1. Consider a gas mixture of carbon dioxide and nitrogen at 298 K and 5 bar.

   (a) How would you model this mixture in terms of its enthalpy and entropy? Be sure to specify your reference states when describing your model.

   (b) Estimate the minimum work required to separate 100 moles of a 40 mole% nitrogen mixture into pure carbon dioxide and nitrogen.

   (c) Would your model need to change if the pressure were increased to 200 bar? If so, how? You are not required to perform detailed calculations, but be sure to give the your approach to solving the problem. Include any parameters that you would need to look up or estimate in order to solve the problem.

2. Given a 3D lattice model, 10x10x10, which is connected to a bath at 298 K and in which there are 100 non-interacting gas particles having no internal structure, each of which are located only at the lattice points, calculate $\underline{U}$, $\underline{S}$, $\underline{G}$, and $\underline{C_v}$.

3. For the same lattice in number 2., but now with only 2 non-interacting particles, each of which can exist in only two states, such that $E_1 = 3$ kcal/mol and $E_2 = 5$ kcal/mol, calculate $\underline{U}$, $\underline{S}$, $\underline{G}$, and $\underline{C_v}$. (Note that this is a simple model of a two-state equilibrium, such as a protein which can exist in either a folded or unfolded state, in solution.)

4. For 0.5 mol of O_2 at 0.1 atm., and 1000 K, compute $\underline{U}$, $\underline{S}$, $\underline{G}$, and $\underline{C_v}$. You may treat O_2 as an ideal gas at these T and P conditions. Note that both O_2 and the O atom have a net spin of 1 in their ground states. Also the first excited electronic state of O_2 occurs at a thermal energy of 11,300 K and has a net spin of 1/2. The bond dissociation energy of O_2 , D_o, is 117.1 kcal/mol and the thermal vibrational and rotational energies are 2230 K and 2.07 K respectively.