Answer on Question #80267, Physics / Other

At what pressure will the mean free path be 50cm for spherical molecules of radius 3.0×10^10? Assume ideal gas at 20°C.

Solution:

In kinetic theory the mean free path of a particle, such as a molecule, is the average distance the particle travels between collisions with other moving particles:

$$l = \frac{1}{\sqrt{2}\pi d^2 \frac{N}{V}}$$

where d is the diameter of the molecule.

From ideal gas law

$$\frac{N}{V} = \frac{P}{k_B T}$$

where k_B is the Boltzmann constant.

So,

$$P = \frac{k_B T}{4\pi\sqrt{2} r^2 l} = \frac{(1.38 \times 10^{-23}\ J/K)(293\ K)}{4\pi\sqrt{2}(3.0 \times 10^{-10}\ m)^2(0.5\ m)} = 0.0051\ Pa = 5.1 \times 10^{-3}\ Pa$$

Answer: $5.1 \times 10^{-3}\ Pa$