

## 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  $\Delta H_f$  or  $\Delta H_f^\circ$  where:

$\Delta$  indicates a change

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

$^\circ$  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

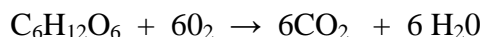
1.  $\Delta H$  for a reaction is equal to the sum of the heats of formation of the product compounds minus the sum of the heats of formation of the reactant compounds:

$$\Delta H = \sum \Delta H_f \text{ products} - \sum \Delta H_f \text{ reactants} \quad (\text{note: } \Delta H \text{ can be } \Delta H_{\text{rxn}}, \Delta H_{\text{combustion}}, \text{ etc..})$$

2.  $\Delta H$  is not dependent on Rxn Pathway
  - o Rxn reversed, sign of  $\Delta H$  reversed
  - o If all coefficients of eqn multiplied or divided, same done to  $\Delta H$

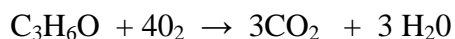
### Problems

1. The heats of combustion for C, H<sub>2</sub>, and CH<sub>4</sub> at 298 K and 1 atm are respectively -393 kJ/mol<sub>rxn</sub>, -286 kJ/mol<sub>rxn</sub> and -892 kJ/mol<sub>rxn</sub>. What is the  $\Delta H_f^\circ$  for CH<sub>4</sub>?
2. Calculate the standard enthalpy for the combustion of the following reaction:



$\Delta H_f^\circ$	kJ/mol
C <sub>6</sub> H <sub>12</sub> O <sub>6</sub>	-1275.0
CO <sub>2</sub>	-393.5
H <sub>2</sub> O	-285.8
O <sub>2</sub>	0

3. Complete combustion of 1.00 mol of acetone (C<sub>3</sub>H<sub>6</sub>O) liberates 1790. kJ/mol<sub>rxn</sub> (hint  $\Delta H_{\text{Comb}}^\circ = -1790 \text{ kJ/mol}_{\text{rxn}}$ )  
Using the information (including table from problem #2. Calculate the enthalpy of formation of acetone:

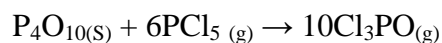


4. The standard enthalpy change,  $\Delta H^\circ$ , for the thermal decomposition of silver nitrate according to the following equation is +78.67 kJ/mol



The standard enthalpy of formation of  $\text{AgNO}_3 (\text{s})$  is -123.02 kJ/mol. Calculate the standard enthalpy of formation of  $\text{AgNO}_2 (\text{s})$

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



- a)  $\text{P}_4 (\text{s}) + 6\text{Cl}_2 (\text{g}) \rightarrow 4\text{PCl}_3 (\text{g})$   $\Delta H^\circ = -1225.6 \text{ kJ/mol}_{\text{rxn}}$   
b)  $\text{P}_4 (\text{s}) + 5\text{O}_2 (\text{g}) \rightarrow \text{P}_4\text{O}_{10}(\text{s})$   $\Delta H^\circ = -2967.3 \text{ kJ/mol}_{\text{rxn}}$   
c)  $\text{PCl}_3 (\text{g}) + \text{Cl}_2 (\text{g}) \rightarrow \text{PCl}_5(\text{g})$   $\Delta H^\circ = -84.2 \text{ kJ/mol}_{\text{rxn}}$   
d)  $\text{PCl}_3(\text{g}) + \frac{1}{2} \text{O}_2 (\text{g}) \rightarrow \text{Cl}_3\text{PO}(\text{g})$   $\Delta H^\circ = -285.7 \text{ kJ/mol}_{\text{rxn}}$

6. The standard heat of combustion of benzene ( $\text{C}_6\text{H}_6$ ) is -3271 kJ/mole<sub>rxn</sub>. The standard heat of formation for  $\text{CO}_2$  is -394 kJ/mol, and for  $\text{H}_2\text{O}$ , it is -286 kJ/mol. Calculate the  $\Delta H^\circ_f$  of benzene?