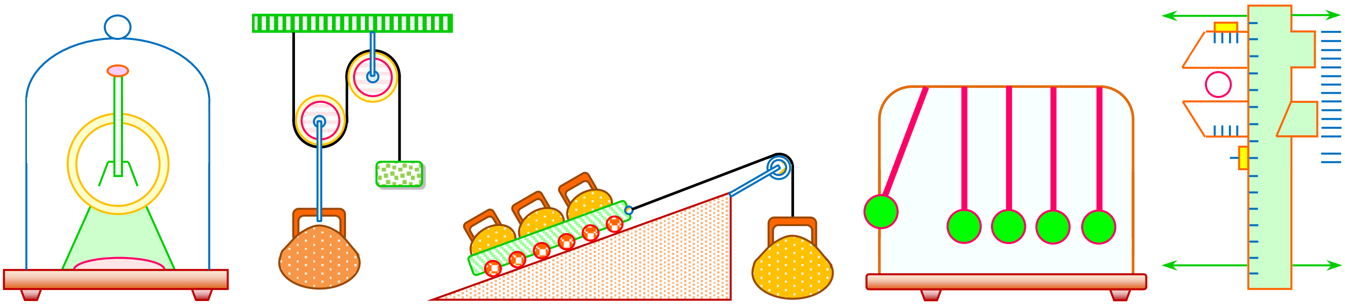


KINETIC THEORY AND THE BEHAVIOUR OF GASES

1 ASSUMPTION OF KINETIC THEORY

(i) Assumptions regarding the molecule :

(a) Every gas consists of extremely small particles known as molecules. The molecules of a given gas are all identical but are different than those another gas.

(b) The molecules of a gas are identical, spherical, rigid and perfectly elastic point masses.

(c) Their size is negligible in comparison to inter molecular distance (10^{-9} m)

(ii) Assumptions regarding volume :

The volume of molecules is negligible in comparison to the volume of gas. (The volume of molecules is only 0.014 % of the volume of gas.)

(iii) Assumptions regarding motion :

(a) Molecules of a gas keep on moving randomly in all possible direction with all possible velocities.

(b) The speed of gas molecules lie between zero and infinity (very high speed).

(c) The number of molecules moving with most probable speeds is maximum.

(iv) Assumptions regarding collision :

(a) The gas molecules keep on colliding among themselves as well as with the walls of containing vessel. These collision are perfectly elastic. (i.e. the total energy before collision = total energy after the collisions).

(b) Molecules move in a straight line with constant speeds during successive collisions.

(c) The distance covered by the molecules between two successive collisions is known as free path and mean of all free paths is known as mean free path.

(d) The time spent is a collision between two molecules is negligible in comparison to time between two successive collisions.

(e) The number of collisions per unit volume in a gas remains constant.

(v) Assumptions regarding force :

(a) No attractive or repulsive force acts between gas molecules.

(b) Gravitational attraction among the molecules is ineffective due to extremely small masses and very high speed of molecules.

(vi) Assumptions regarding pressure :

Molecules constantly collide with the walls of container due to which their momentum changes. This change in momentum is transferred to the walls of the container. Consequently pressure is exerted by gas molecules on the walls of container.

(vii)Assumptions regarding density :

The density of gas is constant at all points of the container.

2 SOME DEFINITIONS

Definition :

(i) Gram mol. or Kilogram mol. :

(a) The quantity of matter in which the number of molecules is equal to the Avogadro's number, is defined as gram mol.

(b) The molecular weight of any substance expressed in kilogram is defined as 1 kilogram mol of that substance.

(c) The molecular weight of any substance expressed in grams is defined as 1 gram mol of that substance.

(d) 1 Kg mol of H_2 = 2 kg.,
1 Kg mol of N_2 = 28 kg.
1 Kg mol of O_2 = 32 kg.,
1 Kg mol of CO_2 = 44 kg.

(e) No. of molecules in 1 mol

$$= \frac{\text{Total number of molecules}}{\text{Number of mols.}}$$

(f) Number of moles = $\frac{\text{Mass of gas}}{\text{Molecular wt. of gas}}$

or $n = \frac{m}{M}$

(g) The mass of 1 mol of a gas is equal to its molecular weight.

(ii) Avogadro's Number (N_A) :

(a) The number of molecules present in 1 mol of a gas is defined as Avogadro's number.

(b) $N_A = 6.01 \times 10^{23}$ per gm. mol.
$= 6.02 \times 10^{26}$ per Kg. mol.

(iii) Molar volume and Molar mass (V_m) :

(a) Molar volume V_m : The volume of 1 mol of gas is known as molar volume (V_m).

(b) $V_m = \frac{V}{n}$

(c) The unit of V_m is m^3/mol.

Molecular weight (M) :

(a) The quantity in 1 mol of matter is its molecular weight.

(b) $M = mN_A$ (m = mass of a single molecule)

(iv) Meaning of NTP : NTP means normal temperature and pressure.

(a) Temperature at NTP = 0º C = 273 K

(b) Pressure at NTP = 76 cm of Hg - column
$= 1.013 \times 10^5$ Newton/meter^2 or Pascal
= 1 atmosphere.

(c) Volume of 1 mol of gas at NTP = 22.4 litre.

(v) Absolute zero temperature (0º K) :

(a) The minimum possible temperature at which all the gas molecules come to rest, is defined as absolute zero temperature (i.e. 0º K).

(b) The temperature at which the kinetic energy of gas molecules become zero is defined as absolute zero temperature.

(c) At this temperature the volume of the gas becomes zero.

Symbols used in this chapter

R = Universal gas constant = 8.314 J/mol-K
= 0.082 Lit-atm/mol-K = 1.986 cal /mol-K
M = Molecular wt in Kg = mass of 6.023×10^{23} molecules of the gas
m = Mass of each molecule in Kg = M/N_0
N_0 = Avogadro's constant = 6.023×10^{23}
k = Boltzman's constant =R/N_0 =1.38×10^{-23}J/K
P = Pressure of the gas in N/m^2
T = Temperature in Kelvin
N = Total number of molecules
d = Density of gas = nM/V
n = No. of moles

3 IDEAL GAS EQUATIONS

PV = RT .... For μ = 1 mole = 1 gm. Molecule
PV = μRT............ For μ = Amount of mole

$$PV = \frac{M}{M_w} RT \qquad [M_w = N_0 m]$$

$$PV = \left(\frac{mN}{mN_0}\right) RT \Rightarrow PV = \left(\frac{R}{N_0}\right) NT \Rightarrow \boxed{PV = NKT}$$

$$\left[\begin{array}{l} K = \frac{R}{N_0} \\ \frac{N}{V} = n = \frac{\rho}{m} \\ \rho = mn \end{array}\right.$$

$$P = K\left(\frac{N}{V}\right) T \Rightarrow \boxed{P = nKT}$$ **Imp.**

$$P = \frac{\rho TK}{m} \text{ or } \boxed{m = \frac{\rho TK}{P}}$$ **Imp.**

QUESTIONS FOR PRACTICE

Q.1 Some container contains on average 5 molecules/cm^3. If the gas has temperature of 3K, then its pressure will be (N/m^2) : (Hint : P = nKT)

[**Ans.** 2×10^{-16}]

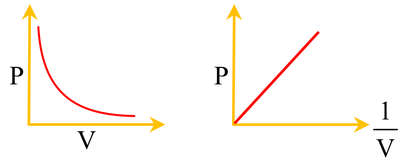
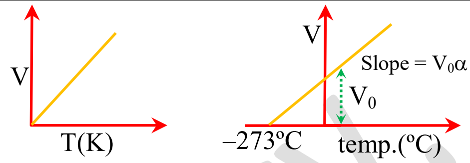
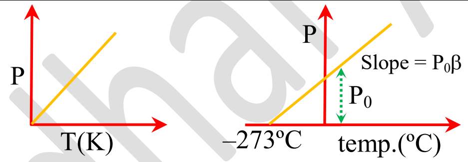
Q.2 State equation for 1 gm. of H_2 = ?

[**Ans.** PV = RT/2]

Q.3 For He, if 4PV = RT then amount of mass M = ?

[**Ans.** M = 1 gm]

4 GAS LAWS

Name of Law	Constant terms	Basic concept	Graph
1. Boyle's Law	(i) Mass of gas (ii) Temperature	PV = constant $V \propto 1/P$ $P_1V_1 = P_2V_2$	
2. Charle's Law	(i) Mass of gas (ii) Pressure	V/T = constant $V \propto T$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $V_t = V_0(1+\alpha t)$	 ($\alpha \to$ volume expansion coefficient = 1/273 per ºC)
3. Gay-Lussac's Law	(i) Mass of gas (ii) Volume	P/T = constant $P \propto T$ $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $P_t = P_0(1+\beta t)$	 ($\beta \to$ pressure expansion coefficient = 1/273 per ºC)

4. **Avogadro's Law:-** At same temperature and pressure equal volumes of all gases contains equal number of molecules.
5. **Dalto's Law:-** According to this law, the pressure exerted by a mixture of several gases equals the sum of the pressure exerted by each component gas present in the mixture i.e.

$$P_{max.} = P_1 + P_2 + P_3............$$

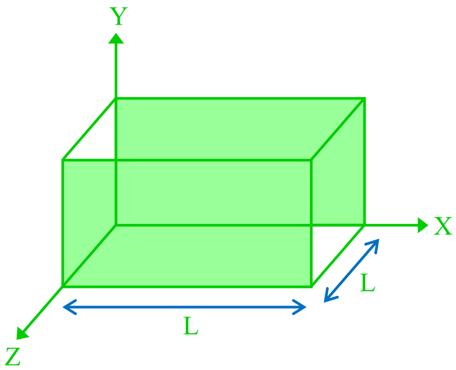
$$P = \left(\frac{RT}{V}\right)\mu \Rightarrow P_{mix.} \propto \mu$$

$$\Rightarrow P_{max} = \frac{RT}{V}[\mu_1 + \mu_2 + \mu_3]$$

6. **Graham's Law of diffusion:-** According to this law, at same temperature and pressure, the rate of diffusion of gas is inversely proportional to the square root of the density of gas i.e.

Rate of diffusion $r_d \propto \frac{1}{\sqrt{\rho}}$; $V_{rms} \propto \frac{1}{\sqrt{\rho}}$; So, $V_{rms} \propto r_d$ [For H_2 gas (Max)]

5 CALCULATION OF PRESSURE OF GAS



1. Consider an ideal gas enclosed in a cubical vessel of edge 'L'
2. Consider a molecule moving with velocity $\vec{v}$ in any direction: $\vec{v} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k}$
3. This molecule collides with the shaded wall with velocity v_x.

(a) momentum before collision = mv_x

(b) momentum after collision = – mv_x
(assuming elastic collision)
$\Rightarrow$ change in momentum of the molecule
$= -mv_x - mv_x = -2mv_x$

4. By the law of conservation of momentum change in momentum of the wall = equal in magnitude but opposite in direction to that of molecule $\Delta P = 2mv_x$
5. The distance travelled parallel to the x-direction = L. Thus, the time between two successive collisions with the shaded wall is , $\Delta t = \frac{2L}{v_x}$

   $\Rightarrow$ number of collisions per second (n) is

   $n = \frac{v_x}{2L}$
6. The momentum imparted per unit time to the wall by this molecule is

   $\Delta F = n\Delta P = \frac{v_x}{2L} 2mv_x = \frac{mv_x^2}{L}$
7. The total force on the wall

   $= F = \Sigma \frac{m}{L} v_x^2 = \frac{m}{L} \sum v_x^2$
8. Assuming average velocity in all direction to be equal, we have

   $\Sigma v_x^2 = \Sigma v_y^2 = \Sigma v_z^2 = \frac{1}{3}\Sigma(v_x^2 + v_y^2 + v_z^2) = \frac{1}{3}\Sigma v^2 \Rightarrow F = \frac{1}{3}\frac{m}{L}\Sigma v^2$
9. If N is the total number of molecules in the sample, $F = \frac{1}{3}\frac{mN}{L}\frac{\Sigma v^2}{N}$

   Pressure on the wall = Force /Area

   $P = \frac{F}{L^2} = \frac{1}{3}\frac{mN}{L^3}\frac{\Sigma v^2}{N}$

   $P = \frac{1}{3}\frac{m_0}{V}\frac{\Sigma v^2}{N}$

   where, m_0 = Total mass of the gas = mN
   V = Volume of the vessel
   m = mass of each molecule

   $\Rightarrow P = \frac{1}{3} d\left(\frac{\Sigma v^2}{N}\right)$ (d = density $= \frac{m_0}{V}$)

   $\Rightarrow$ **$P = \frac{1}{3} d\, v_{rms}^2$** $\because$ ($v_{rms} = \sqrt{\frac{\Sigma v^2}{N}}$)

   or **$PV = \frac{1}{3} m_0 v_{rms}^2$** or **$PV = \frac{1}{3} Nm\, v_{rms}^2$**
10. As we know , energy of each molecule

    $= \frac{1}{2} m\, v_{rms}^2$

    Total energy $= E_0 = \frac{1}{2} Nm\, v_{rms}^2$

    $\Rightarrow Nm\, v_{rms}^2 = 2E_0$

    $\Rightarrow PV = \frac{2}{3} E_0$ or $P = \frac{2}{3} E$

    where E = Energy per unit volume

11. Dependence of pressure :
    (a) $P \propto n$ (Total number of moles)
    (b) $P \propto m$ (Total mass of the gas)

(c) P ∝ v_{rms}^2
(d) P ∝ 1/V (V = Volume)
(e) P ∝ d (d = Density)
(f) P ∝ E (E = Energy per unit volume)

Examples based on **Calculation of pressure of a gas**

Ex.1 A flask of 10^{-3} m^3 volume contains 3 × 10^{22} molecules of oxygen at a certain temperature. The mass of one molecule of oxygen is 5.3 × 10^{-26} Kg and rms velocity of its molecules at the same temperature is 400 m/s. Calculate the pressure of the gas.

