Unit 4: Properties of Solutions

Types of Aqueous Solutions

This worksheet will explore the classification of substances based on their conductivity in aqueous solutions. It covers electrolytes, divided into strong and weak categories, which conduct electricity efficiently by either full or partial ionization. Additionally, nonelectrolytes, mainly molecular solutes, are introduced as substances that do not ionize and, therefore, do not conduct electricity. Understanding these distinctions is essential for grasping the electrical behavior of substances in solutions, with practical applications in various fields, including chemistry and biology.

1. Categorize the following substances as weak or strong electrolytes in an aqueous solution.
    a. Sugar ($C_6H_{12}O_6$)
    b. Sodium chloride (NaCl)
    c. Ethanol (C_2H_5OH)
    d. Acetic acid (CH_3COOH)

2. Categorize the following substances as either an electrolyte or nonelectrolyte in an aqueous solution.
    a. Hydrochloric acid (HCl)
    b. Sodium sulfate (Na_2SO_4)
    c. Methanol (CH_3OH)
    d. Potassium hydroxide (KOH)

3. Explain the difference between a strong electrolyte and a weak electrolyte in aqueous solutions. Provide an example of each.

4. Describe the electrical conductivity of a nonelectrolyte in an aqueous solution. Provide an example of a nonelectrolyte.

5. Explain why electrolytes are crucial in physiological processes within the human body. Provide an example of a physiological process that relies on electrolytes.

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ANSWER KEY:

1. Categorize the following substances as weak or strong electrolytes in an aqueous solution.
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    d. Acetic acid (CH_3COOH)

    a. Sugar ($C_6H_{12}O_6$) - nonelectrolyte (neither a weak or strong electrolyte since it there is no dissociation in water when dissolved)
    b. Sodium chloride (NaCl) - strong electrolyte (salt)
    c. Ethanol (C_2H_5OH) - nonelectrolyte
    d. Acetic acid (CH_3COOH) - weak acid (does not completely dissociate in water, and is not one of the 7 strong acids)

To identify strong electrolytes, they are composed of three categories: strong acids, strong bases, and salts. A weak electrolyte is composed of weak acids and weak bases.

Some ways to determine whether a substance is a strong or weak electrolyte is the following:

1. Is it one of the strong acids? HCl, HBr, HI, HNO_3, $HClO_3$, $HClO_4$, and H_2SO_4
2. Is it one of the strong bases? NaOH, KOH, LiOH, $Ba(OH)_2$, and $Ca(OH)_2$
3. Is it in the form of $Metal(OH)_n$? If yes, then its a strong base
4. Is it in the form of $Metal(X)_n$? If yes, then it is a salt
5. Does the molecular formula start with H? If so, it is *probably* a weak acid
6. Does it have a nitrogen atom? If so, it *might* be a weak base
7. None of the above? Nonelectrolyte

2. Categorize the following substances as either an electrolyte or nonelectrolyte in an aqueous solution.
    a. Hydrochloric acid (HCl)
    b. Sodium sulfate (Na_2SO_4)
    c. Methanol (CH_3OH)
    d. Potassium hydroxide (KOH)

    a. Hydrochloric acid (HCl) - electrolyte (it is a strong acid)
    b. Sodium sulfate (Na_2SO_4) - electrolyte (sodium sulfate is a salt so therefore it dissociates in water when dissolved)
    c. Methanol (CH_3OH) - nonelectrolyte
    d. Potassium hydroxide (KOH) - electrolyte (KOH is a strong base)

3. Explain the difference between a strong electrolyte and a weak electrolyte in aqueous solutions. Provide an example of each.

The distinction between a strong electrolyte and a weak electrolyte in aqueous solutions lies in the extent of ionization when dissolved in water. A strong electrolyte fully dissociates into ions, exhibiting high conductivity. For example, hydrochloric acid (HCl) serves as a strong electrolyte; when dissolved in water, it completely breaks down into H^+ and Cl^- ions, creating a solution with efficient electrical conductivity.

On the other hand, a weak electrolyte only partially ionizes in solution, resulting in lower conductivity compared to strong electrolytes. Acetic acid (CH_3COOH) is an illustration of a weak electrolyte. In its aqueous form, only a fraction of acetic acid molecules ionize into H^+ and CH_3COO^- ions, leading to a less effective conductor of electricity.

4. Describe the electrical conductivity of a nonelectrolyte in an aqueous solution. Provide an example of a nonelectrolyte.

Nonelectrolytes, when dissolved in an aqueous solution, do not conduct electricity. Unlike electrolytes that dissociate into ions, nonelectrolytes typically remain in molecular form, and their molecules do not ionize. As a result, there are no charged particles (ions) available to carry an electric current through the solution. An example of a nonelectrolyte is glucose ($C_6H_{12}O_6$). When glucose dissolves in water, it remains as intact molecules, and the solution does not exhibit electrical conductivity due to the absence of ions.

5. Explain why electrolytes are crucial in physiological processes within the human body. Provide an example of a physiological process that relies on electrolytes.

Electrolytes are vital in the human body as they play a pivotal role in maintaining fluid balance, nerve conduction, and muscle contractions. An example of a physiological process that relies on electrolytes is the action potential in nerve cells. Sodium (Na^+), potassium (K^+), and calcium (Ca^{2+}) ions are essential for transmitting electrical signals along nerve cells, allowing communication within the nervous system.