Name:_____

Biology 3550
Physical Principles in Biology
Fall Semester 2016

Quiz 3
4 November 2016

Please write your name on each page.
Be sure to show your work and include correct units in all of your answers!
25 points total.

Some possibly useful constants:
The Boltzmann constant: $1.3806\times10^{-23}\,\mathrm{J}\cdot\mathrm{K}^{-1}$
The gas constant: $8.314\,\mathrm{J}\cdot\mathrm{mol}^{-1}\mathrm{K}^{-1} = 0.08206\,\mathrm{L}\cdot\mathrm{atm}\cdot\mathrm{K}^{-1}\mathrm{mol}^{-1}$
Avogadro's number: 6.02×10^{23}

1. One of the problems in the recent set addresses the question of how plants that have evolved on earth might fare in the atmosphere of Mars. Suppose that you have decided to do some direct experiments and, therefore, need some artificial Martian "air". Although the Martian atmosphere contains other gasses, it is 96% CO_2, and you have decided that pure CO_2 will be an adequate substitute. From your calculations in the problem set you know (or should know) that the concentration of CO_2 in the Martian atmosphere (at the planet's surface) is about $250\,\mu$M and has a temperature of about 275 K, as compared to $23\,\mu$M at the Earth's surface. Your starting material is some pure CO_2 gas at the concentration found in the Earth's atmosphere (at 275 K), and you need to compress it to match the concentration in the Martian atmosphere. Your knowledge of thermodynamics should enable you to calculate the amount of work this will require!

   (a) (4 pts) Your experiments will require a total of 100 L of substitute Martian atmosphere, at a temperature of 275 K. Calculate the number of moles of CO_2 this will require and the number of liters of your starting CO_2 (also at 275 K) that you will need.

(b) (4 pts) Calculate the pressure of the gas (in atmospheres) at the beginning and end of compressing it, assuming that the temperature is 275 K at the beginning and end.

(c) (4 pts) Calculate the entropy change of the gas for compressing it to the final volume of 100 L, assuming that the starting and final temperatures are the same.

2. Now, consider the amount of work required to compress the gas.

(a) (4 pts) Assuming that heat can flow freely from the gas to its surroundings, calculate the minimum amount of work that will be required to compress the CO_2 at a constant temperature of 275 K.

(b) (4 pts) Briefly describe the process that you will need to use in order to minimize the work required to compress the gas. Explain why an alternative process would require more work.

3. (5 pts) After thinking about this, you have concluded that the process required for the minimum amount of work is impractical, and you have decided that it would be reasonable to expend an extra 5 J of work to compress the gas. As for the ideal process, assume that the temperature at the beginning and end of compression is 275 K. Briefly indicate how the parameters listed below would be affected by using more than the minimum amount of work that you calculated earlier. You should not have to do any calculations, but you should indicate the whether the value of the parameter would be positive, negative or zero, and whether it would be greater (more positive) or less than for the ideal process.

(a) ΔE

(b) w

(c) q

(d) ΔS_{sys}

(e) ΔS_{surr}