Sol. Pressure of the gas

$$P = \frac{1}{3}\frac{mN}{V}v_{rms}^2$$

Here V = $10^{-3}m^3$ N = 3 × 10^{22}

m = 5.3 × 10^{-26} Kg, v_{rms} = 400 m/s

$$\therefore \quad P = \frac{1}{3}\frac{5.3\times10^{-26}\times3\times10^{22}\times(400)^2}{10^{-3}}$$

= 8.48 × 10^4 N/m^2.

Ex.2 The pressure of an ideal gas is written as $P = \frac{2}{3}\frac{E}{V}$. Here E refers to –

(1) Translational kinetic energy
(2) Rotational kinetic energy
(3) Vibrational kinetic energy
(4) Total kinetic energy

Sol.[1] Pressure of the gas

$$P = \frac{1}{3}\frac{mN}{V}v_{rms}^2$$

$$\therefore \quad \text{Energy } E = \frac{1}{2}v_{rms}^2$$

$$= \frac{1}{2}mN\left(\frac{v_1^2+v_2^2+...+v_n^2}{N}\right)$$

$$= \frac{1}{2}mv_1^2+\frac{1}{2}mv_2^2+....+\frac{1}{2}mv_n^2$$

So energy is basically the sum of energies of all molecules which represents translational kinetic energy.

Ex.3 Which of the following parameters is the same for molecules of all gases at a given temperature ?
(1) Mass (2) Speed
(3) Momentum (4) Kinetic energy

Sol.[4] Kinetic energy according to kinetic theory of gases is given by,

$$E = \frac{3}{2}RT$$

R is a universal constant and temperature remains same for all gases. So kinetic energy is same for molecules of all gases at a given temperature.

Ex.4 A gas is filled in a container at pressure 'P_0' . If the mass of each molecule is halved and speeds are double, then resulting pressure will be -
(1) $4P_0$ (2) $2P_0$
(3) P_0 (4) $4P_0/\sqrt{2}$

Sol.[2] $P_0 = \frac{1}{3}\frac{Nm}{V}v_{rms}^2$ (m = mass of each molecule,
V = volume of the gas)
Now , m' = 1/2 m
$v'_{rms} = 2v_{rms}$
$P' = \frac{1}{3}\frac{Nm.4v_{rms}^2}{2V} = 2.\ \frac{1}{3}\frac{Nm}{V}v_{rms}^2 = 2P_0$

Ex.5 The ratio of number of collisions per second at the walls of containers by H_2 and Ne gas molecules kept at same volume and temperature is –
(1) 10 : 1 (2) 1 : 10
(3) 1 : $\sqrt{10}$ (4) $\sqrt{10}$: 1

Sol.[4] Let's consider the wall perpendiculars to x-axis number of collisions per second are given by
$\frac{v_x}{2L}$ Now, $v_x = v_{rms}/\sqrt{3}$.
'L' and 'T' is same of both. Then, Ratio of speed given by
$\frac{v_{rms,H_2}}{v_{rms,Ne}} = \sqrt{\frac{M_{Ne}}{M_{H_2}}} = \sqrt{\frac{20}{2}} = \sqrt{10}:1$

Ex.6 Two containers of equal volumes contain H_2 and O_2 at same temperature. If the number of molecules of these gases is also equal then the ratio of pressure exerted by these will be -
(1) 1 : 1 (2) 4 : 1
(3) 8 : 1 (4) 16 : 1

Sol.[1] Pressure of the gas
$P = \frac{1}{3}\frac{nM}{V}v^2_{rms} = \frac{1}{3}\frac{nM}{V}.\frac{3RT}{M} = \frac{nRT}{V}$
Given, $n_{H_2} = n_{O_2}$, $T_{H_2} = T_{O_2}$
$V_{H_2} = V_{O_2}$
$\Rightarrow$ $P_{H_2} = P_{O_2}$

Ex.7 The density of carbon dioxide gas at 0ºC and at a pressure of 1.0×10^5 newton/metre^2 is 1.98kg/m^3. Find the root mean square velocity of its molecules at 0ºC. Pressure is constant
(1) 39 metre/sec (2) 3.09 metre/sec
(3) 389 metre/sec (4) 38.9 metre/sec

Sol.[3] We know that
$P = \frac{1}{3}\rho\bar{v}^2$
$\therefore$ $v_{rms} = \left(\frac{3P}{\rho}\right)^{1/2}$
Given that ρ = 1.98kg/m^3 and
$P = 1.0 \times 10^5$ N/m^2
$\therefore$ $v_{rms} = \sqrt{\frac{3\times1.0\times10^5}{1.98}}$
$\therefore$ v_{rms} = 389 m/s

6 DIFFERENT K.E. OF GAS

1. Translatory kinetic energy (E_r)

$E_r = \frac{1}{2}Mv_{rms}^2 = \frac{3}{2}PV$

Total internal energy of ideal gas is kinetic

2. Energy per unit volume or energy density (E_v) : (J/M^3)

$E_v = \frac{\text{Total Energy}}{\text{Volume}} = \frac{E}{V}$; $E_v = \frac{1}{2}\left(\frac{M}{V}\right)v_{rms}^2$;

$E_v = \frac{1}{2}\rho v_{rms}^2$

$\because\ P = \frac{2}{3}\left[\frac{1}{2}\rho v_{rms}^2\right]$ *(By pressure expression)*

$P = \frac{2}{3}E_v$; $\boxed{E_v = \frac{3}{2}P}$ *Imp.*

3. Molar K.E. or Mean Molar K.E. (E):- (K.E. of N_0 molecules or K.E. of M_w grams gas)

$E = \frac{1}{2}M_w v_{rms}^2$ $\boxed{E = \frac{3}{2}RT = \frac{3}{2}N_0KT}$ ...(1)

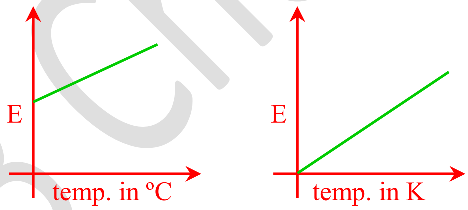
4. Molecular kinetic energy or mean molecular K.E. $(\overline{E})$:- [K.E. of a gas molecule]

$\overline{E} = \frac{E}{N_0}$; $\overline{E} = \frac{3}{2}\frac{RT}{N_0}$ $\boxed{\overline{E} = \frac{3}{2}KT}$ ...(2)

5. Gram K.E. or Mean gram K.E. (E_m):- (K.E. of 1 gram gas)

$E_m = \frac{E}{M_w}$; $\boxed{E_m = \frac{3}{2}\frac{RT}{M_w} = \frac{3}{2}\frac{KT}{m}}$ ...(3)

$\boxed{E_m \propto \frac{1}{M_w}}$



Examples based on **Different kinetic energy of gas**

Ex.8 At what temperature will the root mean square velocity of oxygen molecules be sufficient so as the escape from the earth ?

(1) 1.6×10^5 K (2) 16×10^5K
(3) $.16 \times 10^5$ K (4) 160×10^5 K

Sol.[1] $\therefore\ \frac{3}{2}KT = \frac{1}{2}mv_e^2$

Where v_e = escape velocity of earth = 11.1 km/sec

m = mass of 1 molecule of oxygen = 5.34×10^{-26}

$T = \left(\frac{mv_e^2}{3K}\right)$

$\therefore\ T = \left(\frac{5.32\times10^{-26}\times(11.1\times10^3)}{3\times(1.38\times10^{-23})}\right)$

$\Rightarrow$ $T = 1.6 \times 10^5$ K

Ex.9 The first excited state of hydrogen atom is 10.2 eV above its ground state. What temperature is needed to excite hydrogen atoms to first excited level –

(1) 7.88×10^4K (2) $.788 \times 10^4$ K
(3) 78.8×10^4 K (4) 788×10^4 K

Sol.[1] K.E. Per atom = 3/2 KT

K.E. of the hydrogen atom = 10.2 eV

$\therefore$ 10.2 eV = $10.2 \times (1.6 \times 10^{-19})$ Joule

$$T = \frac{2}{3} \times \frac{\text{K.E. per atom}}{K}$$

$$\therefore T = \frac{2}{3} \times \frac{10.2 \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23}}$$

Where k = 1.38×10^{-23} J/mole. ºK

$\Rightarrow T = 7.88 \times 10^4$ K

Ex.10 At what temperature does the average translational kinetic energy of a molecule in a gas equal to the kinetic energy of an electron accelerated from rest through a potential difference of 5 volt.

(1) 386.5×10^3K (2) 3.865×10^3K
(3) $.38 \times 10^3$K (4) 38.65×10^3 K

Sol.[4] K.E. of the electron is

5 eV = $5 \times 1.6 \times 10^{-19}$J

But K.E. = 3/2 KT

$\therefore 5 \times 1.6 \times 10^{-19} = 3/2\,(1.38 \times 10^{-23}) \times T$

$$\Rightarrow T = \frac{5 \times 1.6 \times 10^{-19} \times 2}{3 \times 1.38 \times 10^{-23}}$$

$\Rightarrow T = 38.65 \times 10^3$ K

7 DIFFERENT TYPE OF SPEED

1. Average velocity:- $(<\bar{v}>)$

$$<\bar{v}> = \frac{\bar{v}_1 + \bar{v}_2 + \dots\dots\dots + \bar{v}_N}{N} = 0$$

Because molecules are in random motion in all possible direction in all possible velocity. Therefore, the velocity of the gas container is zero.

2. Rms speed of molecules:-(v_{rms})

$$V_{rms} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3RT}{M_w}} = \sqrt{\frac{3KT}{m}}$$

$$= 1.732\sqrt{\frac{KT}{m}} \quad \dots\dots(1)$$

3. Mean speed of molecules:- (By maxwell's velocity distribution law) (v_M or $<|\bar{v}|>$)

$$v_{Mean} = \sqrt{\frac{8}{\pi}\frac{P}{\rho}} = \sqrt{\frac{8RT}{\pi M_w}} = \sqrt{\frac{8KT}{\pi m}}$$

$$= 1.595\sqrt{\frac{KT}{m}} \quad \dots\dots\dots(2)$$

$$<|\bar{v}|> = v_{mean} = \frac{|\bar{v}_1| + |\bar{v}_2| + \dots\dots + |\bar{v}_n|}{N}$$

4. Most probable speed of molecules :-(v_{mp})

At a given Temperature the speed to which maximum number of molecules belongs is called as most probable speed (v_{mp})

$$v_{mp} = \sqrt{\frac{2P}{\rho}} = \sqrt{\frac{2RT}{M_w}} = \sqrt{\frac{2KT}{m}} = 1.414\sqrt{\frac{KT}{m}} \quad ...(3)$$

5. **Velocity of sound in gas medium:- (v_s)**

$$v_{sound} = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M_w}} = \sqrt{\frac{\gamma KT}{m}} \qquad [\because 1 < \gamma < 2]$$

Special points :-

1. At any temperature (always)
   $v_{rms} > v_{Mean} > v_{mp} > v_{sound}$
2. For a gas at any temperature (T)
   $\frac{v_{rms}}{v_{sound}} = \sqrt{\frac{3}{\gamma}}$, $\frac{v_{rms}}{v_{mp}} = \sqrt{\frac{3}{2}}$
3. At temp is not possible at which above order can be changed. Always $v_{rms} \neq v_{Mean} \neq v_{mp} \neq v_{sound}$
4. At any given temperature
   Any speed $\propto \sqrt{T}$;
   $\boxed{\text{graph } v_{r.m.s.} v/sT \rightarrow \text{parabola}}$

Examples based on **Different Type of Speed**

Ex.11 The velocities of ten particles in ms^{-1} are : 0, 2, 3, 4, 4, 4, 5, 5, 6, 9. Calculate
(i) Average speed and
(ii) r.m.s. speed
(iii) most probable speed

Sol. (i) Average speed,

$$v_{av} = \frac{0+2+3+4+4+4+5+5+6+9}{10} = \frac{42}{10}$$

$= 4.2\ ms^{-1}$

(ii) R.M.S. speed,

$$V_{r.m.s} = \left[\frac{(0)^2+(2)^2+(3)^2+(4)^2+(4)^2+(4)^2+(5)^2+(5)^2+(6)^2+(9)^2}{10}\right]^{1/2} = \left[\frac{228}{10}\right]^{1/2} = 4.77\ ms^{-1}$$

(iii) most probable speed v_{mp} = 4m/s

Ex.12 At what temperature, will the root mean square velocity of hydrogen be double of its value at S.T.P. , pressure remaining constant ?

Sol. Let V_1 be the r.m.s. velocity at S.T.P. and V_2 be the r.m.s. velocity at unknown temperature T_2.

Here T_1 = 273 K, T_2 = ? $\frac{V_2}{V_1} = 2$

We know, $V^2 \propto T$

$\therefore \frac{V_1^2}{V_2^2} = \frac{T_1}{T_2}$ or $T_2 = T_1\left(\frac{V_2}{V_1}\right)^2$

$= 273 \times (2)^2 = 273 \times 4 = 1092K$

T_2 = (1092 – 273) = 819ºC

Ex.13 Calculate rms velocity of oxygen molecule at 27ºC

Sol. Temperature, T = 27ºC $\Rightarrow$ 273 + 27 = 300 K,
$\therefore$ Molecular weight of oxygen = 32×10^{-3}kg,

$R = 8.31\ J\ mol^{-1}\ K^{-1}$

Now, r.m.s. velocity is

$$V = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.31 \times 300}{32 \times 10^{-3}}} = 483.5\ ms^{-1}$$

Ex.14 Calculate the kinetic energy of a gram molecule of argon at 127ºC.

