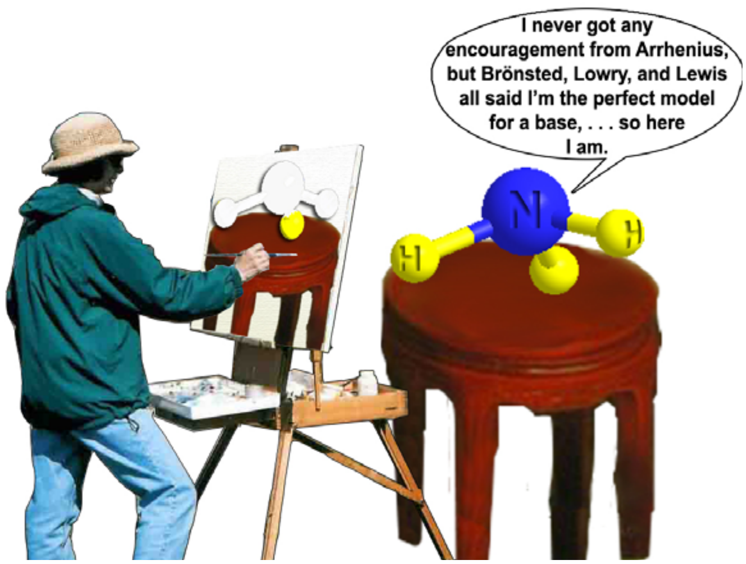
Chemistry: Form WS9.2.2A Name ______________________________

ACIDS AND BASES Date _________________ Period _____

Acids and Bases: An Operational Definition

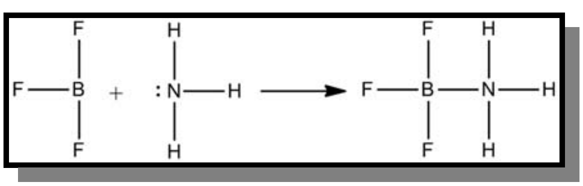
There are three models to explain the nature of acids and bases: [1] The Arrhenius Theory; [2] The Brönsted-Lowry Model; and [3] The Lewis Model. Each of these models is successively more general than the one that precedes it. The more general models include the earlier models.



Ammonia's artistic debut

According to Arrhenius an acid is a substance that yields hydrogen ions (H^+) as the only positive ions in aqueous solution. The properties of acids are caused by excess hydrogen ions. A base, on the other hand, is a substance that yields hydroxide (OH^-) ions as the only negative ions in aqueous solution. The properties of bases are caused by hydroxide ions.

Brönsted-Lowry broadens the definition of acids and bases. According to Brönsted-Lowry, an acid is any species that can donate a proton to another. For example, when ammonia dissolves in water, water donates a proton to form the ammonium ion, so water is a Brönsted-Lowry acid ($NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$). According to Brönsted-Lowry, a base is any species (molecule or ion) that can combine with or accept a proton. In the reaction between water and hydrochloric acid, water acts as a Brönsted-Lowry base by accepting a proton ($HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$). In the reaction $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ between ammonia and water, NH_4^+ and NH_3 are conjugate acid base pairs. NH_4^+ behaves like a Brönsted-Lowry acid, donating a proton to become NH_3. NH_3 behaves like a Brönsted-Lowry base, accepting a proton to become NH_4^+. Conjugate acid-base pairs always differ by one hydrogen atom.



The Lewis model expands the definition of acid and base even further. A Lewis acid is an electron pair acceptor. It has an empty atomic orbital that it can use to accept an electron pair from a molecule with a lone pair. It may be deficient in a pair of electrons. Boron trifluoride (BF_3) is a typical Lewis acid. It is electron deficient. Ammonia (NH_3) is a typical Lewis base. It has a lone pair of electrons. Boron trifluoride and ammonia will combine by forming a coordinate covalent bond.

Answer the questions below based on your understanding of acids-base models.

1. According to Arrhenius, are both HCl(*aq*) and HCl(*g*) acids? Explain. ______________________________

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2. For each of the reactions below, identify the Arrhenius acids, Brönsted-Lowry acids, and Lewis acids. (*NOTE*:A substance may fit more than one model.) If none are present, write *NONE*.

Reaction	Arrhenius	Brönsted-Lowry	Lewis
a. $HI(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + I^-(aq)$			
b. $NH_3(g) + BF_3(g) \rightarrow NH_3BF_3(g)$			
c. $2H_2O(\ell) \rightarrow H_3O^+(aq) + OH^-(aq)$			
d. $NH_3(g) + H_2O(\ell) \rightarrow NH_4^+(aq) + OH^-(aq)$			
e. $NH_4OH(aq) \rightarrow NH_4^+(aq) + OH^-(aq)$			
f. $NH_3(g) + H_2O(\ell) \rightarrow NH_4OH(aq)$			

3. For each of the same reactions below, identify the Arrhenius bases, Brönsted-Lowry basess, and Lewis bases. (*NOTE*:A substance may fit more than one model.) If none are present, write *NONE*.

Reaction	Arrhenius	Brönsted-Lowry	Lewis
a. $HI(aq) + H_2O(\ell) \rightarrow H_3O^+(aq) + I^-(aq)$			
b. $NH_3(g) + BF_3(g) \rightarrow NH_3BF_3(g)$			
c. $2H_2O(\ell) \rightarrow H_3O^+(aq) + OH^-(aq)$			
d. $NH_3(g) + H_2O(\ell) \rightarrow NH_4^+(aq) + OH^-(aq)$			
e. $NH_4OH(aq) \rightarrow NH_4^+(aq) + OH^-(aq)$			
f. $NH_3(g) + H_2O(\ell) \rightarrow NH_4OH(aq)$			

4. Describe how each of the three models of acid-base theory would account for the acid properties of $HNO_3(aq)$?

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