During Class Invention #

Name(s) with Lab section in Group

Brønsted-Lowry acid/base Theory

Define the terms *Brønsted-Lowry acid* and *Brønsted-Lowry base*.

An acid is defined as a substance that donates a proton and a base as a substance that accepts a proton. In the equation below, HCl is a Brønsted acid because it donates a proton (H^+) to H_2O. H_2O is a Brønsted base because it accepts the proton (H^+) from HCl. On the right-hand side of the reaction, Cl^- is a Brønsted base because it accepts the proton (H^+) from H_3O^+. H_3O^+ is a Brønsted acid because it donates a proton (H^+) to Cl^-.

$$\underset{\text{acid}}{HCl_{(aq)}} + \underset{\text{base}}{H_2O_{(l)}} \rightleftharpoons \underset{\text{conj base}}{Cl^-_{(aq)}} + \underset{\text{conj acid}}{H_3O^+_{(aq)}}$$

1. Identify the Brønsted-Lowry acid and Brønsted-Lowry base in each of the following equations.

   i) $HCl_{(aq)} + H_2O_{(l)} \rightarrow Cl^-_{(aq)} + H_3O^+_{(aq)}$

$$\underset{\text{acid}}{HCl_{(aq)}} + \underset{\text{base}}{H_2O_{(l)}} \rightleftharpoons \underset{\text{conj base}}{Cl^-_{(aq)}} + \underset{\text{conj acid}}{H_3O^+_{(aq)}}$$

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

$$\underset{\text{base}}{NH_{3(aq)}} + \underset{\text{acid}}{H_2O_{(l)}} \rightleftharpoons \underset{\text{conj acid}}{NH_4^+{}_{(aq)}} + \underset{\text{conj base}}{OH^-_{(aq)}}$$

2. Identify the conjugate bases for each of the following acids.

   i) NH_4^+ **conjugate base is NH_3**

   ii) H_3PO_4 **conjugate base is $H_2PO_4^-$**

   iii) H_2O **conjugate base is OH^-**

3. Identify the conjugate acid for each of the following bases.

i) Br^- **conjugate acid is HBr**

ii) HSO_4^- **conjugate acid is H_2SO_4**

iii) H_2O **conjugate acid is H_3O^+**

4a. In 1i above which acid is stronger, HCl or H_3O^+? What experiment could be performed to determine which is stronger?

HCl is a stronger acid compared to H_3O^+. This can be verified by the observation that an aqueous solution containing HCl is a good conductor of electricity. This indicates the solution is a strong electrolyte, which suggests the presence of a high concentration of ions. This means the position of the equilibrium lies on the product side of the equation. If H_3O^+ were the stronger acid, the solution would not conduct electricity at all, or at the most, very poorly.

b. Describe the difference between a strong acid and a weak acid.

A strong acid completely dissociates in water producing a high concentration of ions. Strong acids are strong electrolytes. The concentration of ions can easily be measured using a conductivity apparatus. For strong acids, the $[H^+]$ is equal to the concentration of the acid. A weak acid does not completely dissociate in water. Weak acids are weak electrolytes. The $[H^+]$ is less than the concentration of the acid.

Strong acids: HCl, HNO_3, H_2SO_4, $HClO_4$
Weak acids: $HC_2H_3O_2$, HCN, H_2CO_3, HF

5a. In Exercise 1ii above, which base is stronger, NH_3 or OH^-? What experiment could be performed to determine which is stronger?

OH^- is a stronger base compared to NH_3. This can be verified by the observation that an aqueous solution containing NH_3 is a poor conductor of electricity. This indicates a low concentration of ions in solution which suggests the position of equilibrium lies on the reactant side of the equation. Therefore, OH^- prefers to hold the proton, in the form of H_2O, than does NH_3 in the form of NH_4^+. If NH_3 were a stronger base, the solution would be a strong conductor of electricity due to the presence of a high concentration of ions.

b. Describe the difference between a strong base and a weak base.

A strong base completely dissociates in water producing a high concentration of ions. Strong bases are strong electrolytes. The concentration of ions can easily be measured using a conductivity apparatus. For strong bases, the [OH^-], is equal to the concentration of the base. A weak base does not completely dissociate in water. Weak bases are weak electrolytes and the [OH^-] is less than the concentration of the base.
Strong bases: NaOH, $Ba(OH)_2$, KOH, $Ca(OH)_2$
Weak bases: NH_3, CH_3NH_2, $CH_3CH_2NH_2$, $(CH_3)_3N$