CHEM. Ch. 9 Notes ~ CHEMICAL REACTIONS AND BALANCING EQUATIONS
NOTE: Vocabulary terms are in **boldface and underlined**. Supporting details are in *italics.*

9.1 Notes

I. Chemical Reactions (rxns.)
   A. **chemical reaction**—an expression showing the *conversion of reactants to products, forming new substances* with new properties
      1) **reactant**—*starting substance* in a rxn.
      2) **product**—*ending substance* in a rxn.

   REACTANTS → PRODUCTS *(reactants react to produce products)*

      3) word equations do not use chemical formulas:
      lead (II) nitrate + potassium iodide → lead(II) iodide + potassium nitrate
      4) chemical reactions use chemical formulas and are balanced:
      $Pb(NO_3)_2 + \underline{2}KI \rightarrow \underline{2}KNO_3 + PbI_2$
      5) **skeleton equation**—*unbalanced* chemical equation
      $H_2 + O_2 \rightarrow H_2O$
   B. **catalyst**—a substance that *increases the reaction rate without being used up* in the reaction (symbol written above the arrow)

   C. **** clues that a chemical reaction has taken place ****
      1) *solid (precipitate) formation*
      2) *gas production*
      3) *temperature change , without being heated or cooled*
         a) **exothermic** – *giving off energy*
         b) **endothermic** – *absorbing energy*
      4) *odor change*
      5) *cannot be reversed by physical means*

   D. common reaction symbols

+	→	(s)	↓	(cr)	(l)	(aq)	(g)	↑	Δ	heat	Pt and other catalysts…

   E. examples of equations

$NaI\ (aq) + AgNO_3\ (aq) \rightarrow NaNO_3\ (aq) + AgI\ (s)$

$\underline{3}H_2 + N_2 \rightarrow \underline{2}NH_3$

$Zn\ (s) + \underline{2}HCl\ (aq) \rightarrow ZnCl_2(aq) + H_2\ (g)$

$H_2SO_4 + \underline{2}NaOH \rightarrow Na_2SO_4 + \underline{2}H_2O$

II. Balancing Chemical Equations
   A. *Law of Conservation of Mass* = all atoms must be accounted for (balanced eq.)
   B. **balanced equations** must have the same number of atoms on both sides
   C. **coefficient**—a whole number *in front of a formula*, can be changed in order to balance the equation ($4Na_2O$ has a coefficient of 4)
   D. **subscript**—a whole number telling how many atoms are in a chemical formula; *cannot be changed when balancing equations*

"Chartin' Martin Balance Method"   est. 1986

1) *Write the unbalanced equation.*

Be sure all formulas are correct. Separate reactants and products with an arrow.

2) *Draw a small box around each formula.*

This will warn you not to change anything inside while you balance the equation.

3) *Put a blank line (underscore) in front of each boxed formula.*

This is where your coefficients will go as you balance.

4) *Make a chart below the reaction, with two columns, R & P.*

List all symbols shown in the reaction for both sides. If there are polyatomic ions, you may keep them together as a unit for convenience.

5) *Balance the equation.*

Use trial and error, *changing coefficients, not subscripts.* Pay attention to multiples. Change the atom totals in the chart as you balance. The equation is balanced when the numbers of atoms in the R & P columns are equal.

When you become more experienced at balancing, you may not need to use a chart. Some students do not need the chart format at all. I suggest you keep doing steps 1 & 3. Step 2 may become unnecessary in time.

E. examples

E1) iron + oxygen → iron(III) oxide

$Fe + O_2 \rightarrow Fe_2O_3$

$\underline{\ 4\ }\boxed{Fe} + \underline{\ 3\ }\boxed{O_2} \rightarrow \underline{\ 2\ }\boxed{Fe_2O_3}$

	R	P
Fe	~~1~~ 4	~~2~~ 4
O	~~2~~ 6	~~3~~ 6

E2) iron(III) chloride + calcium hydroxide → iron(III) hydroxide + calcium chloride

