PHY 3513 – PROBLEM SET 1

1) Calculate the temperature at which the Fahrenheit and Kelvin numerical values are the same.

2) A state variable X is related to the temperature by one of the two relations given below. At the freezing point of water (0ºC), measurements yield the value $X=X_I$, and at the boiling point of water (100ºC) the value $X=X_S$. For each case, determine the constant values a and b in terms of the two X values X_I and X_S and then derive an expression for the temperature in terms of X, X_I, and X_S.

a) $X = aT+b$

b) $X = \exp[(T-b)/a]$

3) **Text, Problem 1.14**

4) A tank with volume $V=0.5\ m^3$ contains oxygen (O_2) at pressure $P=1.5 \times 10^6$ Pa and temperature T=20ºC. Assume that oxygen can be treated as an ideal gas.

a) Determine the number of moles of oxygen in the tank.

b) Determine the mass of the oxygen in the tank.

c) Calculate the pressure that results if the temperature is increased to T=500ºC without changing the volume of the tank.

d) If the temperature is kept fixed at T=20ºC, how many moles of oxygen would have to be removed from the tank to make the pressure decrease to 10% of its original value?

5) **Text Problem 1.16 –** in part (d), choose the temperature to be 20ºC at all four locations (might not be realistic for the top of Mt. Everest), and note that the molar mass of air is computed in problem 3.

6) **Text Problem 1.19 –** calculate the two rms velocities separately at T=20ºC and then show that the *ratio* of the velocities does not depend on the temperature.

7) **Text, Problem 1.31**

8) **Text, Problem 1.34**

9) 200 moles of a *monatomic* ideal gas have an initial pressure $P_A=2.0 \times 10^5$ Pa and occupy an initial volume $V_A=4.0\ m^3$. In step 1 of a thermodynamic cycle, the gas pressure is increased *isochorically* to double its initial value. In step 2 the gas is allowed to expand *isothermally* until the pressure has returned to its initial value, and in step 3, the gas is compressed *isobarically* until its volume has returned to its initial value. Note that at the end of the complete thermodynamic cycle, both the pressure and volume of the gas have returned to their initial values.

a) Make a PV diagram that shows all three steps of the complete thermodynamic cycle.

b) Calculate T_A, the initial temperature, T_B, the temperature at the end of the first step, and T_C, the temperature at the end of the second step.

c) Find V_C, the volume at the end of the second step.

d) Determine the work done on the gas during each step and the total work done over the whole cycle.

e) Find the heat transferred to the gas during each step and the total heat transfer over the whole cycle.

f) Using the results of parts d and e, show that the first law of thermodynamics is satisfied for this thermodynamic cycle.