JQ.2.8

September 8, 2014

(2.8) Compute the enthalpy of formation of propane at 25^oC from its chemical reaction with oxygen and its ideal heat of combustion given in Table 2.3.

As described in section 2.5 of the textbook, the enthalpy of formation can be considered to be the energy released when a molecule is formed from its component elements. For stable molecules at the reference state (T=25^oC and P=1 atm) the enthalpy of formation is zero. Table 2.2 lists the enthalpies of formation for various moelecules.

Step 1: Balance the chemical reaction using elemental balances:

$$C_3H_8 + aO_2 \rightarrow bCO_2 + dH_2O$$

Find the stoichiometric coefficients a, b,& d.

Step 2: Use equation 2.25 to express the heat of combustion in terms of the heats of formation

$$\Delta\tilde{h}_c = \left(\sum_i \nu_i \Delta\tilde{h}^o_{f,i}\right)_{React} - \left(\sum_j \nu_j \Delta\tilde{h}^o_{f,j}\right)_{Prod}$$

Make sure to check you units since Table 2.3 gives heat of combustion in kJ/g while Table 2.2 gives heat of formation in kJ/mole. Also, note that two values of $\Delta\tilde{h}^o_{f,i}$ are given for water. One value is for liquid water and the other is for water vapor. The difference between the two values is the latent heat of vaporization of water. If the products are at high temperature, we expect the water to be in vapor form. On the other hand, if the products have been cooled to standard conditions, the water will exist as liquid. There will be more energy given up when the water is condensed to liquid and so the heat of combustion using the liquid value is sometimes called the gross (or higher) heat of combustion, while the heat of combustion with water vapor is called the net (or lower) heat of combustion.

The heat of combustion data in Table 2.3 are the net (or lower) heat of combustion. So, you should use the vapor value for the water enthalpy of formation.

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In [39]: nC3H8=1.; nCO2=3.; nH2O=4.; Dhc_lower=46.; hfCO2=-393.5; hfH2O_lower=-241.8; MC3H8=44.; hfH2O_l

In [40]: Dhcmol_lower=Dhc_lower*MC3H8

In [41]: Dhcmol_lower

Out[41]: 2024.0

In [42]: hfC3H8_lower=Dhcmol_lower+nCO2*hfCO2+nH2O*hfH2O_lower

In [43]: hfC3H8_lower

Out[43]: -123.70000000000005

In [44]: Dhcmol_higher=2220.;

In [45]: hfC3H8_higher=Dhcmol_higher+nCO2*hfCO2+nH2O*hfH2O_higher

In [46]: hfC3H8_higher

Out[46]: -104.09999999999991

In [46]:
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