Previous year JEE question 5

A gas bulb of 1 litre capacity contains 2.0×10^{21} molecules of nitrogen exerting a pressure of $7.57 \times 10^{3}\ Nm^{-2}$. Calculate the root mean square (r.m.s) speed and the temperature of the gas molecules. If the ratio of the most probable speed to the root mean square speed is 0.82, calculate the most probable speed for these molecules at this temperature.

(1993 - 4 Marks)

Given $V = 1L = 10^{-3}\ m^3$, $P = 7.57 \times 10^{-3}\ Nm^{-2}$, $R = 8.314J$, $n = 2 \times 10^{21}/6.023 \times 10^{23}$ moles

$$PV = nRT \quad \text{or} \quad T = \frac{PV}{nR}$$

$$= \frac{7.57 \times 10^{-3} \times 10^{-3} \times 6.023 \times 10^{23}}{2 \times 10^{21} \times 8.31} = 274.13\ K$$

$$U_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314 \times 274.13}{28 \times 10^{-3}}}\ m/s = 494.15\ m/s$$

(Given U)

$$\frac{U_{mp}}{U_{rms}} = 0.82 \text{ (given)}$$

$$\therefore U_{mp} = 0.82 \times U_{rms} = 0.82 \times 494.15 = 405.2\ m/sec$$