Sol. Temperature, T = 127ºC = 273 + 127 = 400 K,

R = 8.31 J/mol K

Now, K.E. per gram molecule of argon

$$= \frac{3}{2}RT = \frac{3}{2} \times 8.31 \times 400\ J = 4986\ J$$

QUESTIONS FOR PRACTICE

Q.1 The ratio of number of collision per second at the walls of containers by H_2 and Ne gas molecules kept at same volume and temperature (Hint : $f_c = V_{rms}/2\ell$)

[**Ans.** $\sqrt{10} : 1$]

Q.2 At what temperature will rms velocity of O_2 molecules be equal to that of H_2 at 200 K.
[**Ans.** 3200 K]

Q.3 If $\frac{(V_{rms})He}{(V_{rms})H} = \frac{5}{7}$ and temperature of H_2 is 0ºC then the temperature of He will be.
[**Ans.**5.5º C]

Q.4 What should be temp of O_2 gas molecules from escaping the earth.
[**Ans.** T_{O_2} = 16 × 10^4 K]

Q.5 If speeds of 3 molecules are 0.5, 1 & 2m/sec. respectively then ratio of their root mean square speed and the average speed is.
[**Ans.** 1.1 : 1]

Q.6 The rms velocity of smoke particles of mass 3 × 10^{-17}kg. at 27º C in m/sec. is.
[**Ans.** 2 × 10^{-2} m/sec.]

Q.7 If at STP velocity of sound in a gas is 400 ms^{-1} (γ = 1.5), then what will be the rms velocity of gas molecules at NTP.
[**Ans.** $400\sqrt{2}$ m/sec^{-1}]

Q.8 When gas temperature becomes twice by heating then gas dissociate from molecular form to atomic form. What will be the effect on v_{rms}.
[**Ans.** $v'_{rms} = 2v_{rms}$]

Q.9 At what temperature will the average velocity of oxygen molecules be sufficient so as to escape from the earth ? Escape velocity of earth is 11.0 kms^{-1}
[**Ans.** 1.56 × 10^5 K]

Q.10 An electric bulb of volume 250 cm^3 has been sealed at a pressure of 10^{-3} mm of mercury and temperature 27ºC. Find the number of air molecules in the bulb.
[**Ans.** 80 × 10^{14}]

Q.11 The temperature of a gas is –68ºC. To what temperature should it be heated so that (i) the average kinetic energy of the molecules be doubled, (ii) the root mean square velocity of the molecules be doubled ?
[**Ans.** (i) 137ºC, (ii)547ºC]

Q.12 Calculate for hydrogen at 27ºC : (i) kinetic energy of one gram-molecule of the gas, (ii) kinetic energy of one gram gas and (iii) root mean square velocity of the molecules.
[**Ans.** (i) 3.74 × 10^3 J, (ii) 1.87 × 10^3J (iii) 1933.73 ms^{-1}]

8 MAXWELL'S LAW OF EQUIPARTITION OF ENERGY

The total kinetic energy of a gas molecules is equally distributed among its all degree of freedom and the energy associated with each degree of freedom at absolute temperature T is 1/2 KT

Special point:-

1. At T = 0K, energy of each degree of freedom is 0,

2. AT TK, energy of each degree of freedom is KT/2.
3. If 'f' is the degree of freedom per molecule for a gas, then
   (i) Total energy of each **molecule** = fKT/2
   (ii) Total energy per **mole** of gas = fRT/2
4. For 'μ' mole of a gas

   Internal energy at temperature TK is $U = \frac{\mu f R T}{2} = \mu C_v T$

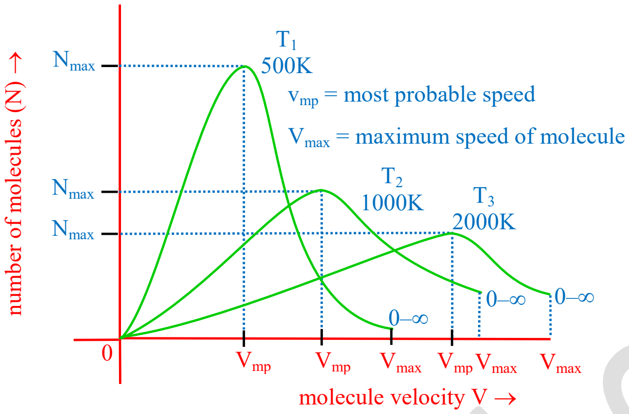
Imp.

5. Change is internal energy is given by

   $\Delta U = \frac{\mu f R}{2}(\Delta T) = \mu C_v \Delta T$

   This change is process independent.

9 MAXWELL'S LAW OF DISTRIBUTION OF VELOCITIES



Special point:-

1. At any given temperature graph drawn in between molecular velocity & number of molecules is known as velocity distribution curve (v.d.c.)
2. The velocities of molecules of a gas are in between zero and infinity (0 – ∞)
3. With the increase in the temperature, the most probable velocity and maximum molecule velocity are increases.
4. The number of molecules within certain velocity range is constant although the velocity of molecule changes continuously at particular temperature
5. The area enclosed between the (N-v) curve and the velocity axis presents the total number of molecules.

Special Conclusion:-

On the basis of velocity distribution Maxwell's gives the law of equipartition of energy for gases of any temperature

10 MEAN FREE PATH OF GAS MOLECULES

"The distance between any two consecutive collision is called free path. The average distance travelled by a molecule between successive collision is called the mean free path".

PMT→ 95

$\lambda_m = \frac{1}{\sqrt{2}\pi d^2 n}$ | d = diameter of molecule

$\lambda_m = \dfrac{m}{\sqrt{2}\pi d^2 (mn)}$ d = molecular density $n = \dfrac{N}{V}$

$\lambda_m = \dfrac{m}{\sqrt{2}\pi d^2 \rho}$ ρ = density of gas $= \rho = \dfrac{M}{V} = \dfrac{mN}{V} = mn$

$\lambda_m = \dfrac{V}{\sqrt{2}\pi d^2 N}$ $PV = NKT \Rightarrow \dfrac{V}{N} = \dfrac{KT}{P}$

$\lambda_m = \dfrac{KT}{\sqrt{2}\pi d^2 P}$

Special point:-

1. At equal temperature pressure condition mean free path will be maximum for molecule of lightest gas (H_2)
2. By increasing amount of gas in a container of definite volume then λ_m decreases.
3. If pressure reduces by taken out some gas from container then λ_m increases.

Specific Coefficient of gas:-

1. Thermal conductivity coefficient $K = \dfrac{1}{3} C_v \rho v_{rms} \lambda_m$
2. Viscosity coefficient of gas $n = \dfrac{1}{3} \rho v_{rms} \lambda_m$

$$\boxed{\lambda_m \propto \frac{1}{v_{rms}}}$$

3. diffusion coefficient of gas $D = \dfrac{1}{3} v_{rms} \lambda_m$

11 REAL GAS

(A) Vanderwaal's Equation:- (For real gas)

Ideal gas equation PV = RT

two correction are made in ideal gas model

1. **Volume correction (Due to finite size of molecules):-**
   $V_{real} = V - b$
   b = decrease in volume for 1 mole gas
2. **Pressure correction (Due to inter molecular forces):-**
   (i) Pressure decreases α $(\text{density})^2$
   (ii) $P_{real} = \dfrac{RT}{V-b} - \dfrac{a}{V^2}$

$$\boxed{\left(P_{real} + \frac{a}{V^2}\right)(V_{Ideal} - b) = RT}$$

$\rightarrow$ For one mole real gas

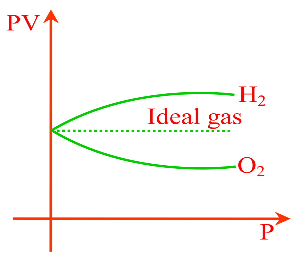
$$\boxed{\left(P_{real} + \frac{a}{V^2}\right)(V_{Ideal} - \mu b) = \mu RT}$$

$\rightarrow$ For μ mole of real gas

$b \rightarrow m^3 \rightarrow M^0L^3T^0$ a

$a \rightarrow Nm^4 \rightarrow ML^5T^{-2}$ (a & b Vanderwaal's gas constant)

(B) Amaghat Experiment:-



At low temperature and high pressure gases shows deviation from Boyle's law.
Graphs are drawn between PV and P at 0ºC for H_2 and O_2

Conclusions:-

(1) All real gases shows deviation at high pressure and low temperature, deviation of CO_2 gas is max.

*(2) According to **Amaghat** every real gas has definite and specific temperature at which it follows Boyle's law this is known as Boyle's temperature of real gas*

Boyle's coefficients :-

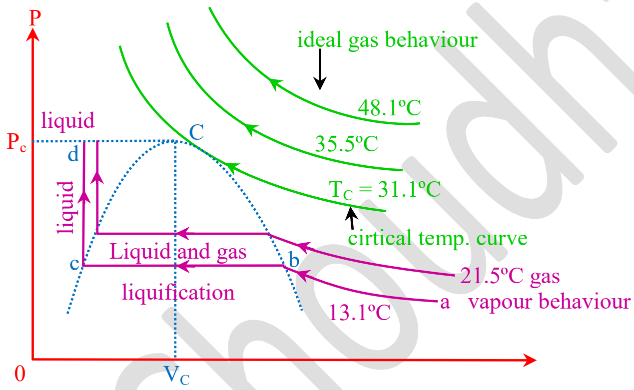
$T_B > T_C$ *[T_B = Boyle's temperature,*

T_C = Critical temperature] $T_B = \frac{a}{Rb}$ *where a & b are Vanderwaal's constant for real gas.*

(C) Dr. Andrewz's Experiment:- (Isothermal curve of real gas)

Dr. Andrewz drawn graphs in between volume and pressure for different constant temperature and curves are obtained these curves are known as isothermal curve

Example:- CO_2 curves at different temperature



(Isothermal curves for CO_2 gas at different temperature)

Special points:-

(1) By meeting edge of horizontal part of these curve parabola is obtained. It peak point is known as critical point

(2) Thermodynamic element corresponding to critical point is known as critical parameters (T_C, V_C, P_C)

(i) **Critical temp (T_C)-** It is that temperature below which a gas can be liquified only by increase in pressure and above which no liquification is possible whatever the pressure may be increased.

Real gas		T_C
He	→	–268ºC
H_2	→	–240ºC
N_2	→	–147ºC
O_2	→	–118ºC
CO_2(CPMT-94)	→	31.1ºC
Steam	→	+365ºC

(ii) **Critical pressure:-(P_C)**

Minimum pressure required to liquiefy a gas when it is at critical temperature is called critical pressure

For He P_C = 2 atmospheric pressure
For CO_2 P_C = 76 atmospheric pressure
For O_2 P_C = 49.7 atmospheric pressure

(iii) **Critical volume:-(V_C)**

At critical pressure and temperature the volume of one mole of gas is called its critical volume (V_C).Critical volume for CO_2 gas = 95×10^6 m^3

Special Results:

1. $V_C = 3b$; $T_C = \frac{8a}{27Rb}$; $P_C = \frac{a}{27b^2}$; $\qquad T_C = \frac{8}{27} T_B$

2. $\frac{P_C V_C}{RT_C} = \frac{3}{8}$

3. **Critical element of gas are derive from vanderwall's gas equation at critical position for which.**

$$\left(\frac{dP}{dV}\right)_{critical} = 0$$

At critical point, slope of the graph is zero.

Sp. Results for Real gas:-

1. All real gases follow Vanderwaal's gas equation at every possible temperature and pressure so these are known as vanderwaal's gases.
2. At a given temperature volume and pressure for real gas are comparatively low than for ideal gas.
3. Internal energy of real gas depends upon its temperature pressure and volume If $\Delta U \rightarrow$ Change in Internal energy

$\mu = 1$ mole
- Ideal gas: $\Delta U = C_v \Delta T$, $U = f(T)$
- Real gas: $(\Delta U)_{Real} = C_v \Delta T + \frac{a}{V^2} \Delta V$, $U_{Real} = f(T, P, V)$

4. Internal Energy of Real gas is always (–ve) at absolute zero temperature.
5. Specific heat of Real gas increases By increasing temperature and decreases By decreasing temperature

12 SPECIAL POINT FOR IDEAL GAS

(1) A gas which follows all gas laws and gas equation at every possible temperature and pressure is known as **ideal** or **perfect gas**.

(2) Molecule of gas can do only and only translational Motion and kinetic energy related to this is known as **translational kinetic energy**. $E_{trans} \propto T$

(3) **Potential energy** of ideal gas is **zero**. So internal energy of ideal gas is perfectly translational K.E. of gas. It is directly proportional to **absolute temperature**. So, internal energy depends only its temperature.

For a substance $U = U_{kinetic} + U_{potential}$

U_{KE} – depends only on temperature,

U_{PE} – depends upon intermolecular forced (Always (–) Ve)

Note:- By taking same amount of mono atomic gas and diatomic gas and same heat energy is given then rise in temp of mono atomic gas is comparatively more.

