Chapter 2 Exercise

2.1 Verify that the average speed of nitrogen molecules at room temperature 295 K is 472 ms^{-1}. Then, use the relative mass ratios to calculate the average velocity at this temperature for molecules of (a) hydrogen, (b) water vapor, (c) argon.

3.2 What is the average speed of nitrogen molecules at (a) 300°C, (b) 77K?

3.3 If the mean free path for nitrogen molecules is 64 mm at 10^{-3} mbar, what will it be at (a) 0.1 mbar, (b) 0.3 mbar?

3.4 How many collisions will a nitrogen molecule have in one second at a pressure of 0.1 mbar?

3.5 At a pressure 10^{-3} mbar, what fraction of nitrogen molecules will travel for 192 mm or more without having a collision?

3.6 The mean free path in helium gas at 10^{-3} mbar is 173 mm. Is this bigger or smaller than that for nitrogen under the same conditions? Is it very different? What will be the mean free path in helium at 10^{-4} mbar?

3.7 If a well-built concert hall of typical dimension 100 m contained just nitrogen gas at a pressure 10^{-7} mbar, what state would the gas be in?

3.8 How many moles of nitrogen impinge in one second on an area of one square cm of surface at pressure of 1000 mbar and at room temperature?

Chapter 3 Exercise

4.1 If a monolayer of gas forms on a surface in 3 seconds at 10^{-6} mbar, how long would it take to form at 5×10^{-8} mbar?

4.2 A cubic vessel of side 10 cm contains a perfect vacuum and its internal walls are covered by a complete monolayer of gas molecules that suddenly desorb and stay in the vacuum space. How many desorb? What pressure will they create in the volume, assumed to be at 295 K?

4.3 For nitrogen gas at 295 K, the expression for the impingement rate of molecules on a surface, is $J = 2.9 \times 10^{20}$ p per cm^2 per second, where the pressure p is in mbar. Re express this so that the units of J are per m^2 per second, with pressure in Pa.

4.4 Verify that the specification of energies as "eV per molecule" is equivalent to 96.5 kJ per mole and that the value of kT at room temperature is 0.025 = 1 /40 eV.

4.5 For molecules that adsorb on a surface with energy 1.0 eV, estimate the average stay time at (a) 295 K, (b) 285 K, (c) 305 K.

4.6 Molecules whose average stay time on a surface is 1 ms impinge on it with sticking coefficient 0.1 at a rate $10^{17} cm^{-2} s^{-1}$. What is the equilibrium population of adsorbed molecules per cm^2? To what fraction of a monolayer does this correspond?

4.7 Molecules of helium and carbon dioxide effuse through an aperture into a very high vacuum from an enclosure in which they originally exert equal partial pressures. What is the ratio of the helium and carbon dioxide effusion rates initially,

4.8 The molar adsorption energy of CO_2 on carbon is approximately 34 kJ/mol. Calculate the mean stay time of CO_2 on carbon at (a) 295 K, (b) 90 K, assuming a pre exponential factor 10^{13}s.

4.9 Estimate the total area of surface in the "sponge-like" structure of a 1cm cube of porous molecular sieve with a 5 nm pore diameter by modeling it as a set of spherical voids packed in a cubic arrangement (i.e., in a simple cubic structure). Assuming that this material presents 1014 adsorption sites per cm^2, estimate the maximum number of molecules that might be captured by it. To how many cm^3 of gas at room temperature and atmospheric pressure would this correspond?