Subject ⇒ Chemistry
Paper ⇒ I-A (Physical chemistry)
Chapter ⇒ Gaseous state (Unit-A)
Topic ⇒ Different type of velocities

Name ⇒ Dr. Amarendra Kumar
Deptt. of chemistry
Jain College, Ara.

Most Probable velocity

The velocity possessed by maximum number of molecules of a gas at a given temperature is called most probable velocity.

According to the calculations made by Maxwell the most probable velocity (V_{mp}) is given by the expression

$$V_{mp} = \sqrt{\frac{2RT}{M}}$$

Substituting the values of R, T and M in this expression, the most probable velocity can be calculated.

Average velocity

The velocity possessed by maximum number of molecules of a gas at a given temperature is called Average velocity.

Let n molecules of a gas having individual velocities $V_1, V_2, V_3 \cdots V_n$

$$\therefore \text{Average velocity } (\bar{V}) = \frac{V_1 + V_2 + V_3 \cdots + V_n}{n}$$

From Maxwell equation it has been established that the average velocity V_{av} is given by the expression

$$\therefore \quad \bar{v} = \sqrt{\frac{8RT}{\pi M}}$$

Substituting the values of R, T, π and M in this expression, the average velocity can be calculated.

Root Mean Square velocity

The square root of the mean of the squares of different velocities possessed by molecules of a gas at a given temperature is called root mean square velocity.

It is denoted by u.

If $v_1, v_2, v_3 \cdots v_n$ are the velocities of n molecules in a gas. Then u: the mean of the squares of all the velocities is

$$u^2 = \frac{v_1^2 + v_2^2 + v_3^2 \cdots + v_n^2}{n}$$

Taking the root

$$u = \sqrt{\frac{v_1^2 + v_2^2 + v_3^2 \cdots + v_n^2}{n}}$$

u is the root mean square velocity or RMS velocity.

The value of root mean square velocity u at a given temperature is calculated from the kinetic gas equation.

$$PV = \frac{1}{3} m N u^2$$

or $u^2 = \frac{3PV}{mN}$

for 1 mole of gas

$$PV = RT$$

$\therefore u^2 = \frac{3RT}{M}$

Where M = Molar Mass

or $u = \sqrt{\frac{3RT}{M}}$

Substituting the values of R, T and M, the Root mean square velocity u can be calculated.

Relation between Average velocity, Root mean square velocity and Most probable velocity

We know that,

Average velocity $(\bar{v}) = \sqrt{\frac{8RT}{\pi M}}$

Root mean square velocity $u = \sqrt{\frac{3RT}{M}}$

$\therefore \frac{\bar{v}}{u} = \sqrt{\frac{8RT}{\pi M}} \times \sqrt{\frac{M}{3RT}}$

$= \sqrt{\frac{8}{3\pi}}$

$= 0.9213$

or $\bar{v} = u \times 0.9213$

$\therefore$ Average velocity = 0.9213 × Root mean square velocity

The most probable velocity.

$$V_{mp} = \sqrt{\frac{2RT}{M}}$$

and $u = \sqrt{\frac{3RT}{M}}$

$$\therefore \frac{V_{mp}}{u} = \sqrt{\frac{2RT}{M}} \times \sqrt{\frac{M}{3RT}}$$

$$= \sqrt{2/3}$$

$$= 0.8165$$

$$\therefore V_{mp} = u \times 0.8165$$

i.e. Most probable velocity = $0.8165 \times$ Root mean square velocity

Root mean square velocity is calculated by the application of kinetic gas equation. Knowing the value of RMS velocity we can calculate the average velocity and most probable velocity.

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