Chemistry 342
Fall 2001
First Hour Exam

1. (20 pts) Use the following information to calculate the enthalpy of formation of $SO_3(g)$.

$PbO(s) + S(s) + 3/2\ O_2(g) \rightarrow PbSO_4(s)$ $\quad \Delta H = -39.56$ kJ/mol

$PbO(s) + H_2SO_4 \bullet 5H_2O(liq) \rightarrow PbSO_4(s) + 6H_2O(liq)$ $\quad \Delta H = -5.57$ kJ/mol

$SO_3(g) + 6H_2O(liq) \rightarrow H_2SO_4 \bullet 5H_2O(liq)$ $\quad \Delta H = -9.82$ kJ/mol

2. (24 pts) The 3D Maxwell-Boltzmann distribution is given by:

$$f(v) = \frac{4v^2}{\sqrt{\pi}\alpha^3} e^{-v^2/\alpha^2},$$

where ½ mα^2 = kT.

a. Determine the average value of the kinetic energy at temperature T. (You must show all your work to get any credit.)

b. What fraction of the molecules have a kinetic energy greater than the average value? (It is sufficient to set up the problem without actually working out the answer in detail.)

Some useful integrals:

$$\int_0^\infty x^{2n} e^{-ax^2}\, dx = \frac{1 \cdot 3 \cdot 5 \cdots (2n-1)}{2^{n+1} a^n} \sqrt{\frac{\pi}{a}}$$

$$\int_0^\infty x^{2n+1} e^{-ax^2}\, dx = \frac{n!}{2a^{n+1}}$$

3. (22 pts) One mole of an ideal gas of atoms occupies a volume of 10 liters at a pressure of one atm. How much work is required to compress it adiabatically and reversibly to a volume of one liter?

4. (24 pts) A benzene molecule is excited to a state that fluoresces with a lifetime of 1 ps (10^{-12} sec.) The fluorescence will be quenched if the molecule undergoes a collision before it has a chance to emit light. What pressure of He is required to quench the fluorescence at 300 K? The collision cross sections of He and benzene are 0.21 and 0.88 nm^2, respectively. Express your answer in atm.

5. (10 pts) Express $\left(\frac{\partial P}{\partial T}\right)_V$ in terms of α and κ_T.

Useful Information: $\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P \quad \kappa_T = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$