Answers to practice problem:
The recipe: $2Al + 3Cl_2 \rightarrow Al_2Cl_6$.
The ingredients: 2.70 g Al and 4.05 g Cl_2.

What is the limiting reactant?
Cl_2

(0.0571 moles Cl_2 will make 0.0190 moles Al_2Cl_6)

(or, 0.0571 moles Cl_2 requires 0.0381 moles Al, and we have 0.100 moles Al)

(or, 0.100 moles Al requires 0.150 moles Cl_2, and we don't have enough Cl_2)

How much product can be made?
0.0190 moles Al_2Cl_6 (5.08 grams)

How much excess reactant is leftover?
1.67 g Al (e.g., 5.08 + 1.67 = 6.75 = 2.70 + 4.05)

Combustion reaction

Combination reaction with oxygen:

$C_{12}H_{22}O_{11}(s) + 12\ O_2(g) \rightarrow 12CO_2(g) + 11H_2O(g)$

Carbon atoms combine with oxygen to form CO_2 molecules.

Hydrogen atoms combine with oxygen to form H_2O molecules.

Phase notation
(g) = gas
(l) = pure liquid
(s) = solid

(aq) = aqueous = dissolved in water

$NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$

For very soluble or reactive compounds,
$NaCl(aq) \Rightarrow Na^+(aq) + Cl^-(aq)$, and
$HCl(aq) \Rightarrow H^+(aq) + Cl^-(aq)$.

For less reactive compounds,
$HF(aq) \neq H^+(aq) + F^-(aq)$.

Exchange reaction

A chemical reaction in which chemical partners are exchanged. Sometimes called a metathesis reaction, sometimes called a displacement reaction. Often refers to a precipitation reaction in which two reactants exchange ions.

$Pb(NO_3)_2$ (aq) + Na_2SO_4 (aq) →

Spectator ion: an ion that does not participate in a chemical reaction.

Net ionic reaction: a balanced chemical equation that shows only the species that participate in the chemical reaction. Spectators are not shown in the net reaction.

Balancing a chemical equation

1. Conservation of mass: the atoms in the reactants must equal the atoms in the products.
2. The arrow shows the more favorable direction for the reaction.
3. Stoichiometry of reactions: coefficients are placed in front of each reactant or product to show the ratio between all species in the chemical reaction. Usually the coefficients are the smallest integers that give a balanced equation.
4. Conservation of charge: the total charge from all the reactants must equal the total charge from all the products.

Acid-base reactions

Acid-base reaction: a reaction in which a proton (H^+) is transferred from one substance to another.

Proton = H^+
Hydronium = $H_3O^+ = H_2O + H^+$

Often, H^+ and H_3O^+ are used interchangeably because H^+ exists in aqueous solutions as H_3O^+.

Acid: a substance that donates a proton, a proton donor. Examples: HCl, H_3O^+.

Base: a substance that accepts a proton, a proton acceptor. Examples: OH^-, NH_3.

Strong acid: an acid that donates practically 100% of its protons to water. Example: 1 mole of HCl will donate 1 mole of H^+ to water. 2.4 moles of HCl will donate 2.4 moles of H^+ to water. 1 mole H^+ for every 1 mole HCl.

$H_2O(l) + HCl(aq) \rightarrow H_3O^+(aq) + Cl^-(aq)$

Weak acid: an acid that donates less than 100% of its protons to water.

$H_2O(l) + HF(aq) \quad H_3O^+(aq) + F^-(aq)$

Strong base: a substance that generates hydroxide ion (OH^-) or accepts protons in stoichiometric (100% mole) amounts. Example:
1 mole of NaOH will generate 1 mole of OH^- in water, or will accept 1 mole of H^+ ions.
1 mole of $Ca(OH)_2$ will generate 2 moles of OH^- in water, or accept 2 moles of H^+ ions.

Weak base: a base that generates OH^- in less than stoichiometric amounts.

$$NH_3(aq) + H_2O(l) \rightarrow OH^-(aq) + NH_4^+(aq)$$

Equivalence point: the moles of OH^- added = the moles of H^+ originally present, OR the moles of H^+ added = the moles of OH^- originally present. Also called the stoichiometric point, sometimes called the neutralization point. Equivalence point and endpoint are not true synonyms, but they are frequently used that way.

Neutralization reaction (titration process)

$NaOH(aq) + HCl(aq) \rightarrow H_2O(l) + NaCl(aq)$

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ (net ionic eqn)