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Subject: Organic Chemistry

Topic: Solubility of Organic Compounds in Water

Given/Introduction:

Given the structures of compounds A and B:

- **Compound A:** Consists of a carboxyl group (COOH) attached to a single carbon.
- **Compound B:** Consists of a carboxyl group (COOH) attached to a carbon chain of five carbon atoms.

Both compounds can form hydrogen bonds with water due to the presence of the hydrogen-bond-accepting carbonyl group (C=O) and the hydrogen-bond-donating hydroxyl group (O-H). Despite this similarity, compound A is soluble in water, while compound B is not. This observation can be explained by considering the factors affecting solubility.

Step-by-Step Explanation:

Step 1: Understanding Hydrogen Bonding with Water

Compound A:

$$\text{HO-C(=O)-H}$$

Compound B:

$$\text{HO-C(=O)-(CH2)4-CH3}$$

Explanation:

Hydrogen bonding occurs between the carboxyl group and water molecules. Both -OH and =O groups can interact with water molecules forming strong hydrogen bonds.

Supporting Statement:

Both compounds contain carboxyl groups capable of hydrogen bonding with water, contributing to their potential for solubility.

Step 2: Influence of Hydrocarbon Chain Length

Explanation:

Compound A has a very short hydrocarbon chain (just one carbon), making it highly polar. Compound B has a longer hydrocarbon chain (five carbons), making it much more non-polar.

Supporting Statement:

As the length of the non-polar hydrocarbon chain increases, the overall polarity of the molecule decreases, reducing its solubility in the polar solvent (water).

Step 3: Solubility and Hydrophobic Effect

Explanation:

Water solubility depends on the balance between hydrophilic (water-attracting) and hydrophobic (water-repelling) parts of the molecule. In compound A, the hydrophilic carboxyl group dominates due to the short hydrocarbon chain, promoting solubility. In compound B, the long hydrophobic hydrocarbon chain outweighs the hydrophilic carboxyl group, leading to insolubility in water.

Supporting Statement:

The solubility of organic molecules in water is influenced by the relative proportions of hydrophilic and hydrophobic parts. Compound A, with its dominant hydrophilic nature, is soluble in water, while the longer hydrophobic chain in compound B makes it insoluble.

Final Solution:

Compound A is soluble in water because its small hydrocarbon chain allows the hydrophilic carboxyl group to dominate, making the molecule overall hydrophilic. Compound B is not soluble in water due to the larger hydrophobic hydrocarbon chain which dominates and results in an overall hydrophobic character.

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