Nature of Acids and Bases

Aim

- classify compounds as acids or bases based on their characteristics

Notes

Properties of acids and bases are caused by ions

- ★ Hydronium ions (H_3O^+) cause acid properties
- ★ Hydroxide ions (OH^-) cause base properties

Water - the neutral substance

- ★ Water is polar
- ★ The positively charged hydrogens in one water molecule are attracted to the negatively charged oxygens of another
- ★ Due to this attraction, water ionizes to a very small extent as follows:

$$2H_2O \rightleftharpoons H_3O^+ + OH^-$$

  - ☆ concentration of the ions in pure water - $[H_3O^+]=[OH^-]=10^{-7}M$
  - ☆ importance of ionization of water
    - ✯ since the concentration of hydronium and hydroxide are equal in pure water, water is neutral
    - ✯ the concentration of ions in pure water is very low because the ions are more likely to combine to form water than water is to ionize
    - ✯ the limited ionization of water is responsible for the properties of acids and bases

Acids

- ★ **Arrhenius Theory** - an acid is a substance that yields hydrogen ions (H^+) as the only positive ions in aqueous solution; the properties of acids are caused by excess hydrogen ions
  - ☆ Acids are polar molecules that contain hydrogen as a metal
  - ☆ Acids ionize in water to produce hydrogen ions (H^+) or hydronium ions (H_3O^+) [H^+ can't exist alone. It combines with water to form H_3O^+]

$$HCl(g) \rightarrow H^+(aq) + Cl^-(aq) \quad or \quad H_2O(\ell) + HCl(g) \rightarrow H_3O^+(aq) + Cl^-(aq)$$

- ★ Other theories explain how substances behave like acids outside of water solution
- ★ Examples
  - ☆ HCl
  - ☆ HNO_3
  - ☆ H_2SO_4

Base

- ★ **Arrhenius' theory** - a base is a substance that yields hydroxide ions as the only negative ions in aqueous solution; the properties of bases are caused by hydroxide ions
  - ☆ Bases are ionic compounds that contain hydroxide as a nonmetal
  - ☆ Bases dissociate in water to release hydroxide ions

$$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$$

- ★ Other theories explain how substances behave like bases outside of water solution
- ★ Examples
  - ☆ NaOH
  - ☆ NH_4OH
  - ☆ $Ca(OH)_2$ [*NOTE:* Alcohols such as ethanol (C_2H_5OH) are bases because they are not ionic, and do not release OH^- in water]

Answer the questions below by circling the number of the correct response

1. In the reversible reaction, $2H_2O \rightleftharpoons H_3O^+ + OH^-$, showing the ionization of water, which of the following is true? (1) The forward reaction forming ions from water is favored. (2) The concentration of ions in pure water is high. (3) The concentration of hydronium in pure water is higher than the concentration of hydroxide. (4) The concentration of ions in pure water is low.

2. The ion represented by the formula H_3O^+ is (1) hydroxide, (2) hydroxyl, (3) hydronium, (4) hydrogen III oxide.

3. In pure water, 10^{-7} M represents the concentration of (1) hydroxide only, (2) hydronium only, (3) both hydroxide and hydronium, (4) neither hydroxide nor hydronium

4. The fact that the concentration of hydronium and hydroxide are equal in pure water accounts for the fact that water is (1) neutral, (2) acid, (3) base.

5. Water tends to ionize because the water molecule is (1) ionic, (2) polar, (3) nonpolar, (4) wet.

For each of the phrases below (questions 6 -7), write the correct number in the appropriate place on the answer sheet to indicate whether the compound described is (1) an acid only (2) a base only, (3) an acid or a base, or (4) neither an acid nor a base.

6. Increases the hydroxide ion concentration of water

7. Increases the hydronium ion concentration of water

8. Which of the following is *NOT* a characteristic of acids? (1) decrease the hydroxide ion concentration of water (2) ionize in water to produce hydronium ions (3) polar molecules that contain hydrogen as a metal (4) contain hydroxide as a nonmetal

9. The compound, NaOH (*aq*), is best described as (1) an acid, (2) a base, (3) neutral

10. The compound, HNO_3 (*aq*), is best described as (1) an acid, (2) a base, (3) neutral

11. As the concentration of hydronium ions increases in water, the hydroxide ion concentration (1) increases, (2) decreases, (3) remain the same.

12. When an acid is added to water the (1) hydronium ion concentration increases, (2) hydroxide ion concentration increases, (3) hydronium ion concentration decreases (4) hydroxide ion concentration first increases and then decreases.

13. When added to water, which of the following will cause the hydroxide ion concentration to increase? (1) NaCl (2) HCl (3) NaOH (4) HOH

14. Which of the following is *NOT* an acid? (1) HCl (2) HNO_3 (3) H_2SO_4 (4) H_2O