

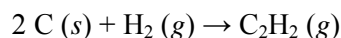
Example Problems for Lecture 15

Summary of Hess's Law

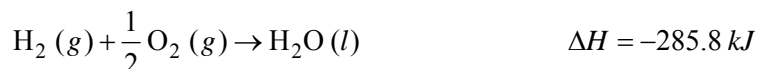
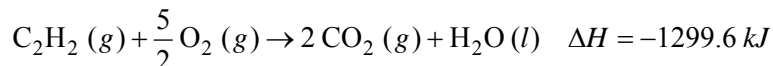
- A reaction and its reverse have equal magnitude, opposite sign ΔH values
If $A \rightarrow B$ has $\Delta H = 100$ kJ, then $B \rightarrow A$ has $\Delta H = -100$ kJ
- If you multiply a reaction by a factor, then you multiply the ΔH by the same factor
If $A \rightarrow B$ has $\Delta H = 100$ kJ, then $2A \rightarrow 2B$ has $\Delta H = 200$ kJ
- When you add two reactions, you add the ΔH values
If $A \rightarrow B$ has $\Delta H = 100$ kJ, and $C \rightarrow D$ has $\Delta H = 50$ kJ,
then $A + C \rightarrow B + D$ has $\Delta H = 100 + 50$ kJ = 150 kJ

You can use Hess's Law to calculate ΔH for a reaction of interest if you can sum other reactions to equal the reaction of interest.

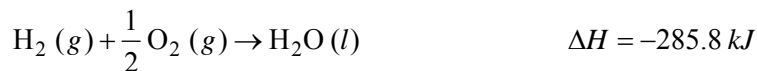
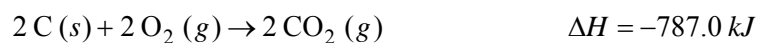
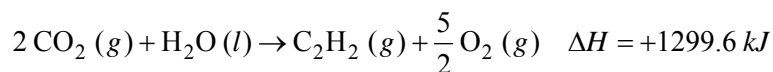
1. Calculate ΔH for the reaction



given the following chemical equations and their respective enthalpy changes.

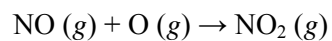


In summary:

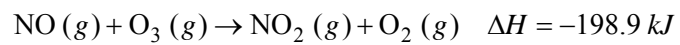


Draw an enthalpy diagram to illustrate this.

2. Calculate ΔH for the reaction



given the following information



Draw an enthalpy diagram to illustrate this.

Answer: -304.1 kJ

You can use a special category of reactions, called *formation reactions*, as the reactions that are summed to equal an overall reaction.

Enthalpy of Formation

An enthalpy of formation, ΔH_f° , is defined as the enthalpy change for the reaction in which a compound is made from its constituent elements with all substances in their standard states.

Standard enthalpies of formation are measured under standard conditions (25°C and 1.00 atm pressure) and they are reported per mole of the substance.

TABLE 5.3 Standard Enthalpies of Formation, ΔH_f° , at 298 K

Substance	Formula	ΔH_f° (kJ/mol)	Substance	Formula	ΔH_f° (kJ/mol)
Acetylene	C ₂ H ₂ (g)	226.7	Hydrogen chloride	HCl(g)	-92.30
Ammonia	NH ₃ (g)	-46.19	Hydrogen fluoride	HF(g)	-268.60
Benzene	C ₆ H ₆ (l)	49.0	Hydrogen iodide	HI(g)	25.9
Calcium carbonate	CaCO ₃ (s)	-1207.1	Methane	CH ₄ (g)	-74.80
Calcium oxide	CaO(s)	-635.5	Methanol	CH ₃ OH(l)	-238.6
Carbon dioxide	CO ₂ (g)	-393.5	Propane	C ₃ H ₈ (g)	-103.85
Carbon monoxide	CO(g)	-110.5	Silver chloride	AgCl(s)	-127.0
Diamond	C(s)	1.88	Sodium bicarbonate	NaHCO ₃ (s)	-947.7
Ethane	C ₂ H ₆ (g)	-84.68	Sodium carbonate	Na ₂ CO ₃ (s)	-1130.9
Ethanol	C ₂ H ₅ OH(l)	-277.7	Sodium chloride	NaCl(s)	-410.9
Ethylene	C ₂ H ₄ (g)	52.30	Sucrose	C ₁₂ H ₂₂ O ₁₁ (s)	-2221
Glucose	C ₆ H ₁₂ O ₆ (s)	-1273	Water	H ₂ O(l)	-285.8
Hydrogen bromide	HBr(g)	-36.23	Water vapor	H ₂ O(g)	-241.8

Copyright © 2006 Pearson Prentice Hall, Inc.

Practice writing formation reactions for several of the compounds in the table above.

3. Use standard enthalpies of formation to calculate the enthalpy of reaction for the combustion of ethanol, $\text{C}_2\text{H}_5\text{OH}(l)$.

Standard enthalpies of formation

$$\Delta H_f^\circ [\text{H}_2\text{O}(l)] = -285.83 \text{ kJ/mol}$$

$$\Delta H_f^\circ [\text{CO}_2(g)] = -393.5 \text{ kJ/mol}$$

$$\Delta H_f^\circ [\text{C}_2\text{H}_5\text{OH}(l)] = -277.7 \text{ kJ/mol}$$

In summary (shortcut):

$$\Delta H_{rxn}^\circ = \sum_{\text{products}} n \Delta H_f^\circ - \sum_{\text{reactants}} m \Delta H_f^\circ \quad \text{where } n \text{ and } m \text{ are stoichiometric coefficients}$$