Answer on the question #63402, Chemistry / General Chemistry

Question:

When 5.38 g of palmitic acid (C16H32O2) burns completely in excess O2 gas at constant pressure and 298 K, it releases -209 kJ of energy.

Write the balanced chemical equation for this reaction. Ignore aggregation states in your answer.
(a) What is the molar energy of combustion (in kJ/mol) of palmitic acid? kJ/mol
(b) How much energy (in kJ) is released per mole of O2 consumed? kJ

Solution:
The balanced equation is:

$$C_{16}H_{32}O_2 + 23O_2 \rightarrow 16CO_2 + 16H_2O.$$

Molar energy of combustion is the energy released within the reaction per mole of palmitic acid:

$$\Delta H_c = \frac{Q}{n(C_{16}H_{32}O_2)} = \frac{-209(kJ)}{n(C_{16}H_{32}O_2)}.$$

Let's find the number of the moles of palmitic acid. For this we divide its mass by molar mass.

$$n(C_{16}H_{32}O_2) = \frac{m(C_{16}H_{32}O_2)}{M(C_{16}H_{32}O_2)} = \frac{5.38(g)}{256.4241\ (g\ mol^{-1})} = 0.0210\ mol$$

$$\Delta H_c = \frac{-209(kJ)}{n(C_{16}H_{32}O_2)} = \frac{-209(kJ)}{0.0210\ (mol)} = -9961.5\ kJ\ mol^{-1}$$

This is the energy of released per the mole of palmitic acid. As we saw from the reaction equation, the number of the moles of palmitic acid and oxygen are related:

$$n(C_{16}H_{32}O_2) = n(O_2)/23$$

Then, the energy per mole of consumed oxygen is the enthalpy of combustion, divided by 23:

$$\Delta H_c = \frac{Q}{n(C_{16}H_{32}O_2)} = \frac{23Q}{n(O_2)}$$

$$\frac{Q}{n(O_2)} = \frac{\Delta H_c}{23} = \frac{-9961.5\ kJ\ mol^{-1}}{23} \cdot 1\ mol = -433.1kJ$$

Answer: (a) $-9961.5\ kJ\ mol^{-1}$ (b) $-433.1kJ$