

Chem 402—Physical Chemistry
Homework Problem Set—Chapter 21

1. Calculate the most probable, mean, and root-mean-square speeds for oxygen molecules at 25 °C.

2. The standard deviation σ of a distribution is given by

$$\sigma = [\langle x^2 \rangle - \langle x \rangle^2]^{1/2}$$

What is the standard deviation of the distribution of speeds v of hydrogen molecules at 298.15 K?

3. The pressure in interplanetary space is estimated to be on the order of 10^{-14} Pa. Calculate (a) the average number of molecules per cubic centimeter, (b) the collision frequency, and (c) the mean free path in miles. Assume that only hydrogen atoms are present, that $d = 0.2$ nm, and that $T = 1000$ K.
4. We stated that $E_T = 3/2 RT$ from the equipartition theorem. Show that the same result may be obtained by averaging over the Maxwell speed distribution to obtain the kinetic energy of an average molecule.

$$\varepsilon = \int_0^{\infty} 1/2 mv^2 f(v) dv$$

5. For O_2 at 10^{-3} bar and 25 °C, (a) what is the collision frequency, and (b) what is the average time between collisions?
6. The diffusion coefficient of oxygen dissolved in water is $200 \times 10^{-11} \text{ m}^2 \text{ s}^{-1}$ at 25 °C. How long, on average, does it take an oxygen molecule to travel 1 mm in a particular direction?