-green (different colors)
- **$VOCl_2$, $CuCl_2$:** Blue and blue (same color)
- **$VOCl_2$, $FeCl_2$:** Blue and pale green (different colors)
- **$VOCl_2$, $MnCl_2$:** Blue and pale pink (different colors)

Therefore, the correct pair of compounds exhibiting the same color (blue) in aqueous solution is $VOCl_2$ and $CuCl_2$, which corresponds to option 2.

Question 13

Which metal has the highest oxidation state in the first row transition series?

Which metal has the highest oxidation state in the first row transition series?

Options:

A. Cr

B. Fe

C. Mn

D. V

Answer: C

Solution:

CONCEPT:

Oxidation States in Transition Metals

- Transition metals exhibit a variety of oxidation states due to the involvement of both (n-1)d and ns electrons in bonding.
- The highest oxidation states are typically observed in the middle of the transition series where the number of unpaired electrons is maximized.

EXPLANATION:

- In the first row transition series, the transition metals are from Scandium (Sc) to Zinc (Zn).
- Among these, Manganese (Mn) exhibits the highest oxidation state.
- Manganese can have an oxidation state of +7 in compounds like MnO_4^- (permanganate ion).

- This high oxidation state is achieved due to the involvement of all seven 3d electrons and the 4s electron in bonding.

Therefore, the metal with the highest oxidation state in the first row transition series is Manganese (Mn).

Question 14

Why do the actinoids exhibit higher number of oxidation states than lanthanoids?

Why do the actinoids exhibit higher number of oxidation states than lanthanoids?

Options:

A. 4f orbitals are more diffused than the 5f orbitals.

B. Energy difference between 5f and 6d is less with respect to the energy difference between 4f and 5d.

C. Energy difference between 5f and 6d is more with respect to the energy difference between 4f and 5d.

D. Actinoids are more reactive in nature than the lanthanoids.

Answer: B

Solution:

CONCEPT:

Oxidation States of Actinoids and Lanthanoids

- Oxidation states are the charges that an atom can acquire in a compound through gain or loss of electrons.
- The actinoids exhibit a higher number of oxidation states compared to the lanthanoids.
- This is primarily due to the energy differences between their respective orbitals.

EXPLANATION:

- The energy difference between the 5f and 6d orbitals in actinoids is relatively small compared to the energy difference between the 4f and 5d orbitals in lanthanoids.
  - This smaller energy gap allows electrons in actinoids to be more easily promoted to higher energy levels, leading to multiple oxidation states.
  - In contrast, the larger energy gap in lanthanoids makes it more difficult for electrons to be promoted, resulting in fewer oxidation states.
- Additionally, the 5f orbitals in actinoids are more extended in space and can participate more effectively in bonding compared to the more contracted 4f orbitals in lanthanoids.
- Therefore, the actinoids exhibit a higher number of oxidation states because the energy difference between 5f and 6d is less with respect to the energy difference between 4f and 5d.

Therefore, the correct answer is option 2: Energy difference between 5f and 6d is less with respect to the energy difference between 4f and 5d.

Question 15

Camphor in nitrogen gas is a type of solution

Options:

A. Gas - Gas

B. Solid-Gas

C. Liquid-Gas

D. Solid - Liquid

Answer: B

Solution:

CONCEPT:

Types of Solutions

- Solutions can be classified based on the states of the solute and solvent involved.
- Common types include:
  - **Gas-Gas**: Both solute and solvent are gases (e.g., air).
  - **Solid-Gas**: Solid solute in a gaseous solvent (e.g., camphor in nitrogen gas).
  - **Liquid-Gas**: Liquid solute in a gaseous solvent (e.g., water vapor in air).
  - **Solid-Liquid**: Solid solute in a liquid solvent (e.g., salt in water).

EXPLANATION:

- In the given problem:

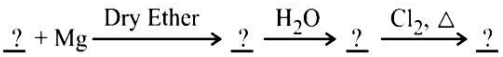
  Camphor in nitrogen gas is described as a solution.

  - **Camphor** is a solid at room temperature.
  - **Nitrogen gas** is the solvent in which camphor is dispersed.
- Given the states of the components:
  - Camphor (solid) is the solute.
  - Nitrogen gas is the gaseous solvent.
- Thus, this type of solution is classified as **Solid-Gas**.

Therefore, the correct answer is option 2: Solid-Gas.

Question 16

Identify the correct order of organic compounds in the following chemical reaction :



(A) CH_3MgBr

(B) CH_3Br

(C) CH_3Cl

(D) CH_4

Choose the correct answer from the options given below:

Options:

A. (B), (A), (D), (C)

B. (A), (C), (B), (D)

C. (B), (A), (C), (D)

D. (C), (B), (D), (A)

Answer: A

Solution:

CONCEPT:

Nucleophilic Substitution Reactions

- A nucleophilic substitution reaction is a type of chemical reaction in which a nucleophile selectively bonds with or attacks the positive or partially positive charge of an atom or a group of atoms to replace a leaving group.
- In organic chemistry, these reactions are common with alkyl halides, where the halide ion is the leaving group.

EXPLANATION:

- In the given chemical reaction, the order of organic compounds is as follows:

  (B) $CH_3Br \rightarrow$ (A) $CH_3MgBr \rightarrow$ (D) $CH_4 \rightarrow$ (C) CH_3Cl

  - First, CH_3Br (B) can react with Mg in dry ether to form CH_3MgBr (A), which is a Grignard reagent.
  - Next, the Grignard reagent (CH_3MgBr) reacts with a proton source to form methane (CH_4).

- Finally, methane (CH_4) can be chlorinated to form CH_3Cl (C).

Therefore, the correct order of organic compounds is (B) CH_3Br, (A) CH_3MgBr, (D) CH_4, (C) CH_3Cl.

Question 17

Consider the following statements regarding osmotic pressure :

(A) Molar mass of a protein can be determined using osmotic pressure method.

(B) The osmotic pressure is proportional to the molarity.

(C) Reverse osmosis occurs when a pressure larger than osmotic pressure is applied to the concentrated solution side.

(D) Edema occurs due to retention of water in tissue cells as a result of osmosis.

Choose the correct statements with reference to osmotic pressure:

Options:

A. (A), (B) and (D) only

B. (A), (B) and (C) only

C. (A), (B), (C) and (D)

D. (B), (C) and (D) only

Answer: C

Solution:

CONCEPT:

Osmotic Pressure

- Osmotic pressure is the pressure required to stop the flow of solvent molecules through a semipermeable membrane from a dilute solution into a concentrated solution.
- The osmotic pressure (π) is directly proportional to the molarity (C) of the solution at a given temperature (T) and can be expressed by the equation:

  $\pi = iCRT$

- Where:
  - i = van 't Hoff factor
  - C = molarity of the solution
  - R = universal gas constant
  - T = temperature in Kelvin
- Reverse osmosis occurs when a pressure greater than the osmotic pressure is applied to the concentrated solution side, causing the solvent to flow in the reverse direction.
- Edema is the swelling of tissues due to the retention of water, which can occur when the osmotic balance between the blood and the tissue fluids is disrupted.

EXPLANATION:

- Statement (A): Molar mass of a protein can be determined using osmotic pressure method.
  - This statement is correct. The molar mass of large molecules like proteins can be determined by measuring the osmotic pressure of their solutions.
- Statement (B): The osmotic pressure is proportional to the molarity.
  - This statement is correct. According to the equation $\pi = iCRT$, osmotic pressure is directly proportional to the molarity of the solution.
- Statement (C): Reverse osmosis occurs when a pressure larger than osmotic pressure is applied to the concentrated solution side.
  - This statement is correct. Reverse osmosis involves applying a pressure greater than the osmotic pressure to force the solvent to move from the concentrated solution to the dilute solution.
- Statement (D): Edema occurs due to retention of water in tissue cells as a result of osmosis.
  - This statement is correct. Edema can occur when osmotic pressure causes water to accumulate in tissue cells, leading to swelling.

Therefore, the correct statements are (A), (B), (C), and (D).