$(\Delta T)_{Mono} > (\Delta T)_{dia} > (\Delta T)_{tri}$ –

$\because f = 3 \rightarrow$ for monoatomic (100% trans)

$f = 5 \rightarrow$ for diatomic (60% T + 40% R)

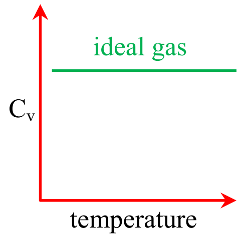
$E_{Trans} \propto T$

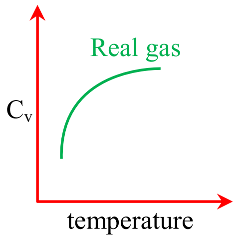
$f = 7 \rightarrow$ for triatomic (T : R : V : : 3 : 2 : 2)

$E_{Trans} \propto T$

4. According to Dr. **Andrewz ideal** gas cannot be liquidified and solidified. There are **no critical elements** for ideal gas (T_c, P_c, & V_c)
Critical Temperature for CO_2 gas = 31.1ºC

5. **Specific heat** of ideal gas is **constant** quantity and it does not change with temperature





Imp.6. *All real gases behaves as **ideal gas** at **high temperature** and **low pressure**.*

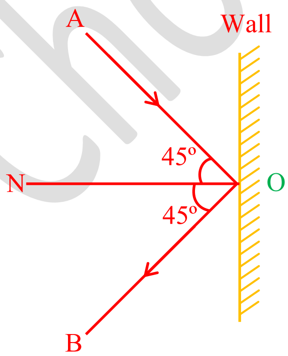
7. *Volume expansion coefficient (α) and pressure expansion coefficient (β) is same for a ideal gas and value of each is 1/273 per ºC*
$\alpha = \beta$ = 1/273 per ºC

8. *Gas molecule have point mass and negligible volume and velocity is very high (10^7 cm./sec.)*

Examples based on Ideal Gas

Ex.1 The mass of hydrogen molecules is 3.32×10^{-27}kg. If 10^{23} hydrogen molecules strike a fixed wall of area 2 cm^2 at an angle 45º to the normal and rebound elastically with a speed of 10^3m/s calculate the pressure exerted on the wall –
(1) 2.347×10^3 N/m^2 (2) 23.47×10^4 N/m^2
(3) 234.7×10^3 N/m^2 (4) 23.47×10^3 N/m^2

Sol.[1]



The molecule strikes the wall along AO and rebound along OB such that

$$\angle AON = \angle NOB = 45º$$

The change in component momentum of each H_2 molecule in a perpendicular direction the wall
= $\Delta P = 2\, mv \cos\theta$,
where mv = momentum of molecule
$\therefore$ $\Delta P = (3.32 \times 10^{-27}) \times 10^3 \cos 45º$
$\Rightarrow$ $\Delta P = 4.692 \times 10^{-24}$ kg m/sec
Force exerted by N molecules on the wall
= $\Delta P \times N$
if A is the area of the wall on which the molecule strike, then pressure

$$P = F/A = \frac{N \times \Delta P}{A} = \frac{10^{23} \times 4.692 \times 10^{24}}{2 \times 10^{-4}}$$
$$= 2.347 \times 10^3 \text{ N/m}^2$$

Ex.2 Two ideal gases at temperature T_1 and T_2 are mixed. There is no loss of energy. If the masses of molecules of the two gases are m_1 and m_2 and number of their molecules are n_1 and n_2 respectively, the temperature of the mixture will be

(1) $\frac{T_1+T_2}{n_1+n_2}$ (2) $\frac{T_1}{n_1}+\frac{T_2}{n_2}$

(3) $\frac{n_2T_1+n_1T_2}{n_1+n_2}$ (4) $\frac{n_1T_1+n_2T_2}{n_1+n_2}$

Sol.[4] Total energy of molecules of first gas

$$= \frac{3}{2} n_1 K T_1$$

Total energy of molecules of second gas

$$= \frac{3}{2} n_2 KT_2$$

Total energy of molecules of mixture

$$= \frac{3}{2} K (n_1T_1 + n_2T_2)$$

$\therefore$ $\frac{3}{2}(n_1 + n_2) KT = \frac{3}{2} K(n_1T_1 + n_2T_2)$

$\Rightarrow T = \frac{n_1T_1+n_2T_2}{(n_1+n_2)}$

Ex.3 The atomic weight of iodine is 127. A standing wave in a tube filled with iodine gas at 400 K has nodes that are 6.77cm apart when the frequency is 1000 vib/sec. iodine is

(1) Monoatomic (2)Diatomic

(3) Triatomic (4) None of these

Sol.[2] $\therefore$ $\lambda = 2 \times 6.77$ cm = 13. 54cm

$v = n\lambda = 1000 \times 13.54 = 1.354 \times 10^4$cm/sec.

we know that

$v = \sqrt{\frac{VR}{T/M}}$ where molecular weight

M = Ax with x = 1 if iodine is monoatomic x = 2 it diatomic and A is atomic weight

$\therefore$ $\gamma = \frac{Axv^2}{RT} = 0.7x$

Where x = 2 as iodine is diatomic

$\therefore$ $\gamma = 1.4$ (right value of diatomic gas)

Ex.4 Certain perfect gas is found obey $PV^{3/2}$ = const. during adiabatic process. If such a gas at initial temperature T is adiabatically compressed to half the initial volume, in final temperature will be –

(1) $\sqrt{2}$ T (2) 2T

(3) $2\sqrt{2}$ T (4) 4T

Sol.[1] $\therefore$ $PV^{3/2}$ = constant

(given)

Put $P = \frac{nRT}{V}$

$\therefore$ $\left(\frac{nRT}{V}\right)(V^{3/2})$ = constant

When V changes to V/2 the temperature becomes $\sqrt{2}$ T.

Ex.5 In a certain process the pressure of one mole ideal gas varies with volume according to the relation $P = \frac{a}{\left[1+\left(\frac{V}{b}\right)^2\right]}$, where a, b are constants, when the volume of gas V = b, then temperature of the gas will be -

(1) $\frac{ab}{2R}$ (2) ab/R
(3) ab (4) zero

Sol.[1] $\therefore$ $T = \frac{PV}{R}$

at $V = b, P = \frac{a}{(1+1)} = \frac{a}{2}$

$\therefore$ $T = \frac{ab}{2R}$

Ex.6 An air bubble of volume V_0 is released by a fish at a depth h in a lake. The bubble rises to the surface. Assume constant temperature and standard atmospheric pressure above the lake. The volume of the bubble just before touching the surface will be (density) of water is ρ
(1) V_0 (2) $V_0(\rho gh/P)$
(3) $\frac{V_0}{\left(1+\frac{\rho gh}{P}\right)}$ (4) $V_0\left(1+\frac{\rho gh}{P}\right)$

Sol.[4] As the bubble rises the pressure gets reduced for constant temperature, if P is the standard atmospheric pressure, then

$(P + \rho gh) V_0 = PV$

or $V = V_0\left(1+\frac{\rho gh}{P}\right)$

Ex.7 Two gases occupy two containers A and B the gas in A, of volume $0.10 m^3$, exerts a pressure of 1.40 MPa and that in B of volume $0.15 m^3$ exerts a pressure 0.7 MPa. The two containers are united by a tube of negligible volume and the gases are allowed to intermingle. Then it the temperature remains constant, the final pressure in the container will be (in MPa) –
(1) 0.70 (2) 0.98
(3) 1.40 (4) 2.10

Sol.[2] We Know that

$P_AV_A = n_ART, P_BV_B = n_B RT$

and $P_f (V_A + V_B) = (n_A + n_B) RT$

$P_f (V_A + V_B) = P_AV_A + P_BV_B$

$\therefore$ $P_f = \left(\frac{P_AV_A + P_BV_B}{V_A + V_B}\right)$

$= \frac{1.4\times0.1+0.7\times0.15}{0.1+0.15}$ MPa

= 0.98 MPa

Ex.8 If the pressure of a gas contained in a closed vessel is increased by 0.5% when heated by 2ºC, then the initial temperature must be
(1) 127ºC (2) 273ºC
(3) 400ºC (4) 673ºC

Sol.[1] Using PV = nRT, we note that

$P_1V = nRT_1$

$P_1 (1.005)V = nR (T_1 + 2)$

(note $\Delta P = P_2 - P_1 = 0.005 P_1$ and

$\Delta T = 2ºC = 2K$

Dividing we get $1.005 = \frac{T_1+2}{T_1}$

or $0.005T_1 = 2 \Rightarrow T_1 = 400$

Thus in 0ºC, $t_1 = 400 - 273 = 127ºC$.

Ex.9 What is the degree of freedom of gas ? If at STP the velocity of sound in it is 330 m/sec and gas density = 1.3 mg/cm^3.

(1) 2 (2) 3
(3) 5 (4) 4

Sol. [3] $\therefore \quad v = \sqrt{\frac{\gamma P}{\rho}}$

$P = 1.013 \times 10^5\ N/m^2$, $\rho = 1.3 kg/m^3$, $v = 330$ m/s

$$\gamma = \frac{v^2 P}{\rho} = 1.4$$

Let f be the number of degree of freedom then

$C_v = f\,R/2$ and $C_p = fR/2 + R = R\,(1 + f/2)$

$$\therefore \quad \gamma = \frac{C_P}{C_V} = \frac{2+f}{f} = 1.4$$

$\Rightarrow$ (f = 5)

Ex.10 A closed container of volume 0.02 m^3 contains a mixture of neon and argon gases at temperature of 27ºC and pressure of $1 \times 10^5\ Nm^2$. The total mass of the mixture is 28 g. If the gram molecular weights of neon and argon are 20 and 40 respectively, find the masses of the individual gases in the container, assuming them to be ideal. Given R = 8.314 J/mol/K.

Sol. Let m g be the mass of neon. Then, the mass of argon is (28 – m)g.

Total number of moles of the mixture,

$$\mu = \frac{m}{20} + \frac{28-m}{40} = \frac{28+m}{40} \quad ...(1)$$

Now, $\mu = \frac{PV}{RT} = \frac{1\times10^5 \times 0.02}{8.314\times300} = 0.8$ ...(2)

Equating (1) and (2), $\frac{28+m}{40} = 0.8$

or 28 + m = 32

or m = 4g mass of argon = (28 – 4)g = 24 g

Ex.11 Calculate the temperature of the Sun if density is 1.4 g cm^{-3}, pressure is 1.4×10^9 atmosphere and average molecular weight of gases in the Sun in 2 gm/mole Given R = 8.4 J $mol^{-1}K^{-1}$.

Sol. We know that PV = μRT or $T = \frac{PV}{\mu R}$ ...(1)

But $\mu = \frac{M}{M_w}$ and $\rho = \frac{M}{V}$

or M = ρV $\therefore$ $\mu = \frac{\rho V}{M_w}$

From equation (1), $T = \frac{PVM_w}{\rho VR} = \frac{PM_w}{\rho R}$

Given : $P = 1.4 \times 10^9$ atmosphere

$= 1.4 \times 10^9 \times 1.01 \times 10^5\ Nm^{-2}$

$\rho = 1.4\ g\ cm^{-3} = 1.4 \times 1000\ kg\ m^{-3}$,

$M_w = 2 \times 10^{-3}$ kg/mol

Substituting values,

$$T = \frac{1.4\times10^9 \times 1.01\times10^5 \times 2\times10^{-3}}{1.4\times1000\times8.4} K$$

$= 2.4 \times 10^7$ K

Ex.12 The speed of ten particles in ms^{-1} are
0, 1.0, 2.0, 3.0, 3.0, 3.0, 4.0, 4.0, 5.0 and 6.0. Find
(a) the average speed, (b) the root-mean square speed, and
(c) the most probable speed of these particles.

Sol. (a) The average speed is

$$\bar{v} = \frac{0+1.0+2.0+3.0+3.0+3.0+4.0+4.0+5.0+6.0}{10}$$

(b) The mean-square speed is

$$\bar{v}^2 = \frac{1}{10}[0 + (2.0)^2 + (1.0)^2 + (3.0)^2 + (3.0)^2 + (3.0)^2 + (4.0)^2 + (4.0)^2 + (5.0)^2 + (6.0)^2]$$

$= 12.5\ m^2\ s^{-2}$,

and the root-mean square speed is

$v_{rms} = \sqrt{12.5\ m^2 s^{-2}} = 3.5\ ms^{-1}$

(c) Of the ten particles, three have speed of $3.0\ ms^{-1}$, two have speed of $4.0\ ms^{-1}$ and each of the other five has a different speed. So the most probable speed of the particle is $3.0\ ms^{-1}$.

Ex.13 Calculate the total number of degrees of freedom possessed by the molecules in one cm^3 of H_2 gas at NTP.

Sol. 22400 cm^3 of every gas constains 6.02×10^{23} molecules

∴ Number of molecules in 1 cm^3 of H_2 gas

$= \frac{6.02 \times 10^{23}}{22400} = 0.26875 \times 10^{20}$

Number of degrees of freedom of a H_2 gas molecule = 5

∴ Total number of degrees of freedom of $0.26875 \times 10^{20} \times 5 = 1.34375 \times 10^{20}$.

Ex.14 A vessel of volume $8.0 \times 10^{-3}\ m^3$ contains an ideal gas at 300 K and 200 kPa. The gas is allowed to leak till the Pressure falls to 125 kPa. Calculate the amount of the gas (in moles) leaked asssming that the temperature remains constant.

Sol. As the gas leaks out, the volume and the temperature of the remaining gas do not change. The number of moles of the gas in the vessel in given by $n = \frac{PV}{RT}$. The number of moles in the vessel before the leakage is,

$n_1 = \frac{P_1 V}{RT}$

and that after the leakage is,

$n_2 = \frac{P_2 V}{RT}$

Thus, the amount leaked is,

$n_1 - n_2 = \frac{(P_1 - P_2)V}{RT}$

$= n_1 - n_2$

$= \frac{(200-125)\times 10^3 N/m^3 \times 8.0 \times 10^{-3} m^3}{(8.3 J/mol-K)\times(300K)}$

Ex.15 At the top of a mountain a thermometer reads 7ºC and barometer reads 70 cm of Hg. At the bottom of the mountain they read 27ºC and 76 cm of Hg respectively. Compare the density of the air at the top with that at the bottom.

Sol. According to gas equation = $PV = \mu RT$

PV = $\frac{M}{M_w}RT$ $\left[\text{as } \mu = \frac{M}{M_w}\right]$

or $\frac{P}{\rho T} = \frac{R}{M_w}$ $\left[\text{as} \frac{M}{V} = \rho\right]$

Now as M and R are same for top and bottom

$\left(\frac{P}{\rho T}\right)_T = \left(\frac{P}{\rho T}\right)_B$ i.e., $\frac{\rho_T}{\rho_B} = \frac{P_T}{P_B} \times \frac{T_B}{T_T}$

So $\frac{\rho_T}{\rho_B} = \frac{70}{76} \times \frac{300}{280} = \frac{75}{76}$ = 0.9868

Ex.16 During an experiment an ideal gas is found to obey an additional law VP^2 = constant. The gas is initially at temperature T and volume V. What will be the temperature of the gas when it expands to a volume 2V.

Sol. According to given problem VP^2 = constant. So gas equation PV = μRT in the light of above (eliminating P) yields.

