

Class \Rightarrow B.Sc. (Part-I) Subsidiary

Subject \Rightarrow Chemistry

Chapter \Rightarrow Gaseous State

Topic \Rightarrow Calculation of gas constant
and Kinetic energy.

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A Calculation of gas Constant

Ideal-gas equation,

$$PV = nRT \quad (\text{where } R \text{ is called})$$

$$\text{or } R = \frac{PV}{nT} \quad \textcircled{1} \quad \text{(gas constant)}$$

We know that one mole of any gas at STP occupies a volume of 22.4 litres.

Putting this value in equation $\textcircled{1}$ we get

$$R = \frac{1 \text{ atm} \times 22.4 \text{ litres}}{1 \text{ mole} \times 273 \text{ K}}$$

$$\text{or, } R = 0.0821 \text{ atm} \cdot \text{litre mol}^{-1} \text{ K}^{-1}$$

It may be noted that the unit for R is complex. It is composite of all the units used in calculating the constant.

If the pressure is written as force per unit area and volume as area times length.

Then eqn. $\textcircled{1}$ becomes

$$R = \frac{(\text{Force/area}) \times \text{area} \times \text{length}}{nT} = \frac{\text{Force} \times \text{length}}{nT}$$

or $R = \frac{\text{work}}{nT}$ Hence R is expressed in units of work or energy per degree per mole. The

actual value of R depends on the unit of P and V.

Value of R in different units

$$(i) 0.0821 \text{ litre-atm K}^{-1} \text{ mol}^{-1}$$

$$(ii) 8.314 \text{ Joule K}^{-1} \text{ mol}^{-1}$$

$$(iii) 8.314 \times 10^7 \text{ erg K}^{-1} \text{ mol}^{-1}$$

$$(iv) 1.987 \text{ cal K}^{-1} \text{ mol}^{-1}$$

(B) Calculation of Kinetic Energy

If N be the no. of molecules in a given mass of gas,

$$PV = \frac{1}{3} m N U^2 \quad (\text{Kinetic gas eqn.})$$

$$\text{or } PV = \frac{2}{3} N \times \frac{1}{2} m U^2$$

$$\text{or } PV = \frac{2}{3} N \times e$$

Where e is the average kinetic energy of a single molecule.

$$\therefore PV = \frac{2}{3} N e = \frac{2}{3} E$$

$$\text{or, } PV = \frac{2}{3} E \quad \text{--- (1)}$$

Where E = Total kinetic energy of all the N molecules.
Equation (1) is called the kinetic gas eqn. in terms of K.E.

We know that the ideal gas eqn. is

$$PV = n RT \quad \text{--- (2)}$$

from eqn. (1) and (2) we get

$$\frac{2}{3} E = n RT \quad \text{--- (3)}$$

for 1 mole of gas, the kinetic energy of N molecules is
 $E = 3RT/2$

Since, the no. of gas molecules in one mole of gas N_0 (Avogadro no.)

$$\text{Then } e = E/N_0 = 3RT/2N_0$$

$$\text{or } e = \frac{3RT}{2N_0} \quad \text{--- (4)}$$

Substituting the value of R, T, N_0 in eqn. (4) the average kinetic energy of gas molecule is calculated.