Question 18

Vapour pressures of pure liquids 'A' and 'D' at 50°C are 500 mm Hg and 800 mm Hg respectively. The binary solution of 'A' and 'D' boils at 50°C and 700 mm Hg pressure. The mole percentage of 'D' in the solution is:

Options:

A. 33.33 mole percent

B. 66.67 mole percent

C. 25.75 mole percent

D. 75.25 mole percent

Answer: B

Solution:

CONCEPT:

Raoult's Law and Vapor Pressure

- Raoult's law states that the partial vapor pressure of each volatile component in a solution is equal to the vapor pressure of the pure component multiplied by its mole fraction in the solution.
- The total vapor pressure of the solution is the sum of the partial vapor pressures of all components.
- The equation for Raoult's law is:

  Ptotal = PA * XA + PD * XD

  Where Ptotal is the total vapor pressure, PA and PD are the vapor pressures of pure components A and D respectively, and XA and XD are their mole fractions.

EXPLANATION:

- Given:
  - Vapor pressure of pure liquid A (PA) = 500 mm Hg
  - Vapor pressure of pure liquid D (PD) = 800 mm Hg
  - Total vapor pressure of the solution at 50°C (Ptotal) = 700 mm Hg
- Using Raoult's law:
  - $P_{total} = P_A * X_A + P_D * X_D 700 = 500 * X_A + 800 * X_D$
- Since the mole fractions of A and D must add up to 1:
  - $X_A + X_D = 1 X_A = 1 - X_D$
- Substitute XA in the Raoult's law equation:
  - $700 = 500 * (1 - X_D) + 800 * X_D 700 = 500 - 500 * X_D + 800 * X_D 700 = 500 + 300 * X_D 200 = 300 * X_D X_D = 200/300 X_D = 2/3 X_D = 0.6667$
- Mole percentage of D in the solution:
  - Mole percentage of D = XD * 100
  - Mole percentage of D = 0.6667 * 100
  - Mole percentage of D = 66.67%

Therefore, the mole percentage of D in the solution is 66.67%, which corresponds to option 2.

Question 19

For the following reaction :

$$2\ \mathrm{A_2(\ g)} + \frac{1}{4}\mathrm{X(\ g)} \rightarrow 2\ \mathrm{A_2X(\ g)}$$

volume is increased to double its value by decreasing the pressure on it. If the reaction is first order with respect to Xand second order with respect to A_2, the rate of reaction will:

Options:

A. Decrease by eight times of its initial value

B. Increase by eight times of its initial value

C. Increase by four times of its initial value

D. Remain unchanged

Answer: A

Solution:

CONCEPT:

Reaction Rate and Volume Change

- The rate of a reaction depends on the concentrations of the reactants, which are influenced by changes in volume and pressure.
- If the volume of the system is increased, the concentrations of gaseous reactants will decrease.
- For the given reaction, the rate law is:

  Rate = $k[A_2]^2[X]$

EXPLANATION:

- In the given reaction:

  $2\ A_2(g) + 1/4\ X(g) \rightarrow 2\ A_2X(g)$

  - The reaction is first order with respect to X and second order with respect to A_2.
- When the volume of the system is doubled, the concentration of each gaseous reactant is halved (since concentration is inversely proportional to volume).
- Therefore, the new concentrations are:
  - $[A_2] = [A_2]_{initial} / 2$
  - $[X] = [X]_{initial} / 2$
- Substituting these into the rate law:
  - Rate = $k([A_2]_{initial} / 2)^2([X]_{initial} / 2)$
  - Rate = $k([A_2]_{initial})^2[X]_{initial} / 8$

Therefore, the rate of the reaction will decrease by eight times of its initial value.

Question 20

The total number of sigma bonds present in P_4O_{10} are:

Options:

A. 6

B. 7

C. 16

D. 17

Answer: C

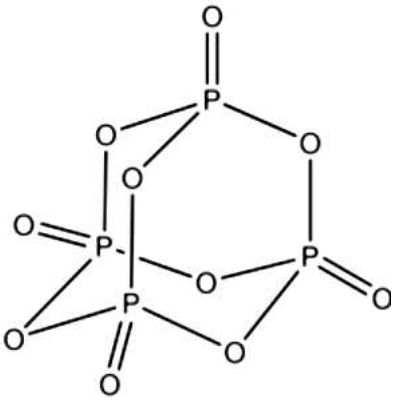
Solution:

CONCEPT:

Sigma Bonds

- Sigma bonds (σ bonds) are the strongest type of covalent chemical bond. They are formed by the head-on overlapping of atomic orbitals.
- In a molecule, sigma bonds are present in single bonds, and also as one of the bonds in double and triple bonds.

EXPLANATION:



- 16 sigma bond

Therefore, the total number of sigma bonds present in P_4O_{10} is 16.

Question 21

In the electrolysis of alumina to obtain Aluminium metal, the cryolite is added mainly to

Options:

A. lower the melting point of alumina.

B. dissolve the alumina in the molten cryolite.

C. remove the impurities of alumina.

D. increase the electrical conductivity.

Answer: A

Solution:

CONCEPT:

Electrolysis of Alumina

- Alumina (Al_2O_3) is electrolyzed to obtain aluminum metal.
- The melting point of pure alumina is very high (over 2000°C), making it impractical for electrolysis.
- Cryolite (Na_3AlF_6) is added to alumina during the electrolysis process.

EXPLANATION:

- The primary reason for adding cryolite to alumina in the electrolysis process is to lower the melting point of alumina.
- The cryolite helps to dissolve the alumina and form a molten solution at a lower temperature (around 950°C).

Reasons for Adding Cryolite:

1. Lowering the melting point of alumina, making the process more energy-efficient.
2. Facilitating the dissolution of alumina in the molten cryolite for easier electrolysis.

CONCLUSION:
Therefore, the correct answer is option 1: to lower the melting point of alumina.

Question 22

Identify the order of reaction if its rate constant is $k = 2\times 10^{-2}\ s^{-1}$.

Options:

A. Zero order

B. First order

C. Second order

D. Half order

Answer: B

Solution:

CONCEPT:

Order of Reaction

- The order of a reaction refers to the power to which the concentration of a reactant is raised in the rate law equation.
- It can be determined by the units of the rate constant (k).
- For different orders of reaction, the units of k are different:
  - Zero order: M s^{-1}
  - First order: s^{-1}
  - Second order: M^{-1} s^{-1}
  - Third order: M^{-2} s^{-1}

EXPLANATION:

- The unit of the given rate constant is s^{-1}.
- By comparing the units with the standard units for different orders of reaction, we can identify that the unit s^{-1} corresponds to a first-order reaction.

Therefore, the order of the reaction is first order.

Question 23

For a complex reaction, the order of reaction is equal to

Options:

A. Sum of stoichiometric coefficients in balanced chemical reaction

B. The molecularity of overall reaction

C. Order of fastest step of the reaction

D. The molecularity of slowest step of reaction

Answer: D

Solution:

CONCEPT:

Order of Reaction in Complex Reactions

- The order of a reaction refers to the power to which the concentration of a reactant is raised in the rate equation.
- For a complex reaction, the overall order of the reaction is determined by the rate-determining step, which is the slowest step in the reaction mechanism.

EXPLANATION:

- In a multi-step reaction mechanism, each step can have its own rate law and order.
- The slowest step, also known as the rate-determining step, controls the overall rate of the reaction.
- Therefore, the order of the overall reaction is equal to the order of the rate-determining (slowest) step.
- This means that the molecularity of the slowest step determines the order of the overall reaction.

Therefore, for a complex reaction, the order of reaction is equal to the molecularity of the slowest step of the reaction.

Question 24

A molecule X associates in a given solvent as per the following equation:

$$X \rightleftharpoons (X)_n$$

For a given concentration of X, the van't Hoff factor was found to be 0.80 and the fraction of associated molecules was 0.3. The correct value of 'n' is:

Options:

A. 2

B. 3

C. 1

D. 5

Answer: B

Solution:

CONCEPT:

Van't Hoff Factor (i)

- The van't Hoff factor (i) is a measure of the effect of solute particles on properties of solutions such as boiling point elevation, freezing point depression, and osmotic pressure.
- For a solute that dissociates or associates in solution, the van't Hoff factor can be less than or greater than 1.
- For a molecule X that associates in the form of $(X)_n$, the van't Hoff factor can be given by:

  $i = 1 - \alpha + (\alpha/n)$

  where α is the fraction of associated molecules and n is the number of molecules that associate.

EXPLANATION:

- Given the following data:
  - Van't Hoff factor (i) = 0.80
  - Fraction of associated molecules (α) = 0.3
- Using the van't Hoff factor equation:
  - $i = 1 - \alpha + (\alpha/n)$
  - $0.80 = 1 - 0.3 + (0.3/n)$
  - $0.80 = 0.7 + (0.3/n)$
  - $0.10 = 0.3/n$
  - $n = 0.3 / 0.1$
  - $n = 3$

Therefore, the correct value of 'n' is 3.