$\left(\frac{K}{\sqrt{V}}\right)V = \mu RT$, i.e., $\sqrt{V} = \frac{\mu R}{K}T$

$\therefore$ $\frac{\sqrt{V_1}}{\sqrt{V_2}} = \left(\frac{T_1}{T_2}\right)$ i.e., $\frac{\sqrt{V}}{\sqrt{2V}} = \frac{T}{T'}$

or T ' = $(\sqrt{2})T$

Ex.17 The specific heat of argon at constant volume is 0.075 kcal/kg K. Calculate its atomic weight, [R = 2cal/mol K]

Sol. As argon is monatomic, its molar specific heat at constant volume will be

$C_V = \frac{3}{2}R = \frac{3}{2}2 = 3$ cal/mol K

Now as $C_V = Mc_V$ with C_V = 0.075 cal/gK

3 = M × 0.075

$M_w = \frac{3}{0.075}$ = 40 gm/mole

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1

Q.1 The gas molecules are not accumulated at the bottom of the container because -
(1) These do not have gravitation force between them
(2) Molecules have less mass and high velocities and therefore no gravitational force
(3) The direction of motion of molecules is changing on account of collisions.
(4) These is cohesive force between the gas molecules and the wall of the container acting in all direction.

Q.2 In kinetic theory of gases, it is assumed that molecules -
(1) Have same mass but can have different volume
(2) Have same volume but masses can be different.
(3) Have both mass and volume different
(4) Have same mass but negligible volume.

Q.3 The postulates of kinetic theory will be true if the number of molecules be -
(1) Any
(2) Very large
(3) Very small
(4) Avogadro's number

Q.4 When two molecules of a gas come closer then -
(1) Their direction get changed
(2) There exists a force of attraction
(3) There exist a force of repulsion
(4) Kinetic energy is not conserved.

Q.5 Which of the following statement is not according to the postulates of kinetic theory of gases.-
(1) Gas molecules are of small size
(2) Gas molecules are always in motion with all possible velocities
(3) There is no force between the molecules
(4) None of these

Q.6 The molecular weight of O_2 and H_2 are 32 and 2 respectively. Then the ratio of the rms velocities of H_2 and oxygen is -
(1) 4 : 1 (2) 2 : 3 (3) 1 : 4 (4) 16 : 1

Q.7 Two vessels which have same volume are filled with H_2 and He respectively and at 1 and 2 atmospheric pressure. If temperature of both vessels is same then mean velocity of H_2 molecule is how many times the mean velocity of helium -
(1) Equal (2) Double
(3) Half (4) $\sqrt{2}$ times

Q.8 If velocities of 5 molecules of certain gas are –7, 5, 4, –3 and 1 m/sec respectively then mean speed of molecules is (m/sec) -
(1) Zero (2) 20 (3) 4 (4) $\sqrt{20}$

Q.9 If the rms speed of the nitrogen molecules of the gas at room temperature is 500 m/s, then the rms speed of the hydrogen molecules at the same temperature will be -
(1) 1870 m/s (2) 1935 m/s
(3) 7000 m/s (4) 83.7 m/s

Q.10 The rms velocity of molecules of a gas at temperature T is v_{rms}. Then the root mean square of the component of velocity in any one particular direction will be -
(1) $v_{rms}/\sqrt{3}$ (2) $\sqrt{3}\ v_{rms}$ (3) $v_{rms}/3$ (4) $3v_{rms}$

Q.11 The root mean square speed of molecules of ideal gases at the same temperature are -
(1) The same
(2) Inversely proportional to the square root of the molecular weight.
(3) Directly proportional to molecular weight.
(4) Inversely proportional to the molecular weight.

Q.12 The temperature of an ideal gas is increased from 27ºC to 927ºC. The rms speed of its molecules becomes -
(1) Twice (2) Half
(3) Four times (4) One fourth

Q.13 At what temperature rms speed of gaseous hydrogen molecules equal to that of oxygen molecules at 47ºC -
(1) 20 K (2) 80 K (3) –73 K (4) 3 K

Q.14 At what temperature, pressure remaining unchanged will the rms. velocity of hydrogen molecule be twice its value at S.T.P.?
(1) 1000K (2) 1050 K
(3) 1092 K (4) 2010K

Q.15 The speed sound in a gas is v the rms velocity of gas molecules is (c), if $C_p/C_v = \gamma$ for the gas then the ratio of v to c is -
(1) $3/\gamma$ (2) $\gamma / 3$
(3) $\sqrt{3/\gamma}$ (4) $\sqrt{\gamma/3}$

Q.16 A sample of gas is at 0ºC. The temperature at which its rms speed of the molecules will be doubled is -
(1) 103ºC (2) 273ºC
(3) 723ºC (4) 819ºC

Q.17 The mass of an oxygen molecule is about 16 times that of hydrogen molecules. At room temperature, the rms speed of oxygen molecule is v. The rms speed of the hydrogen molecule at the same temperature will be -
(1) v/6 (2) v/4 (3) 4v (4) 16v

Q.18 RMS velocity of which of the following gas at a given temperature is minimum -
(1) O_2 (2) N_2 (3) Cl_2 (4) He

Q.19 At 0ºC temperature root mean square speed of which of the following gases be maximum –
(1) H_2 (2) N_2 (3) O_2 (4) SO_2

Q.20 The root mean square velocity of the molecules of an ideal gas is -
(1) $\sqrt{RT/M}$ (2) $\sqrt{3RT/TM}$
(3) $\sqrt{3RT/M}$ (4) $\sqrt{RT/3M}$

Q.21 N_2 molecule is 14 times heavier than a H_2 molecule. At what temperature will the rms speed of H_2 molecules be equal to that of N_2 molecule at 27ºC -
(1) 50ºC (2) 2ºC
(3) 21.4ºC (4) 21.4 K

Q.22 Equal masses of H_2 , He having molecular weight of 2 and 4 respectively are filled at same temperature in two containers of equal volumes. If H_2 gas has a pressure of 4 atmospheres, then He gas will have pressure as -
(1) 1 atmosphere (2) 4 atmosphere
(3) 2 atmosphere (4) 8 atmosphere

Q.23 The ratio of number of collisions per second at the wall of containers by H_2 and Ne gas molecules kept at same volume and temperature is given by -
(1) 10 : 1 (2) 1 : 10
(3) $1 : \sqrt{10}$ (4) $\sqrt{10} : 1$

Q.24 The mass of a gas molecules is 4×10^{-30} kg. If such 10^{23} molecules per second strikes onto $4m^2$ area with velocity 10^7 m/sec, then the exerted pressure will be -
(1) 1 dyne/cm^2 (2) 1 N/m^2
(3) 2 N/m^2 (4) 2 dyne/cm^2

Q.25 The mass of hydrogen molecules is 3.32×10^{-24} gm. If 10^{23} H_2 molecules strike 2 sq. cm are per second with velocity of 10^5 cm/sec at an angle of 45º to the normal to wall, then the exerted pressure will be -
(1) 2.35 N/m^2 (2) 23.5 N/m^2
(3) 235 N/m^2 (4) 2350 N/m^2

Q.26 Molecules of a gas of mass m and velocity $\vec{v}$ after colliding normally with the wall change in momentum of the molecule will be -
(1) mv (2) 2mv (3) – mv (4) – 2mv

Q.27 If some gas has pressure P then pressure exerted by molecules along x direction will be -
(1) P (2) P/2 (3) P/3 (4) P/6

Q.28 When a gas is forced in a smaller volume without change in temperature, its pressure increases because its molecules -
(1) Strike the unit area of the container walls more often.
(2) Strike the unit area of the container walls at higher speed.
(3) Strike the unit area of the container wall with greater force.
(4) Have more energy.

Q.29 In a cubical box of volume V, there are N molecules of a gas moving randomly. If m is mass of each molecule and v^2 is the mean square of x component of the velocity of molecules, then the pressure of the gas is -
(1) $P = \frac{1}{3}\frac{mNv^2}{V}$ (2) $P = \frac{mNv^2}{V}$
(3) $P = \frac{1}{3}mNv^2$ (4) $P = mNv^2$

Q.30 Gas exerts pressure on the walls of the container because the molecules are -
(1) Colliding with each other and exchanging momenta.
(2) Colliding with the walls of the container and transferring energy to the walls.
(3) Colliding with the walls and transferring momentum to the walls of the container.
(4) Accelerated towards the walls.

Q.31 Pressure exerted by a gas is -
(1) Independent of density of the gas.
(2) Inversely proportional to the density of the gas.
(3) Directly proportional to the density of the gas.
(4) Directly proportional to the square root of the density of the gas.

Q.32 The pressure of a gas increases on raising the temperature of a given gas in a container because -
(1) The average velocity of molecules increase so that per second the number of collisions on the wall increases.
(2) The mass of molecules increases
(3) The molecules get smaller time to remain in contact with the wall
(4) There is a loss of energy in each collisions of the molecules

Q.33 Two containers are of equal volume. One contains O_2 while the other has H_2. Both are kept at same temperature. The ratio of their pressure will be (rms velocity of these gases have ratio as 1 : 4) for 1 mole of each gas -
(1) 1 : 1 (2) 1 : 4 (3) 1 : 8 (4) 1 : 2

Q.34 O_2 is 16 times heavier that H_2. If at same temperature the O_2 molecules have average kinetic energy E than at the same temperature the average kinetic energy of H_2 molecules will be -
(1) E/4 (2) 4E (3) E (4) E/16

Q.35 The average translational kinetic energy of 10 gram H_2 at 27 º C is -
(1) 37250 J (2) 18675 J
(3) 12450 (4) 3737 J

Q.36 At 27ºC, the average total energy of O_2 molecule is approximately -
(1) 6×10^{21} J (2) 10×10^{-21} J

(3) 6×10^3 J (4) 6×10^{-23} J

Q.37 If the total translational kinetic energy of H_2 molecules is 7.5×10^3 J for the filled in a container of 10 litre capacity, then the pressure will be in Nm^{-2} -
(1) 5×10^2 (2) 3×10^2
(3) 2×10^2 (4) 5×10^5

Q.38 Degree of freedom of a monoatomic gas due to its rotational motion will be -
(1) 3 (2) 5 (3) 0 (4) 6

Q.39 Degree of freedom of hydrogen and ozone gases will be respectively -
(1) 3 and 5 (2) 5 and 6
(3) 6 and 5 (4) 5 and 3

Q.40 Mean translational kinetic energy of each degree of freedom of one molecule of a gas will be -
(1) RT/2 (2) kT/2 (3) 3RT/2 (4) 3RT/2

Q.41 The value of rotational K.E. at temperature T of one gram molecule of a diatomic gas will be-
(1) RT (2) 3RT/2
(3) 5RT (6) RT/2

Q.42 CO_2 is linear triatomic molecule. The average K.E. at temperature T will be -
(1) 3kT/2 (2) 5kT/2
(3) 6kT/2 (4) 7kT/2

Q.43 The kinetic energy of rotation of diatomic gas at 27º C will be ($k = 1.38 \times 10^{-23}$ Joule/K) -
(1) 2.07×10^{-21} Joule/molecule
(2) 4.14×10^{-21} Joule/molecule
(3) 6.14×10^{-23} Joule/molecule
(4) 3.07×10^{-23} Joule/molecule

Q.44 The gases are at the absolute temperature 300K and 350K respectively. The ratio of average kinetic energy of their molecules -
(1) 7 : 6 (2) 6 : 7
(3) 36 : 49 (4) 49 : 36

Q.45 Mean kinetic energy of one gram helium at 27º C will be -
(1) 3527×10^{-7} Joule
(2) 6×10^{-18} Joule
(3) 933×10^{-3} Joule
(4) 933.7 Joule

Q.46 The pressure of a gas is P N/m^2. The mean kinetic energy of one gram - mole gas at NTP (in joule) will be -
(1) 3.36×10^{-2} P (2) 3/2 P
(3) 2.24×10^{-2} P (4) 3.36 P

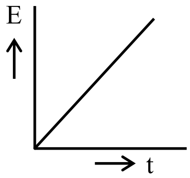
Q.47 CO_2 (O–C–O) is a triatomic gas. Mean kinetic energy of one gram gas will be –
(If N - Avogadro number, k - Boltzmann constant and molecular weight of CO_2 = 44) -
(1) 3/88 N k T
(2) 5/88 N k T
(3) 6/88 N k T
(4) 7/88 N k T

Q.48 The kinetic energy of gas molecules at 300 K is 75 joule. This energy at 500 K will be -
(1) 125 Joule (2) 208 Joule
(3) 270 Joule (4) 375 Joule

Q.49 In a container the number of hydrogen molecules is double of the number of oxygen molecules. Both gases are at a temperature 300 K. The ratio of mean kinetic energy per molecule of these gas molecules will be -

(1) 1 : 1 (2) 2 : 1
(3) 1 : 4 (4) 1 : 8

Q.50 The graph which represent the variation of mean kinetic energy of molecules with temperature tºC, is -

(1)


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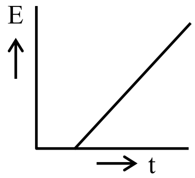

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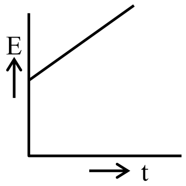

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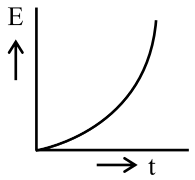


Q.51 The average translational kinetic energy of molecule of ideal gas at 47ºC will be -

(1) 0.41×10^{-2} eV (2) 4.1×10^{-2} eV
(3) 0.41×10^{-3} eV (4) 4.1×10^{-4} eV

Q.52 If the number of molecules of hydrogen gas is double the number of molecules of oxygen gas, then the ratio of total kinetic energy of hydrogen and total kinetic energy of oxygen at 300 K is -

(1) 1 : 1 (2) 1 : 2
(3) 2 : 1 (4) 1 : 16

Q.53 n molecules of an ideal gas are enclosed in cubical box at temperature T and pressure P. If the number of molecules in the box is trippled then new temperature and pressure become T´ and P´ respectively, but the total energy of gas system remains unchanged, then -

