AP Chem - Unit 4 - Hess' law of constant heat summation

Review

The symbol for the standard heat of formation (also known as the standard enthalpy of formation) is ΔH_f or $\Delta H_f°$ where:

Δ indicates a change

H indicates enthalpy, which is only measured as a change, not as an instantaneous value

° indicates a standard enthalpy change for any reaction under standard conditions of temp and pressure 25°C, 1 atm, 1 Molarity

f means "formed" or that a compound is being formed from its component elements

$\Delta H = - q$

2 possible ways to solve Hess problems

1. ΔH for a reaction is equal to the sum of the heats of formation of the product compounds minus the sum of the heats of formation of the reactant compounds:

   $\Delta H = \Sigma \Delta H_f$ products - $\Sigma \Delta H_f$ reactants (note: ΔH can be ΔH_{rxn}, $\Delta H_{combustion}$, etc..)

2. ΔH is not dependent on Rxn Pathway
   - Rxn reversed, sign of ΔH reversed
   - If all coefficients of eqn multiplied or divided, same done to ΔH

Problems

1. The heats of combustion for C, H_2, and CH_4 are 298 K and 1 atm are respectively -393 KJ/mol_{rxn}, -286 KJ/mol_{rxn} and -892 KJ/mol_{rxn}. What is the $\Delta H°_f$ for CH_4?

2. Calculate the standard enthalpy for the combustion of the following reaction:

   $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6 H_20$

$\Delta H°_f$	kJ/mol
$C_6H_{12}O_6$	-1275.0
CO_2	-393.5
H_20	-285.8
0_2	0

3. Complete combustion of 1.00 mol of acetone (C_3H_6O) liberates 1790. kJ/mol_{rxn} (hint $\Delta H°_{Comb} = -1790 kJ/mol_{rxn}$)
   Using the information (including table from problem #2. Calculate the enthalpy of formation of acetone:

   $C_3H_6O + 4O_2 \rightarrow 3CO_2 + 3 H_20$

4. The standard enthalpy change, $\Delta H°$, for the thermal decomposition of silver nitrate according to the following equation is +78.67 kJ/mol

$$AgNO_3\,(s) \rightarrow AgNO_{2\,(s)} + \frac{1}{2}\,O_{2\,(g)}$$

The standard enthalpy of formation of $AgNO_3$ (s) is -123.02 kJ/mol. Calculate the standard enthalpy of formation of $AgNO_{2\,(s)}$

5. Calculate the value of $\Delta H°$ for the following reaction:

$$P_4O_{10(S)} + 6PCl_{5\,(g)} \rightarrow 10Cl_3PO_{(g)}$$

a) $P_{4\,(s)} + 6Cl_{2\,(g)} \rightarrow 4PCl_{3\,(g)}$ $\Delta H° = -1225.6$ kJ/mol$_{rxn}$

b) $P_{4\,(s)} + 5O_{2\,(g)} \rightarrow P_4O_{10(S)}$ $\Delta H° = -2967.3$ kJ/mol$_{rxn}$

c) $PCl_{3\,(g)} + Cl_{2\,(g)} \rightarrow PCl_{5(g)}$ $\Delta H° = -84.2$ kJ/mol$_{rxn}$

d) $PCl_{3(g)} + \frac{1}{2}\,O_{2\,(g)} \rightarrow Cl_3PO_{(g)}$ $\Delta H° = -285.7$ kJ/mol$_{rxn}$

6. The standard heat of combustion of benzene (C_6H_6) is -3271 kJ/mole$_{rxn}$. The standard heat of formation for CO_2 is -394 kJ/mol, and for H_2O , it is -286 kJ/mol. Calculate the $\Delta H°_f$ of benzene?