Question 25

The oxidation number of Co in complex $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$ is

Options:

A. 3

B. 4

C. 2

D. 5

Answer: A

Solution:

CONCEPT:

Oxidation Number

- The oxidation number (or oxidation state) of an element in a compound is the charge that the element would have if the compound was composed of ions.
- In coordination complexes, the oxidation number of the central metal atom can be determined by considering the charges of the ligands and the overall charge of the complex.

EXPLANATION:

- Given the complex $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$:
  - The overall charge of the complex is neutral (0).
  - Ethylenediamine ($H_2NCH_2CH_2NH_2$) is a neutral ligand, so it does not contribute to the charge.
  - Sulfate (SO_4) has a charge of -2.
- Let the oxidation number of Co be x.
  - There are 2 Co ions and 3 sulfate ions.
  - Equation: 2x + 3(-2) = 0
  - Simplifying: 2x - 6 = 0
  - 2x = 6
  - x = 3

Therefore, the oxidation number of Co in the complex $[Co(H_2NCH_2CH_2NH_2)_3]_2(SO_4)_3$ is 3.

Question 26

The correct structure of dipeptide, Gly-Ala (glycyl alanine) is

Options:

A. $H_2N – CH_2– CO – NH – CH(CH_3) – COOH$

B. $HOOC – CH_2– NH – CO – CH(CH_3) – NH_2$

C. $HOOC – CH(CH_3) – NH – CO – CH_2– NH_2$

D. $H_2N – CH(CH_3) – CO – NH – CH_2– COOH$

Answer: A

Solution:

CONCEPT:

Structure of a Dipeptide

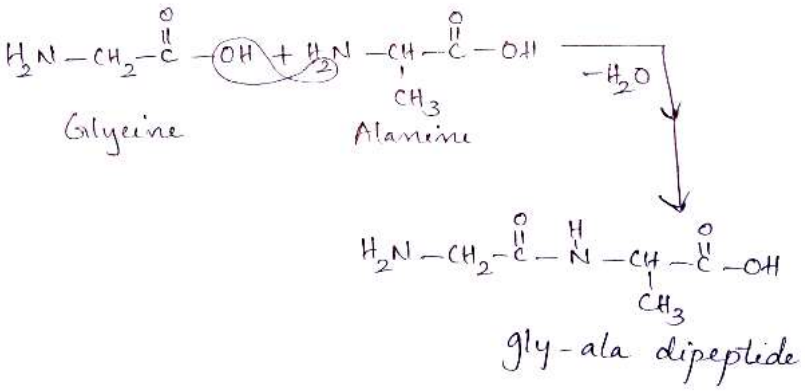
- A dipeptide is formed by the condensation of two amino acids, resulting in a peptide bond (amide bond) between them.
- Gly-Ala (glycyl alanine) is a dipeptide composed of glycine and alanine, where glycine is at the N-terminus (amino end) and alanine is at the C-terminus (carboxyl end).

EXPLANATION:

- **Glycine (Gly):** H_2N-CH_2-COOH
- **Alanine (Ala):** H_2N-$CH(CH_3)$-COOH
- In the dipeptide Gly-Ala, the carboxyl group of glycine (Gly) forms a peptide bond with the amino group of alanine (Ala).

Formation of the Dipeptide:

- The peptide bond is formed between the carboxyl group of glycine and the amino group of alanine, resulting in the following structure:



- $H_2N – CH_2 – CO – NH – CH(CH_3) – COOH$

CONCLUSION:

- The correct structure of the dipeptide Gly-Ala (glycyl alanine) is:

- $H_2N - CH_2 - CO - NH - CH(CH_3) - COOH$

Therefore, the correct answer is option 1: $H_2N - CH_2 - CO - NH - CH(CH_3) - COOH$.

Question 27

The total number of ions produced from the complex $[Cr(NH_3)_6]Cl_3$ in aqueous solution will be _____.

Options:

A. 2

B. 3

C. 4

D. 5

Answer: C

Solution:

CONCEPT:

Ionization of Complex Compounds

- When a complex compound dissolves in water, it dissociates into its constituent ions.
- The number of ions produced depends on the dissociation of the complex ion and its counter ions.

EXPLANATION:

- Given complex: [Cr(NH3)6]Cl3
- When [Cr(NH3)6]Cl3 dissolves in water, it dissociates as follows:

  $[Cr(NH3)6]Cl3 \rightarrow [Cr(NH3)6]^{3+} + 3Cl^-$

- In this dissociation:
  - $[Cr(NH3)6]^{3+}$ is one ion.
  - $3Cl^-$ are three separate chloride ions.
- Total number of ions produced:
  - 1 (from $[Cr(NH3)6]^{3+}$) + 3 (from $3Cl^-$) = 4 ions

Therefore, the total number of ions produced from the complex [Cr(NH3)6]Cl3 in aqueous solution is 4.

Question 28

Arrange the following in decreasing order of number of molecules contained in:

(A) 16 g of O_2

(B) 16 g of CO_2

(C) 16 g of CO

(D) 16 g of H_2

Choose the correct order from the options given below:

Options:

A. (A), (B), (C), (D)

B. (D), (C), (A), (B)

C. (B), (A), (D), (C)

D. (C), (B), (D), (A)

Answer: B

Solution:

CONCEPT:

Number of Molecules

- The number of molecules in a given mass of a substance can be calculated using Avogadro's number (6.022 x 10^{23} molecules/mol) and the molar mass of the substance.
- The formula to calculate the number of molecules is:

  Number of molecules = (Given mass / Molar mass) x Avogadro's number

EXPLANATION:-

- Number of molecules:
  - For O_2: (16 g / 32 g/mol) x 6.022 x 10^{23} molecules/mol = 0.5 x 6.022 x 10^{23} = 3.011 x 10^{23}
  - For CO_2: (16 g / 44 g/mol) x 6.022 x 10^{23} molecules/mol = 0.364 x 6.022 x 10^{23} = 2.192 x 10^{23}
  - For CO: (16 g / 28 g/mol) x 6.022 x 10^{23} molecules/mol = 0.571 x 6.022 x 10^{23} = 3.437 x 10^{23}
  - For H_2: (16 g / 2 g/mol) x 6.022 x 10^{23} molecules/mol = 8 x 6.022 x 10^{23} = 4.818 x 10^{24}

Therefore, the decreasing order of the number of molecules is: (D), (C), (A), (B)

Question 29

The Cu metal crystallises into fcc lattice with a unit cell edge length of 361 pm. The radius of Cu atom is:

Options:

A. 127 pm

B. 181 pm

C. 157 pm

D. 108 pm

Answer: A

Solution:

CONCEPT:

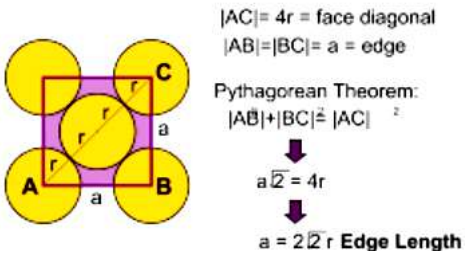
Face-Centered Cubic (FCC) Lattice

- In a face-centered cubic (FCC) lattice, atoms are located at each of the corners and the centers of all the cube faces of the unit cell.
- The relation between the edge length (a) of the unit cell and the atomic radius (r) in an FCC lattice is given by:

  $a = 2\sqrt{2}r$

EXPLANATION:

- Given the unit cell edge length of copper (Cu) is 361 pm.



- Using the relation for an FCC lattice:

a = 2√2r

- We can rearrange the equation to solve for the atomic radius (r):

  r = a / (2√2)

- Substitute the given edge length (a = 361 pm) into the equation:

  r = 361 pm / (2√2)

- Calculate the value:

  r = 361 pm / 2.828

  r ≈ 127.7 pm

Therefore, the radius of the Cu atom is approximately 127 pm.

Question 30

If 75% of a first order reaction gets completed in 32 minutes, time taken for 50% completion of this reaction is

Options:

A. 16 minutes

B. 78 minutes

C. 8 minutes

D. 4 minutes

Answer: A

Solution:

CONCEPT:

First-Order Reaction Kinetics

- A first-order reaction is one in which the rate of the reaction is directly proportional to the concentration of one of the reactants.
- The integrated rate law for a first-order reaction is given by:

  $\ln\left(\frac{[A]_0}{[A]}\right) = kt$

- The half-life ($t_{1/2}$) for a first-order reaction is the time required for the concentration of a reactant to decrease by half, and it is given by:

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

EXPLANATION:

- Given that 75% of a first-order reaction gets completed in 32 minutes, this means that 25% of the reactant remains.

