Homework #2

1. Research in surface science is carried out using ultra-high vacuum chambers that sustain pressures as low as 10^{-12} torr. How many molecules are there in a 1.00 cm^3 volume inside such an apparatus at 298K? What is the corresponding molar volume?

2. Use the following data for an unknown gas at 300 K to determine the molecular mass and the second virial coefficient, B_{2V}, for the gas.

P/bar	0.1000	0.5000	1.000	1.01325	2.000
$\rho/g{\cdot}L^{-1}$	0.1771	0.8909	1.796	1.820	3.652

3. Compare the pressures given by (a) the ideal gas equation, (b) the van der Waals equation, (c), the Redlich-Kwong equation, and (d) the Peng-Robinson equation for propane at 400 K and $\rho = 10.62\ mol{\cdot}dm^{-3}$. The experimental value is 400 bar. You can get the van der Waals and Redlich-Kwong parameters from McQuarrie and Simon. Use $\alpha = 9.6938\ L^2{\cdot}bar{\cdot}mol^{-2}$ and $\beta = 0.05632\ L{\cdot}mol^{-1}$ for the Peng-Robinson equation.

4. a) Use the following data for ethane and argon at $T_R = 1.64$ to illustrate the law of corresponding states by plotting i) Z against $\overline{V}_R$ and ii) Z against P_R.
   b) Using your two plots as examples, define the law of corresponding states.
   c) Give a physical description of any and all deviations (positive or negative) from the ideal for both of your plots.

Ethane (T = 500 K)		**Argon (T = 247 K)**	
P / bar	$\overline{V}$ ***/ L·mol^{-1}***	***P / bar***	$\overline{V}$ ***/ L·mol^{-1}***
20.00	2.028	20.00	0.9857
40.00	0.9907	40.00	0.4795
60.00	0.6461	60.00	0.3114
80.00	0.4750	80.00	0.2279
100.0	0.3734	100.0	0.1785
120.0	0.3068	120.0	0.1462
160.0	0.2265	160.0	0.1076
200.0	0.1819	200.0	0.08630
240.0	0.1548	240.0	0.07348
300.0	0.1303	300.0	0.06208
350.0	0.1175	350.0	0.05626
400.0	0.1085	400.0	0.05219
450.0	0.1019	450.0	0.04919
500.0	0.09676	500.0	0.04687
600.0	0.08937	600.0	0.04348
700.0	0.08421	700.0	0.04108

5. The isothermal compressibility κ is defined as

$$\kappa = -\frac{1}{\overline{V}}\left(\frac{\partial \overline{V}}{\partial P}\right)_T$$

Show that, for an ideal gas,

$$k = \frac{1}{P}$$

** The key to the problem is understanding partial differential notation. If you don't know how to do this problem, ask!! This type of problem will reoccur often in CHE371!**

6. In the Lennard-Jones notation, ε is the depth of the potential energy well describing intermolecular forces. This is a measure of how strongly molecules attract each other. Using the Lennard-Jones parameters given in Table 16.7 of McQuarrie and Simon, compare the strength of attraction *between* O_2 molecules to the strength of an O_2 covalent bond (i.e., the dissociation energy, D_0, of O_2). Report numerical comparisons in **kJ/mol** and describe the physical meaning of these numbers.