Answer on Question #56495, Physics / Other

3/ A flask with a volume of 1.50 L, provided with a stopcock, contains ethane gas (C2H6) at 300 K and atmospheric pressure ($1.013 \cdot 10^5$ Pa). The molar mass of ethane is 30.1 g/mol. The nsystem is warmed to a temperature of 380 K with the stopcock open to the atmosphere. The stopcock is then closed, and the flask is cooled to its original temperature.

(a) What is the final pressure of the ethane in the flask?

(b) How many grams of ethane remain in the flask?

Solution:

An ideal gas can be characterized by three state variables: absolute pressure (P), volume (V), and absolute temperature (T). The relationship between them may be deduced from kinetic theory and is called the *ideal gas law*:

$$PV = nRT$$

where n = number of moles,

R = universal gas constant = 8.315 J/mol K

The number of moles n_1, in the "cold" flask is

$$n_1 = \frac{PV_1}{RT_1} = \frac{1.013 \cdot 10^5 \cdot 1.50 \cdot 10^{-3}}{8.315 \cdot 300} = 0.061 \text{ mol}$$

The number of moles n_2, in the "hot" flask is

$$n_2 = \frac{PV_1}{RT_2} = \frac{1.013 \cdot 10^5 \cdot 1.50 \cdot 10^{-3}}{8.315 \cdot 380} = 0.048 \text{ mol}$$

(a) The final pressure of the ethane in the flask when its cooled is

$$P_2 = \frac{n_2 RT_1}{V_1} = \frac{0.048 \ \cdot 8.315 \cdot 300}{1.50 \cdot 10^{-3}} = 79824 \text{ Pa} = 0.798 \cdot 10^5 \text{ Pa}$$

(b) in the flask remain n_2 moles of ethane

Thus , the mass is

$$m = n_2 M = 0.048 \cdot 30.1 = 1.445 \text{ g}$$

Answer: (a) $0.798 \cdot 10^5$ Pa; (b)

4/ Smoke particles in the air typically have masses of the order of 10^{-16} kg. The motion of these particles, resulting from collisions with air molecules, can be observed with a microscope.

(a) Find the root-mean-square speed for a particle with a mass of $3.00 \cdot 10^{-16}$ kg in air at 300 K.

(b) Would the root-mean-square speed be different if the particle were in hydrogen gas at the same temperature? Explain.

Solution:

(a) The translational kinetic energy of a particle is (3/2)kT? Where k is Boltzman's constant and T is Kelvin temperature. If v_{rms} is root mean square speed of the particle, then

$$\frac{1}{2}m(v_{rms})^2 = \frac{3}{2}kT$$

or

$$v_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3 \cdot 1.38 \cdot 10^{-23} \cdot 300}{3.00 \cdot 10^{-16}}} = 0.006434 \text{ m/s} \approx 0.64 \text{ cm/s}$$

(b) No, because of the equipartition of energy. Every degree of freedom has energy 1/2 kT

Answer: (a) 0.64 cm/s; (b) No, because of the equipartition of energy