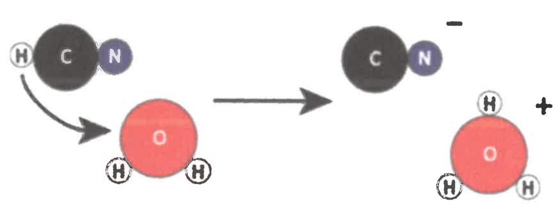
Brønsted-Lowry Theory of Acids and Bases

- the Brønsted-Lowry theory was needed to explain the existence of EQUILIBRIUM reactions between acids & bases

BRØNSTED-LOWRY THEORY
ACID = any substance than can **donate** a proton to another substance (proton donor)
BASE = any substance that can **accept** a proton from another substance (proton acceptor)

Consider the following Brønsted-Lowry acid-base equation:

$$HCN(g) + H_2O(l) \rightleftarrows H_3O^+(aq) + CN^-(aq)$$



In the **forward** reaction:

> HCN acts as an **acid** - it **loses** an H and a +1 charge to become CN-
> H_2O acts as a **base** - it **gains** an H and a +1 charge to become H_3O^+

In the **reverse** reaction:

> H_3O^+ is acting as the acid
> CN^- is acting as the base

*Notice that in a Brønsted-Lowry equilibrium there is a an acid and base in the forward reaction and in the reverse reaction.

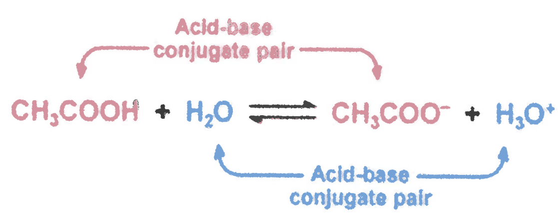
$$\underset{acid}{HCN(g)} + \underset{base}{H_2O(l)} \rightleftarrows \underset{acid}{H_3O^+(aq)} + \underset{base}{CN^-(aq)}$$

In the equation:

$$HCN(g) + H_2O(l) \rightleftarrows H_3O^+(aq) + CN^-(aq)$$

- HCN and CN^- only differ from each other by one proton (H^+)
- H_2O and H_3O^+ also only differ from one another by one proton (H^+)
- two substances that differ from each other by only **one** proton are referred to as CONJUGATE ACID-BASE PAIRS
- in any Brønsted-Lowry equation there are two conjugate pairs

conjugate acid-base pairs = pairs of chemicals that differ by only one proton **conjugate acid** has an extra proton **conjugate base** lacks a proton



1. What is the formula for the conjugate base of HNO_3 and HSO_4^-?

↳ lacks a p+

NO_3^- & SO_4^{2-}

2. What is the formula for the conjugate acid of OH^- and PO_4^{3-}?

↳ extra p+

HOH & HPO_4^{2-}

3. Identify the two Brønsted acids and two bases in the reaction:

$$\underset{A}{HSO_4^-} + \underset{B}{PO_4^{3-}} \leftrightarrows \underset{B}{SO_4^{2-}} + \underset{A}{HPO_4^{2-}}$$

Consider the following two Brønsted-Lowry equilibria:

$$HCN(g) + H_2O(l) \leftrightarrows H_3O^+(aq) + CN^-(aq)$$

$$NH_3(aq) + H_2O(l) \leftrightarrows NH_4^+(aq) + OH^-(aq)$$

- in the first equation, H_2O gains a proton to become H_3O^+ so it is acting as a BASE
- in the second equation, H_2O loses a proton to become OH^- hence it is acting as an ACID

AMPHIPROTIC = substances that can act as either an acid or base depending on the kind of substances they react with

Acids that can only donate one proton are called **monoprotic** acids while acids that can donate more than one proton are **polyprotic.**

MONOPROTIC acid → ONE proton

$$HCl \rightarrow H^+ + Cl^-$$

DIPROTIC acid → TWO protons

$$H_2SO_4 \rightarrow H^+ + HSO_4^- \rightarrow H^+ + SO_4^{2-}$$

TRIPROTIC acid → THREE protons

$$H_3PO_4 \rightarrow H^+ + H_2PO_4^- \rightarrow H^+ + HPO_4^{2-} \rightarrow H^+ + PO_4^{3-}$$

*notice that the chemical species HSO_4^-, $H_2PO_4^-$, HPO_4^{2-} are also amphiprotic

Recognizing amphiprotic substances:

1. possesses a NEGATIVE CHARGE and
2. still has an easily removable HYDROGEN

(apart from hydrogen attached to carbon, assume that all hydrogens on a negatively charged ion are "easily removable")