THERMOCHEMISTRY WORKSHEET KEY

1. The following describes the reaction that takes place when a typical fat, glyceryl trioleate, is metabolized by the body:

   $2C_{57}H_{104}O_6(s) + 160O_2(g) \rightarrow 114CO_2(g) + 104H_2O(l) \qquad \Delta H° = -6.70 \times 10^4 \text{ kJ}$

   a. How much heat energy must be expelled by the body to rid the body of one pound of fat?

   $$\text{? kJ} = 1 \text{ lb fat} \left(\frac{453.6 \text{ g}}{1 \text{ lb}}\right)\left(\frac{1 \text{ mol fat}}{885.458 \text{ g fat}}\right)\left(\frac{-6.70 \times 10^4 \text{ kJ}}{2 \text{ mol fat}}\right) = \mathbf{1.72 \times 10^4 \text{ kJ}}$$

   b. If a swimmer burns off 2000 kJ for each 100 laps she swims, how much fat will she burn off (in pounds) if she swims 20 laps. (Assume all of the energy comes from the above reaction.)

   $$\text{? lb fat} = 20 \text{ laps} \left(\frac{-2000 \text{ kJ}}{100 \text{ laps}}\right)\left(\frac{2 \text{ mol fat}}{-6.70 \times 10^4 \text{ kJ}}\right)\left(\frac{885.458 \text{ g fat}}{1 \text{ mol fat}}\right)\left(\frac{1 \text{ lb}}{453.6 \text{ g}}\right) = \mathbf{0.0233 \text{ lb}}$$

2. 0.100 g of H_2 and an excess of O_2 are compressed into a bomb calorimeter containing 1200 g of water. The temperature before the reaction is 25.00 °C, and after the reaction it goes to 27.16 °C. The heat capacity of the calorimeter is 72.5 J/K. Calculate the heat of combustion of hydrogen gas.

   $$q_v = -\left[C_{cal} + \frac{0.00418 \text{ kJ}}{\text{g °C}} m_w\right]\Delta T = -\left[\frac{0.0725 \text{ kJ}}{\text{°C}} + \frac{0.00418 \text{ kJ}}{\text{g °C}} 1200 \text{ g}\right] 2.16 \text{ °C} = -11.0 \text{ kJ}$$

   $$\Delta E° = \frac{\text{? kJ}}{\text{mol } H_2} = \frac{-11.0 \text{ kJ}}{0.100 \text{ g } H_2}\left(\frac{2.01594 \text{ g } H_2}{\text{mol } H_2}\right) = -222 \frac{\text{kJ}}{\text{mol } H_2}$$

   $\Delta H° = \Delta E° + (\Delta n)RT \qquad H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

   $$\Delta H° = -222 \text{ kJ} + (0 - 1.5) \text{ mol} \frac{0.008314 \text{ kJ}}{\text{K mol}} 298.15 \text{ K} = \mathbf{-226 \text{ kJ/mol } H_2}$$

3. The heat of combustion of liquid cyclohexane, $C_6H_{12}(l)$, is −3924 kJ/mole. 8.25 g of cyclohexane is placed in the bomb of a bomb calorimeter with excess oxygen. The calorimeter contains 825.0 g of water. When the mixture is ignited, the temperature increases from 18.2 °C to 25.6 °C. Calculate the heat capacity of the calorimeter.

   $C_6H_{12}(l) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$

   $$\Delta E° = \Delta H° - (\Delta n)RT = -3924 \text{ kJ} - (6 - 9) \text{ mol} \frac{0.008314 \text{ kJ}}{\text{K mol}} 298.15 \text{ K} = -3917 \frac{\text{kJ}}{\text{mol } C_6H_{12}}$$

   $$q_v = \text{? kJ} = 8.25 \text{ g } C_6H_{12}\left(\frac{1 \text{ mol } C_6H_{12}}{84.162 \text{ g } C_6H_{12}}\right)\left(\frac{-3917 \text{ kJ}}{1 \text{ mol } C_6H_{12}}\right) = -384 \text{ kJ}$$

   $$q_v = -\left[C_{cal} + \frac{0.00418 \text{ kJ}}{\text{g °C}} m_w\right]\Delta T$$

   $$C_{cal} = -\frac{q_v}{\Delta T} - \frac{0.00418 \text{ kJ}}{\text{g °C}} m_w = -\frac{-384 \text{ kJ}}{(25.6 - 18.2) \text{ °C}} - \frac{0.00418 \text{ kJ}}{\text{g °C}} 825.0 \text{ g} = \mathbf{48 \text{ kJ/ C}}$$