(1) P = P´ and T = T´

(2) P = 3P´ and $T' = \frac{1}{3}T$

(3) P´ = 3P and T´ = T

(4) P´ = P and $T' = \frac{T}{3}$

Q.54 An 8 gram sample of a gas occupies 12.3 liters at a pressure of 40.0 cm Hg. Then the volume when the pressure is increased to 60.0 cm Hg will be at constant temperature -

(1) 18.45 L (2) 12.30 L
(3) 8.20 L (4) None

Q.55 The volume of a gas at 20ºC is 200 ml, if the temperature is reduced to –20ºC at constant pressure. Its volume will be -

(1) 172.6 ml (2) 17.26 ml
(3) 192.7 ml (4) 19.27 ml

Q.56 A perfect gas at 27ºC is heated at constant pressure so as to double its volume. The temperature of the gas will be -

(1) 300ºC (2) 327ºC (3) 600ºC (4) 54ºC

Q.57 It is required to double the pressure of helium gas, contained in a steel cylinder, by heating. If the initial temperature of helium be 27ºC the temperature up to which it ought to be heated is -

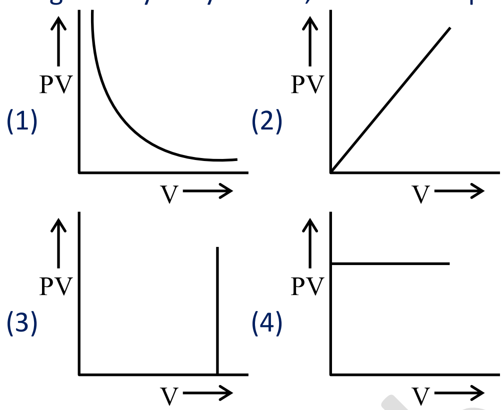
(1) 54ºC (2) 108ºC (3) 273ºC (4) 327ºC

Q.58 If pressure of a gas contained in a closed vessel is increased by 0.4%. When heated by 1ºC the initial temperature must be –
(1) 250 K (2) 250ºC (3) 2500K (4) 25ºC

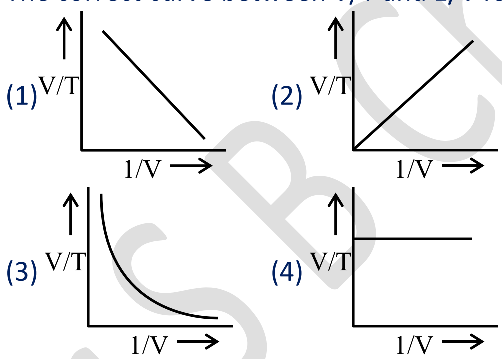
Q.59 The volumes of two vessels are 5 litre and 3 litre respectively. Air is filled in them at pressure of 3 atmos and 5 atmos respectively. At constant temperature if they are connected through a tube, the resultant pressure will be -
(1) 3.5 atmos (2) 3.75 atmos
(3) 4 atmos (4) 4.25 atmos

Q.60 A vessel of volume 5000 cm^3 contains (1/20) mole of molecular nitrogen at 1800 K. If 30% of the molecules are now dissociated the pressure inside the vessel in Pa will be -
(1) 1.49×10^5 (2) 1.94×10^5
(3) 2.25×10^5 (4) 3.78×10^5

Q.61 If a gas obeys Boyle's law, then the shape of graph between PV and V will be -



Q.62 The correct curve between V/T and 1/V for a gas at constant pressure is -



Q.63 For ideal gas equation PV = XT, X is proportional to -
(1) Absolute temperature
(2) Density of gas
(3) Number of molecules of the gas in container
(4) None of these

Q.64 The Boyle's law is stated by PV = k, k depends on -
(1) Nature of gas
(2) Atomic weight of gas
(3) Temperature of gas
(4) Quantity and temperature of gas

Q.65 For some ideals gas of given mass the equation PV/T = constant is true -
(1) Only when isothermal changes are taking place
(2) Only when adiabatic changes are taking place
(3) Only when isobaric variations are taking place

(4) When no changes are there in the gas parameters.

Q.66 A gas has thermodynamical variables P, V and T and is in container A. Another gas in container b has variables 2P, V/4 and 2T. The ratio of molecules in container A to B is -
(1) 4 : 1
(2) 2 : 1
(3) 1 : 2
(4) 1 : 1

Q.67 The size of container B is double that of A and gas in B is at double the temperature and pressure than that in A. The ratio of molecules in the two containers will then be -
(1) $\frac{N_B}{N_A} = \frac{1}{1}$ (2) $\frac{N_B}{N_A} = \frac{2}{1}$
(3) $\frac{N_B}{N_A} = \frac{4}{1}$ (4) $\frac{N_B}{N_A} = \frac{1}{2}$

Q.68 If Avogadro's number is 6×10^{23}, then approximate number of molecules in 1 cm^3 of water will be -
(1) 1×10^{23} (2) 6×10^{23}
(3) 22.4×10^{23} (4) $(1/3) \times 10^{23}$

Q.69 8 gm O_2, 14gm N_2 and 22gm CO_2 is mixed in a container of 10 litre capacity at 27ºC. The pressure exerted by the mixture in terms of atmospheric pressure will be -
(1) 1 (2) 3 (3) 9 (4) 18

Q.70 Two gases each having pressure P, volume V and temperature T are mixed so that mixture has volume V and temperature T, then the composite pressure will be -
(1) P (2) 2P (3) P/2 (4) 4P

Q.71 Two containers of equal volumes contain H_2 and O_2 at same temperature. If the number of molecules of these two gases is also equal than the ratio of pressure exerted by these will be -
(1) 1 : 1 (2) 4 : 1
(3) 8 : 1 (4) 16 : 1

Q.72 Some container contains on average 5 molecules/cm^3. If the gas has temperature of 3 K, then its pressure will be (N/m^2) -
(1) 2×10^{-15} (2) 2×10^{-16}
(3) 2×10^{-18} (4) 2×10^{-20}

Q.73 Real gas behaves like an ideal gas at -
(1) High temperature
(2) Low pressure
(3) High temperature and low pressure
(4) Low temperature and high pressure

Q.74 The constant 'a' in the equation $\left(P + n^2\frac{a}{V^2}\right)$ (V – nb) = n R T for a real gas has unit of -
(1) $N\text{-}m^{-4}$ (2) $N\text{-}m^{-2}$
(3) $N\text{-}m^2$ (4) $N\text{-}m^4$

Q.75 The unit of a × b in Vander Waal's equation is -

(1) N/m^2 (2) $N-m^7$
(3) $N-m^4$ (4) N/m^3

Q.76 The value of $\frac{RT_c}{P_cV_c}$ is -
(1) 8/3 (2) 3/8
(3) 2/7 (4) 1/2

Q.77 If the critical temperature of a gas is 100 K then its Boyle temperature will be -
(1) 337 K (2) 500 K
(3) 33.3 K (4) 103 K

Q.78 The temperature which the gas cannot be liquified by applying pressure alone, is called-
(1) Temperature of inversion
(2) Boyle temperature
(3) Neutral temperature
(4) Critical temperature

Q.79 The critical temperature of a Vander Waal's gas is -
(1) $\frac{a}{27b^2}$ (2) $\frac{3a}{8b}$
(3) $\frac{8a}{27Rb}$ (4) $\frac{8a}{3Rb}$

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2

Q.1 In the following table the number of molecules N_i moving with definite velocity v_i m/s are given -

v_i	1.0	2.0	3.0	4.0	5.0
N_i	2	4	6	8	2

The mean speed of particle is –
(1) 3.2 m/s (2) 4.4 m/s
(3) 5.2 m/s (4) 6.1 m/s

Q.2 In the above question, the root mean square speed of particle is -
(1) 2.8 m/s (2) 3.4 m/s
(3) 4.2 m/s (4) 5.4 m/s

Q.3 At a certain temperature a vessel of volume 1×10^{-3} m^3 has $3.0 \times 10^{+22}$ molecules of oxygen gas. The mass of a oxygen molecules is 5.3×10^{-26} kg and at the same temperature root mean square velocity of molecules is 400 m/s. The pressure of oxygen gas in the vessel is -
(1) 4.24×10^4 N/m^2 (2) 2.12×10^4 N/m^2
(3) 8.48×10^3 N/m^2 (4) 8.48×10^4 N/m^2

Q.4 A container is filled with one gram mole oxygen at a pressure of one atom and temperature 27ºC. It is assumed that molecules of the gas are moving with velocity v_{rms}, then v_{rms} will be -
(1 Atoms = 10^5 N/m^2 and k = 1.38×10^{-23} J/K)
(1) 4.8×10^2 m/s (2) 48×10^2 m/s
(3) 4.8×10^2 cm/s (4) 48×10^2 cm/s

Q.5 One gram mole gas in container A is in thermal equilibrium with one gram mole of another gas in container B. For these gases -
(1) $P_A = P_B$ (2) $V_A = V_B$
(3) $\frac{P_A}{V_A} = \frac{P_B}{V_B}$ (4) $P_AV_A = P_BV_B$

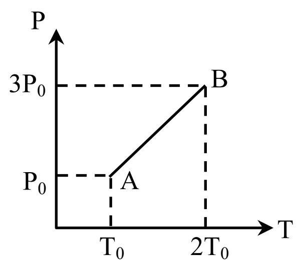
Q.6 A container of volume 30 litre is filled with an ideal gas at one atoms pressure and 0ºC temperature. Keeping the temperature constant some mass of gas is allowed to escape from the container. Due to this the pressure of the gas decreases to 0.78 atoms from the previous one. If the density of the gas at N.T.P. is1.3 gm/litre, the mass of the gas remaining is -
(1) 30.4 gm (2) 25.5 gm
(3) 18.3 gm (4) 12.7 gm

Q.7 A container is filled with 7 gram nitrogen and 11 gram CO_2 at 290 K. If the pressure of the mixture is 1 atoms, then the density of mixture is -
(1) 1.25 kg/m^3 (2) 1.35 kg/m^3
(3) 1.55 kg/m^3 (4) 1.75 kg/m^3

Q.8 If at constant volume the amount of heat required to raise the temperature of one gm mole of monoatomic ideal gas from 300 K to 400 K is Q, and the amount of heat required to raise the temperature of one gm-mole of diatomic ideal gas from 320 K to 380 K is Q´. Then the ratio of Q/Q´ is -
(1) 0.5 (2) 1 (3) 2 (4) 3

Q.9 Two glass bulbs of equal volume are connected by a narrow tube and are filled with a gas at 0ºC and a pressure of 76 cm of mercury. One of the bulbs is then placed in melting ice and the other is placed in water bath maintained at 62ºC. What is the new value of the pressure inside the bulbs? The volume of the connecting tube is negligible-
(1) 8.375 cm of Hg (2) 83.75 cm of Hg
(3) 0.8375 cm of Hg (4) None of these

Q.10 Pressure versus temperature graph of an ideal gas is as shown in figure. Density of the gas at point A is ρ_0. Density at B will be



(1) $\frac{3}{4}\rho_0$ (2) $\frac{3}{2}\rho_0$
(3) $\frac{4}{3}\rho_0$ (4) $2\rho_0$

Q.11 The average translational KE in one milli litre volume of the oxygen at NTP is-
(1) 0.15 J (2) 0.036 J
(3) 0.56 J (4) 152 J

Q.12 A box containing N molecules of a perfect gas at temperature T_1 and pressure P_1. The number of molecules in the box is doubled keeping the total KE of the gas same as before. If the new pressure is P_2 and temperature T_2 then -.
(1) $P_2 = P_1$, $T_2 = T_1$ (2) $P_2 = P_1$, $T_2 = T_1/2$
(3) $P_2 = 2P_1$, $T_2 = T_1$ (4) $P_2 = 2P_1$, $T_2 = T_1/2$

Q.13 The mean kinetic energy of a gas molecules at 27ºC is 6.21×10^{-21} Joule. Its value at 227ºC will be-
(1) 9.35×10^{-21} Joule (2) 10.35×10^{-21} Joule
(3) 11.35×10^{-21} Joule (4) 12.35×10^{-21} Joule

Q.14 A gas is filled in a container at any temperature and at pressure 76 cm of Hg. If at the same temperature the mass of gas is increased by 50% then the resultant pressure will be -
(1) 114 cm of Hg (2) 76 cm of Hg
(3) 152 cm of Hg (4) 38 cm of Hg

Q.15 In outer space there are 10 molecules/cm^3 on an average and temperature there is 3K. The average pressure of this light gas is -
(1) 0.4×10^{-16} N/m^2 (2) 4.14×10^{-16} N/m^2
(3) 5×10^{-14} N/m^2 (4) 10^5 N/m^2

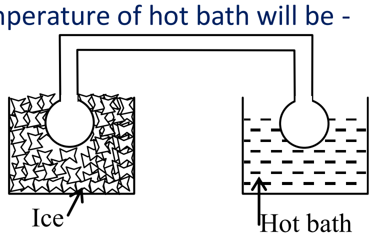
Q.16 At what temperature the linear kinetic energy of a gas molecule will be equal to that of an electron accelerated through a potential difference of 10 volt -
(1) 77.3×10^3 K (2) 38.65×10^3 K
(3) 19×10^3 K (4) 273K

Q.17 The temperature, pressure and volume of two gases X and Y are T, P and V respectively. When the gases are mixed then the volume and temperature of mixture become V and T respectively. The pressure and mass of the mixture will be -
(1) 2P and 2M (2) P and M
(3) P and 2M (4) 2P and M

Q.18 When the momentum of molecules of a gas increased by 20%, the percentage increases in the kinetic energy of the molecules will be -
(1) 44% (2) 80%
(3) 40% (4) 100%

Q.19 The speed of a molecules of gas in a cubical vessel of side 5 meter is 15 m/s. This molecule is constantly colliding with the walls of the container. The collision frequency will be -
(1) 0.2 per second (2) 2.25 per second
(3) 5 per second (4) 1.5 per second

Q.20 Two identical glass bulbs are interconnected by a thin glass tube. A gas is filled in these bulbs at N.T.P. If one bulb is placed in ice and another bulb is placed in hot bath, then the pressure of the gas becomes 1.5 times. The temperature of hot bath will be -



(1) 100º C (2) 182º C
(3) 256º C (4) 546º C

Q.21 A gas at absolute temperature 300 K has pressure = 4×10^{-10} N/m^2. Boltzmann constant = k = 1.38 × 10^{-23} J/K. The number of molecules per cm^3 is of the order of -

(1) 100 (2) 10^5
(3) 10^8 (4) 10^{11}

Q.22 If the volume of a gas is to be increased by 4 times -

(1) Temperature must be doubled.
(2) At constant 'P' temperature must be increased by four times.
(3) At constant 'T' the pressure must be increased four times.
(4) It cannot be increased.

