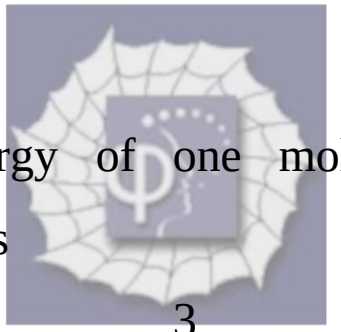
**211.**

**Problem 23.27 (RHK)**

*Oxygen* $(O_2)$, *gas at* $15^0$C *and* 1.0 atm *pressure is confined to a cubical box* 25 *cm on a side. We have to calculate the change in gravitational potential energy of a mole of oxygen molecules in falling the height of the box to the total kinetic energy of the molecules.*

**Solution:**



The kinetic energy of one mole of molecules at temperature T K is

$$E_i = \frac{3}{2} N_A kT,$$

where $N_A = 6.02 \times 10^{23}$ is the Avogadro number and $k = 1.38 \times 10^{-23}$ J/K is the Boltzmann constant.

Temperature of $15^0$C is 288.16 K. Therefore,

$$E_i = \frac{3}{2} \times 6.02 \times 10^{23} \times 1.38 \times 10^{-23} \times 288.16 \text{ J}$$
$$= 3590.8 \text{ J}.$$

Molecular weight of $O_2$ is $32 \times 10^{-3}$ kg, therefore the change in gravitational potential energy of one mole of

oxygen molecules when they drop in height by 25 cm will be

$$E_p = 32\times10^{-3}\times25\times10^{-2}\times9.8\ \text{J} = 7.84\times10^{-2}\ \text{J}.$$

Ratio of change in gravitational potential energy of one mole of oxygen molecule in a vertical distance of 25 cm to the thermal energy at $15^0\text{C}$ will be

$$\frac{E_p}{E_i} = \frac{7.84\times10^{-2}}{3590.8} = 2.2\times10^{-5}.$$