Connected Chemistry
Thermodynamics Unit
Student Appendix A: Calculating Hess's Law

Sample Calculation

Methane gas is a small hydrocarbon fossil fuel which combusts when oxygen and a spark are added. The balanced equation for the combustion of methane and oxygen is

$$CH_4\ (g) + 2\ O_2\ (g) \rightarrow CO_2\ (g) + 2\ H_2O\ \ (l)$$

1. Look at table in "Appendix B: Enthalpy Data" on page 93 for enthalpy values.

$$\Delta H_f°\ CH_4\ (g) = -\ 74.81\ kJ/mol$$

$\Delta H_f°$ **of** O_2 **(g) = 0 kJ/mol** (recall that pure oxygen is a diatomic element)

$$\Delta H_f°\ of\ CO_2\ (g) = -\ 393.\ 509\ kJ/mol$$

$$\Delta H_f°\ of\ H_2O\ (l) = -285.\ 83\ kJ/mol$$

2. Make sure the equation is balanced and multiply by the coefficients. Sum the products and reactants separately.

Products

$$\Sigma\Delta H_{f\,products} = \Delta H_f\ \ of\ CO_2\ (g) + \Delta H_f\ \ of\ H_2O\ (l)$$

$$\Delta H_f\ of\ CO_2\ (g) = \Delta H_f°\ of\ CO_2\ (g) \times 1\ mol\ \ of\ CO_2\ (g) = -393.\ 509\ kJ/mol \times 1\ mol\ CO_2(g)$$

$$= -393.509\ kJ$$

$$\Delta H_f\ \ of\ H_2O\ (l) = \Delta H_f°\ of\ H_2O\ (l) \times 2\ mol\ of\ H_2O\ (l) = -285.\ 83\ kJ/mol \times 2\ mol\ H_2O\ (l)$$

$$= -\ 571.66\ kJ$$

$$\Sigma\Delta H_{f\,products} = -393.509\ kJ + (-571.66\ kJ) = -965.17\ kJ$$

Reactants

$$\Sigma \Delta H_{f\ reactants} = \Delta H_f \text{ of } CH_4\,(g) + \Delta H_f^o \text{ of } O_2\,(g)$$

$$\Delta H_f \text{ of } CH_4\,(g) = \Delta H_f^o \text{ of } CH_4\,(g) \times 1 \text{ mol } CH_4\,(g) = -74.8 \text{ kJ/mol} \times 1 \text{ mol } CH_4\,(g)$$

$$= -74.8 \text{ kJ}$$

$$\Delta H_f \text{ of } O_2\,(g) = \Delta H_f \text{ of } O_2\,(g) \times 2 \text{ mol } O_2\,(g) = 0 \text{ kJ/mol} \times 2 \text{ mol } O_2\,(g)$$

$$= 0 \text{ kJ}$$

$$\Sigma \Delta H_{f\ reactants} = -74.8 \text{ kJ} + 0 \text{ kJ} = -74.8 \text{ kJ}$$

3. Use Hess's Law to calculate ΔH_{rxn}

$$\Delta H_{rxn} = \Sigma \Delta H_{f\ products} - \Sigma \Delta H_{f\ reactants}$$

$$-965.1 \text{ kJ} - (-74.8 \text{ kJ}) = -890.3 \text{ kJ}$$

$$\Delta H_{rxn} = -890.3 \text{ kJ}$$

Student Appendix B: Enthalpy Data

Species	ΔH_f^o kJ/mol
H_2 (g)	0
O_2 (g)	0
NH_3 (g)	-45.95
NO (g)	90.25
CH_4 (g)	-74.81
H_2O (g)	-241.83
H_2O (l)	-285.83
CO_2 (g)	-393.508
C_3H_8 (g)	-104.7
C_5H_{12} (l)	-146.44
Na^+ (aq)	-239.7
HCO_3^- (aq)	-691.1
H^+ (aq)	0
$C_2H_3O_2^-$ (aq)	-483.4
H_2O_2 (l)	-191.17

Kotz, J. C., Treichel, P., & Weaver, G. C. (2006). Chemistry & chemical reactivity. Belmont, CA: Thomson Brooks/Cole.
Masterton, Slowinski & Stanitski (1983). Chemical Principles. CBS Publishing.