Example (cont'd.)

- How many moles of Ag^+ left in the solution?

Solubility and Stoichiometry

What mass of solid NaCl must be added to 1.50 L of a 0.100 M $AgNO_3$ solution to precipitate all of the Ag^+?

Acid-Base Reactions

Generally, in an acid-base reaction,

- H^+ from acid reacts with the OH^- from base to form water, H_2O
- The cation (M^+) from base combines with anion from acid (X^-) to form a salt.

A general equation for an acid-base neutralization reaction is shown below:

$$HX(aq) + MOH(aq) \rightarrow H_2O(l) + MX$$

acid base water salt

Acid-Base Rxns

Brønsted-Lowry Theory: acid/base reactions are proton-transfer processes.

- **acid** is **proton-donor** (H^+ ion donor).
- **base** is **proton- acceptor** (H^+ ion acceptor).

When an **acid** gives its proton to water, water is acting as a **base.**

When a **base** accepts a proton from water, water is acting as an **acid.**

Strong and Weak Acids

- **Strong acids** (think "strong electrolyte") undergo complete ionization.
  - *For HCl, essentially all the HCl molecules split up into ions.*

$$HCl(aq) + H_2O(l) \longrightarrow \boxed{H_3O^+(aq) + Cl^-(aq)}$$

Dominant species

- **Weak acids** (think "weak electrolyte") undergo incomplete ionization.
  - *For HF, only a very few H^+ and F^- ions exist in solution....the reverse reaction dominates the chemistry*
  - *Weak acids are like insoluble salts....they don't like to dissociate very much.*

$$\boxed{HF(aq) + H_2O(l)} \longrightarrow H_3O^+(aq) + F^-(aq)$$

Dominant species

Strong and Weak Acids

- Strong acids to know:
  - Two well-known oxyacids: nitric (HNO_3), sulfuric (H_2SO_4)
  - Group 7 acids: hydrochloric (HCl), hydrobromic (HBr), hydroiodic (HI)
  - Two chlorine oxyacids: chloric ($HClO_3$), perchloric ($HClO_4$)

Any other acids we see in this course will be weak.

- Polyprotic acids lose only their first H^+ easily, producing $H_3O^+(aq)$ and an acid anion:

$$H_2SO_4(aq) + H_2O(l) \rightarrow HSO_4^-(aq) + H_3O^+(aq)$$

The acid anion of sulfuric acid, the hydrogen sulfate anion, is also an acid, but it does not dissociate as readily as sulfuric acid...it is a weak acid.

Selected Acids and Bases

Acids	Bases
Strong: $H^+(aq) + A^-(aq)$	**Strong: $M^+(aq) + OH^-(aq)$**
	(M is Group I or II metal)
hydrochloric, HCl	
hydrobromic, HBr	lithium hydroxide, LiOH
hydroiodic, HI	sodium hydroxide, NaOH
nitric acid, HNO_3	potassium hydroxide, KOH
sulfuric acid, H_2SO_4	calcium hydroxide, $Ca(OH)_2$
chloric acid, $HClO_3$	strontium hydroxide, $Sr(OH)_2$
perchloric acid, $HClO_4$	barium hydroxide, $Ba(OH)_2$
Weak	**Weak**
hydrofluoric, HF	ammonia, NH_3
phosphoric acid, H_3PO_4	(accepts proton from water to
acetic acid, CH_3COOH	form: $NH_4^+(aq)$ and $OH^-(aq)$)

Writing Balanced Equations for Neutralization Reactions - I

Write balanced equations (molecular, total ionic, and net ionic) for the following chemical reactions:

a. calcium hydroxide (aq) and hydroiodic acid (aq)
b. lithium hydroxide (aq) and nitric acid (aq)
c. barium hydroxide (aq) and sulfuric acid (aq)

Acid/Base and Stoichiometry

What volume of 0.125 M HCl is needed to neutralize 200.0 mL of a 0.00955 M $Ca(OH)_2$ solution?

Acid/Base and Limiting Reagent

75.0 mL of 0.250 M HCl is added to 225.0 mL of 0.0590 M $Ba(OH)_2$ solution. What is the concentration of the excess H^+ or OH^- ions left in this solution?

$$2\,HCl\,(aq) + Ba(OH)_2\,(aq) \rightarrow 2\,H_2O\,(l) + BaCl_2\,(aq)$$

1. How many moles of each reactant?
2. Which is limiting?
3. How much H^+ or OH^- is left over?
4. What is the new volume?
5. What is the concentration of the excess reactant?

Acid / Base Titrations
An application of stoichiometry

- Sometimes we need to know information about an acid or a base – exact molarity.
- This is important for chemicals that are hard to weigh out (example: solid NaOH absorbs water form the air)
- Titrate it with a known solution!

What we want to know about goes here

What we know already goes here

Acid / Base Titrations

Example: Titrating an unknown concentration of NaOH solution with 0.500 M HCl solution

HCl is added slowly from the buret to the solution of NaOH in the flask.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

An indicator is added that changes color when moles of HCl = moles of NaOH
This is the **equivalence point.**

Read the volume of HCl solution added – now you know the moles of HCl and the moles of NaOH