# Acid-Base Reactions

**Unit 14A:** Aqueous Reactions/Descriptive Chemistry and Acids & Bases

### Knowledge/Understanding Goals:

* weak vs. strong acids & bases

### Skills:

* write neutralization reactions for acid-base reactions

### Notes:

According to Svante Arrhenius’s definitions:

* acids produce H+ ions in aqueous solutions
* bases produce OH− ions in aqueous solutions

\*Note that the difference between produce and donate. A compound does not have to donate H+ or OH- ions into solution to be an acid or a base, it may also cause these ions to form via equilibrium reactions with water.

NaOH → Na+ + OH- vs NH3 +H2O NH4+ +OH-

titration: measuring the volume of a standard solution used to neutralize a known volume of an unknown solution. The concentration of the unknown solution can then be calculated using stoichiometry (the moles of standard solution added must equal the moles of H+ or OH− neutralized).

strong acid: an acid that ionizes completely in water.

HCl (aq) → H+ (aq) + Cl− (aq)

Any acid with a negative *pKa* value (see reference table in your textbook) is a strong acid. Memorize the following strong acids: HCl, HBr, HI, HNO3, H2SO4, and HClO4.

weak acid: an acid that ionizes only partially in water.

HF (aq)  H+ (aq) + F− (aq)

Assume that any acid you will see on the AP Chemistry exam is a weak acid unless it is one of the strong acids listed above.

strong base: a base that ionizes completely in water.

NaOH (aq) → Na+ (aq) + OH− (aq)

Any base whose conjugate acid has a *pKa* value greater than 14 is a strong base. All soluble oxides and hydroxides of group I and group II metals are strong bases.

(Except that aqueous Mg(OH)2 *acts* like a weak base because its solubility is so low that the concentration of OH− ions in solution is similar to that produced by a weak base.)

weak base: a base that ionizes only partially in water. Weak bases react with H2O, creating the conjugate acid and OH−.

NH3 (aq) + H2O (ℓ)  NH4+ (aq) + OH− (aq)

Assume that any base you see on the AP Chemistry exam is a weak base unless it is one of the strong bases listed above.

**Ions in Solution**

Strong acids and bases are strong electrolytes, meaning that they ionize to produce a large number of ions in water, and the resulting solution is a good conductor of electricity.

Weak acids and bases ionize only partially. This often means that the resulting solution is a weak electrolyte (poor conductor of electricity).

However, note that if the weak acid or base is itself an ion, the solution will be a strong electrolyte regardless of the amount of dissociation of the acid or base.

H2PO4- (aq) + H2O (l)HPO42- (aq) + H3O+(aq)

Note that the ions produced by the dissociation of strong acids and bases (*e.g.,* Li+, Na+, K+, Ca2+, Sr2+, Ba2+, Cl−, Br−, I−, NO3−, ClO4−, SO4−) act as spectator ions, because their conjugate acids & bases do not form in aqueous solution. (Dissociation heavily favored)

Note, however, that anions whose conjugates are weak acids (*e.g.,* F−, CH3COO−, CO32−, PO43−, *etc.*) are basic. Similarly, cations whose conjugates are weak bases (*e.g.,* NH4+) are acidic in solution. Note also that cations whose hydroxides are insoluble are acidic in solution because they remove OH− from solution.

Thus, salts formed from weak acid or base reactions will influence the final pH of the solution.

* A salt that is comprised of an acidic cation (such as NH4+) and a spectator anion (such as Cl−) will be acidic in solution.
* A salt that is comprised of a spectator cation (such as Na+) and a basic anion (such as CO32−) will be basic in solution.
* A cation resulting in an insoluble hydroxide salt will be acidic in solution.

**Acid-Base Reactions**

### Strong Acid/Strong Base

Because strong acids hydrolyze completely in water, the net ionic reaction for any strong acid/strong base reaction is:

H+ (aq) + OH− (aq) → H2O (ℓ)

If you write out the detailed ionic equation, you will see that all of the other ions are spectators, as in the following example:

HNO3 (aq) + NaOH (aq) → NaNO3 (aq) + H2O (ℓ)

H+ (aq) + ~~NO~~3− (aq) + ~~Na~~+ (aq) + OH− (aq) → ~~Na~~+ (aq) + ~~NO~~3− (aq) + H2O (ℓ)

H+ (aq) + OH− (aq) → H2O (ℓ)

### Weak Acid/Strong Base

1. Write the weak reaction (ionization of the weak acid) first.
2. Write the reaction for the H+ combining with OH− from the strong base to form H2O.
3. Combine the two reactions.
4. Cancel out H+ from both sides.

For example, in the reaction between HF (weak acid) and NaOH (strong base):

HF (aq)  H+ (aq) + F− (aq)

H+ (aq) + OH− (aq) → H2O (ℓ)

HF (aq) + ~~H~~+ (aq) + OH− (aq) → ~~H~~+ (aq) + F− (aq) + H2O (ℓ)

HF (aq) + OH− (aq) → F− (aq) + H2O (ℓ)

### Strong Acid/Weak Base

1. Write the weak reaction (reaction of the weak base with water) first.
2. Write the reaction for the OH− combining with H+ from the strong acid to form H2O.
3. Combine the two reactions.
4. Cancel out OH− and H2O from both sides.

For example, in the reaction between HCl (strong acid) and NH3 (weak base):

NH3 (aq) + H2O (ℓ)  NH4+ (aq) + OH− (aq)

H+ (aq) + OH− (aq) → H2O (ℓ)

NH3 (aq) + ~~H~~~~2~~~~O~~ (ℓ) + H+ (aq) + ~~OH~~− (aq) → NH4+ (aq) + ~~OH~~− (aq) + ~~H~~~~2~~~~O~~ (ℓ)

NH3 (aq) +  H+ (aq)  → NH4+ (aq)