1. **Vapor pressure equation** (David) Consider a phase transformation between either solid or liquid and gas. Assume that the volume of the gas is way bigger than that of the liquid or solid, such that $\Delta V \approx V_g$. Furthermore, assume that the ideal gas law applies to the gas phase. **Note:** this problem is solved in the textbook, in the section on the Clausius-Clapeyron equation.

   a) Solve for $\frac{dp}{dT}$ in terms of the pressure of the vapor and the latent heat $L$ and the temperature.
   
   b) Assume further that the latent heat is roughly independent of temperature. Integrate to find the vapor pressure itself as a function of temperature (and of course, the latent heat).

   Note that this is a rather coarse approximation, since the latent heat of water varies by about 10% between 0°C and 100°C. Still, you will see a pretty cool result, that is roughly accurate (and good enough for the problems below).

2. **Entropy, energy, and enthalpy of van der Waals gas** (K&K 9.1) In this entire problem, keep results to first order in the van der Waals correction terms $a$ and $b$.

   a) Show that the entropy of the van der Waals gas is

   $$ S = Nk \left\{ \ln \left( \frac{n_0(V - N b)}{N} \right) + \frac{5}{2} \right\} \tag{1} $$

   b) Show that the energy is

   $$ U = \frac{3}{2} NkT - \frac{N^2 a}{V} \tag{2} $$

   c) Show that the enthalpy $H \equiv U + pV$ is

   $$ H(T, V) = \frac{5}{2} NkT + \frac{N^2 b kT}{V} - 2 \frac{N^2 a}{V} \tag{3} $$

   $$ H(T, p) = \frac{5}{2} NkT + Nbp - \frac{2 Nap}{kT} \tag{4} $$

3. **Calculation of $\frac{dT}{dp}$ for water** (K&K 9.2) Calculate based on the Clausius-Clapeyron equation the value of $\frac{dT}{dp}$ near $p = 1$ atm for the liquid-vapor equilibrium of water. The heat of vaporization at 100°C is 2260 J g$^{-1}$. Express the result in kelvin/atm.

4. **Heat of vaporization of ice** (Modified K&K 9.3) The pressure of water vapor over ice is 518 Pa at −2°C. The vapor pressure of water at its triple point is 611 Pa, at 0.01°C (see Wikipedia water data page). Estimate in J mol$^{-1}$ the heat of vaporization of ice just under freezing. How does this compare with the heat of vaporization of water?
Figure 1: Effects of High Altitude by Randall Munroe, at xkcd.