Department of Earth & Climate Sciences Name_____
San Francisco State University

ERTH 260: Laboratory Exercise 4 Key
Understanding the Concept of the Gas Law
100 points
(Due Friday 23 February)

The "simplified" or conceptual (explained in class) Ideal Gas Law (Equation of State) is:

$$p = \rho RT$$

or (1a,b)

$$p\alpha = RT$$

where p is pressure, ρ is density, R is a constant called the "gas constant", T is temperature and α is specific volume. In 1(b) the specific volume is the volume a unit amount of gas, in this case 1 kilogram, occupies. You can just think of this as "volume". In reality, specific volume and density are inversely related.

$$\alpha = \frac{1}{\rho} \qquad (2)$$

As you can reason out, in the MKS system, the units of specific volume are $m^3\ kg^{-1}$ and of density, $kg\ m^{-3}$. **Answer in complete sentences and on separate sheets.**

1. Examine equation 1(a). In a situation in which temperature remains constant, are pressure and density directly or inversely related? Explain? (Answer in complete sentences) (20 points)

   In a situation in which temperature remains constant, pressure is directly related to density. Since R and T are constant, to keep the equality, as density goes up, pressure must go up.

2. Examine equation 1(b). In situation in which volume remains constant, are pressure and temperature directly or inversely related? Explain. (20points)

   In a situation in which volume (density) remains constant, pressure and temperature are directly related. Since R and V (or rho) are constant, as temperature goes up, pressure must go up.

3. Consider a situation in which there are two air parcels side by side (Parcel A and Parcel B) at the 500 mb level. Say Parcel A has a temperature of -10°C

and Parcel B has a temperature of 0°C. According to equation 1(a) which air parcel is less dense. (20 points)

In a situation in which two air parcels, A and B, are side by side at the 500 mb level, since each air parcel is at the same pressure, temperature and density are inversely related. Hence, for this case at the 500 mb level, Parcel B, the warmer air parcel, is less dense than Parcel A.

4. Examine the weather map, given as Figure 1, below:

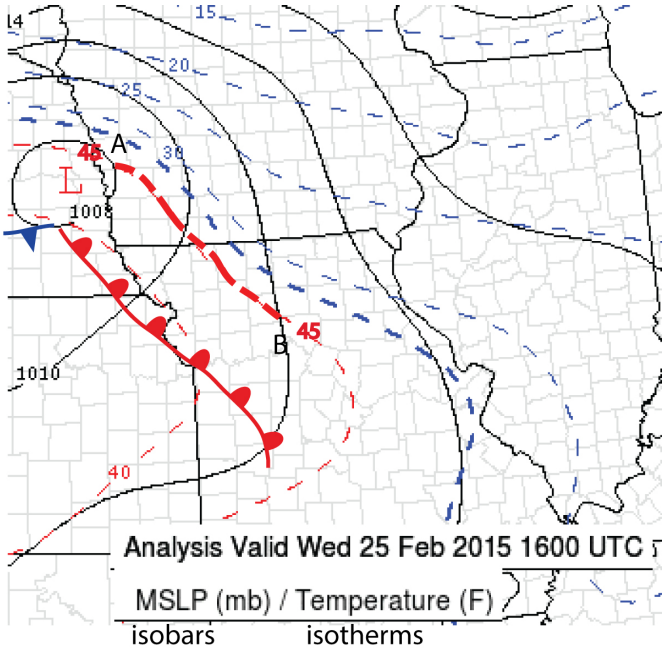

Figure 1: Sea level pressure (isobars, 2 mb intervals) and temperature (isotherms, 5F intervals), for 1600 UTC 25 February 2015

Notice the highlighted portion of the 45F isotherm, extending from point A where the pressure is 1008 mb to point B where the pressure is 1012 mb. You are going to be asked, below, to use the gas law to say something about the variation of density along the isotherm highlighted.

(a) Given the constraints of the problem, what is constant in Equation (1a) (give me the symbols and a short one sentence explanation); (20 pts)

The gas constant, R, and temperature, T, are constant. Temperature is constant because the gas law is evaluated, in this case, along an isotherm. Along an isotherm, by definition, temperature is constant.

(b) At which location, A or B is the density greater? Provide at least a COMPLETE one or two sentence explanation.(20 pts)

For this problem, the gas law reduces to an expression in which the temperature and gas contant are together a constant, k.

$$p = \rho k$$

Thus, pressure and density are directly proportional. If pressure and density are directly proportional, the density is greatest at point B, since at that point pressure is higher.