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 C_8H_{18}), that the average heat of combustion of C_8H_{18}(l) is 5400 kJ/mol, and that gasoline has an average density of 0.70 g/mL. The density of ethanol is 0.79 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: $m(C_8H_{18}) = V(C_8H_{18}) * \rho(C_8H_{18}) = 3500 * 0.7 = 2450g$

1.2) Calculate the amount of substance of gasoline: $\nu(C_8H_{18}) = \frac{m(C_8H_{18})}{M(C_8H_{18})} = \frac{2450}{114} = 21.4912\ mol$

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

$$\mathrm{E} = \nu(C_8H_{18}) * Q_M(C_8H_{18}) = 21.4912 * 5400 = 116052.48\ kJ$$

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:

$$\Delta H_f^0\left(C_2H_5OH(l)\right) = -277.38\frac{kJ}{mol},$$
$$\Delta H_f^0\left(H_2O(g)\right) = -241.83\frac{kJ}{mol},$$
$$\Delta H_f^0(CO_2(g)) = -277.38\frac{kJ}{mol}.$$

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:

$$C_2H_5OH(l) + 3O_2(g) = 2CO_2(g) + 3H_2O(g)$$

$$\Delta H_c^0\left(C_2H_5OH(l)\right) = 3 * (-241.83) + 2 * (-393.52) - (-277.38) = -1235.15\frac{kJ}{mol}$$

So, the molar heat of combustion for ethanol is 1235.15 kJ/mol.

2.2) Calculate the mass of ethanol:

$$m(C_2H_5OH) = V(C_2H_5OH) * \rho(C_2H_5OH) = 3500 * 0.79 = 2765g$$

2.3) Calculate the amount of substance of ethanol:

$$\nu(C_2H_5OH) = \frac{m(C_2H_5OH)}{M(C_2H_5OH)} = \frac{2765}{46} = 60.1087\ mol$$

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

$$\mathrm{E} = \nu(C_2H_5OH) * Q_M(C_2H_5OH) = 60.1087 * 1235.15 = 74243.26\ kJ$$

Answer: the energy produced by combustion of 3.5 L of gasoline is $116052.48\ kJ$, the energy produced by combustion of 3.5 L of ethanol is $74243.26\ kJ$.