Chapter 21 - The Kinetic Theory of Gases

Note Title 7/16/2007

2. A sealed cubical container 20.0 cm on a side contains three times Avogadro's number of molecules at a temperature of 20.0°C. Find the force exerted by the gas on one of the walls of the container.

$PV = nRT = \frac{N}{N_A} RT$. Here, $N = 3N_A$

$\therefore PV = 3RT$, $T = 293\,K$, $R = 8.315\,J/mole\text{-}K$

$V = (0.2)^3 = 0.008\,m^3$

$\therefore P = \frac{3(8.315)(293)}{0.008} = 9.14 \times 10^5\,Pa$

$\therefore F = P \cdot area = (9.14 \times 10^5\,Pa)(0.04\,m^2)$

$= 3.65 \times 10^4$ Newtons

10. A 5.00-L vessel contains nitrogen gas at 27.0°C and a pressure of 3.00 atm. Find (a) the total translational kinetic energy of the gas molecules and (b) the average kinetic energy per molecule.

(a) $PV = nRT$, $n = \frac{PV}{RT} = \frac{(3.0)(5.00)}{(0.082)(300)}$

$= 0.610\,mole = (0.610)(6.02 \times 10^{23})$

$= 3.67 \times 10^{23}$ molecules

$$\overline{K.E.} = \frac{3}{2} k_B T = (1.5)(1.38 \times 10^{-23}\ J/k)(300)$$

$$= 6.21 \times 10^{-21}\ J/\text{molecule}$$

$$\therefore (3.67 \times 10^{23})(6.21 \times 10^{-21}) = \underline{2.28 \times 10^{3}\ J}$$

(6) as above, $\overline{K.E.} = 6.21 \times 10^{-21}\ J/\text{molecule}$

27.]Air in a thundercloud expands as it rises. If its initial temperature is 300 K and no energy is lost by thermal conduction on expansion, what is its temperature when the initial volume has doubled?

$T_i V_i^{\gamma-1} = T_f V_f^{\gamma-1}$, $\gamma = 1.4$ for air.

$$\therefore \frac{T_i}{T_f} = \left(\frac{V_f}{V_i}\right)^{\gamma-1} = 2^{0.4} = 1.32$$

$$\therefore T_f = \frac{T_i}{1.32} = \frac{300}{1.32} = \underline{227\ K}$$