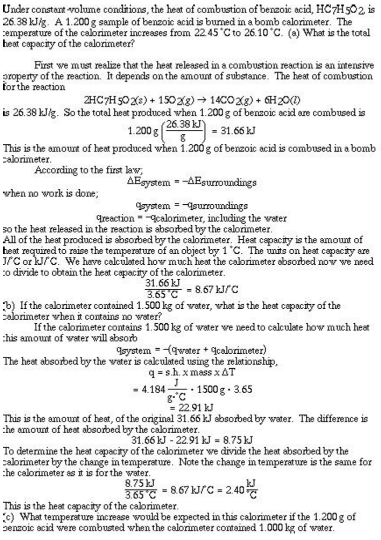

Under constant-volume conditions, the heat of combustion of benzoic acid, $HC_7H_5O_2$, is 26.38 kJ/g. A 1.200 g sample of benzoic acid is burned in a bomb calorimeter. The temperature of the calorimeter increases from 22.45 °C to 26.10 °C. (a) What is the total heat capacity of the calorimeter?

First we must realize that the heat released in a combustion reaction is an intensive property of the reaction. It depends on the amount of substance. The heat of combustion for the reaction

$$2HC_7H_5O_2(s) + 15O_2(g) \rightarrow 14CO_2(g) + 6H_2O(l)$$

is 26.38 kJ/g. So the total heat produced when 1.200 g of benzoic acid are combused is

$$1.200\,g\left(\frac{26.38\,kJ}{g}\right) = 31.66\,kJ$$

This is the amount of heat produced when 1.200 g of benzoic acid is combused in a bomb calorimeter.

According to the first law;

$$\Delta E_{system} = -\Delta E_{surroundings}$$

when no work is done;

$$q_{system} = -q_{surroundings}$$

$$q_{reaction} = -q_{calorimeter}\text{, including the water}$$

so the heat released in the reaction is absorbed by the calorimeter.

All of the heat produced is absorbed by the calorimeter. Heat capacity is the amount of heat required to raise the temperature of an object by 1 °C. The units on heat capacity are J/°C or kJ/°C. We have calculated how much heat the calorimeter absorbed now we need to divide to obtain the heat capacity of the calorimeter.

$$\frac{31.66\,kJ}{3.65\,^\circ C} = 8.67\,kJ/^\circ C$$

(b) If the calorimeter contained 1.500 kg of water, what is the heat capacity of the calorimeter when it contains no water?

If the calorimeter contains 1.500 kg of water we need to calculate how much heat this amount of water will absorb

$$q_{system} = -(q_{water} + q_{calorimeter})$$

The heat absorbed by the water is calculated using the relationship,

$$q = s.h. \times mass \times \Delta T$$

$$= 4.184\,\frac{J}{g\cdot{}^\circ C}\cdot 1500\,g\cdot 3.65$$

$$= 22.91\,kJ$$

This is the amount of heat, of the original 31.66 kJ absorbed by water. The difference is the amount of heat absorbed by the calorimeter.

$$31.66\,kJ - 22.91\,kJ = 8.75\,kJ$$

To determine the heat capacity of the calorimeter we divide the heat absorbed by the calorimeter by the change in temperature. Note the change in temperature is the same for the calorimeter as it is for the water.

$$\frac{8.75\,kJ}{3.65\,^\circ C} = 8.67\,kJ/^\circ C = 2.40\,\frac{kJ}{^\circ C}$$

This is the heat capacity of the calorimeter.

(c) What temperature increase would be expected in this calorimeter if the 1.200 g of benzoic acid were combusted when the calorimeter contained 1.000 kg of water.