Study material: For B.Sc. part-I

Subject: Organic Chemistry, paper-I (A)

Topic: Gaseous State

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Calculation of kinetic energy of gas:→

The kinetic gas equation is

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

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

$$\frac{3}{2} PV = N \times \frac{1}{2} m u^2 \quad \text{—— (I)}$$

If we consider 1 mol of a gas.

$N = N_A$ then $PV = RT$ —— (II)

from equation (I) and (II)

$$\frac{3}{2} RT = N_A \times \frac{1}{2} m u^2 \quad \text{—— (III)}$$

for 1 mol

$$\boxed{[KE]_{mol^{-1}} = \frac{3}{2} RT} \quad \text{—— (IV)}$$

for n moles.

$$\boxed{K_E = n \cdot \frac{3}{2} RT} \quad \text{—— (V)}$$

Equation (III) can be written as.

$$\frac{1}{2} m u^2 = \frac{3}{2} \frac{R}{N_A} T$$

Kinetic energy per molecule.

$$\boxed{\frac{1}{2} m u^2 = \frac{3}{2} kT} \quad \text{—— (VI)}$$

for N molecules

$$KE = N \cdot \frac{3}{2} k_b T \quad \text{(vii)}$$

where,

k_b = Boltzmann constant
$= R / N_A$
$= \frac{8.314 \text{ J mol}^{-1} K^{-1}}{6.022 \times 10^{23} \text{ molecules mol}^{-1}}$
$= 1.38 \times 10^{-23}$ J molecules^{-1} K^{-1}
= Universal gas constant per molecules.

Molecular velocities:→

In the given sample of the gas different molecules have different velocities. Even the velocity of particular molecule is also changes contineously due to molecular collision.

Therefore, the molecular velocities of a gas are expressed in three different ways.

[i] Average velocity →

The mean of velocities of various molecules of the gas is called its average velocity. It is denoted by Va or $\bar{c}$.

In terms of quantum mechanics it is denoted by <c> where < is called Bra and > is called ket. [vi]

$$V_a = \frac{V_1 + V_2 + V_3 + V_4 + \ldots + V_n}{n}$$

$$V_a = \sqrt{\frac{8RT}{\pi M}} \qquad V_a = 145.5\sqrt{\frac{T}{M}} \text{ ms}^{-1}$$

where T → temperature of the gas.
M → Molar mass of gas.

It is obvious that the average velocity of a gas [v]

(a) increases with increasing temperature
(b) decreases with increasing molar mass

[II] Most probable velocity (U_{mp}) →

The velocity possessed by maximum number of molecules of a gas is called its most probable velocity.

$$U_{mp} = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2KT}{m}}$$

$$U_{mp} = 129\sqrt{\frac{T}{M}}\ ms^{-1}$$

[III] Root mean square velocity (U_{rms}) →

The square root of mean of square of velocities of various molecules of a gas is called root mean square velocity.

$$U_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + v_3^2 - - - - + V_n^2}{n}} = \sqrt{\frac{3RT}{M}}$$

The velocity term in kinetic gas equation is root mean square velocity.

$$PV = \frac{1}{3} mNv^2$$

for 1mol of gas

$PV = RT$

$mN = m \cdot N_A$

$= M$ (Molar mass)

$$\Rightarrow \quad v = \sqrt{\frac{3PV}{mN}}$$

$$\Rightarrow \quad v = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{m}} = \sqrt{\frac{3P}{d}}$$

$$U_{rms} = 158\sqrt{\frac{T}{M}}\ ms^{-1}$$

U_{rms}	:	U_{av}	:	U_{mp}
$\sqrt{\frac{3RT}{M}}$	:	$\sqrt{\frac{8RT}{\pi M}}$	:	$\sqrt{\frac{2RT}{M}}$
$\sqrt{3}$	:	$\sqrt{8/\pi}$	:	$\sqrt{2}$
1	:	0.9213	:	0.8615.
1.224 / 1.26		1.128		1

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