  $\frac{[A]}{[A]_0} = 0.25 \ln\left(\frac{[A]_0}{[A]}\right) = kt \ln\left(\frac{[A]_0}{0.25[A]_0}\right) = k \times 32 \ln(4) = k \times 32k = \frac{\ln(4)}{32} k = \frac{1.386}{32} \approx 0.0433 \text{ min}^{-1}$

- To find the time taken for 50% completion of the reaction:

  For 50% completion, $\frac{[A]}{[A]_0} = 0.5$

  Using the integrated rate law again:

  $\ln\left(\frac{[A]_0}{0.5[A]_0}\right) = kt_{50\%} \ln(2) = 0.0433 \times t_{50\%} 0.693 = 0.0433 \times t_{50\%} t_{50\%} = \frac{0.693}{0.0433} t_{50\%} \approx 16 \text{ minutes}$

Therefore, the time taken for 50% completion of the reaction is 16 minutes.

Question 31

Which of the following compounds will be repelled when placed in an external magnetic field?

Options:

A. $Na_2[CuCl_4]$

B. $Na_2[CdCl_4]$

C. $K_4[Fe(Cl)_6]$

D. $K_3[Fe(CN)_6]$

Answer: B

Solution:

CONCEPT:

Diamagnetism and Paramagnetism

- When a compound is placed in an external magnetic field, it can either be attracted or repelled based on the magnetic properties of the compound.
- Diamagnetic compounds are repelled by a magnetic field. These compounds have all their electrons paired.
- Paramagnetic compounds are attracted by a magnetic field. These compounds have one or more unpaired electrons.

EXPLANATION:

- **$Na_2[CuCl_4]$:** Cu^{2+} has an unpaired electron in the d-orbital, making it paramagnetic.
- **$Na_2[CdCl_4]$:** Cd^{2+} has a filled d^{10} configuration, meaning all electrons are paired, making it diamagnetic.
- **$K_4[Fe(Cl)_6]$:** Fe in the +2 oxidation state with a high-spin configuration, meaning all electrons are unpaired, making it paramagnetic.
- **$K_3[Fe(CN)_6]$:** Fe in the +3 oxidation state with a low-spin configuration has an unpaired electron in the d-orbital, making it paramagnetic.

Therefore, the compound that will be repelled when placed in an external magnetic field is $Na_2[CdCl_4]$.

Question 32

The spin only magnetic moment of Hexacyanidomanganate(II) ion is BM.

Options:

A. 5.90

B. 1.73

C. 4.90

D. 3.87

Answer: B

Solution:

CONCEPT:

Spin-Only Magnetic Moment

- The spin-only magnetic moment (μ) of a complex is determined by the number of unpaired electrons in the d-orbitals of the central metal ion.
- The spin-only magnetic moment is given by the formula:

  $\mu_{so} = \sqrt{n(n+2)}BM$

- where n is the number of unpaired electrons.
- The unit of the magnetic moment is Bohr Magneton (BM).

EXPLANATION:

- Hexacyanidomanganate(II) ion is [Mn(CN)6]{4-}.
- Manganese in the +2 oxidation state (Mn2+) has an electron configuration of [Ar] 3d5.
- Since cyanide (CN-) is a strong field ligand, it causes pairing of electrons.
- This results in the low-spin configuration:

  $Mn^2+ : t_{2g}^6 e_g^0$

- However, with d5 low-spin configuration, there is one unpaired electron.
- Using the spin-only formula:

$\mu_{so} = \sqrt{1(1+2)}BM\mu_{so} = \sqrt{3}BM\mu_{so} \approx 1.73BM$

Therefore, the spin-only magnetic moment of the Hexacyanidomanganate(II) ion is 1.73 BM.

Question 33

The correct order of increasing boiling points of the following compounds is:

Pentan-1-ol, n-Butane, Pentanal, Ethoxyethane

Options:

A. Ethoxyethane, Pentanal, n-Butane, Pentan-1-ol

B. Pentanal, n-Butane, Ethoxyethane, Pentan-1-ol

C. n-Butane, Pentanal, Ethoxyethane, Pentan-1-ol

D. n-Butane, Ethoxyethane, Pentanal, Pentan-1-ol

Answer: D

Solution:

CONCEPT:

Boiling Points of Compounds

- The boiling point of a compound depends on the strength of intermolecular forces present in the compound.
- Types of intermolecular forces in compounds include hydrogen bonding, dipole-dipole interactions, and London dispersion forces (van der Waals forces).
- Hydrogen bonding is the strongest intermolecular force, followed by dipole-dipole interactions, and then London dispersion forces.

EXPLANATION:

- n-Butane (C_4H_{10}):
  - It is a non-polar molecule and exhibits only London dispersion forces.
  - It has the weakest intermolecular forces among the given compounds.
  - Therefore, it has the lowest boiling point.
- Ethoxyethane ($C_2H_5OC_2H_5$):
  - It is a polar molecule and exhibits dipole-dipole interactions.
  - However, it does not form hydrogen bonds.
  - Therefore, it has a higher boiling point than n-Butane but lower than compounds with hydrogen bonding.
- Pentanal ($C_5H_{10}O$):
  - It is also a polar molecule and exhibits dipole-dipole interactions.
  - It has a slightly higher molecular weight and stronger dipole-dipole interactions than Ethoxyethane.
  - Therefore, it has a higher boiling point than Ethoxyethane.
- Pentan-1-ol ($C_5H_{11}OH$):
  - It contains an -OH group and can form hydrogen bonds.
  - Hydrogen bonding is the strongest type of intermolecular force.
  - Therefore, it has the highest boiling point among the given compounds.

Therefore, the correct order of increasing boiling points is: n-Butane, Ethoxyethane, Pentanal, Pentan-1-ol.

Question 34

In the following reaction, identify the product D.

$$C_6H_5 - OH \xrightarrow{\text{Zn dust}} A \xrightarrow{CH_3Cl + \text{anhy. } AlCl_3} B$$

$$\xrightarrow{K_2Cr_2O_7 + H_2SO_4} C \xrightarrow{H_2SO_4 + HNO_3} D$$

Options:

A. o-Nitrobenzoic acid

B. p-Nitrobenzoic acid

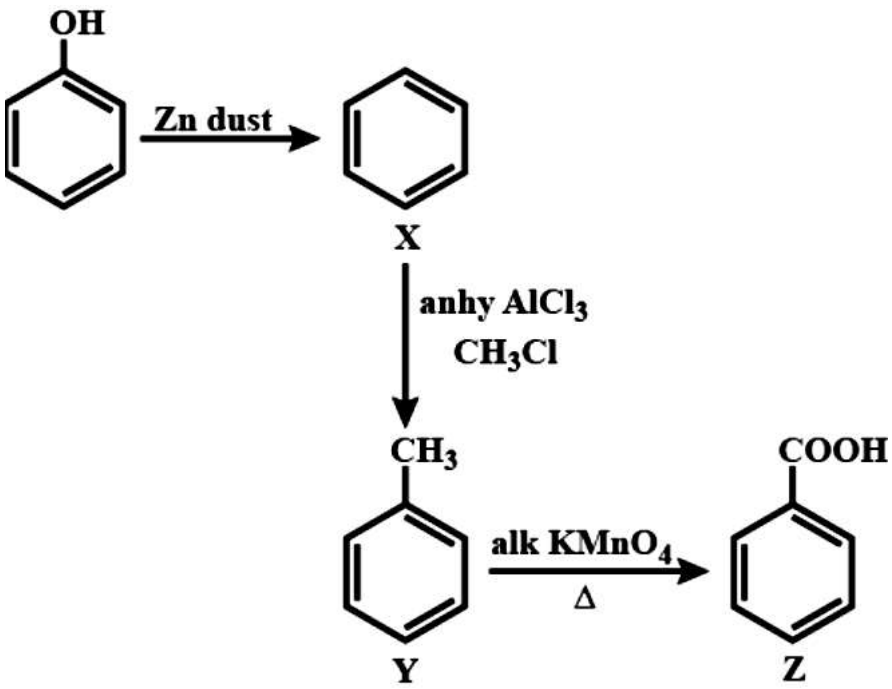
C. o,p-Dinitrobenzoic acid

D. m-Nitrobenzoic acid

Answer: D

Solution:

