

Calorimetry Worksheet

- 1) If 0.315 moles of hexane (C_6H_{14}) is combusted in a bomb calorimeter containing 5.65 liters of water, calculate the molar heat of combustion of hexane if the water temperature rises $55.4\text{ }^\circ\text{C}$? The specific heat capacity of water is $4.184\text{ J/g }^\circ\text{C}$.

$$\begin{aligned}\Delta H &= ms\Delta T \\ \Delta H &= (5,650\text{ grams H}_2\text{O})(4.184\text{ J/g }^\circ\text{C})(55.4\text{ }^\circ\text{C}) \\ \Delta H &= 1310\text{ kJ}\end{aligned}$$

This is the amount of energy generated when 0.315 moles of hexane is burned. To find the molar heat of combustion:

$$\Delta H = -1310\text{ kJ}/0.315\text{ moles} = -\underline{4160\text{ kJ/mol.}}$$

- 2) If 22.0 grams of propane (C_3H_8) is combusted in a bomb calorimeter containing 3.25 liters of water, calculate the molar heat of combustion of propane if the water temperature rises $29.5\text{ }^\circ\text{C}$?

$$\begin{aligned}\Delta H &= ms\Delta T \\ \Delta H &= (3250\text{ grams H}_2\text{O})(4.184\text{ J/g }^\circ\text{C})(29.5\text{ }^\circ\text{C}) \\ \Delta H &= 4.01 \times 10^2\text{ kJ}\end{aligned}$$

This is the amount of energy generated when 22.0 g of propane is burned. To find the molar heat of combustion:

$$\Delta H = (-4.01 \times 10^2\text{ kJ}/22.0\text{ g})(44.0\text{ g/ mole}) = -\underline{802\text{ kJ/mol.}}$$

- 3) As it turns out, the data from the two experiments described above would not give the correct molar heats of combustion for the compounds stated. Explain why this is, based on your knowledge of how bomb calorimetry works.

The experimental data ignores the mass and heat capacity of the bomb itself. Because the bomb has a finite mass and heat capacity, one would have to determine the amount of energy absorbed by the bomb to truly determine the amount of heat given off in the combustion of each compound.

- 4) When 1.38 g of liquid PCl_3 at $25.55\text{ }^\circ\text{C}$ is added to $1.00 \times 10^2\text{ g}$ of water at $25.55\text{ }^\circ\text{C}$ in a 'coffee-cup' calorimeter, the temperature of the resulting solution increases to $32.00\text{ }^\circ\text{C}$. If the specific heat capacity of the solution is $4.184\text{ J}/^\circ\text{Cg}$, and the heat capacity of the Styrofoam cup is negligible, calculate the molar heat of solution of PCl_3 in water.

$$\Delta H = ms\Delta T$$

$$\Delta H = (101\text{ grams soln.}) (4.184\text{ J/g }^\circ\text{C}) (6.45\text{ }^\circ\text{C})$$

$$\Delta H = -2720\text{ J}$$

This is the amount of energy generated when 1.38 g of phosphorus trichloride is dissolved. To find the molar heat of solution:

$$\Delta H = (-2720\text{ J}/1.38\text{ g PCl}_3)(137.33\text{ g/ mole})(1\text{kJ}/1000\text{J}) = \underline{-271\text{ kJ/mol.}}$$

- 5) A 'coffee-cup' calorimeter contains 150g of water at $24.6\text{ }^\circ\text{C}$. A 110 g block of molybdenum metal is heated to $100\text{ }^\circ\text{C}$ and then placed in the water in the calorimeter. The contents of the calorimeter come to an average temperature of $28.0\text{ }^\circ\text{C}$. What is the specific heat capacity of the molybdenum metal if the specific heat capacity of water is assumed to be $4.184\text{ J}/^\circ\text{Cg}$?

$$\Delta H = ms\Delta T$$

$$\Delta H = (150\text{ grams H}_2\text{O}) (4.184\text{ J/g }^\circ\text{C}) (28.0 - 24.6\text{ }^\circ\text{C})$$

$$\Delta H = 2100\text{ J}$$

This is the amount of energy released by 110 g of molybdenum. To find the heat capacity:

$$s = \Delta H / m \Delta T$$

$$s = (-2100\text{ J})/(110\text{ g Mb}) (-72\text{ }^\circ\text{C})$$

$$\Delta H = 0.27\text{ J/g}^\circ\text{C}$$

- 6) When a 0.235 g sample of benzoic acid, $\text{C}_7\text{H}_6\text{O}_2$, is combusted in a bomb calorimeter, a $3.62\text{ }^\circ\text{C}$ rise in temperature occurs. When a 0.305 g sample of citric acid, $\text{C}_6\text{H}_8\text{O}_7$, is burned, a $1.83\text{ }^\circ\text{C}$ temperature rise is observed. If the heat of combustion of benzoic acid is 26.38 kJ/g , what is the molar heat of combustion of citric acid?

First you need to calculate the heat capacity of the bomb calorimeter. Given that the temperature of the bomb calorimeter increases by $3.62\text{ }^\circ\text{C}$, the heat capacity of the calorimeter can be determined from the heat of combustion of benzoic acid.

$$\Delta H_{\text{combustion}} = -26.38\text{ kJ/g}$$

$$q = (26.38\text{ kJ/g})(0.235\text{ g}) = -6.20\text{ kJ}$$

This is the amount of energy released when the benzoic acid was combusted. To find the heat capacity of the calorimeter:

$$C = q / \Delta T$$
$$C = (6.20 \text{ kJ}) / (3.62 \text{ }^\circ\text{C})$$
$$C = 1.71 \text{ kJ/}^\circ\text{C}$$

The heat evolved when 0.305 g of citric acid is combusted in the bomb calorimeter can be determined from the heat change and the heat capacity:

$$q = C \times \Delta T$$
$$q = (1.71 \text{ kJ/}^\circ\text{C})(1.83 \text{ }^\circ\text{C})$$
$$q = 3.13 \text{ kJ}$$

The molar mass of citric acid is 192.14 g/mol. The sample, 0.305 g, is equivalent to 1.59×10^{-3} mol.

$$\Delta H_{\text{combustion}} = q/\text{moles}$$
$$\Delta H_{\text{combustion}} = -3.13 \text{ kJ} / 1.59 \times 10^{-3} \text{ mol}$$
$$\Delta H_{\text{combustion}} = -1970 \text{ kJ/mol}$$