$FeCl_3 + Ca(OH)_2 \rightarrow Fe(OH)_3 + CaCl_2$

$\underline{\ 2\ }\boxed{FeCl_3} + \underline{\ 3\ }\boxed{Ca(OH)_2} \rightarrow \underline{\ 2\ }\boxed{Fe(OH)_3} + \underline{\ 3\ }\boxed{CaCl_2}$

	R	P
Fe	~~1~~ 2	~~1~~ 2
Cl	~~3~~ 6	~~2~~ 6
Ca	~~1~~ 3	~~1~~ 3
(OH)	~~2~~ 6	~~3~~ 6

9.2 Notes

III. Classifying Chemical Reactions

A. **synthesis (combination)**   **A + B → AB**

1) *two or more reactants combine to form one product*
2) energy is given off
3) examples

$SO_3 + H_2O \rightarrow H_2SO_4$ $CaO + H_2O \rightarrow Ca(OH)_2$ $Cu + S \rightarrow CuS$

B. **decomposition** **AB → A + B**

1) *one reactant decomposes into two or more products*
2) most decomposition rxns. require energy
3) examples

$NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$ $NiCO_3 \xrightarrow{\Delta} NiO + CO_2$

C. **single replacement (single displacement)** **A + BC → AC + B**

1) *atoms replace other atoms* in a compound
2) *"activity series"* shows which will be displaced

ACTIVITY SERIES:

HIGH → → → → decreasing activity → → → → LOW																		
(will displace others)																	(will not displace)	
F_2					Cl_2								Br_2					I_2
Li	Rb	K	Ba	Ca	Na	Mg	Al	Mn	Zn	Fe	Ni	Sn	Pb	H	Cu	Hg	Ag	Pt Au

3) examples

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ (Zn > H; Zn displaces the H)

$Sn + NaNO_3 \rightarrow$ N.R. (no rxn.) (Sn < Na; Sn is not "strong" enough to displace Na)

D. **double replacement (double displacement)** **AB + CD → AD + CB**

1) a *swapping* of cations in a reaction
2) usually occurs in aqueous solution (aq)
3) **** characteristics of at least one of the products: solid* (**precipitate**), *gas, or molecular cmpd.*
4) examples

$NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$ $BaCl_2 + K_2CO_3 \rightarrow BaCO_3 + 2KCl$

E. **combustion**

1) *burning*
2) *always involves oxygen (O_2) as a reactant*
3) hydrocarbon **complete combustion**:

$$\boxed{\mathbf{C_xH_y + O_2 \rightarrow CO_2 + H_2O}}$$

$$\mathbf{C_xH_y + (x + y/4)O_2 \rightarrow xCO_2 + (y/2)H_2O}$$

4) hydrocarbon **incomplete conbustion** (general format):

$$\boxed{\mathbf{C_xH_y + O_2 \rightarrow CO + H_2O}}$$

9.3 Notes

IV. Reactions in Aqueous Solution

A. **aqueous solution (aq)—***homogeneous mixture of solute and solvent*

1) **solute**—*substance being dissolved*
   a) can be a solid, liquid, or gas
   b) can be molecular (polar) or ionic
2) **solvent**—*substance doing the dissolving* (in this case, water)

B. types of reactions in aqueous solutions

1) rxns that form precipitates
(**precipitate**—*a solid formed from a chemical reaction)*
2) rxns. that form water
3) rxns. that form gases

C. net ionic equations

1) **complete ionic equation**—an equation showing dissolved (aq) ionic cmpds. (compounds) as free ions
2) **spectator ions**—*ions not directly involved* in the rxn.
3) **net ionic equation**—equation only showing particles involved in the rxn.
   a) *leave (s), (g), (l) intact*
   b) *go backwards from crisscross to "take ionic cmpds. apart"*
   c) *eliminate ions which are shown as spectator ions on both sides*
   d) *balance the net ionic equation when finished*

4) examples

E3) $Pb(NO_3)_2\ (aq) + KI\ (aq) \rightarrow PbI_2\ (s) + KNO_3\ (aq)$ unbalanced