Explantion:-



1. **Step 1:**

   C_6H_5–OH (Phenol) reacted with Zn dust:

   C_6H_5–OH + Zn → C_6H_6 + ZnO

   Product A: Benzene (C_6H_6)

2. **Step 2:**

   Benzene reacts with CH_3Cl and anhydrous $AlCl_3$:

   $C_6H_6 + CH_3Cl + AlCl_3 \rightarrow C_6H_5CH_3 + HCl$

   Product B: Toluene ($C_6H_5CH_3$)

3. **Step 3:**

   Toluene reacts with $K_2Cr_2O_7$ and H_2SO_4:

   $C_6H_5CH_3 + K_2Cr_2O_7 + H_2SO_4 \rightarrow C_6H_5COOH$

   Product C: Benzoic acid (C_6H_5COOH)

4. **Step 4:**

   Benzoic acid reacts with H_2SO_4 and HNO_3:

   $C_6H_5COOH + HNO_3 \rightarrow NO_2\text{-}C_6H_4COOH$

   Since the carboxyl group (–COOH) is a meta-directing group, nitration occurs predominantly at the meta position.

   Product D: m-Nitrobenzoic acid (NO_2-C_6H_4-COOH)

Therefore, the product D is m-Nitrobenzoic acid (NO_2-C_6H_4-COOH).

Question 35

The gold number range of some of the lyophilic colloids is given below:

A : 0.005-0.01, B : 0.15-0.25, C : 0.04-1.0and D : 15-25.

Which among these can be used as a better protective colloid?

Options:

A. A

B. B

C. C

D. D

Answer: A

Solution:

CONCEPT:

Gold Number

- The gold number is a measure of the protective power of a colloid. It is defined as the minimum amount (in milligrams) of a protective colloid required to prevent the coagulation of 10 ml of a gold sol when 1 ml of a 10% sodium chloride (NaCl) solution is added to it.
- A lower gold number indicates a better protective colloid because less quantity is needed to prevent coagulation.

EXPLANATION:

- The smaller the gold number, the better the protective colloid:
  - Colloid A has the smallest gold number range (0.005-0.01), indicating it is the most effective as a protective colloid.
  - Colloid B has a gold number range of 0.15-0.25.
  - Colloid C has a gold number range of 0.04-1.0.
  - Colloid D has the largest gold number range (15-25), indicating it is the least effective as a protective colloid.

Therefore, the correct answer is option 1 (Colloid A).

Question 36

Reaction of aniline with conc. HNO_3 and conc. H_2SO_4 at 298 K will produce 47% of

Options:

A. p-Nitroaniline

B. o-Nitroaniline

C. m-Nitroaniline

D. 2, 4-Dinitroaniline

Answer: C

Solution:

CONCEPT:

Nitration of Aniline

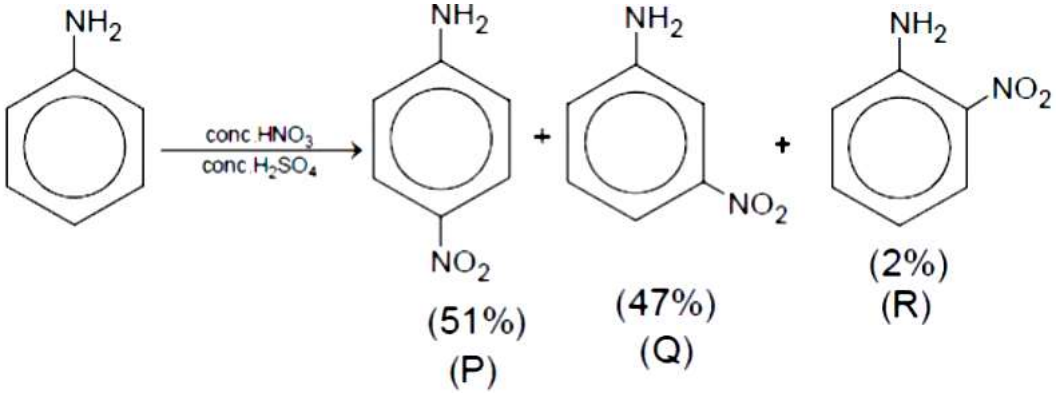
- Nitration is an electrophilic aromatic substitution reaction where a nitro group (-NO_2) is introduced into an aromatic ring.

- Aniline ($C_6H_5NH_2$) is a primary aromatic amine and reacts with concentrated nitric acid (HNO_3) and concentrated sulfuric acid (H_2SO_4).

EXPLANATION:

- In the nitration of aniline:

  $C_6H_5NH_2 + HNO_3 + H_2SO_4 \rightarrow$ Nitroaniline (mixture)



- Due to the presence of the amino group ($-NH_2$), aniline is a strong activating group and directs the incoming nitro group to the ortho (o-) and para (p-) positions.
  - However, under strong acidic conditions, the amino group can get protonated to form anilinium ion ($C_6H_5NH_3^+$), which is deactivating and meta (m-) directing.
- As a result, nitration of aniline under such conditions gives a significant amount of meta-nitroaniline.

Therefore, the reaction of aniline with conc. HNO_3 and conc. H_2SO_4 at 298 K will produce 47% of meta-nitroaniline.

Question 37

What will be increasing order of basic strength of the following compounds ?

$C_2H_5NH_2$, $(C_2H_5)_2NH$, $(C_2H_5)_3N$, $C_6H_5NH_2$

Options:

A. $C_2H_5NH_2 < (C_2H_5)_2NH < (C_2H_5)_3N < C_6H_5NH_2$

B. $C_6H_5NH_2 < (C_2H_5)_3N < C_2H_5NH_2 < (C_2H_5)_2NH$

C. $(C_2H_5)_3N < (C_2H_5)_2NH_6H_5NH_{22}H_5NH_2$

D. $(C_2H_5)_2NH < (C_2H_5)_3N_2H_5NH_{26}H_5NH_2$

Answer: B

Solution:

CONCEPT:

Basic Strength of Amines

- The basic strength of amines is influenced by the availability of the lone pair of electrons on the nitrogen atom for protonation.
- Factors affecting basic strength include:
  - Alkyl groups: Alkyl groups are electron-donating and increase the electron density on nitrogen, making it more basic.
  - Aryl groups: Aryl (phenyl) groups are electron-withdrawing due to conjugation, reducing the electron density on nitrogen and decreasing basic strength.
  - Steric hindrance: The presence of bulky groups can hinder the approach of protons, reducing basic strength.

EXPLANATION:

- Aniline ($C_6H_5NH_2$): The phenyl ring withdraws electron density via resonance, making nitrogen less basic.
- Ethylamine ($C_2H_5NH_2$): A primary amine, moderately basic due to the electron-donating ethyl group.
- Diethylamine ($(C_2H_5)_2NH$): A secondary amine, more basic than ethylamine **because there are two electron-donating ethyl groups increasing electron density on nitrogen.**
- Triethylamine ($(C_2H_5)_3N$): Although it has three ethyl groups, **steric hindrance significantly reduces the basic strength** despite high electron density.

Increasing order of basic strength:

$C_6H_5NH_2 < (C_2H_5)_3N < C_2H_5NH_2 < (C_2H_5)_2NH$

Question 38

Which of the following compounds will give Hell-Volhard-Zelinsky reaction?

Options:

A.

$R - CH_2 - COOH$

B.

$R_3C - CHO$

C.

R_2CO

D.

$H - COOH$

Answer: A

Solution:

CONCEPT:

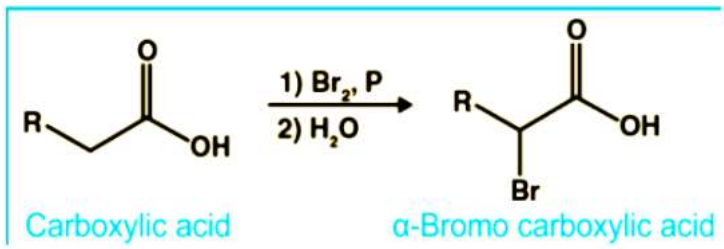
Hell-Volhard-Zelinsky Reaction (HVZ Reaction)

- The Hell-Volhard-Zelinsky reaction is a specific halogenation reaction of carboxylic acids at the alpha position (the carbon next to the carboxyl group).
- This reaction involves the conversion of a carboxylic acid to an acyl halide, followed by halogenation at the alpha carbon.
- The general reaction scheme is:

  R-CH2-COOH + Br2 + PBr3 → R-CHBr-COOH + HBr

EXPLANATION:

- For a compound to undergo the Hell-Volhard-Zelinsky reaction, it must have a hydrogen atom on the alpha carbon (adjacent to the carboxyl group).
- Let's analyze the given options:
  - Option 1: R-CH2-COOH
    - This compound has two hydrogen atoms on the alpha carbon (CH2 group), making it suitable for the HVZ reaction.



