Different kinds of velocities in gaseous state :

(i) **RMS velocity**: RMS velocity may be defined as the square root of the mean of the squares of the velocities of the molecules of a gas.

Calculation of RMS velocity :

According to kinetic gas equation,

$$PV = \frac{1}{3} mnc^2 \Rightarrow c^2 = \frac{3PV}{mn}$$

For one mole of a gas, $n = N$

$$\therefore c^2 = \frac{3PV}{mN}, \quad m \times N = M$$

$$= \frac{3PV}{M}$$

$$\Rightarrow c = \sqrt{\frac{3PV}{M}} \quad \text{— (1)}$$

But, $\frac{M}{V} = \rho$ (or) d. Hence,

$$c = \sqrt{\frac{3P}{\rho}}$$

Since, $PV = RT$ — (2)

$$c = \sqrt{\frac{3RT}{M}} \quad \text{— (3)}$$

Depending upon the data available, one of the above equations can be used to calculate RMS velocity.

(ii) **Average velocity (or) Mean velocity**: It is defined as the arithmetic mean (or) the average of the velocities of all the molecules present in the system.

$$\bar{C} = \sqrt{\frac{8RT}{\pi M}}$$

Average velocity is slightly less than RMS velocity.

$$\bar{C} = \text{RMS velocity} \times 0.9213$$

(iii) Most probable velocity: It is defined as the velocity possessed by the greatest number of molecules present in the system.

$$C_{MP} = \sqrt{\frac{2RT}{M}}$$

$$C_{MP} = \text{RMS V} \times 0.816$$

$$\text{RMSV} : \bar{C} : C_{MP} = 1 : 0.9213 : 0.816$$

Ex.1. Calculate the RMS velocity and average velocity of CH_4 molecule at 27°C?

Sol: $R = 8.314\ JK^{-1}mol^{-1}$, $T = 27°C = 300K$,

$M = 16 \times 10^{-3}\ kg\ mol^{-1}$

$$C = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314 \times 300}{16 \times 10^{-3}}} = 683.6\ ms^{-1}$$

$$\bar{C} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.314 \times 300 \times 7}{22 \times 16 \times 10^{-3}}} = 630\ ms^{-1}$$

Ex.2. Calculate the kinetic energy of 2 moles of CO_2 at 27°C in Joules and Cals assuming the gas to be ideal.

Sol: $n = 2$ moles, $R = 8.314\ JK^{-1}mol^{-1}$, $T = 27°C = 300K$

(i) KE in Joules, $KE = \frac{3}{2}nRT = \frac{3}{2} \times 2 \times 8.314 \times 300$

$= 7482.60$ Joules.

(ii) KE in Cals, $KE = \frac{3}{2}nRT = \frac{3}{2} \times 2 \times 1.987 \times 300$

$= 1788.3$ Cals