

6 • Energy and Chemical Reactions

HESS'S LAW CALCULATIONS

The enthalpy of the reactants, $H_{\text{reactants}}$ and the enthalpy of the products, H_{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".

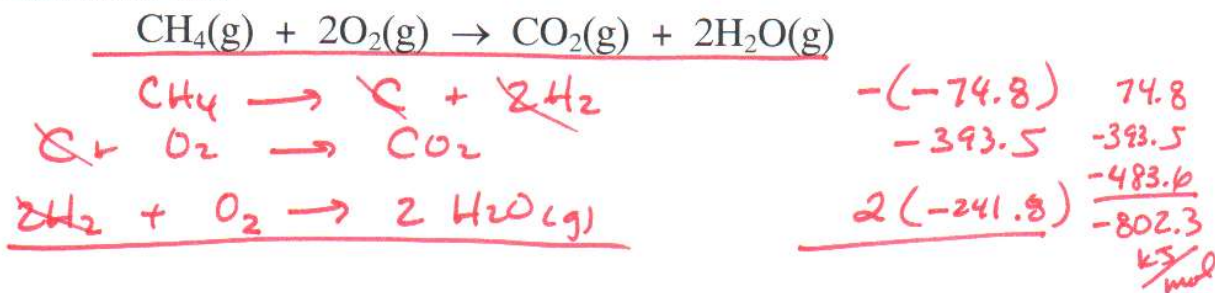
Practically speaking, if we can find several equations that "add up" to the equation we want, the $\Delta H_{\text{reactions}}$ will add up to the overall ΔH . This is called Hess's Law.

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

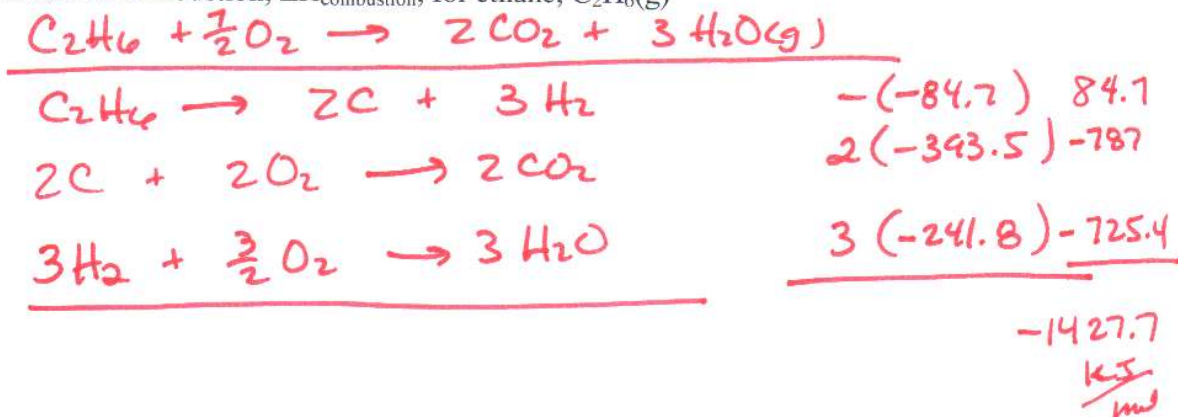
Compound	Formation Equation	ΔH_f (kJ·mol ⁻¹)
CH ₄ (g)	C(s) + 2H ₂ (g) → CH ₄ (g)	-74.8
H ₂ O(l)	H ₂ (g) + ½ O ₂ (g) → H ₂ O(l)	-285.8
H ₂ O(g)	H ₂ (g) + ½ O ₂ (g) → H ₂ O(g)	-241.8
CO ₂ (g)	C(s) + O ₂ (g) → CO ₂ (g)	-393.5
C ₂ H ₆ (g)	2C(s) + 3H ₂ (g) → C ₂ H ₆ (g)	-84.7
C ₃ H ₈ (g)	3C(s) + 4H ₂ (g) → C ₃ H ₈ (g)	???
C ₄ H ₁₀ (g)	4C(s) + 5H ₂ (g) → C ₄ H ₁₀ (g)	-125.6

Example in class:

Calculate the $\Delta H_{\text{combustion}}$ for CH₄:

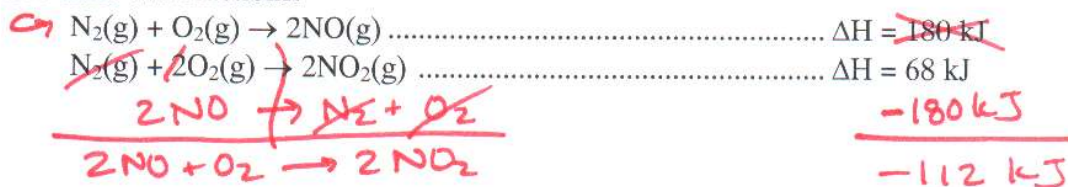


a) Calculate the heat of combustion, $\Delta H_{\text{combustion}}$, for ethane, C₂H₆(g)



- 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? reverse it What do you do to the ΔH_f ? change sign

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

what do you do to the equation? mult by 3 What do you do to the ΔH_f ? x 3

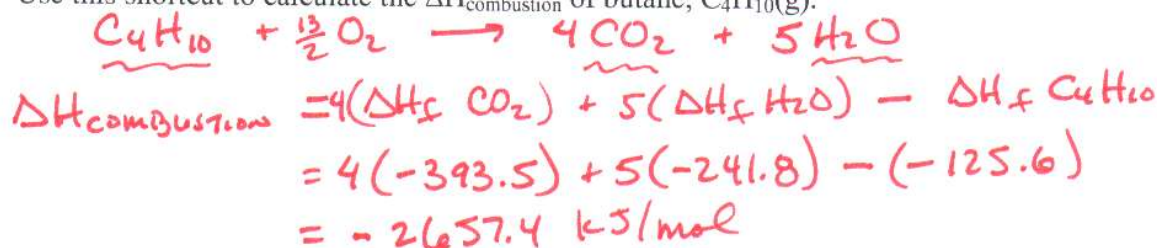
Write the "shortcut version" of Hess's Law (when using H_f 's):

$$\Delta\text{H}_{\text{rxn}} = \sum \Delta\text{H}_f \text{ PRODUCTS} - \sum \Delta\text{H}_f \text{ REACTANTS}$$

" Σ " = sum

Compound	ΔH_f ($\text{kJ}\cdot\text{mol}^{-1}$)
$\text{H}_2\text{O}(\text{g})$	-241.8
$\text{CO}_2(\text{g})$	-393.5
$\text{C}_4\text{H}_{10}(\text{g})$	-125.6

- c) Use this shortcut to calculate the $\Delta\text{H}_{\text{combustion}}$ of butane, $\text{C}_4\text{H}_{10}(\text{g})$.



- d) The heat of combustion of propane, C_3H_8 , is $-2220 \text{ kJ}\cdot\text{mol}^{-1}$.

Set up the shortcut for the calculation of the $\Delta\text{H}_{\text{combustion}}$ of propane.

Use this information to calculate the ΔH_f of C_3H_8 .