Therefore, the correct answer is option 1: R-CH2-COOH.

Question 39

Arrange the following acids in increasing order of their acidic strengths :

$HCOOH, FCH_2COOH, NO_2CH_2COOH, ClCH_2COOH$

Options:

A. $HCOOH < FCH_2COOH < NO_2CH_2COOH < ClCH_2COOH$

B. $HCOOH < NO_2CH_2COOH < ClCH_2COOH < FCH_2COOH$

C. $NO_2CH_2COOH < HCOOH < ClCH_2COOH < FCH_2COOH$

D. $HCOOH < ClCH_2COOH < FCH_2COOH < NO_2CH_2COOH$

Answer: D

Solution:

CONCEPT:

Acidic Strength

- Acidic strength refers to the ability of an acid to donate a proton (H^+). The stronger the acid, the more readily it donates a proton.
- The presence of electronegative groups attached to the carbon chain in carboxylic acids can increase the acidic strength by stabilizing the negative charge on the conjugate base through inductive or resonance effects.

EXPLANATION:

- Electronegative substituents (F, NO_2, Cl) increase the acidity by stabilizing the conjugate base through the inductive effect:
  - Fluorine (F) is the most electronegative, followed by Nitrogen in the NO_2 group, and then Chlorine (Cl).
- Arranging the acids in order of increasing acidic strength based on the stability of their conjugate bases:
  - Formic acid (HCOOH) has no electronegative substituent.
  - Chloroacetic acid ($ClCH_2COOH$) has one chlorine atom.
  - Fluoroacetic acid (FCH_2COOH) has one fluorine atom.
  - Nitroacetic acid (NO_2CH_2COOH) has one nitro group, which is a strong electron-withdrawing group.

Therefore, the correct order of increasing acidic strength is $HCOOH < ClCH_2COOH < FCH_2COOH < NO_2CH_2COOH$

Question 40

In the following compounds, what is the increasing order of their reactivity towards nucleophilic addition reactions?

Benzaldehyde, p-Tolualdehyde, p-Nitrobenzaldehyde, Acetophenone

Options:

A. Benzaldehyde

B. Acetophenone

C. Acetophenone

D. Benzaldehyde

Answer: C

Solution:

CONCEPT:

Reactivity of Aldehydes and Ketones Towards Nucleophilic Addition

- Aldehydes are generally more reactive than ketones towards nucleophilic addition reactions due to less steric hindrance and the presence of only one alkyl group (or hydrogen) attached to the carbonyl carbon.
- The presence of electron-donating groups (EDGs) or electron-withdrawing groups (EWGs) on the aromatic ring can further influence the reactivity. EWGs increase reactivity by stabilizing the negative charge on the intermediate, while EDGs decrease reactivity by destabilizing the intermediate.

EXPLANATION:

- Among the given compounds:
  - **Benzaldehyde** has no additional substituents, serving as a reference point.
  - **p-Tolualdehyde** has a methyl group (an EDG) at the para position, which decreases its reactivity compared to benzaldehyde.
  - **p-Nitrobenzaldehyde** has a nitro group (an EWG) at the para position, which increases its reactivity compared to benzaldehyde.
  - **Acetophenone** is a ketone, which is generally less reactive than aldehydes.
- Based on these factors, the increasing order of reactivity towards nucleophilic addition reactions is:
  - Acetophenone < p-Tolualdehyde < Benzaldehyde < p-Nitrobenzaldehyde

Therefore, the correct answer is option 3: Acetophenone < p-Tolualdehyde < Benzaldehyde < p-Nitrobenzaldehyde.

Question 41

The Gatterman-Koch reaction is used in the industrial preparation of benzaldehyde. The electrophile involved in this reaction is

Options:

A.

CO^+

B.

$HCl + CO_2 +$ anhydrous$AlCl_3$

C.

HCO^+

D.

$CO +$ anhydrous$AlCl_3$

Answer: C

Solution:

CONCEPT:

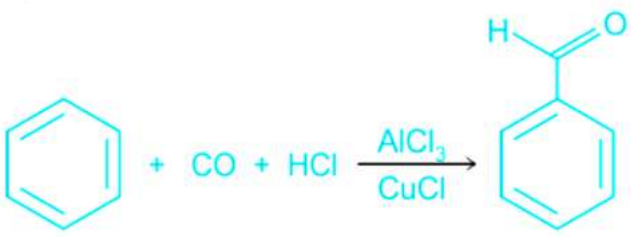
Gatterman-Koch Reaction

- The Gatterman-Koch reaction is an industrial method used for the preparation of benzaldehyde from benzene.
- In this reaction, the electrophile plays a crucial role in the formylation of benzene.
- The reaction typically involves the use of carbon monoxide (CO) and hydrogen chloride (HCl) in the presence of a Lewis acid catalyst like anhydrous aluminum chloride ($AlCl_3$).

EXPLANATION:

- In the Gatterman-Koch reaction:

  Benzene + CO + HCl → Benzaldehyde



- The electrophile involved in this reaction is the formyl cation (HCO^+), which is generated in situ from CO and HCl in the presence of $AlCl_3$.
- The formyl cation (HCO^+) then reacts with benzene to form benzaldehyde.
- Other options provided (CO^+, $HCl + CO_2$ + anhydrous $AlCl_3$, CO + anhydrous $AlCl_3$) are not correct because they do not represent the actual electrophile involved in the formylation process.

Therefore, the correct electrophile involved in the Gatterman-Koch reaction is the formyl cation (HCO^+), which corresponds to option 3.

Question 42

Formaldehyde undergoes Cannizzaro reaction because

(A) It has alpha-hydrogen atom.

(B) It does not have alpha-hydrogen atom.

(C) It does not undergo self-oxidation and reduction on heating with concentrated alkali.

(D) It undergo self-oxidation and reduction on heating with concentrated alkali.

Choose the correct answer from the options given below:

Options:

A.

(B) and (D) only

B.

(A) and (C) only

C.

(B) and (C) only

D.

(A) and (D) only

Answer: A

Solution:

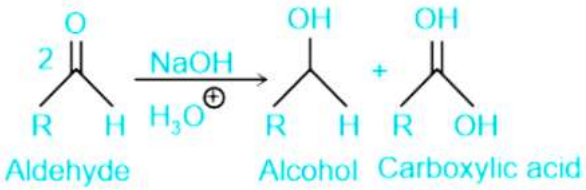
CONCEPT:

Cannizzaro Reaction

- The Cannizzaro reaction is a redox reaction (disproportionation) where an aldehyde that lacks an alpha-hydrogen undergoes self-oxidation and reduction in the presence of a strong base.
- In this reaction, one molecule of the aldehyde is reduced to an alcohol, while another molecule is oxidized to a carboxylic acid.

EXPLANATION:

- Formaldehyde (HCHO) is an aldehyde and does not have an alpha-hydrogen atom.
  - An alpha-hydrogen is a hydrogen atom attached to the carbon atom adjacent to the carbonyl group. In formaldehyde, the carbonyl carbon is bonded to two hydrogen atoms, and there is no adjacent carbon atom.



- Because formaldehyde lacks an alpha-hydrogen atom, it can undergo the Cannizzaro reaction.
  - When heated with a concentrated alkali, formaldehyde undergoes self-oxidation and reduction (disproportionation), forming methanol (CH_3OH) and formic acid (HCOOH).

Therefore, the correct answer is option 1: (B) and (D) only.

Question 43

In the reaction, $(CH_3)_3C\text{-}O\text{-}CH_3$+ HI →Products

CH_3OH and $(CH_3)_3CI$ are the products and not CH_3I and $(CH_3)_3C\text{-}OH$. It is because,

(A) in step 2 of the reaction the departure of leaving group ($HO\text{-}CH_3$) creates less stable carbocation.

