**CH301H – Principles of Chemistry I: Honors**
Fall 2013, Unique 52195
**Homework, Week 13**

1. a) A sealed vessel containing an ideal gas at a pressure of 0.5 atm is opened in a room at approximately atmospheric pressure (1.0 atm). What happens?

b) A sealed vessel containing an ideal gas at a pressure of 1.5 atm is opened in the same room. What happens?

c) The pressure of a poisonous gas inside a sealed vessel is 1.47 atm at 20˚C. If the atmospheric pressure is 1.0 atm, what temperature must the container and its contents to cooled to so that the container can be opened with no risk for gas escaping?

2. You need to perform a reaction using the compound $H_2Te$, a colorless, odorless, highly toxic ideal gas. In order to follow basic lab safety protocols, you look up as much information about this compound as possible, and find the following piece of information on Wikipedia: "The weight of one liter of $H_2Te(g)$ is 6.234 g."

a) Is there any value in this information whatsoever?

b) At what temperature is this statement true, if the gas is at 1.0 atm?

3. Research in surface science is carried out using ultra-high vacuum chambers that can 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 298 K? What is the corresponding molar volume at this temperature and pressure? Assume the gas is ideal.

4. The van der Waals equation is a state function that can be used to describe a non-ideal gas. Use the ideal and van der Waals state functions to determine the pressure of 1 mole of ethane ($C_2H_6$) gas under the following conditions, and comment on any differences.

a) In a container of volume 22.4 L at 273.15 K.

b) In a container of volume 0.100 L at 1000 K.

5. Interstellar space has an average temperature of 10 K and average density of hydrogen gas of about 1 molecule $m^{-3}$. Determine the mean free path of hydrogen gas in interstellar space. You may assume that $H_2(g)$ is a sphere of diameter 1.15 Å.

6. A sample of argon gas is held in a 1 L vessel and maintained at 25˚C. At what pressure does the mean free path of the gas become comparable to the size of the container? You may assume the diameter of the argon atom is 1.9 Å.

7. The following table describes the pressure and temperature of Earth's upper atmosphere as a function of altitude:

| altitude (km) | $P$ (bar) | $T$ (K) |
|---|---|---|
| 20.0 | 0.056 | 220 |
| 40.0 | $3.2 \times 10^{-3}$ | 260 |
| 60.0 | $2.8 \times 10^{-4}$ | 260 |
| 80.0 | $1.3 \times 10^{-5}$ | 180 |

Assuming that the atmosphere is composed of 80% $N_2(g)$ and 20% $O_2(g)$, determine the frequency of collisions between nitrogen and oxygen gas at each of these altitudes. You may assume the molecules are spheres with a diameter of 3.8 Å for $N_2(g)$ and 3.6 Å for $O_2(g)$.

8. The interior of the Sun is thought to consist of 36% H and 64% He by mass, at a density of 158 g $cm^{-3}$. Both atoms are completely ionized. The approximate dimensions of the nuclei can be calculated from the formula $r_{nucleus} = 1.4 \times 10^{-15} A^{1/3}$ m, were $A$ is the mass number. (The size of the free electron is $10^{-18}$ m, and is negligible compared to the size of the nuclei.) The pressure in the stellar interior is thought to be $2.5 \times 10^{11}$ atm.

a) Determine the excluded volume of 1.0 $cm^3$ of the stellar interior based on this model. The excluded volume is the volume of a sphere of radius equal to the sum of the radii of the collision pair.

b) Determine the temperature in the stellar interior based on this model. Would the van der Waals equation be more appropriate for this system?