Answer on Question #63278 - Chemistry - General Chemistry

Question: The automobile fuel called E85 consists of 85% ethanol and 15% gasoline. E85 can be used in so-called flex-fuel vehicles (FFVs), which can use gasoline, ethanol, or a mix as fuels. Assume that gasoline consists of a mixture of octanes (different isomers of \( \text{C}_8\text{H}_{18} \)), that the average heat of combustion of \( \text{C}_8\text{H}_{18}(l) \) is 5400 \( \text{kJ/mol} \), and that gasoline has an average density of 0.70 \( \text{g/mL} \). The density of ethanol is 0.79 \( \text{g/mL} \).

1) By using the information given, calculate the energy produced by combustion of 3.5 L of gasoline.

2) By using the information given as well as data in Appendix C, calculate the energy produced by combustion of 3.5 L of ethanol. Consider that water is in the gaseous state.

Solution

1) Calculation of the energy produced by combustion of 3.5 L of gasoline

1.1) Calculate the mass of gasoline:

\[ m(\text{C}_8\text{H}_{18}) = V(\text{C}_8\text{H}_{18}) \times \rho(\text{C}_8\text{H}_{18}) = 3500 \times 0.7 = 2450 \text{ g} \]

1.2) Calculate the amount of substance of gasoline:

\[ n(\text{C}_8\text{H}_{18}) = \frac{m(\text{C}_8\text{H}_{18})}{M(\text{C}_8\text{H}_{18})} = \frac{2450}{114} = 21.4912 \text{ mol} \]

1.3) Calculate the energy produced by combustion of this amount of gasoline:

\[ E = n(\text{C}_8\text{H}_{18}) \times Q_M(\text{C}_8\text{H}_{18}) = 21.4912 \times 5400 = 116052.48 \text{ kJ} \]

2) Calculation of the energy produced by combustion of 3.5 L of ethanol

To calculate the enthalpy and thereof energy of combustion for ethanol, we need to take the standard enthalpies of formation for the compounds involved into the reaction:

\[ \Delta H_f^0(\text{C}_2\text{H}_5\text{OH}(l)) = -277.38 \frac{\text{kJ}}{\text{mol}} \]

\[ \Delta H_f^0(\text{H}_2\text{O}(g)) = -241.83 \frac{\text{kJ}}{\text{mol}} \]

\[ \Delta H_f^0(\text{CO}_2(g)) = -277.38 \frac{\text{kJ}}{\text{mol}} \]

For oxygen gas, the standard enthalpy of formation is equal to 0 as for an element in its standard state.

2.1) Write the equation of combustion for ethanol and calculate the enthalpy of combustion:

\[ \text{C}_2\text{H}_5\text{OH}(l) + 3\text{O}_2(g) = 2\text{CO}_2(g) + 3\text{H}_2\text{O}(g) \]

\[ \Delta H_f^0(\text{C}_2\text{H}_5\text{OH}(l)) = 3 \times (-241.83) + 2 \times (-393.52) - (-277.38) = -1235.15 \frac{\text{kJ}}{\text{mol}} \]

So, the molar heat of combustion for ethanol is 1235.15 \( \text{kJ/mol} \).

2.2) Calculate the mass of ethanol:

\[ m(\text{C}_2\text{H}_5\text{OH}) = V(\text{C}_2\text{H}_5\text{OH}) \times \rho(\text{C}_2\text{H}_5\text{OH}) = 3500 \times 0.79 = 2765 \text{ g} \]

2.3) Calculate the amount of substance of ethanol:

\[ n(\text{C}_2\text{H}_5\text{OH}) = \frac{m(\text{C}_2\text{H}_5\text{OH})}{M(\text{C}_2\text{H}_5\text{OH})} = \frac{2765}{46} = 60.1087 \text{ mol} \]

2.4) Calculate the energy produced by combustion of this amount of ethanol:

\[ E = n(\text{C}_2\text{H}_5\text{OH}) \times Q_M(\text{C}_2\text{H}_5\text{OH}) = 60.1087 \times 1235.15 = 74243.26 \text{ kJ} \]

Answer: the energy produced by combustion of 3.5 L of gasoline is 116052.48 \( \text{kJ} \), the energy produced by combustion of 3.5 L of ethanol is 74243.26 \( \text{kJ} \).