Calculating changes in enthalpy (ΔH)

1. Using enthalpies of formation, calculate the standard change in enthalpy for the thermite reaction:

$$2\ Al\ (s)\ +\ Fe_2O_3\ (s)\ \rightarrow\ Al_2O_3\ (s)\ +\ 2\ Fe\ (s)$$

$\Delta H^\circ_{rxn} = \Sigma n\ \Delta H^\circ_f\ (\text{prod.}) - \Sigma m\ \Delta H^\circ_f\ (\text{reac.})$

$\Delta H^\circ_{rxn} = (1\ \text{mol})(-1669.8\ \text{kJ/mol}) + (2\ \text{mol})(0) - [(2\ \text{mol})(0) + (1\ \text{mol})(-822.2\ \text{kJ/mol})$

$\Delta H^\circ_{rxn} = \mathbf{-847.6\ kJ}$

2. a) Nitroglycerin is a powerful explosive, giving four different gases when detonated.

$$2\ C_3H_5(NO_3)_3\ (l)\ \rightarrow\ 3\ N_2\ (g)\ +\ 1/2\ O_2\ (g)\ +\ 6\ CO_2\ (g)\ +\ 5\ H_2O\ (g)$$

Given that the enthalpy of formation of nitroglycerin, ΔH_f°, is –364 kJ/mol, calculate the energy (heat at constant pressure) released by this reaction.

$\Delta H^\circ_{rxn} = \Sigma n\ \Delta H^\circ_f\ (\text{prod.}) - \Sigma m\ \Delta H^\circ_f\ (\text{reac.})$

$\Delta H^\circ_{rxn} = (3\ \text{mol})(0) + (1/2\ \text{mol})(0) + (6\ \text{mol})(-393.5\ \text{kJ/mol}) + (5\ \text{mol})(-241.8\ \text{kJ/mol}) - (2\ \text{mol})(-364\ \text{kJ/mol})$

$\Delta H^\circ_{rxn} = \mathbf{-2842\ kJ}$

b) Calculate the energy liberated when 10.0 g of nitroglycerin are detonated.

$$10.0\ \text{g NG} \times \frac{1\ \text{mol NG}}{227\ \text{g NG}} = 0.0441\ \text{mol NG}$$

$$0.0441\ \text{mol NG} \times \frac{-2842\ \text{kJ}}{2\ \text{mol NG}} = \mathbf{-62.7\ kJ}$$

3. Diborane (B_2H_6) is a highly reactive boron hydride, which was once considered as a possible rocket fuel for the U.S. space program. Calculate ΔH for the synthesis of diborane from its elements, according to the equation

$$2\ B\ (s)\ +\ 3\ H_2\ (g)\ \rightarrow\ B_2H_6\ (g)$$

using the following data:

	ΔH
$2\ B\ (s)\ +\ 3/2\ O_2\ (g) \rightarrow B_2O_3\ (s)$	–1273 kJ
$B_2H_6\ (g)\ +\ 3\ O_2\ (g) \rightarrow B_2O_3\ (s)\ +\ 3\ H_2O\ (g)$	–2035 kJ
$H_2\ (g)\ +\ 1/2\ O_2\ (g) \rightarrow H_2O\ (l)$	–286 kJ
$H_2O\ (l) \rightarrow H_2O\ (g)$	+44 kJ

$2\ B\ (s)\ +\ 3/2\ O_2\ (g) \rightarrow B_2O_3\ (s)$	$\Delta H = -1273$ kJ
$3\ H_2\ (g)\ +\ 3/2\ O_2\ (g) \rightarrow 3\ H_2O\ (l)$	$\Delta H = 3(-286$ kJ)
$B_2O_3\ (s)\ +\ 3\ H_2O\ (g) \rightarrow B_2H_6\ (g)\ +\ 3\ O_2\ (g)$	$\Delta H = +2035$ kJ
$3\ H_2O\ (l) \rightarrow 3\ H_2O\ (g)$	$\Delta H = 3(+44$ kJ)
$2\ B\ (s)\ +\ 3\ H_2\ (g) \rightarrow B_2H_6\ (g)$	**$\Delta H = 36$ kJ**