EG240
Homework #5
Spring 2001 (due 2/7)

1. From thermal expansion experiments, it is determined that in zinc metal, there exists 1.0 vacancy for every 10^6 lattice sites at 450 °C, and 2.2 vacancies for every 10^6 lattice sites at 475 °C.

   Using the equation: $\left(\frac{N_v}{N}\right) = A_o \exp\left(\frac{-Q_v}{kT}\right)$

   a) What is the activation energy for vacancy formation in zinc (in J)? [Once again, your book assumes a little too much with some units in the front cover of your book. Note there that Boltzmann's constant shows units of J/atom·K. That would actually be okay in this case, because we are talking about atoms, but it is more correct to not specify "atom" in the denominator so we could apply it to other things, like electrons. Technically, k should have units of J/K, period! (or other units of energy/absolute temperature)]

   b) How many vacancies are there per 10^6 sites at 500 °C?

2. The electrical properties of semiconductive silicon can be altered by the precise incorporation of impurities. Intentional addition of impurities for this purpose is called "doping".

   An exposed, initially pure silicon surface is p-doped with gallium (Ga), by exposure to gallium in the vapor phase at 1100 °C. The vapor creates a dissolved gallium concentration at the silicon surface of 0.00100 (mole fraction gallium).

   a) A target doping level is required, such that the concentration of dissolved gallium 1.0 µm below the silicon surface becomes 0.00035 (mole fraction gallium). How long will the doping process take if it is conducted at 1100 °C (D for gallium into silicon at 1100 °C is 7.0×10^{-17} m^2/s)?

   b) At the time specified above, what is the gallium concentration (mole fraction gallium) at depths of 0.25, 0.5, and 0.75 µm ?

   c) At the time specified in part (a) for the 1100 °C process, what is the gallium weight fraction at the 1.0 µm depth?

   d) The activation energy for the diffusion of gallium into silicon is 330,000 J/mol. At what temperature would the diffusion coefficient be increased to a value of 5.0×10^{-16} m^2/s?