

## 6 • Energy and Chemical Reactions

### HESS'S LAW CALCULATIONS

The enthalpy of the reactants,  $H_{\text{reactants}}$  and the enthalpy of the products,  $H_{\text{products}}$  depend on the bonding of the reactants and products... nothing else. So, the  $\Delta H_{\text{reaction}}$  only depends on the initial and final state of the reaction, not how you got from one state to another state. It is called a "state function".

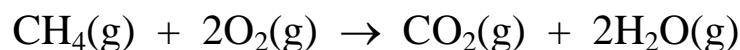
Practically speaking, if we can find several equations that "add up" to the equation we want, the  $\Delta H_{\text{reactions}}$  will add up to the overall  $\Delta H$ . This is called Hess's Law.

Heats of Formation: Write the formation equations for the following. [See Table 6.2 on page 270 of text.]

Compound	Formation Equation	$\Delta H_f$ (kJ·mol <sup>-1</sup> )
CH <sub>4</sub> (g)	C(s) + 2H <sub>2</sub> (g) → CH <sub>4</sub> (g)	-74.8
H <sub>2</sub> O(l)		-285.8
H <sub>2</sub> O(g)		-241.8
CO <sub>2</sub> (g)		-393.5
C <sub>2</sub> H <sub>6</sub> (g)		-84.7
C <sub>3</sub> H <sub>8</sub> (g)		???
C <sub>4</sub> H <sub>10</sub> (g)		-125.6

Example in class:

Calculate the  $\Delta H_{\text{combustion}}$  for CH<sub>4</sub>:



- a) Calculate the heat of combustion,  $\Delta H_{\text{combustion}}$ , for ethane, C<sub>2</sub>H<sub>6</sub>(g)

- b) Calculate the energy for the reaction between nitrogen and oxygen to form nitrogen dioxide:  
 $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g}) \dots\dots\dots \Delta\text{H} = ?$

Use these two reactions:



- c) Notice that we do the same thing each time.

If a compound is a **reactant**...

what do you do to the equation? \_\_\_\_\_ What do you do to the  $\Delta\text{H}_f$ ? \_\_\_\_\_

If a compound has a **coefficient of 3**...

what do you do to the equation? \_\_\_\_\_ What do you do to the  $\Delta\text{H}_f$ ? \_\_\_\_\_

Write the “shortcut version” of Hess’s Law (when using  $\text{H}_f$ ’s):

$$\Delta\text{H}_{\text{rxn}} = \Sigma$$

Compound	$\Delta\text{H}_f$ (kJ·mol <sup>-1</sup> )
H <sub>2</sub> O(g)	-241.8
CO <sub>2</sub> (g)	-393.5
C <sub>4</sub> H <sub>10</sub> (g)	-125.6

- c) Use this shortcut to calculate the  $\Delta\text{H}_{\text{combustion}}$  of butane, C<sub>4</sub>H<sub>10</sub>(g).

- d) The heat of combustion of propane, C<sub>3</sub>H<sub>8</sub>, is -2220 kJ·mol<sup>-1</sup>.  
 Set up the shortcut for the calculation of the  $\Delta\text{H}_{\text{combustion}}$  of propane.  
 Use this information to calculate the  $\Delta\text{H}_f$  of C<sub>3</sub>H<sub>8</sub>.