(B) in step 2 of the reaction the departure of leaving group ($HO\text{-}CH_3$) creates more stable carbocation.

(C) the reaction follows S_N1 mechanism.

(D) the reaction follows S_N2 mechanism.

Choose the correct answer from the options given below:

Options:

A. (B) and (D) only

B. (B) and (C) only

C. (A) and (D) only

D. (A) and (C) only

Answer: B

Solution:

CONCEPT:

Reaction Mechanisms: SN1 and SN2

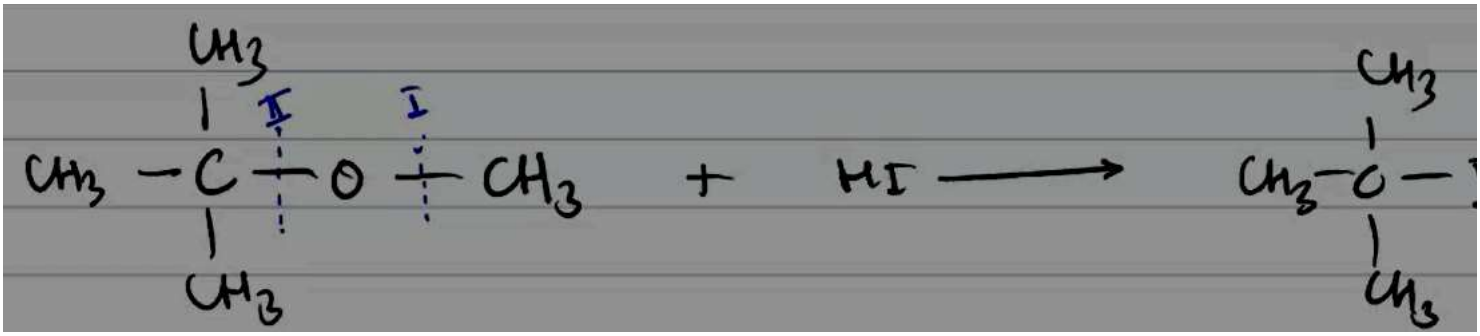
- The SN1 mechanism is a two-step process where the rate-determining step involves the formation of a carbocation intermediate.
- The SN2 mechanism is a one-step process where the nucleophile attacks the substrate from the opposite side of the leaving group, leading to a backside attack and inversion of configuration.

EXPLANATION:

- In the given reaction:

  $(CH_3)_3C\text{-}O\text{-}CH_3 + HI \rightarrow$ Products

  - The products are CH_3OH and $(CH_3)_3CI$ and not CH_3I and $(CH_3)_3C\text{-}OH$.



- This is because:
  - Option (B): In step 2 of the reaction, the departure of the leaving group ($HO\text{-}CH_3$) creates a more stable carbocation. The $(CH_3)_3C^+$ carbocation is more stable due to hyperconjugation and inductive effects from the three methyl groups.
  - Option (C): The reaction follows the SN1 mechanism. The formation of the stable $(CH_3)_3C^+$ carbocation is consistent with the SN1 mechanism, where the stability of the carbocation intermediate is a key factor.

Therefore, the correct answer is (B) and (C) only.

Question 44

Aniline does not undergo Friedel-Crafts reaction because

(A) It forms salt with the Lewis acid catalyst, $AlCl_3$.

(B) Nitrogen of aniline acquires negative charge.

(C) Nitrogen of aniline acquires positive charge.

(D) Nitrogen acts as a strong deactivating group in the further reaction.

Choose the correct answer from the options given below:

Options:

A. (A), (B) and (D) only

B. (A), (B) and (C) only

C. (A), (C) and (D) only

D. (B), (C) and (D) only

Answer: C

Solution:

CONCEPT:

Friedel-Crafts Reaction and Aniline

- Friedel-Crafts reactions are a type of electrophilic aromatic substitution that involve the use of a Lewis acid catalyst, such as $AlCl_3$, to generate the electrophile.
- Aniline, an aromatic amine, has a nitrogen atom with a lone pair of electrons that can interact with the Lewis acid catalyst.

EXPLANATION:

- When aniline is treated with $AlCl_3$:
  - It forms a salt with the Lewis acid catalyst ($AlCl_3$) because the lone pair of electrons on the nitrogen atom can coordinate with $AlCl_3$.
  - As a result, the nitrogen acquires a positive charge due to the formation of the complex.
  - This positively charged nitrogen deactivates the benzene ring towards further electrophilic substitution because it withdraws electron density from the ring.
- Thus, the reasons aniline does not undergo Friedel-Crafts reactions are:
  - (A) It forms salt with the Lewis acid catalyst, $AlCl_3$.
  - (C) Nitrogen of aniline acquires positive charge.
  - (D) Nitrogen acts as a strong deactivating group in the further reaction.

Therefore, the correct answer is option 3: (A), (C) and (D) only.

Question 45

Although chlorine is an electron withdrawing group, yet it is ortho- and para-directing in electrophilic aromatic substitution reaction because

(A) Chlorine withdraws electrons through inductive effect.

(B) Chlorine destabilises the intermediate carbocation formed during electrophilic substitution.

(C) Chlorine accepts electrons through resonance.

(D) Chlorine releases electrons through resonance.

Choose the correct answer from the options given below:

Options:

A. (A), (B) and (D) only

B. (A), (B) and (C) only

C. (A), (C) and (D) only

D. (B), (C) and (D) only

Answer: A

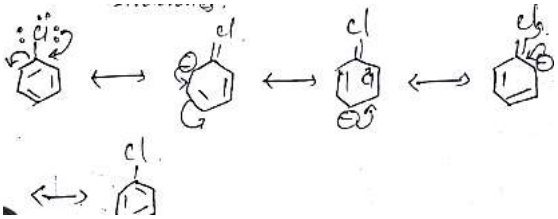
Solution:

CONCEPT:

Ortho- and Para-Directing Groups in Electrophilic Aromatic Substitution

- In electrophilic aromatic substitution reactions, substituents already present on the benzene ring influence the position where the new electrophile will attack.
- Substituents can either be activating or deactivating. Activating groups typically direct electrophiles to the ortho and para positions, while deactivating groups direct to the meta position.
- Chlorine is unique because it is an electron withdrawing group through inductive effect, yet it is ortho- and para-directing due to its resonance effect.

EXPLANATION:



- Chlorine withdraws electrons through its inductive effect due to its high electronegativity:
  - Chlorine is more electronegative than carbon, leading to a withdrawal of electron density from the benzene ring through the sigma bonds (inductive effect).
- Despite this, chlorine releases electrons through resonance, which stabilizes the intermediate carbocation formed during electrophilic substitution:
  - Chlorine has lone pairs of electrons that can participate in resonance with the benzene ring. This delocalization of electrons can stabilize the positively charged intermediate formed during the substitution.
  - Resonance donation of electron density to the ortho and para positions makes these positions more reactive towards electrophilic attack.

Therefore, the correct answer is (A), (B), and (D) only.

Question 46

In Etard reaction, the final product is

Options:

A. Aromatic aldehyde

B. Aromatic chloride

C. Aromatic amine

D. Aromatic alcohol

Answer: A

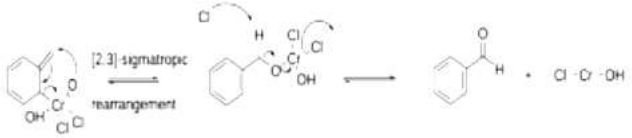
Solution:

CONCEPT:

Etard Reaction

- The Etard reaction is a chemical reaction where a methyl group attached to an aromatic ring is selectively oxidized to a formyl group, resulting in the formation of an aromatic aldehyde.

EXPLANATION:



- In the Etard reaction:

  $Ar\text{-}CH_3 + CrO_2Cl_2$ (chromyl chloride) → Ar-CHO (aromatic aldehyde)

  - $Ar\text{-}CH_3$ represents an aromatic methyl group.
  - CrO_2Cl_2 is chromyl chloride, which is used as the oxidizing agent.
  - The reaction converts the methyl group ($-CH_3$) into a formyl group (-CHO), resulting in the formation of an aromatic aldehyde.

- Therefore, the final product of the Etard reaction is an aromatic aldehyde.

Therefore, the correct answer is option 1: Aromatic aldehyde.

