CEM 924 (Spring 2001) - Problem Set #1

(1) (a) (10 points) For pure N_2 gas at 300 K, what is the number density (molecules cm^{-3}) of molecules at (i) standard atmospheric pressure (ii) 10^{-10} mbar (UHV and the pressure about 1000 km above the Earth's surface). Assume N_2 behaves as an ideal gas. You only need the equations given in the lecture notes.

(b) (10 points) Calculate the mean velocity of a N_2 molecule at (i) atmospheric pressure (ii) 10^{-10} mbar

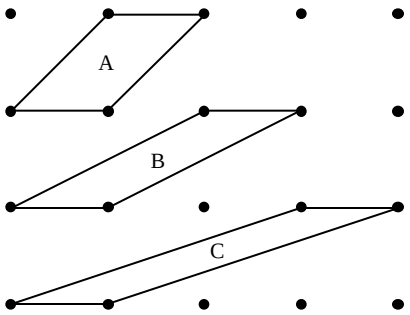
(c) (10 points) Calculate the gas phase collision frequency, z, for a N_2 molecule (σ=0.43 nm^2) at 10^{-10} mbar (the number of collisions a single molecule makes in 1 second).

(d) (15 points) Now, ignoring gas-gas collisions, if 10^{-10} mbar of N_2 is contained in a cubic chamber of internal dimensions 20 x 20 x 20 cm, what is the average collision rate of a *single* N_2 molecule with the inside walls of the chamber?

(2) (15 points) Briefly describe the operating principles of (a) a thermocouple gauge (b) a Pirani gauge (c) an ionization gauge (Bayard-Alpert design).

(3) (10 points) A particular element crystalizes into a FCC crystal structure with a two atom basis located at 0 0 0 and 0.25 0.25 0.25. Draw this crystal structure. What can you say about the bond lengths and coordination geometry in this structure? Which element could this be?

(4) (5 points) For the square 2-D plane lattice below, calculate the areas of the three surface nets shown assuming a lattice point spacing of 1.



Now use the Wigner-Seitz method to create a fourth unit cell. Calculate it's area. What do you notice about these values?