Chemistry Lecture #90: Arrhenius, Bronsted-Lowry, and Lewis Theories of Acids & Bases

The Arrhenius model of acids says that an acid is a substance that contains hydrogen and ionizes to produce hydrogen ions in aqueous solutions. For example, HCl gas would be an acid since it ionizes in water to produce H^+.

$$HCl(g) \xrightarrow{water} H^+(aq) + Cl^-(aq)$$

The Arrhenius model of bases says that a base is a substance that contains a hydroxide group and dissociates to produce OH^- in aqueous solution. For example, NaOH would be a base since it dissociates in water to produce OH^-.

$$NaOH\ (s) \xrightarrow{water} Na^+(aq) + OH^-\ (aq)$$

The Arrhenius model is not the only definition for an acid and base. You need to be aware of two other models: the Bronsted-Lowry model and the Lewis model.

The Bronsted-Lowry model states that an acid is a hydrogen ion donor. A base is a hydrogen ion acceptor. For example, when NH_3 and water are mixed, water will act as an acid and donate a hydrogen ion to the NH_3.

H_2O	+	NH_3	$\rightleftharpoons$	OH^-	+	NH_4^+
acid		base		conjugate		conjugate
donates H^+		accepts H^+		base		acid

Notice that if the reaction goes in reverse, NH_4^+ could donate H^+ and OH^- could accept it. Since NH_4^+ and OH^- are on the right side of the arrows, we'll call them the conjugate acid and base.

After an acid donates its H^+, it becomes a conjugate base.
After a base accepts an H^+, it becomes a conjugate acid.

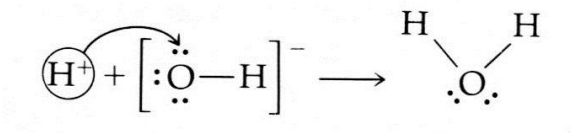
Here's another reaction:

HCl	+	H_2O	$\rightleftharpoons$	Cl^-	+	H_3O^+
acid		base		conjugate		conjugate
donates H^+		accepts H^+		base		acid

In this reaction, H_2O accepts the H^+, so it acts as a base. H_2O can either donate or accept a hydrogen ion; it can be an acid or a base. A substance that can act as an acid or a base is said to be amphoteric.

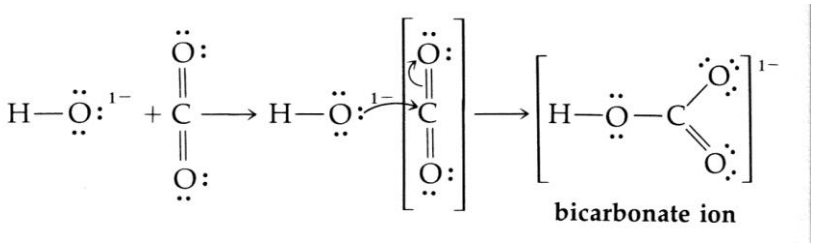
The Lewis model of acids and bases states that a base is a substance that can donate a pair of electrons to the formation of a covalent bond. An acid is a substance that can accept a pair of electrons to form the covalent bond.

For example, OH^- has a pair of electrons that are accessible. A hydrogen ion, H^+, can accept these electrons and form a covalent bond.



OH^- donates the electrons and is the base. H^+ accepts the electrons and is the acid.

In another example, OH^- can donate electrons to CO_2 and form a covalent bond between the two.



In this reaction, the OH^- is the base and the CO_2 is the acid.
This is how carbon dioxide gas is removed from the atmosphere in space ships. Carbon dioxide passes through a filter that contains LiOH. The carbon dioxide bonds with the OH^- and the resulting bicarbonate ion remains in the filter, thus removing CO_2 from the air.