Q.23 Temperature of a diatomic gas is 300 K. If moment of inertia of its molecules is 8.28×10^{-38} gm-cm^2, root mean square angular velocity is -

(1) 10^{12} rad/s
(2) $\sqrt{10} \times 10^8$ rad/s
(3) $\sqrt{1.5} \times 10^{12}$ rad/s
(4) $\sqrt{15} \times 10^8$ rad/s

Q.24 N molecules each of mass (m) of gas (A) and 2N molecules, each of mass (2m) of gas (B) are contained in the same vessel which maintained at a temperature (T). The mean square of the velocity of molecules of (B) type is denoted by (v^2) and the mean square of the (X) component of the velocity of (A) type is denoted by (ω^2) then ω^2 / v^2 is -

(1) 2 (2) 1 (3) 1/3 (4) 2/3

Q.25 The densities of hydrogen and oxygen at STP are 0.8×10^{-4} g/cc and 12.8×10^{-4} g/cc respectively. The rms velocity of H_2 is v_1 and that of O_2 is v_2. Then -

(1) $v_1 = v_2$ (2) $v_1 = 2v_2$
(3) $v_1 = 4v_2$ (4) $v_1 = 8v_2$

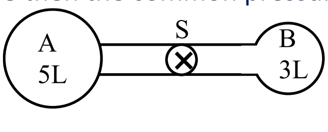
Q.26 An ideal gas is found to obey an additional law P^2V = constant. The gas is initially at temperature T and volume V. When it expands to a volume 2V, the temperature becomes -

(1) T (2) $\sqrt{2}$ T
(3) 2T (4) $2\sqrt{2}$ T

Q.27 For n moles of a real gas, the Vander Wals equation is -

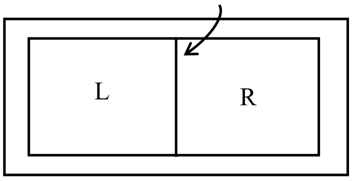
(1) $\left(P+\frac{a}{V^2}\right)(V - b) = RT$
(2) $\left(P+\frac{an^2}{V^2}\right)(V - nb) = RT$
(3) $\left(P+\frac{a}{nV^2}\right)(V - nb) = RT$
(4) $\left(P+\frac{an^2}{V^2}\right)(V - nb) = nRT$

Q.28 A vessel A of volume 5 litre has a gas at pressure of 80 cm column of Hg. This is joined to another evacuated vessel B of volume 3 litre. If now the stopcock S is opened and the apparatus is maintained at constant temperature then the common pressure will become -



(1) 80 cm of Hg (2) 50 cm of Hg
(3) 30 cm of Hg (4) None of these

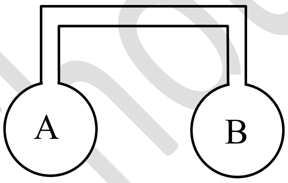
Q.29 A vessel is partitioned in two equal halves by a fixed diathermic separator. Two different ideal gases are filled in left (L) and right (R) halves. The rms speed of the molecules in L part is equal to the mean speed of molecules in the R part. Then the ratio of the mass of a molecules in L part to that of a molecules in R part is -



(1) $\frac{3}{2}$ (2) $\frac{\pi}{4}$ (3) $\frac{2}{3}$ (4) $\frac{3\pi}{8}$

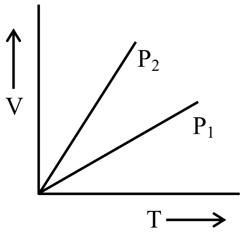
Q.30 The temperature of neon gas is increased by 2ºC at constant volume. If the amount of heat supplied is shared in increasing the translational and rotational kinetic energies, respectively, of the gas molecules, then the ratio in which the amount of heat energy is shared , is -
(1) 50% : 50% (2) 66.66% : 33.33%
(3) 0% : 100% (4) 100% : 0%

Q.31 Two spherical vessels of equal volumes are connected by a narrow tube. The apparatus contain an ideal gas at one atmosphere and 300K. Now if one vessel is immersed in a bath of constant temperature 600 K and the other in a bath of constant temperature 300 K then the common pressure will be -



(1) 1 atm (2) 4/5 atm
(3) 4/3 atm (4) 3/4 atm

Q.32 For V versus T curves at constant pressure P_1 and P_2 for an ideal gas shown in figure -



(1) $P_1 > P_2$ (2) $P_1 < P_2$
(3) $P_1 = P_2$ (4) $P_1 \geq P_2$

Q.33 If C_p and C_V are molar specific heats at constant pressure and constant volume. For hydrogen gas $C_p - C_V = a$ and for oxygen gas $C_p - C_V = b$ so the relation between a and b is -
(1) a = 16b (2) 16a = b
(3) a = 4b (4) a = b

Q.34 One mole of an ideal gas required 207 J heat to raise the temperature by 10 K when heated at constant pressure. If the same gas is heated at constant volume to raise the temperature by the same 10 K, the heat required is -

(R = 8.3 J/mol K^{-1})-

(1) 198.7 J (2) 29 J
(3) 215.3 J (4) 124 J

Q.35 Ne^{20} and Ne^{22} mixture will have ratio of rms velocities of the respective molecules -

(1) $\frac{11}{10}$ (2) $\sqrt{\frac{11}{10}}$
(3) $\frac{10}{11}$ (4) $\sqrt{\frac{10}{11}}$

Q.36 What will be the pressure in terms of atmospheric pressure of a mixture of 1 litre of N_2 and 1 atmospheric pressure and O_2 at 0.5 atmospheric pressure and of 2 litre volume, mixed in a container of 1 litre capacity at constant temperature -

(1) 0.75 (2) 1.0
(3) 1.5 (4) 2.0

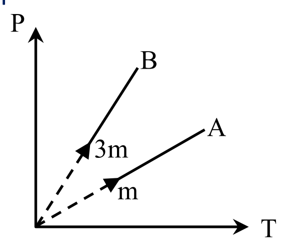
Q.37 A container of 5 litre has a gas at pressure of 0.8 m column of Hg. This is joined to an evacuated container of 3 litre capacity. The resulting pressure will be -

(1) 4/3 m (2) 0.5 m
(3) 2.0 m (4) 3/4 m

Q.38 The temperature of Argon gas is increased by 1ºC at constant volume. If the heat supplied is divided equally between translational and rotational energies, then their ratio will be -

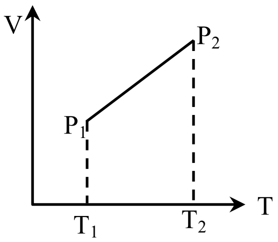
(1) 60 % : 40% (2) 50% : 50%
(3) 100% : 0% (4) 40% : 60%

Q.39 Two different masses m and 3m of an ideal gas are heated separately in a vessel of constant volume, the pressure P and absolute temperature T, graphs for these two cases are shown in the figure as A and B. The ratio of slopes of curves B to A is -



(1) 3 : 1 (2) 1 : 3
(3) 9 : 1 (4) 1 : 9

Q.40 From the following V-T diagram we can conclude -



(1) $P_1 = P_2$ (2) $P_1 > P_2$
(3) $P_1 < P_2$ (4) None of these

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 3

Q.1 The pressure exerted by the gas on the walls of the container because-
(1) It losses kinetic energy
(2) It sticks with the walls
(3) On collision with the walls there is a change in momentum
(4) It is accelerated towards the walls

Q.2 The equation for an ideal gas is PV = μRT, where V represents the volume of-
(1) 1 gm gas
(2) Any mass of the gas
(3) μ mole gas
(4) One litre gas

Q.3 If the pressure in a closed vessel is reduced by drawing out some gas, the mean free path of the molecules-
(1) is decreased
(2) is increased
(3) remains unchanged
(4) increases or decreases according to the nature of the gas

Q.4 For Boyle's law to hold the gas should be-
(1) Perfect and of constant mass and temperature
(2) Real and of constant mass and temperature
(3) Perfect and at constant temperature but variable pass
(4) Real and at constant temperature but variable mass

Q.5 Speed of sound in a gas is v and r.m.s. velocity of the gas molecules is c. The ratio of v to c is-
(1) $\frac{3}{\gamma}$ (2) $\frac{\gamma}{3}$ (3) $\sqrt{\frac{3}{\gamma}}$ (4) $\sqrt{\frac{\gamma}{3}}$

Q.6 The absolute temperature of a gas is increased 3 times. The root mean square velocity of the gas molecules will be-
(1) 3 times (2) 9 times
(3) 1/3 times (4) $\sqrt{3}$ times

Q.7 Absolute zero temperature is one at which-
(1) All liquids convert into solid
(2) All gases convert to solid
(3) All matter is in solid state
(4) The K.E. of as molecules becomes zero

Q.8 Equal molar amount of H_2, He having molecular weight of 2 and 4 respectively are filled at same temperature in two containers of equal volumes. If H_2 gas has a pressure of 4 atmospheres, then He gas will have pressure as-
(1) 1 atmosphere (2) 4 atmosphere
(3) 2 atmosphere (4) 8 atmosphere

Q.9 Three containers of the same volume contain three different gases. The masses of the molecules are m_1, m_2 and m_3 and the number of molecules in their respective containers are N_1, N_2 and N_3. The gas pressure in the containers are P_1, P_2 and P_3 respectively. All the gases are now mixed and put in one of the containers. The pressure P of mixture will be-
(1) $P < (P_1 + P_2 + P_3)$ (2) $P = \frac{P_1 + P_2 + P_3}{3}$
(3) $P = P_1 + P_2 + P_3$ (4) $P > (P_1 + P_2 + P_3)$

Q.10 A gas is at 0ºC. Upto what temperature the gas is to be heated so that the root mean square velocity of its molecules be doubled.-
(1) 273ºC (2) 1092ºC
(3) 819ºC (4) 100ºC

Q.11 The equation of state corresponding to 8g of O_2 is-
(1) PV = 8RT (2) $PV = \frac{RT}{4}$
(3) PV = RT (4) $PV = \frac{RT}{2}$

Q.12 At 0 K which of the following properties of an ideal gas will be non zero-
(1) Kinetic energy (2) Potential energy
(3) Vibrational energy (4) Density

Q.13 Relation PV = RT is given for following condition for real gas-
(1) High temperature and high density
(2) Low temperature and low density
(3) High temperature and low density
(4) Low temperature and high density

Q.14 The equation of state for 5g of oxygen at a pressure P and temperature T, when occupying a volume V, will be- (where R is the gas constant)
(1) PV = 5RT (2) PV = (5/2) RT
(3) PV = (5/16) RT (4) PV = (5/32) RT

Q.15 Two gases of equal molar mass are in thermal equilibrium. If P_A, P_B and V_A and V_B are their respective pressure and volumes, then which relation is true-
(1) $P_A \neq P_B$, $V_A = V_B$ (2) $P_A = P_B$, $V_A \neq V_B$,
(3) $P_A/V_A = P_B/V_B$ (4) $P_AV_A = P_BV_B$

Q.16 v_{rms}, v_{av} and v_{mp} are root mean square, average and most probable speeds of molecules of a gas obeying maxwellian velocity distribution. Which of the following statements is correct-
(1) $v_{rms} < v_{av} < v_{mp}$ (2) $v_{rms} > v_{av} > v_{mp}$
(3) $v_{mp} > v_{rms} > v_{av}$ (4) $v_{mp} > v_{rms} < v_{av}$

Q.17 Two balloons are filled, one with pure He gas and the other by air, respectively. If the pressure and temperature of these balloons are same then the number of molecules per unit volume is-
(1) more in the He filled balloon
(2) same in both balloons
(3) more in air filled balloon
(4) in the ratio of 1 : 4

Q.18 At 10ºC the value of the density of a fixed mass of an ideal gas divided by its pressure is x. At 110ºC this ratio is-
(1) $\frac{10}{110}x$ (2) $\frac{283}{383}x$
(3) x (4) $\frac{383}{283}x$

Q.19 The average kinetic energy of a gas molecule at 27ºC is 6.21×10^{-21} J, then its average kinetic energy at 227ºC is-
(1) 10.35×10^{-21} J (2) 11.35×10^{-21} J
(3) 52.2×10^{-21} J (4) 5.22×10^{-21} J

Q.20 The dimensional formula of the constant a in van der Waal's gas equation :
$\left(P + \frac{a}{V^2}\right)(V - b) = RT$, is-
(1) $[ML^4T^{-1}]$ (2) $[ML^2T^{-2}]$
(3) $[ML^5T^{-3}]$ (4) $[ML^5T^{-2}]$

Q.21 The value of critical temperature in terms of van der Waal's constants a and b is given by-
(1) $T_C = \frac{a}{2Rb}$ (2) $T_C = \frac{a}{27Rb}$
(3) $T_C = \frac{8a}{27Rb}$ (4) $T_C = \frac{17a}{8Rb}$

Q.22 At 27ºC temperature the kinetic energy of an ideal gas is E_1. If the temperature is increased to 327ºC then the kinetic energy will be-

(1) $\frac{E_1}{\sqrt{2}}$ (2) $\sqrt{2}\,E_1$

(3) $2\,E_1$ (4) $\frac{E_1}{2}$

Q.23 Pressure of an ideal gas is increased by keeping temperature constant. What is the effect on kinetic energy of molecules ?

