NOTES#18/STANDARD ENTHALPY OF FORMATION AND RXN/AP CHEMISTRY

I. **FORMATION RXNS**:

a. Standard Enthalpy of Formation: _____ - the heat that is released or absorbed when

_____ of a compound is formed (from it's elements in their _____) at a pressure of 1 atm.

EX: Write the formation reaction for Methane, CH_4_____ $\Delta H°f$ = _____

Write the formation reaction for H_2O (l) : _____ $\Delta H°f$ = _____

Or…

b. Trends for $\Delta H°f$ values…*Look at the table of common $\Delta H°f$ in your book (Appendix C)*

- Notice that the $\Delta H°f$ for an element in it's most stable form is always _____.

Q: What's more stable, $O_2(g)$ or $O_3(g)$? _____

Q: What's more stable, C (graphite) or C (diamond)?_____

- Notice that $\Delta H°f$ values are almost ALWAYS _____. This means that the process of forming a compound from elements is almost always _____. *Does this make sense?*

II. Determining a $\Delta H°f$ value.....TWO WAYS.

a. THE DIRECT METHOD - if a compound is *easily* made from it's elements, just carry out the reaction in a calorimeter and measure the heat produced!!!

EX: Measuring $\Delta H°f$ for CO_2: C (graphite) + O_2 (g) -------> CO_2 (g) $\Delta H°f$ = -393 kJ

Measuring $\Delta H°f$ for P_4O_{10} (s): P_4 (white) + 5 O_2 (g) ------> P_4O_{10} (s) $\Delta H°f$ = _____
(ok, so maybe there are limitations)

b. THE INDIRECT METHOD - For reactions that are too complex or that do not go cleanly in a calorimeter.

- Use **Hess's Law**: if a reaction is the sum of several reaction steps, then the enthalpy change for the overall reaction is _____of the enthalpy changes of the intermediate steps. In other words, when reactants are converted into products, the change in enthalpy is the _____ whether the reaction takes place in one step or in a series of steps.

Ex: Calculate the $\Delta H°f$ for H_2S (g). **S (s) + H_2 (g) → H_2S (g) $\Delta H°f$ = ?**

The reaction enthalpies for the following reactions involving sulfur and hydrogen are well known from bomb calorimetry.

S (s) + O_2 (g) -------> SO_2 (g)	$\Delta Hrxn$ = -296.1 kJ
H_2 (g) + 1/2 O_2 (g) -----> H_2O (l)	$\Delta Hrxn$ = -285.8 kJ
H_2S (g) + 3/2 O_2 (g) ------> SO_2 (g) + H_2O (l)	$\Delta Hrxn$ = -561.7 kJ

*How can you arrange these equations so that their SUM is equal to the formation reaction of H_2S (g)?

*If you need to, you can REVERSE a rxn (just change sign of ΔH) or Multiply/Divide through the coefficients....
EX1: From the following heats of combustion with fluorine, calculate the enthalpy of formation of CH_4.

First, what is the formation reaction for CH_4 (g)?_____

CH_4 (g) + 4 F_2 (g) -------> CF_4 (g) + 4 HF (g)	ΔHrxn = -1942 kJ
C (graphite) + 2 F_2 (g) -------> CF_4 (g)	ΔHrxn = -933 kJ
H_2 (g) + F_2 (g) -------> 2 HF (g)	ΔHrxn = -542 kJ

III. What can you DO with ΔH°f values? You can use them to calculate ΔH for *any* reaction!!
- Rather than measuring a standard enthalpy change (ΔH°) using calorimetry for EVERY chemical reaction, chemists have devised a way to use the ΔH°f values of compounds involved in a reaction. Enthalpies of formation can be used to predict the ΔH for any reaction for which ΔH°f is known for all reactants and products. The relationship is:

ΔHrxn = | |

****A thoughtful aside.....**
Calorimetry is an *EXPERIMENTAL* way of determining ΔH° or ΔH_{rxn}.
Using ΔH°f is a *THEORETICAL* way of determining ΔH° or ΔH_{rxn}.

EX2: Calculate the standard enthalpy of formation of octane, C_8H_{18}, given the following combustion reaction.

2 C_8H_{18} (l) + 25 O_2 (g) --------> 16 CO_2 (g) + 18 H_2O (l) ΔHrxn = -11,020 kJ

ΔH°f (CO_2, g) = -393.5 kJ/mol ΔH°f (H_2O, l) = -285.8 kJ/mol ΔH°f (O_2, g) = _____kJ/mol