THERMOCHEMISTRY - Ch. 6
-changes in heat during chemical reactions

In order for these types of rxns to take place, ENERGY is supplied and needed. *Heat (q)* is energy that can flow from a warmer object to a colder one.
Ex. Gasoline - potential to kinetic E

1st Law of Thermodynamics: THE ENERGY OF THE UNIVERSE IS CONSTANT.
Energy can be changed through work. As the LAW OF CONSERVATION OF ENERGY says: In a chemical or physical rxn, energy is neither created nor destroyed. The change in the internal energy of the system which is equal in size but opposite in sign to that of the surroundings, is equal to the sum of the heat and work.

$$\Delta E = q + w$$

$\Delta E = -$ means the system loses energy
$\Delta E = +$ means the system gains energy

HEAT CAPACITY VS. SPECIFIC HEAT CAPACITY

Heat is measured in calories (cal) and joules (J). calorie is not the same as Calorie.
"Calorie" is used to measure the amount of heat that your body generates after eating and exercise
"calorie" is the quantity of heat the raises the T of 1 g of pure water 1^0C.

1 Calorie = 1000 cal = 1 kcal
1 kcal = 4l8J

The amount of heat it takes to change and object's T by 1^0C per gram - HEAT CAPACITY.

SPECIFIC HEAT CAPACITY (just specific heat) - same as heat capacity, just referring to specific substances.

$$HEAT = M \quad \Delta T \quad S$$

EXOTHERMIC vs. ENDOTHERMIC RXNS

The reaction between a system and the surroundings.

> CALORIMETRY: Measurement of the heat change for chemical and physical processes.
> Calorimeter - device

What is measured? **ENTHALPY** - H - (heat content of a system)

ENTHALPY = HEAT

endothermic rxn- enthalpy is pos.
exothermic rxn - enthalpy is neg.

<u>THERMOCHEMICAL EQUATIONS</u>

Heat of reaction - the heat change for the equation based on a standard value. (1 atm and 25^0C)

Formation of calcium hydroxide from calcium oxide and water -   EXO $\Delta H = -65.2$ kJ
Decomposition of baking soda (sodium bicarbonate) -   ENDO $\Delta H = +129$ kJ

The physical states next to each substance must be written in the equation!

Heat of combustion - the heat of rxn for the complete burning of 1 mole of a hydrocarbon.

<u>HEAT AND CHANGES OF STATE</u>

HEAT OF FUSION - ΔH_{fus}- The heat required to absorb 1 mol of a solid changes to a liquid at constant T.

HEAT OF SOLIDIFICATION - ΔH_{solid} - The heat lost when 1 mol of liquid changes to a solid at constant T.

Due to the LAW of CONSERVATION OF ENERGY, $\Delta H_{fus} = - \Delta H_{solid}$

HEAT OF VAPORIZATION - ΔH_{vap}
HEAT OF CONDENSATION - ΔH_{cond}

HEAT OF SOLUTION - ΔH_{soln} The dissolution of 1 mol of substance. Ex: hot and cold packs (NaOH and NH_4OH are commercially used)

<u>All ΔH's must be given or retrieved from an appendix or reference or can be calculated.</u>

2nd Law of Thermodynamics:

The total energy, including heat, in a (closed) system is conserved.

By ``closed'', we mean a system that is completely cut-off, or insulated from its surroundings, so that no material or energy enters or leaves.

If you place an ice cube outside on a hot day, the ice cube will melt. From the point of view of energy, what has happened is that some of the heat from the surrounding air enters the ice cube, raising its temperature, and eventually melting it. The surrounding air subsequently cools somewhat. However, nothing from energy conservation, or Newton's laws in general, would prevent heat from leaving the ice cube, making the ice cube colder and the surrounding air warmer. Why then doesn't this latter phenomena occur?

The answer lies in the statement of the 2nd law of thermodynamics, which can be given in three equivalent forms:

1. Heat flows spontaneously from a hot body to a cool one.

2. One cannot convert heat completely into useful work.

3. Every isolated system becomes a disordered one in time.

HESS'S LAW OF HEAT SUMMATION: When you add 2 or more equations to give a final one, then you must add the ΔHs to give a final change. (use your algebra and practice - remember in reverse rxns, change the sign of the ΔH.
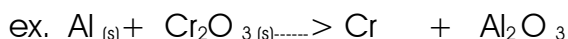Sample exercise : 6.7 p. 258
Ex. Conversion of diamond to graphite

STANDARD HEATS OF FORMATION

Sometimes it is hard to measure the ΔH, so you can calculate the ΔH from a known value called STANDARD HEAT OF FORMATION - ΔH_f^0

$$\Delta H^0 = \Delta H_f^0 \text{ (sum of products) - } \Delta H_f^0 \text{ (sum of rxts)}$$

If ΔH is neg, the rxn is _____.

ex. $Al_{(s)} + Cr_2O_{3\,(s)}\text{------}> Cr \quad + \quad Al_2O_3$

   #1 Calculate the $\Delta H°$ for this reaction:

$[2(0) + -1676] + [2(0) + (-1128)] = -548$ kJ

   #2 How much energy per gram of metal was formed?

2 moles of Cr or 104.0 g of Cr formed. The heat evolved per gram =

   548 kJ/104.0 g = -5.27 kJ/g Cr formed

I** Remember: In a balanced chem equation, you must multiply the number of mol (coefficients) by the ΔH_f^0.

Read Sec 6.5 and 6.6 Present Sources of Energy and New Energy Sources