Strengths of Acids

Strong and Weak Acids and Bases

Acids are classified as strong or weak depending on the degree to which they ionize in water. In general, **strong acids** are completely ionized in aqueous solution.

$$HCl_{(g)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)} \quad \text{(100\% ionized)}$$

Weak acids ionize only slightly in aqueous solution.

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$$

In this reaction, fewer than 1% of ethanoic acid (CH_3COOH) molecules are ionized at any instant. Therefore, ethanoic acid is considered to be a weak acid.

Table 19.6 (pg. 605) shows the relative strengths of some common acids and bases.

We can write the equilibrium constant expression from the balanced chemical equation. The K_{eq} for ethanoic acid would be.

$$K_{eq} = \frac{[H_3O^+] \times [CH_3COO^-]}{[CH_3COOH] \times [H_2O]}$$

For dilute solutions, K_{eq} can be combined with water to give an acid dissociation constant (K_a).

$$K_{eq} \times [H_2O] = K_a = \frac{[H_3O^+] \times [CH_3COO^-]}{[CH_3COOH]}$$

K_a reflects the fraction of an acid in the ionized form.

In general, $K_a = \frac{[H^+][A^-]}{[HA]}$

where $[A^-]$ is the negative ion from the dissociation and [HA] is the acid.

Weak acids have small K_a values. The stronger an acid is, the larger is its K_a value.

For example, nitrous acid (HNO_2) has a K_a value of 4.4×10^{-4}, where ethanoic acid has a K_a value of 1.8×10^{-5}. This means that nitrous acid is a stronger acid than ethanoic acid.

Diprotic and triprotic acids lose their hydrogens one at a time. Each ionization reaction has a separate K_a value.

Looking at the table on page 607, as hydrogens are lost in ionization, what is the trend in K_a?

Just as there are strong and weak acids, there are also strong and weak bases.

Strong bases dissociate completely into metal ions and hydroxide ions.

Weak bases react with water to form the hydroxide ion and the conjugate acid of the base.

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

Using this weak base example, we can set up a similar constant for bases that was done for acids.

$$K_{eq} = \frac{[NH_4^+] \times [OH^-]}{[NH_3] \times [H_2O]}$$

$$K_{eq} \times [H_2O] = K_b = \frac{[NH_4^+] \times [OH^-]}{[NH_3]}$$

In general, the base dissociation constant (K_b)

$$K_b = \frac{[\text{conjugate acid}] \times [OH^-]}{[\text{base}]}$$

The magnitude of K_b indicates the ability of a weak base to compete with the strong base OH^- for hydrogen ions.

The smaller the value of K_b, the weaker the base.

Example

A 0.1000M solution of ethanoic acid is only partially ionized. From measurements of the pH of the solution, $[H^+]$ is found to be 1.34×10^{-3}M. What is the K_a of ethanoic acid?

Try questions 22-29 on page 610-611