Chem. I Ch. 20 Overview Notes ~ THERMOCHEMISTRY

NOTE: Vocabulary terms are in **boldface and underlined**. Supporting details are in *italics.*

I. **Energy**—*the capacity to do work or supply heat*

A. types of energy

potential—energy at rest; energy of position *thermal—heat energy*
kinetic—energy of motion ($1/2\ mv^2$) *radiant—light energy*

** **chemical energy** (**chemical potential energy**)—
energy stored in chemical bonds

B. **Law of Conservation of Energy**— *in a physical or chemical change, energy cannot be created nor destroyed, it merely changes form*

C. **heat** (**q**)—energy flowing from warmer to cooler objects or areas

D. **thermochemistry**

1) *the study of heat changes in chemical reactions and physical changes*
2) *the study of heat flow between a system and its surroundings*
   a. **system**—specific part being analyzed
   b. **surroundings**—everything outside the system (usually the immediate area)
   c. **universe** = system + surroundings
3) **thermochemical equations**—*equations that show heat changes*
4) **enthalpy** *(H)—heat content of a substance*
5) *change in enthalpy = ΔH*; heat change for a process at constant pressure; usually measured in kJ (kilojoules)
6) ΔH is used interchangeably with q

ENDOTHERMIC:	**+ΔH**	***heat absorbed* into system; surroundings cool down**
		(A + B + ENERGY → C + D) +ΔH
EXOTHERMIC:	**-ΔH**	***heat released* from system; surroundings heat up**
		(A + B → C + D + ENERGY) -ΔH

II. Heat Capacity

A. **heat capacity**—*amount of heat required to change a substance's temperature by exactly 1 °C;* common unit: **J / °C**

B. **calorie** *(calorie with a lower-case c)*—amount of heat required to raise the temp of 1 g of pure water by 1 °C

C. **Calorie** (Calorie, with an upper-case c*)*—"diet Calorie" = 1000 calories

D. **Joule**—*SI unit of heat and energy*; amount of heat required to raise the temp of 1 g of pure water by 0.239 °C.

UNIT CONVERSIONS:
1 Cal (diet Calorie) = 1000 cal = 1 kcal = 4.184 J
1 J = 0.239 cal
4.184 J = 1 cal

E. heat changes can be measured with a **calorimeter**, which is a covered cuplike container

III. Specific Heat Capacity

A. **Specific heat capacity** *(C or c_p)—amount of heat required to raise the temperature of 1 g of a substance by exactly 1 °C.*

B. C deals with *heat requirements* and *heat retention* :

1) *low C = low requirements and retention = heats up quickly and cools down quickly*

2) *high specific heat = high requirements and retention = heat up slowly and cool down slowly*

C. common unit: **J / g °C**

D. heat changes can be measured with a **calorimeter**

E. metals have low specific heats

F. water has the highest specific heat of common substances = 4.184 J/g °C

G. equation Δ = delta = "change in" ΔT = (T final – T initial)

$$\mathbf{C = \frac{q}{m\ \Delta T}}$$

H. examples

E1) The temperature of an 89.1 g piece of metal rises from 22.0 °C to 51.1 °C when the metal absorbs 794 J of energy. What is the specific heat of the metal?

SOLUTION: m = 89.1 g q = 794 J T = 51.1 – 22.0 = 29.1 °C

$$C = \frac{q}{m\ \Delta T} = \frac{794\ J}{(89.1\ g)(29.1\ °C)} = \boxed{0.306}\ \frac{J}{g\ °C}$$

E2) How much heat energy is needed to increase the temperature of 44.7 g of water from 20.0 to 36.3 °C?

SOLUTION:

m = 44.7 g ΔT = 16.3 °C C = 4.184 J/g °C ΔT = 36.3 °C – 20.0 °C – 16.3 °C

$$C = \frac{q}{m\ \Delta T} \qquad q = m\ \Delta T\ C \qquad q = 44.7\ \cancel{g}\ (16.3\ \cancel{°C})\ 4.184\ \frac{J}{\cancel{g}\ \cancel{°C}} = \boxed{3050\ J \text{ or } 3.05\ kJ}$$

IV. **calorimetry**—the accurate and precise measurement of the heat change for chemical reactions and physical changes

A. equation

$$\boxed{\mathbf{q = \Delta H = m\ C\ \Delta T} \quad \text{(rearrangement of the specific heat equation)}}$$

q = ΔH = (mass of water)(specific heat of water)(change in temp)

B. lab steps

1) water is measured and poured into the calorimeter
2) initial temp is recorded (of external measured solutions to be tested) OR initial temp is recorded (of the water, before a measured solid to be tested is added)
3) substance to be tested is placed in the calorimeter
4) lid is closed immediately
5) mixture is stirred
6) final temp is recorded

V. Other Thermochemistry concepts

A. Chemical change heat transfers:

ΔH_r or ΔH_{rxn} = generic HEAT OF REACTION =
heat absorbed or released in a chemical rxn.

ΔH_{comb} = MOLAR HEAT OF COMBUSTION =
heat released in combustion of 1 mol of substance

ΔH_f = HEAT OF FORMATION =
heat absorbed or released to make 1 mol of a cmpd from its elements

$\Delta H°_f$ = STANDARD HEAT OF FORMATION =
heat absorbed or released to make 1 mol of a cmpd from its elements in their standard states at 298 K (25 °C)

B. **Hess' Law**—the overall ΔH for a rxn. equals the sum of all ΔH's for the individual steps involved