8-1

Unit 8. Chemical Reactivity

8-2

Observing Chemical Reactions

Changes in physical properties are indicative of a chemical reaction.

Physical Properties:
- Color
- Density
- Hardness
- Solubility
- mp/bp
- Odor
- Energy Changes

8-3

Equations Hold a Wealth of Information

$Pb(NO_3)_2\,(aq) + K_2CrO_4\,(aq) \rightarrow PbCrO_4\,(ppt) + 2\,KNO_3\,(aq)$

Equations must represent reality.

Equations must be balanced.

Precipitate (ppt)- an insoluble product formed in a rxn

8-4

Reading Chemical Equations

Reactant(s) $\longrightarrow$ Product(s)

Name compounds by the rules we learned previously

8-5

Chemical Equations: Coefficients

$2\,K(s) + Cl_2(g) \longrightarrow 2\,KCl(s)$

2 K denotes how many react.

The 2 relates to everything which follows in the compound.

8-6

Chemical Equations: Subscripts and Superscripts

$2\,K(s) + Cl_2(g) \longrightarrow 2\,KCl(s)$

Cl_2 denotes 2 atoms of chlorine in a chlorine molecule (*diatomic*)

Superscripts will denote the charge on an ion

Ca^{2+}

$CaCl_2 + H_2O \longrightarrow Ca^{2+} + 2\,Cl^-$

8-7

Chemical Equations: State

$2K(s) + Cl_2(g) \longrightarrow 2\ KCl(s)$

(s)(l)(g)(aq) denote the *state* of the molecules

8-8

Chemical Equations

Equations to chemists are like sentences to readers; they specify exactly what happens in a reaction.

$SO_4^{2-} + BaCl_2 \longrightarrow BaSO_4 + 2Cl^-$

You should be able for the exam to "read" a chemical equation.

8-9

Chemical Equations Must Be Balanced

There must be an equal number of atoms of each element on both sides of the equation.

$2K(s) + Cl_2(g) \longrightarrow KCl\ (s)$ is not balanced

$2K\ (s) + Cl_2\ (g) \longrightarrow 2\ KCl\ (s)$ is balanced

8-10

Balancing Equations by Inspection

Consider the substance with the most atoms first.

Don't change formulas of molecules or subscripts.

Don't forget that if you use a coefficient, all of the atoms in the molecule are increased.

8-11

The Mole (mol)

$2K\ (s) + Cl_2\ (g) \longrightarrow 2\ KCl\ (s)$

8-12

The Mole

Mole (mol) is the unit abbreviation for amount

1 mol sodium chloride (NaCl) has the same number of molecules as 1 mol of table sugar ($C_{12}H_{22}O_{11}$)

that number is Avagadro's number, 6.02×10^{23}

8-13

Molar Mass

Molar Mass- The mass, in grams, numerically equal to the atomic weight of each element in the molecule.

AKA: molecular weight

8-14

Sample Test Question

What is the the molar mass of NaCl?

1. Count the total atoms of each element (Be careful around parentheses).
2. Multiply by atomic weight off periodic chart.
3. Add up all the atomic weights.

What is the the molar mass of $C_{12}H_{22}O_{11}$?

What is the the molar mass of $Fe_2(NO_3)_3$?

8-15

Sample Test Questions

If I need 1.5 moles of water, how much water do I weigh out?

How many moles are in 500 g water?

8-16

How Much Product will be Formed in a Reaction?

$$CH_4 + 2\ O_2 \longrightarrow CO_2 + 2\ H_2O$$

How many moles of CO_2 would be produced if 1 mol of CH_4 were burned in excess O_2?

How many moles of H_2O would be produced if 1 mol of CH_4 were burned in excess O_2?

Stoichiometry- the ratio of product to reactant in a chemical reaction.

AKA mole ratio

8-17

How Much Product will be Formed in a Reaction?

$$CH_4 + 2\ O_2 \longrightarrow CO_2 + 2\ H_2O$$

Sample test question: Using the equation above, calculate the mass of carbon dioxide produced if 25.0 g of methane are burned in excess oxygen.

1. Convert mass to moles.
2. Do stoichiometry.
3. Convert moles to mass.

8-18

More Practice Problems

$$CH_4 + 2\ O_2 \longrightarrow CO_2 + 2\ H_2O$$

1. How many g O_2 would you need if you wanted to burn 25 g CH_4?
2. If you wanted to produce 25 g of CO_2, how much methane would you have to burn?

8-19

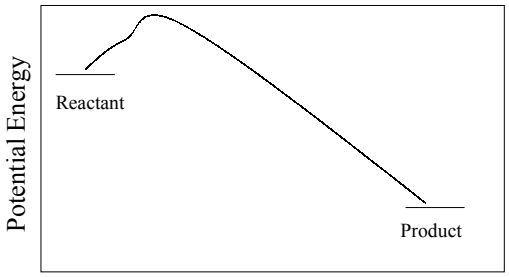
Fast Reactions, Slow Reactions

Fast -burning of natural gas
-exploding TNT
Slow -rusting of a car
-aging

Reaction rate- amount of reactant converted to product in a set period of time.

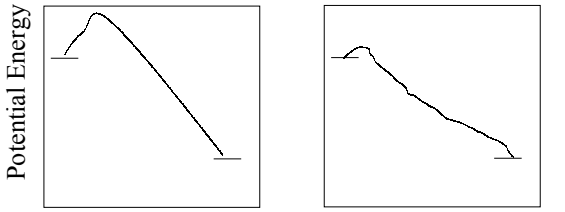
8-20

Activation Energy- "energy required to get a reaction to go."



8-21

Rapid Reactions are Characterized by A Small Activation Energy



8-22

Three Main Ways to Control Reaction Rate

1. Temperature
2. Concentration
3. Add a *catalyst* to speed the rxn up

Catalyst- is not a product or reactant, it only lowers the activation energy. A catalyst is not changed in the reaction.

8-23

Reaction Equilibrium

Not all reactions go from A to B, very often some B is converted back to A.

In theory, all reactions are reversible.

8-24

Equilibrium Constant

$$A + B \rightleftharpoons C + D$$

$$Keq = \frac{[Products]}{[Reactants]} = \frac{[C][D]}{[A][B]}$$

Keq big, $\longrightarrow$

Keq small, $\longleftarrow$

8-25

LeChatlier's principle

LeChatlier's principle- a reaction is shifted from equilibrium by addition of more product or reactant.

The shift is in the direction to relieve stress and is temporary.

8-26

Why Does a Reaction Happen?

1. Change in energy.
2. Change in entropy.

Entropy- a measure of disorder in a system.

8-27

First and Second Laws of Thermodynamics

First Law of Thermodynamics- Energy cannot be created nor destroyed, but it can be converted to other forms.

Second Law of Thermodynamics- The total entropy of the universe is increasing.

8-28

Why Does a Reaction Happen? 1. Energy Changes

Exothermic Reaction- gives off energy (naturally occurring events).

Endothermic Reaction- absorbs energy (generally will not occur on its own). If you supply energy, the reaction will proceed.

8-29

Why Does a Reaction Happen? 2. Entropy Changes

A change from low entropy to high entropy:

Gas molecules less ordered than liquid molecules.

Liquid molecules less ordered than solid molecules.