pH AND SOLUBILITY

$$Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2\,OH^-(aq)\ ;\ K_{sp} = 1.8 \times 10^{-11}$$

This compound's solubility is pH dependent. How?

* In a BASIC solution, the concentration of hydroxide ion in solution is high.
, so solubility is LOWER than in pure water.

* In an ACIDIC solution, we have a significant amount of hydronium, which can react with hydroxide. This lowers the hydroxide concentration and makes magnesium hydroxide MORE SOLUBLE

Generalizing

If a compound is BASIC, then it will be LESS SOLUBLE in basic solutions, and MORE SOLUBLE in acidic solutions!

If a compound is ACIDIC, then it will be MORE SOLUBLE in basic solutions, and LESS SOLUBLE in acidic solutions!

If a compound is NEUTRAL (neither acidic nor basic), then its solubility will be UNAFFECTED by pH

LEWIS THEORY

- Lewis theory treats acid-base chemistry as ELECTRON-TRANSFER chemistry involving pairs of electrons

- Lewis acid-base reactions form new covalent bonds (of interest to organic chemists!)

ACIDS are ACCEPTORS of electron pairs

... this is why some METAL IONS, even though they contain no hydorgen ions, can exhibit ACIDIC character. Many metal ions can accept a pair of electrons to form a COMPLEX with a Lewis base! ex: $Ag(NH_3)_2^+$

BASES are DONORS of electron pairs.

... so, Lewis bases have LONE PAIRS OF ELECTRONS in their Lewis structures

$$A + :B \rightleftharpoons A-B$$

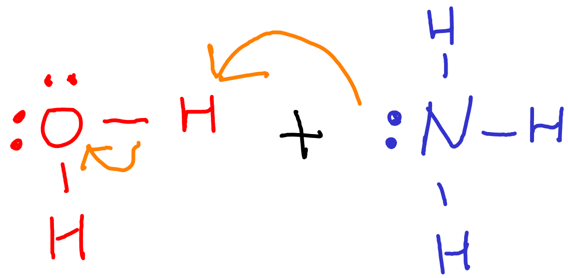
Lewis acid (A) — Lewis base (:B)

... In a Lewis acid-base reaction, electrons are donated from the Lewis base to the Lewis acid. This forms a new COVALENT BOND between the acid and the base.

LEWIS THEORY

Example: ammonia and water

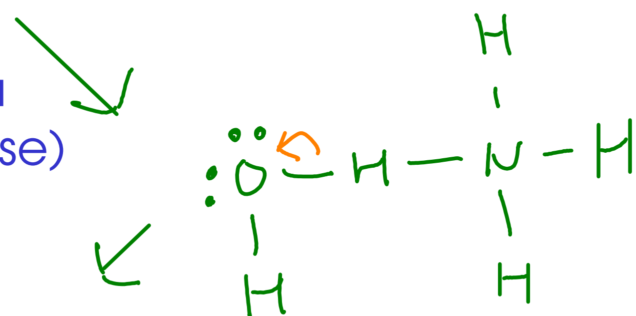
$$H_2O + :NH_3 \rightleftharpoons NH_4^+ + OH^-$$

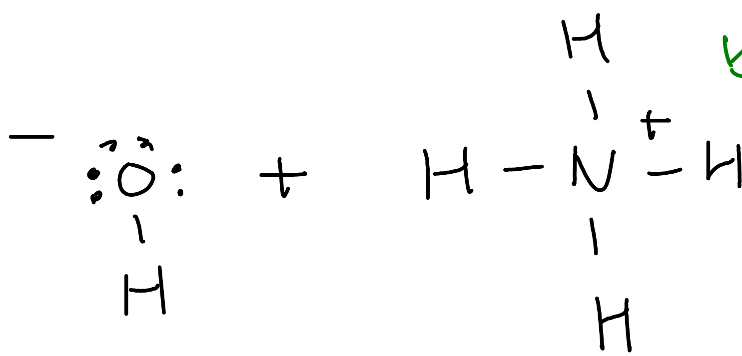


Ammonia donates
a pair of electrons to
a hydrogen on the water molecule,
forming a new covalent bond (and breaking another)

water
(Lewis acid)

ammonia
(Lewis base)





hydroxide ion

ammonium ion

Overall: $H_2O + NH_3 \rightleftharpoons NH_4^+ + OH^-$

COMPARING THE THEORIES

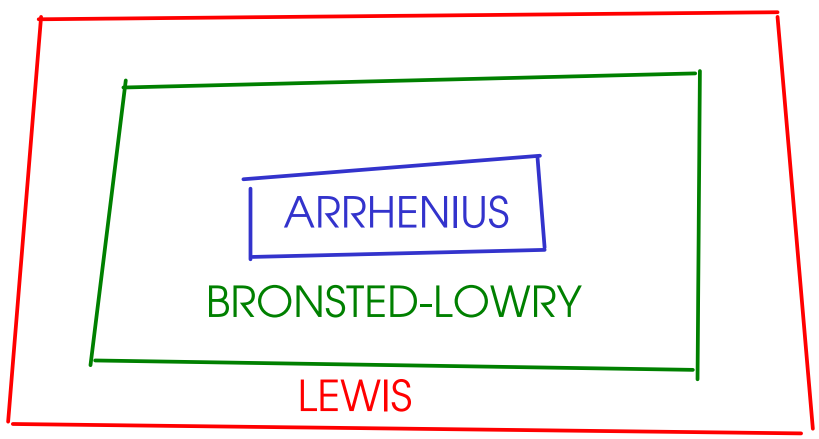
- From Arrhenius to Lewis, the definitions get broader as you go along. In other woeds, the later definitions include MORE SUBSTANCES under the acid/base umbrella.

If something is an Arrhenius acid, it is also an acid in the Bronsted or Lewis picture.

If something is an Arrhenius base, it is also a base in the Bronsted or Lewis picture.

All Bronsted acids are Lewis acids, and all Bronsted bases are Lewis bases.

... but not all Lewis acids/bases (like the metal ions) are Bronsted or Arrhenius acids/bases.



... We have mostly used BRONSTED-LOWRY theory to this point in the course!

COMPLEX IONS

- are ions that result from the reaction of a Lewis base (like water, ammonia, hydroxide ion, etc.) with a metal ion

- The Lewis base attaches to the metal ion by forming a COORDINATE COVALENT BOND with the metal ion.

$$Ag^{+}(aq) + 2\ :NH_3(aq) \longrightarrow H_3N-Ag^{+}-NH_3(aq)$$

$$\left(Ag^{+}(aq) + 2NH_3(aq) \rightarrow Ag(NH_3)_2^{+}(aq) \right)$$

- The product of the reaction is called a "COMPLEX", and the attached Lewis bases are called "LIGANDS"

COMPLEX ION EQUILIBRIUM

- Described by the FORMATION CONSTANT, Kf

$$A^+ + B \rightleftharpoons AB^+$$

$$K_f = \frac{[AB^+]}{[A^+][B]}$$

ex: $Ag^+ + 2NH_3 \rightleftharpoons Ag(NH_3)_2^+$

$$K_f = \frac{[Ag(NH_3)_2^+]}{[Ag^+][NH_3]^2} = \underline{1.7 \times 10^7}$$

What does this value for the equilibrium constant say about the favorability of the formation of the complex ion?