Chemistry 2720 Fall 2001 Assignment 2

Due: Tuesday, Sept. 18, 9:25 a.m.

1. Define temperature and heat. Explain briefly the relationship between these two concepts. [6 marks]

2. 18 mol of nitrogen are held at a pressure of 1.08 atm and a temperature of 20°C. The external pressure is changed very suddenly to 0.35 atm and is held constant during the expansion. The gas is in good thermal contact with its surroundings, whose temperature is a constant 20°C so that by the end of the expansion, the temperature of the gas has returned to equilibrium with the surroundings.

   (a) Treat nitrogen as an ideal gas and calculate the work done during the expansion. Explain the meaning of the sign of the work. [10 marks]

   (b) Suppose that the work done on or by the gas results from the raising or lowering of a 2.3 kg mass. The work done when a mass is raised is $w = mgh$ where h is the height to which the mass is raised (negative if lowered). How far does the mass have to move, and in what direction? [5 marks]

   Note: I would suggest that you think about the signs rather than simply taking a purely algebraic approach in this problem.

3. Solids and liquids are often said to be incompressible, which means that changing the pressure does not change their volumes. Because of this, we tend to ignore the effect of pressure on solids and liquids when solving thermodynamic problems. However, this is not exactly true. For copper for instance, the relationship between pressure and molar volume at constant temperature is

   $$P = \frac{1}{\kappa_T} \ln\left(\frac{\bar{V}^\circ}{\bar{V}}\right) + P^\circ$$

   where κ_T, $\bar{V}^\circ$ and P° are constants with the values

   $$\begin{aligned} \kappa_T &= 7.25 \times 10^{-12}\,\text{Pa}^{-1}, \\ \bar{V}^\circ &= 7.093 \times 10^{-6}\,\text{m}^3/\text{mol}, \\ P^\circ &= 101\,325\,\text{Pa}. \end{aligned}$$

   Calculate the work done per mole when copper is compressed reversibly and isothermally from an initial pressure of 1 atm to a final pressure of 1000 atm. This is roughly equivalent to the pressure change which a piece of copper would experience if it was dropped from the ocean's surface to the bottom of the Marianas trench, the deepest ocean trench on Earth. Based on your calculation, do you think that ignoring pressure-volume terms (such as the work) is justifiable for solids? [10 marks]

   Useful fact: $\int \ln(a/V)\,dV = V \ln(a/V) + V$