Question 47

Match List-I with List-II:

	List-I		List-II
(A)	Amino acids linked in a specificsequence	(I)	Primary structure of proteins
(B)	Regular folding of a specific sequenceof amino acids due to H-bonding	(II)	Secondary structure of proteins
(C)	Fibrous proteins	(lII)	Quaternary structure of proteins
(D)	Spatial arrangement of two or morepolypeptide chains	(IV)	Tertiary structure of proteins

Choose the correct answer from the options given below:

Options:

A. (A) - (I), (B) - (II), (C) - (III), (D) - (IV)

B. (A) - (I), (B) - (III), (C) - (II), (D) - (IV)

C. (A) - (I), (B) - (II), (C) - (IV), (D) - (III)

D. (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Answer: C

Solution:

CONCEPT:

Protein Structure Levels

- Proteins have four levels of structure: primary, secondary, tertiary, and quaternary.
- The **primary structure** refers to the specific sequence of amino acids in a polypeptide chain.
- The **secondary structure** refers to the regular folding of the polypeptide chain into structures like alpha helices and beta sheets, primarily due to hydrogen bonding.
- The **tertiary structure** refers to the overall three-dimensional shape of a single polypeptide chain, including interactions like hydrogen bonds, ionic bonds, and disulfide bridges.
- The **quaternary structure** refers to the spatial arrangement of two or more polypeptide chains in a multi-subunit complex.

EXPLANATION:

- For each item in List-I, we match it with the correct description in List-II:
- (A) Amino acids linked in a specific sequence:
  - This describes the primary structure of proteins, as the primary structure is the sequence of amino acids.
- (B) Regular folding of a specific sequence of amino acids due to H-bonding:
  - This describes the secondary structure of proteins, as secondary structures are formed by hydrogen bonding within the polypeptide chain.
- (C) Fibrous proteins:
  - This describes the tertiary structure of proteins, as fibrous proteins have a specific three-dimensional shape that gives them their fibrous nature.
- (D) Spatial arrangement of two or more polypeptide chains:
  - This describes the quaternary structure of proteins, as quaternary structure involves the arrangement of multiple polypeptide chains.

Therefore, the correct matching isoption 3.

Question 48

Match List-I with List-II:

	List-I		List-II
(A)	Tollen's reagent	(I)	Rochelle salt
(B)	Jones reagent	(Il)	Conc. HCl and$ZnCl_2$
(C)	Lucas reagent	(lII)	Ammoniacal silver nitrate
(D)	Fehling solution	(IV)	Chromium trioxide-sulphuric acid

Choose the correct answer from the options given below:

Options:

A. (A) - (III), (B) - (IV), (C) - (II), (D) - (I)

B. (A) - (IV), (B) - (III), (C) - (I), (D) - (II)

C. (A) - (I), (B) - (IV), (C) - (II), (D) - (III)

D. (A) - (III), (B) - (I), (C) - (IV), (D) - (II)

Answer: A

Solution:

CONCEPT:

Common Reagents in Organic Chemistry

- **Tollen's reagent:** It is ammoniacal silver nitrate, used to distinguish between aldehydes and ketones. Aldehydes reduce Tollen's reagent to metallic silver.
- **Jones reagent:** It is a mixture of chromium trioxide and sulphuric acid, used for oxidizing primary and secondary alcohols to carboxylic acids and ketones, respectively.
- **Lucas reagent:** It is a mixture of concentrated hydrochloric acid (HCl) and zinc chloride (ZnCl2), used to differentiate between primary, secondary, and tertiary alcohols.
- **Fehling solution:** It is composed of copper(II) sulfate, sodium potassium tartrate (Rochelle salt), and sodium hydroxide, used to detect reducing sugars.

EXPLANATION:

- Given the reagents and their corresponding components:
  - (A) Tollen's reagent is ammoniacal silver nitrate.
  - (B) Jones reagent is chromium trioxide-sulphuric acid.
  - (C) Lucas reagent is conc. HCl and ZnCl2.
  - (D) Fehling solution contains Rochelle salt.
- Matching List-I with List-II:
  - (A) - (III) Tollen's reagent - Ammoniacal silver nitrate
  - (B) - (IV) Jones reagent - Chromium trioxide-sulphuric acid
  - (C) - (II) Lucas reagent - Conc. HCl and ZnCl2
  - (D) - (I) Fehling solution - Rochelle salt

Therefore, the correct answer is option 1: (A) - (III), (B) - (IV), (C) - (II), (D) - (I).

Question 49

Match List-I with List-II:

	List-I		List-II
(A)	Swarts Reaction	(I)	$C_6H_5NH_2$+ $NaNO_2$+ HX + Cu_2X_2→ C_6H_5X+ N_2
(B)	Finkelstein reaction	(II)	2RX + 2Na→ R - R + 2NaX
(C)	Sandmeyer's reaction	(lII)	RX + AgF→ R - F +AgX
(D)	Wurtz reaction	(IV)	RX + NaI → R - I +NaX

Choose the correct answer from the options given below:

Options:

A. (A) - (I), (B) - (II), (C) - (III), (D) - (IV)

B. (A) - (I), (B) - (III), (C) - (II), (D) - (IV)

C. (A) - (I), (B) - (II), (C) - (IV), (D) - (III)

D. (A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Answer: D

Solution:

CONCEPT:

Chemical Reactions and Their Specific Names

- Various chemical reactions have specific names based on the reactants involved and the products formed.
- Understanding these specific reactions helps in identifying the process and predicting the products of the reaction.

EXPLANATION:

- In the given list:
  - **Swarts Reaction:** This reaction involves the formation of alkyl fluorides from alkyl halides using silver fluoride.

    $RX + AgF \rightarrow R - F + AgX$

    So, (A) matches with (III).

  - **Finkelstein Reaction:** This reaction involves the substitution of a halogen atom in an alkyl halide with iodine using sodium iodide.

    $RX + NaI \rightarrow R - I + NaX$

    So, (B) matches with (IV).

  - **Sandmeyer's Reaction:** This reaction involves the conversion of aniline derivatives to aryl halides using sodium nitrite and cuprous halide.

    $C6H5NH2 + NaNO2 + HX + Cu2X2 \rightarrow C6H5X + N2$

    So, (C) matches with (I).

  - **Wurtz Reaction:** This reaction involves the coupling of two alkyl halides using sodium to form a higher alkane.

    $2RX + 2Na \rightarrow R - R + 2NaX$

    So, (D) matches with (II).

Therefore, the correct answer is:

(A) - (III), (B) - (IV), (C) - (I), (D) - (II)

Option 4 is correct.

Question 50

Match List-I with List-II:

	List-I (Biomolecule)		List-II (Function/Diseases)
(A)	Vitamin A	(I)	Menstrual cycle
(B)	Thiamine	(II)	Xerophthalmia
(C)	Glucocorticoids	(lII)	Beri-Beri
(D)	Estradiol	(IV)	Addison's disease

Choose the correct answer from the options given below:

Options:

A. (A) - (III), (B) - (II), (C) - (I), (D) - (IV)

B. (A) - (II), (B) - (III), (C) - (I), (D) - (IV)

C. (A) - (III), (B) - (II), (C) - (IV), (D) - (I)

D. (A) - (II), (B) - (III), (C) - (IV), (D) - (I)

Answer: D

Solution:

CONCEPT:

Functions and Deficiency Diseases of Biomolecules

- Each biomolecule has a specific function in the body, and deficiencies in these biomolecules can lead to various diseases or disorders.
- Understanding the relationship between biomolecules and their functions or associated diseases is essential in biochemistry and medicine.

EXPLANATION:

- Vitamin:
  - Vitamin A deficiency can lead to Xerophthalmia, a condition characterized by dryness of the conjunctiva and cornea.
- Thiamine (Vitamin B1):
  - Deficiency of Thiamine leads to Beri-Beri, a disease affecting the cardiovascular, muscular, gastrointestinal, and nervous systems.
- Glucocorticoids:
  - Glucocorticoids are involved in the body's stress response and immune system regulation. Addison's disease is caused by a deficiency in glucocorticoids.
- Estradiol:
  - Estradiol is a form of estrogen, a hormone that regulates the menstrual cycle and reproductive system in females.

Therefore, the correct matching is:

- (A) Vitamin - (II) Xerophthalmia
- (B) Thiamine - (III) Beri-Beri
- (C) Glucocorticoids - (IV) Addison's disease
- (D) Estradiol - (I) Menstrual cycle

Therefore, the correct answer is option 4:

- (A) - (II), (B) - (III), (C) - (IV), (D) - (I)
