HW4, PHYS 3113

P1 (3.37) Consider a monatomic ideal gas that lives at a height z above sea level, so each molecule has potential energy mgz in addition to its kinetic energy.

(a) Using the formula

$$\mu = -T\left(\frac{\partial S}{\partial N}\right)_{U,V},$$

show that the chemical potential is the same as if the gas were at sea level, plus an additional term mgz:

$$\mu(z) = \mu(0) + mgz$$

(b) Suppose you have two chunks of helium gas, one at sea level and one at height z, each having the same temperature and volume. Assuming that thery are in diffusive equilibrium, show that the number of molecules in the higher chunk is

$$N(z) = N(0)\exp\left(\frac{-mgz}{kT}\right).$$

P2 Starting from the Sackur-Tetrode equation, and using the formula

$$P = T\left(\frac{\partial S}{\partial V}\right)_{U,N},$$

derive the equation of state for the ideal gas $PV = NkT$.

P3 Derive $C_P - C_V$ for a Van der Waals gas

$$P = \frac{nRT}{V - nb} - a\frac{n^2}{V^2}$$

using the formula

$$C_P - C_V = T\left(\frac{\partial V}{\partial T}\right)_P\left(\frac{\partial P}{\partial T}\right)_V.$$