

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, CH₄ _____ ΔH^{of} = _____

Write the formation reaction for H₂O (l) : _____ ΔH^{of} = _____

Or...

b. Trends for ΔH^{of} values... Look at the table of common ΔH^{of} in your book (Appendix C)

- Notice that the ΔH^{of} for an element in it's most stable form is always _____.

Q: What's more stable, O₂(g) or O₃(g) ? _____

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

- Notice that ΔH^{of} 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 ΔH^{of} 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 ΔH^{of} for CO₂: C (graphite) + O₂ (g) -----> CO₂ (g) ΔH^{of} = -393 kJ

Measuring ΔH^{of} for P₄O₁₀ (s): P₄ (white) + 5 O₂ (g) -----> P₄O₁₀ (s) ΔH^{of} = _____
(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 ΔH^{of} for H₂S (g). S (s) + H₂ (g) → H₂S (g) ΔH^{of} = ?

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

S (s) + O₂ (g) -----> SO₂ (g) ΔH_{rxn} = -296.1 kJ

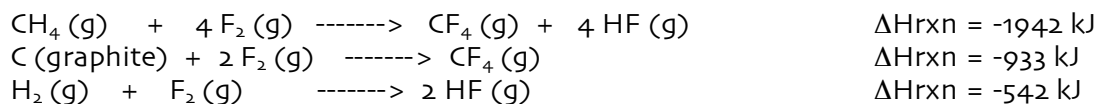
H₂ (g) + 1/2 O₂ (g) -----> H₂O (l) ΔH_{rxn} = -285.8 kJ

H₂S (g) + 3/2 O₂ (g) -----> SO₂ (g) + H₂O (l) ΔH_{rxn} = -561.7 kJ

*How can you arrange these equations so that their SUM is equal to the formation reaction of H₂S (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)? _____



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:

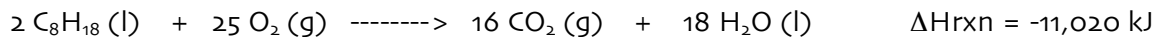
$\Delta H_{\text{rxn}} =$

****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.



$\Delta H^\circ_f(\text{CO}_2, \text{g}) = -393.5 \text{ kJ/mol}$ $\Delta H^\circ_f(\text{H}_2\text{O}, \text{l}) = -285.8 \text{ kJ/mol}$ $\Delta H^\circ_f(\text{O}_2, \text{g}) = \text{_____ kJ/mol}$