

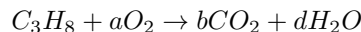
## JQ.2.8

September 8, 2014

(2.8) Compute the enthalpy of formation of propane at  $25^\circ\text{C}$  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 ( $T=25^\circ\text{C}$  and  $P=1$  atm) the enthalpy of formation is zero. Table 2.2 lists the enthalpies of formation for various molecules.

Step 1: Balance the chemical reaction using elemental balances:



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

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

Make sure to check your 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  $\Delta \tilde{h}_{f,i}^o$  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_upper=99.8
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In [40]: Dhcmol_lower=Dhc_lower*MC3H8
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In [41]: Dhcmol_lower
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Out[41]: 2024.0
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In [42]: hfC3H8_lower=Dhcmol_lower+nCO2*hfCO2+nH2O*hfH2O_lower
```

```
In [43]: hfC3H8_lower
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```
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]: -104.09999999999999
```

```
In [46]:
```