Internal Energy

1. What is internal energy?

   It is the energy on the molecular level. If you were to look at a cup of coffee sitting on a table - the internal energy is related to the unseen energy of the all the molecules in the coffee moving rapidly throughout the container (kinetic) and the energy stored in the bonds within and between molecules (potential energy).

2. What equation relates internal energy, E, to heat and work?

$$\Delta E = q + w$$

3. When utilizing the above equation, 2 things must be kept in mind.

   a. The numerical values of q and w

   b. The signs of q and w. The signs are based on whether the system loses or gains heat/work energy.

4. One mol of $H_2O_{(g)}$ @ 1.00 atm and 100. °C has a volume of 30.6L. When one mol of $H_2O_{(g)}$ is condensed to one mol $H_2O_{(l)}$ @ 1.00 atm and 100.°C, 40.66kJ of heat is released. Calculate ΔE for the condensation of 1.00 mol H_2O @ 1.00atm and 100.°C.

   We will start this problem by first looking at the information given. The question indicates that there are 40.66 kJ of heat <u>released</u> by this reaction. Heat is represented by q and released translates into a negative sign.

$$q = -\ 40.66\ kJ$$

We are also told that there is an expansion of $H_2O_{(l)}$ to $H_2O_{(g)}$; this means that PV work took place. So we will be looking at the formula,

$$w = -P\Delta V = -P\,(V_F - V_i)$$

If we look at the information provided in the question there is no indication as to the final volume of the H_2O sample. Ultimately, because the sample was initially a gas, the volume of the liquid is comparatively insignificant – it is too small, comparatively, to matter. So we can ignore it.

That means that when we plug in to solve for work we get…

$$w = -P\Delta V = -P\,(V_F - V_i) = -(1.00\ atm)(\ -30.6\ L) = 30.6\ Latm$$

When we are doing these calculations it is very important to keep units in mind. For energy, we will typically use joules or kilojoules when reporting our answer. That means you must be very conscientious about converting work units over from L atm to kJ. This conversion factor is -

$$1\ L\ atm = 0.101325\ kJ$$

Performing the conversion for the work we calculated -

$$30.58\ L\ atm \quad \frac{0.101325\ kJ}{1\ L\ atm} = 3.10\ kJ$$

Now that we have a handle on the information provided in the question we can look at what we are supposed to solve for, ΔE. Based on the variables provided we will use the formula:

$$\Delta E = q + w$$

Plugging in we solve and get…

$$\Delta E = -40.66\ kJ + 3.10\ kJ = \boxed{-37.6\ kJ}$$