Answers to Questions involving a Calculation

ALE 27. Hess's Law

(Reference: Chapter 6 - *Silberberg 4th edition*)

Important!! For answers that involve a calculation you must show your work neatly using dimensional analysis with correct significant figures and units to receive full credit. No work, no credit. Report numerical answers to the correct number of significant figures. **CIRCLE ALL NUMERICAL RESPONSES**.

Exercises

A. A **combustion reaction** is one in which a substance reacts with gaseous molecular oxygen. The **complete** combustion reactions of graphite, hydrogen, and methane are:

$$C(s, \text{graphite}) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -394 \text{ kJ}$$

$$H_2(g) + \tfrac{1}{2} O_2(g) \rightarrow H_2O(l) \qquad \Delta H = -286 \text{ kJ}$$

$$CH_4(g) + 2\, O_2(g) \rightarrow CO_2(g) + 2\, H_2O(l) \qquad \Delta H = -891 \text{ kJ}$$

Use the above combustion reactions and Hess's Law to determine the heat of the following reaction:

$$C(s, \text{graphite}) + 2\, H_2(g) \rightarrow CH_4(g) \qquad \mathbf{\Delta H = -75 \text{ kJ}}$$

B.① Write the balanced *formation reaction* for $Fe_3O_4(s)$. *Hint*: What are the naturally-occurring states of iron and oxygen?

② Calculate the heat of formation (ΔH_f) for $Fe_3O_4(s)$ given the following "bank" of thermo-chemical equations:

EQN 1 $\quad Fe_2O_3(s) + 3\, CO(g) \rightarrow 2\, Fe(s) + 3\, CO_2(g) \qquad \Delta H = -28$ kJ

EQN 2 $\quad 3\, Fe_2O_3(s) + CO(g) \rightarrow 2\, Fe_3O_4(s) + CO_2(g) \qquad \Delta H = -59$ kJ

EQN 3 $\quad 2\, CO(g) + O_2(g) \rightarrow 2\, CO_2(g) \qquad \Delta H = -568$ kJ

$\Delta H = -1123.5 \text{ kJ} = -1124 \text{ kJ}$

D. Problem 6.51: Consider the following balanced thermochemical equation for the decomposition of the mineral magnesite:

$$MgCO_{3(g)} \rightarrow MgO_{(s)} + CO_{2(g)} \qquad \Delta H_{rxn} = 117.3 \text{ kJ}$$

c.) What is ΔH when 5.35 mol of CO_2 reacts with excess MgO? *Show work and circle your answer*.

$$\mathbf{\Delta H_{rxn} = -628 \text{ k}}$$

d.) What is ΔH when 35.5 g of CO_2 reacts with excess MgO? *Show work and circle your answer*.

$$\mathbf{\Delta H_{rxn} = -94.6 \text{ kJ}}$$

E. Problem 6.53: When 1 mol of solid potassium bromide, KBr, decomposes to its elements, 394 kJ of heat is absorbed.

a.) Write the balanced thermochemical equation for this reaction.

b.) How much heat is released when 10.0 kg of KBr forms from its elements? *Show work and circle your answer*.

$q = -3.31 \times 10^4$ kJ

F. Problem 6.59: Sucrose (table sugar, $C_{12}H_{22}O_{11}$) is oxidized in the body by O_2 via a complex set of reactions (glycolysis, Krebs cycle and electron transport chain) that ultimately produces $CO_{2(g)}$ and $H_2O_{(l)}$ and releases 5.64×10^3 kJ/mol sucrose.

a.) Write the balanced thermochemical equation for this reaction.

$$C_{12}H_{22}O_{11}(s) + 12\ O_2(g) \rightarrow 12\ CO_2(g) + 11\ H_2O(l) \quad \Delta H_{rxn} = -5.64 \times 10^3 \text{ kJ}$$

b.) How much heat is released per gram of sucrose oxidized? *Show work and circle your answer*.

q(kJ) = –16.5 kJ/g

G. Problem 6.64: Given the thermochemical reactions 1 and 2, below, calculate ΔH_{rxn} for reaction #3. *Show work and circle your answer*.

Reaction #1: $\frac{1}{2} N_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow NO_{(g)}$ $\Delta H_{rxn} = 90.3$ kJ

Reaction #2: $NO_{(g)} + \frac{1}{2} Cl_{2(g)} \rightarrow NOCl_{(g)}$ $\Delta H_{rxn} = -38.6$ kJ

Reaction #3: $2\ NOCl_{(g)} \rightarrow N_{2(g)} + O_{2(g)} + Cl_{2(g)}$ $\Delta H_{rxn} = ???$

$\Delta H_{rxn} = -103.4$ kJ