$Pb^{2+}(aq) + (NO_3)^-\ (aq) + K^+\ (aq) + I^-\ (aq) \rightarrow PbI_2\ (s) + K^+\ (aq) + (NO_3)^-\ (aq)$
$Pb^{2+}(aq) + \cancel{(NO_3)^-\ (aq)} + \cancel{K^+\ (aq)} + I^-\ (aq) \rightarrow PbI_2\ (s) + \cancel{K^+\ (aq)} + \cancel{(NO_3)^-\ (aq)}$
$Pb^{2+}(aq) + I^-\ (aq) \rightarrow PbI_2\ (s)$ unbalanced
$Pb^{2+}(aq) + 2I^-\ (aq) \rightarrow PbI_2\ (s)$ balanced

E4) $Ca(OH)_2\ (aq) + H_3PO_4\ (aq) \rightarrow Ca_3(PO_4)_2\ (aq) + H_2O\ (l)$ unbalanced

$Ca^{2+}\ (aq) + (OH)^-\ (aq) + H^+\ (aq) + (PO_4)^{3-}\ (aq) \rightarrow Ca^{2+}\ (aq) + (PO_4)^{3-}\ (aq) + H_2O\ (l)$
$\cancel{Ca^{2+}\ (aq)} + (OH)^-\ (aq) + H^+\ (aq) + \cancel{(PO_4)^{3-}\ (aq)} \rightarrow \cancel{Ca^{2+}\ (aq)} + \cancel{(PO_4)^{3-}\ (aq)} + H_2O\ (l)$
$(OH)^-\ (aq) + H^+\ (aq) \rightarrow H_2O\ (l)$ balanced

V. Nature of Reactions

A. **reversible reactions**—reactions which can *change direction* (reversible reaction arrow is used) $\rightleftharpoons$

1) **equilibrium**—a system in *balance* (no net change)
2) **dynamic equilibrium**— forward and backward reactions occur at the same rate
3) *LeChatlier's Principle—if a system at equilibrium is disturbed, it will correct itself to reestablish equilibrium*

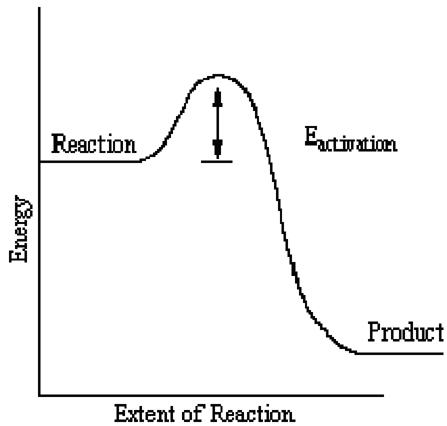
$$\mathbf{A + B \rightleftharpoons C + D}$$

a) Changing direction
- add more A/B, or remove C/D, so more C/D will be produced
- add more C/D, or remove A/B to form more A/B

b) Adding or removing energy (heat)

B. reaction rate

1) **activation energy** (E_a) – amount of energy needed to initiate a reaction



2) **catalyst**—*substance which lowers the activation energy without acting as reactant or product (makes it easier to react)*
3) **inhibitor—**substance which retards reaction rate
4) *reaction speed*— measure production of products or disappearance of reactants
5) effects of *temperature*—more reactions go faster at higher temps.
6) *concentration*—increased concentration of reactants should increase reaction rate
7) **limiting reactant**—the parent chemical which will run out first; this controls the reaction

REACTION SUMMARY

1)	**SYNTHESIS (COMBINATION)**	$A + B \rightarrow AB$
2)	**DECOMPOSITION**	$AB \rightarrow A + B$
3)	**SINGLE REPLACEMENT (SINGLE DISPLACEMENT)**	$A + BC \rightarrow AC + B$
4)	**DOUBLE REPLACEMENT (DOUBLE DISPLACEMENT)**	$AB + CD \rightarrow AD + CB$
5)	**COMBUSTION**	
	hydrocarbon COMPLETE COMBUSTION	$C_xH_y + O_2 \rightarrow CO_2 + H_2O$
	hydrocarbon INCOMPLETE COMBUSTION	$C_xH_y + O_2 \rightarrow CO + H_2O$