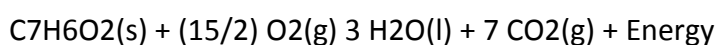


A bomb calorimeter, or a constant volume calorimeter, is a device often used to determine the heat of combustion of fuels and the energy content of foods.

In an experiment, a 0.6738 g sample of benzoic acid ( $C_7H_6O_2$ ) is burned completely in a bomb calorimeter. The calorimeter is surrounded by  $1.190 \times 10^3$  g of water. During the combustion the temperature increases from 25.91 to 28.80 °C. The heat capacity of water is  $4.184 \text{ J g}^{-1}\text{°C}^{-1}$ .

The heat capacity of the calorimeter was determined in a previous experiment to be 961.3 J/°C.

Assuming that no energy is lost to the surroundings, calculate the molar heat of combustion of benzoic acid based on these data.



### Solution

We have a reaction of combustion, where heat is released. This heat is absorbed by water in calorimeter and calorimeter itself.

1. Find heat absorbed by water:

$$Q_{\text{water}} = cm\Delta T;$$

$$c = 4.184 \text{ J g}^{-1}\text{°C}^{-1};$$

$$m(H_2O) = 1.190 \cdot 10^3 \text{ g} = 1190 \text{ g};$$

$$\Delta T = T_2 - T_1 = 28.80 - 25.91 = 2.89 \text{ (°C)};$$

$$Q_{\text{water}} = 4.184 \cdot 1190 \cdot 2.89 = 14389.19 \text{ J.}$$

2. Find heat absorbed by calorimeter:

$$Q_{\text{cal}} = C_{\text{cal}} \cdot \Delta T;$$

$$C_{\text{cal}} = 961.3 \text{ J/°C};$$

$$\Delta T = T_2 - T_1 = 28.80 - 25.91 = 2.89 \text{ (°C)};$$

$$Q_{\text{cal}} = 961.3 \cdot 2.89 = 2778.16 \text{ J.}$$

3. Find total heat absorbed by water and calorimeter:

$$Q_{\text{surrounding}} = Q_{\text{water}} + Q_{\text{cal}};$$

$$Q_{\text{surrounding}} = 14389.19 + 2778.16 = 17167.35 \text{ (J)}$$

4. Heat of combustion is the same in magnitude but opposite in sign( heat of combustion is the internal energy that is decreased while the external energy is increased ).

$$Q_{\text{reaction}} = -Q_{\text{surrounding}} = -17167.35 \text{ J.}$$

5. Find molar heat of combustion:

$$\text{Chemical amount of benzoic acid } n(C_7H_6O_2) = m/M;$$

$$M(C_7H_6O_2) = 12.01 \cdot 7 + 1.01 \cdot 6 + 16.00 \cdot 2 = 122.13 \text{ (g/mol)};$$

$$n(C_7H_6O_2) = 0.6738 / 122.13 = 0.00552 \text{ (mol)}.$$

When 0.00552 mol of benzoic acid is burned -- heat of combustion is -17167.35 J,

When 1 mole of benzoic acid is burned – heat of combustion is x J.

$$0.00552/1 = -17167.35/x;$$

$$x = -3110027.17;$$

$$\Delta H_{\text{comb}} = -3110027.17 \text{ J/mol} = -3110 \text{ kJ/mol}$$

**Answer:** -3110kJ/mol