PHYSICS 114 Contemporary Physics II – Homework 3

In all problems involving solutions to problems involving equations, leave your solution in "equation" form until the last step.

1. Easy expansion problem. A monotomic ideal gas is expanded slowly from an initial volume V_i to a final Volume V_f. During the expansion there is a transfer of heat which maintains the temperature of the gas at its initial value ($T_f = T_i$).

   (a) What is the initial and final pressure of the gas P_i, P_f

   (b) What is the pressure of the gas $P(V)$ as a function of volume, during the expansion?

   (c) What is the work done by the gas during the expansion (in terms of n, T_i, V_i, V_f)?

   (d) What is the heat added to the system?

   Some thoughts on work under different conditions. You can write the answers basically in terms of constants and terms I give you. Hint, you have all the formulas in the book. Think of the definition of work and the relationship between thermal energy Q and temperature under these conditions.

   Isochoric (constant volume (also known as isovolumetric)) changes.
   Suppose you changed your a monotomic ideal gas in a chamber from so that the pressure changed from P_1 to P_2 and the temperature changes from T_1 to T_2 *but the volume stays the same!.*

2. (a) What is the total amount of *work* that you have done on the system?

   (b) What is the total amount of energy Q you have added *to* the system?

3. We derived in class the ideal gas law

$$PV = NkT \tag{1}$$

   We can take into account, some of the deficiencies in the ideal gas law by using the following 'fixed' gas law:

$$(P + \frac{aN^2}{V^2})(V - Nb) = NkT \tag{2}$$

where b represents the volume of a gas molecule (that is the real volume is less by Nb if i have N particles) and a represents the fact that all molecules feel an attractive force (called the van der waals force) that goes as $1/r^6$ which is in terms of volumes scaling as $1/V^2$, hence the pressure is reduced by an amount proportional to $1/V^2$.

(a) Rewrite this expression so we have a function of P in terms of all the other terms.

(b) Write down an expression for how much work is done on a gas that is compressed isotermally from V_i to V_f. The answer you write down will simply be in integral form, that you do not have to solve. While such equations, are somewhat difficult to solve for analytically, you can actually solve this trivially using python using the techniques you learned earlier in recitation!

12.P.26 a only
12.P.28 (the don't get any ideas problem)
12.P.33