(1) Increase
(2) Decrease
(3) No change
(4) Can't be determined

Q.24 At what temperature, the mean kinetic energy of O_2 molecule will be the same as that of H_2 molecule at –73ºC ?

(1) 127ºC (2) 527ºC
(3) –73ºC (4) –173ºC

Q.25 A gas consists of a mixture of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the mixture is-

(1) 6RT (2) 8RT
(3) 10RT (4) 11RT

Q.26 P,V,T respectively denote pressure, volume and temperature of two gases. On mixing, new temperature and volume are respectively T, V. Final pressure of the mixture is-

(1) P (2) 2P
(3) zero (4) 3P

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 4

Q.1 Cooking gas container are kept in a lorry moving with uniform speed. The temperature of the gas molecules inside will-

(1) Increase
(2) Decrease
(3) Remain same
(4) Decrease for some, while increase for others

Q.2 Three closed vessels A, B and C are at the same temperature and contain gases which obey the Maxwellian distribution of velocities. Vessel A contain only O_2, B only N_2 and C a mixture of equal quantities of O_2 and N_2. If the average speed of O_2 molecules in vessel A is v_1, that of the N_2 molecules in vessel B is v_2, the average speed of the O_2 molecules in vessel C is -

(1) $(v_1 + v_2)/2$ (2) v_1
(3) $(v_1v_2)^{½}$ (4) $\sqrt{(3kT/M)}$

Q.3 The temperature of an ideal gas is increased from 120 K to 480K. If at 120 K the root mean square velocity of the gas molecules is v, at 480 K is becomes -

(1) 4v (2) 2v (3) v/2 (4) v/4

Q.4 The average translational kinetic energy of O_2 (molar mass 32) molecules at a particular temperature is 0.048 eV. The translational kinetic energy of N_2 (molar mass 28) molecules is eV at the same temperature is -

(1) 0.0015 (2) 0.003 (3) 0.048 (4) 0.768

Q.5 A vessel contains 1 mole of O_2 (molar mass 32) at a temperature T. The pressure of the is P. An identical vessel containing one mole of He gas (molar mass 4) at a temperature 2T has a pressure of -
(1) P/8 (2) P (3) 2P (4) 8P

Q.6 The average translational energy and the rms speed of molecules in a sample of oxygen gas at 300 K are 6.21×10^{-21} J and 484 m/s respectively. The corresponding values at 600 K are nearly (assuming ideal gas behavior) -
(1) 12.42×10^{-21}J, 968 m/s
(2) 8.78×10^{-21}J, 684 m/s
(3) 6.21×10^{-21} J, 968 m/s
(4) 12.42×10^{-21}J, 684 m/s

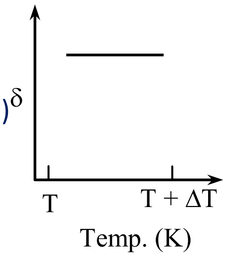
Q.7 Two cylinders A and B fitted with piston contain equal amounts of an ideal diatomic gas at 300 K. The piston of s is free to move, while that of b is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30 K, then the rise in temperature of the gas in B is -
(1) 30 K (2) 18 K
(3) 50 K (4) 42 K

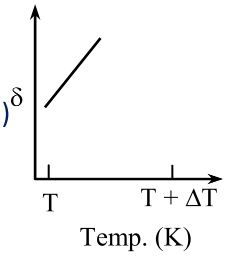
Q.8 Let v, v_{rms} and v_p respectively denote the mean speed, root mean square speed and most probable speed of the molecules in an ideal monoatomic gas at absolute temperature T. The mass of a molecule is m. Then -
(1) $v_p < v < v_{rms}$
(2) The average kinetic energy of a molecule is (3/4) mv_p^2.
(3) Both of these
(4) None of these

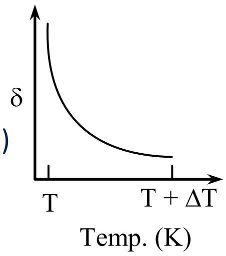
Q.9 A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300 K. The ratio of the average rotational kinetic energy per O_2 molecule to that per N_2 molecule is -
(1) 1 : 1
(2) 1 : 2
(3) 2 : 1
(4) Depends on the moments of inertia of the two molecules

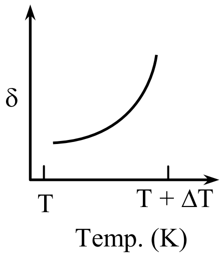
Q.10 A closed compartment containing gas is moving with some acceleration in horizontal direction. Neglect effect of gravity, then the pressure in the compartment is -
(1) same everywhere
(2) lower in the front
(3) lower in the rear side
(4) lower in the upper side

Q.11 An ideal gas is initially at temperature T and volume V. Its volume is increased by ΔV due to an increase in temperature ΔT, pressure remaining constant. The quantity $\delta = \Delta V/(V\Delta T)$ varies with temperature as -

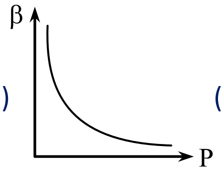
(1) 

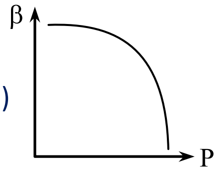
(2) 

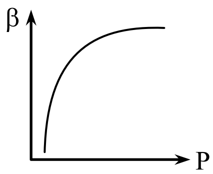
(3) 

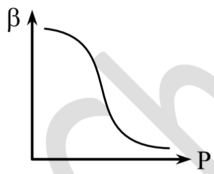
(4) 

Q.12 Which of the following graphs correctly represents the variation of $\beta = -\frac{dV/dP}{V}$ with P for an ideal gas at constant temperature ?

(1) 

(2) 

(3) 

(4) 

Q.13 According to the kinetic theory of gases the rms velocity of molecules of a gas is proportional to-
(1) T (2) $T^{1/2}$ (3) T^2 (4) $T^{-1/2}$

Q.14 The average translational kinetic energy of molecule depends on-
(1) Pressure
(2) Temperature
(3) Volume
(4) Pressure and volume both

Q.15 According to kinetic theory of gases, at a given temperature-
(1) Light molecule will have less kinetic energy
(2) Light molecule will have more average kinetic energy
(3) All molecules have same kinetic energy
(4) Insufficient information

Q.16 If the rms velocity of molecules of a gas in a container is doubled then the pressure will-
(1) Become four times
(2) Also get doubled
(3) Be same
(4) Become one half

Q.17 The rms velocity of gas molecules is C at temperature T. If the rms velocity is increased to 4C, then what will be the corresponding temperature ?
(1) 16 T (2) 4 T
(3) 8 T (4) 2 T

Q.18 Which of the following statement is true according to kinetic theory of gases ?
(1) The collision between two molecules is in elastic and the time between two collision is less than the time taken during the collision
(2) There is a force of attraction between the molecules
(3) All the molecules of a gas move with same velocity
(4) The average of the distances travelled between two successive collisions is mean free path

Q.19 Which of the following statement is not according to the postulates of kinetic theory of gases-
(1) Gas molecules are of small size
(2) Gas molecules are always in motion with all possible velocities
(3) There is no force between the molecules
(4) none of the above

Q.20 Critical temperature is that temperature-
(1) Above which a gas cannot be liquified only by increasing pressure
(2) Above which the gas can be liquified only by increasing pressure
(3) Below which the gas cannot be liquified only by increasing pressure
(4) None of the above

Q.21 A box contains N molecules of a gas. If the number of molecules is doubled, then the pressure will-

(1) Decrease (2) Be same
(3) Be doubled (4) Get tripled

Q.22 If a container is filled with the mixture of H_2 and O_2 then-
(1) RMS velocity of H_2 molecules is more
(2) RMS velocity of O_2 molecules is more
(3) Average energy of O_2 molecules is more
(4) Average energy of H_2 molecules is less

Q.23 RMS velocity of which of the following gases at a given temperature is minimum-
(1) O_2 (2) N_2 (3) CO_2 (4) He

Q.24 Gases obey vander-waal's equation at-
(1) Only normal temperature and pressure
(2) Only high temperature and high pressure
(3) Only high temperature and low pressure
(4) All temperature and pressure

Q.25 The vander-Waal's equation of-
(1) $(P + a/V^2)(V - b) = RT$
(2) $(P - a/V^2)(V - b) = RT$
(3) $(P - a/V^2)(V + b) = RT$
(4) $(P + a/V^2)(V + b) = RT$

Q.26 If T is the temperature at which the root mean square velocity of molecules of a gas becomes double of its value at 100ºC then T is-
(1) 200ºC (2) 400ºC (3) 473ºC (4) 1219ºC

Q.27 At 0ºC temperature root mean square speed of which of the following gases will be maximum-
(1) H_2 (2) N_2 (3) O_2 (4) SO_2

Q.28 The total kinetic energy of 1 mole of N_2 at 27ºC will be approximately-
(1) 1500 Joule (2) 1500 Calories
(3) 1500 kilo Calories (4) 1500 erg.

Q.29 Equal volume of H_2, O_2 and He gases are at same temperature and pressure. Which of these will have large number of molecules-
(1) H_2
(2) O_2
(3) He
(4) All the gases will have same number of molecules

Q.30 An ideal gas at 1 atmospheric pressure and at 273 K has 22.4 litre of volume. This is heated to 546 K and then by applying pressure its volume is reduced to 4.48 litre, then the resulting pressure will be-
(1) 20 atm (2) 10 atm
(3) 5 atm (4) 2.5 atm

Q.31 Following is not a postulate of kinetic theory of gases-
(1) Gas molecules are hard solid sphere of negligible volume
(2) Gas molecules are in continuous random motion
(3) Collisions are perfectly elastic
(4) none of the above

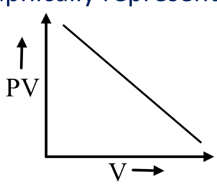
Q.32 The rms velocity of gas molecules at 800 K is-
(1) 4 times of that at 200 K
(2) Half of that at 200 K
(3) 2 times of that at 200 K
(4) Same as that at 200 K

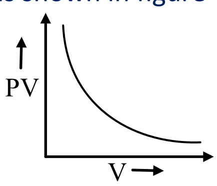
Q.33 If an ideal gas compressed during isothermal process then-
(1) No work is done against gas
(2) Heat is rejected by gas
(3) It's internal energy will increase
(4) Pressure does not change

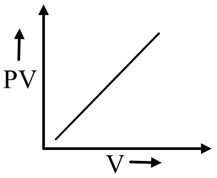
Q.34 O_2 gas is filled up in a cylinder. If pressure is increased 2 times, temperature becomes four times, then how much times their density will be-
(1) 2 (2) 4 (3) $\frac{1}{4}$ (4) $\frac{1}{2}$

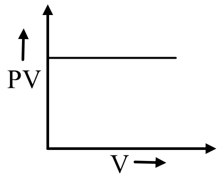
Q.35 In vanderwall's equation $\left(P+\frac{a}{V^2}\right)(V-b)$ =RT, the dimension of a is-
(1) $M^1L^5T^{-2}$ (2) $M^0L^2T^{-3}$
(3) $M^1L^3T^{-2}$ (4) $M^1L^1T^{-2}$

Q.36 The variation of PV graph with V of a fixed mass of an ideal gas at constant temperature is graphically represented as shown in figure-

(1) 

(2) 

(3) 

(4) 

Q.37 The number of oxygen molecules in a cylinder of volume 1 m^3 at a temperature of 27ºC and pressure 13.8 Pa is- (Boltzmaan's constant k = 1.38×10^{-23} JK^{-1})
(1) 6.23×10^{26} (2) 0.33×10^{28}
(3) 3.3×10^{21} (4) None of these

Q.38 A cylinder contains 10 kg of gas at pressure of 10^7 N/m^2. The quantity of gas taken out of the cylinder, if final pressure is 2.5×10^6 N/m^2, will be (temperature of gas is constant) -
(1) 15.2 kg (2) 3.7 kg
(3) zero (4) 7.5 kg

Q.39 The thermodynamic coordinates of a jar filled with gas A are P, V and T and another jar B filled with another gas are 2P, V/4 and 2T, where the symbols have their usual meaning. The ratio of the number of molecules of jar A to those of jar B is-
(1) 4 : 1 (2) 2 : 1
(3) 1 : 2 (4) 1 : 1

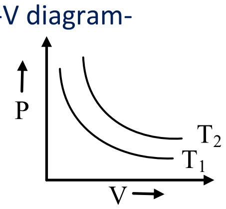
Q.40 At N.T.P. the volume of a gas is changed to one fourth volume, at constant temperature then the new pressure will be- (Given $\gamma = 5/3$)
(1) 2 atm (2) $2^{5/3}$ atm
(3) 4 atm (4) 1 atm

Q.41 A gas contained in a box of 0.1 m^3 at atmospheric pressure is connected to another vessel of 0.09 m^3. Consequent change in pressure is X mm of Hg. Then X in metre is-
(1) 0.4 (2) 0.5
(3) 0.36 (4) 0.3

Q.42 Temperature at which the velocity of sound in O_2 is the same as that on N_2 at 27ºC is approximately -
(1) 60ºC (2) 80ºC
(3) 70ºC (4) 27ºC

Q.43 The mean kinetic energy of a molecule of an ideal gas is-
(1) $\frac{3}{2}kT$ (2) 2kT (3) $\frac{1}{2}kT$ (4) kT

Q.44 Find the correct relation in given P-V diagram-



(1) $T_1 = T_2$ (2) $T_1 > T_2$
(3) $T_1 < T_2$ (4) $T_1 \lessgtr T_2$

Q.45 The equation of state of a gas is given by $\left(P + \frac{aT^2}{V}\right)V^c = (RT + b)$, where a, b, c and R are constants. The isotherms can be represented by P = $AV^m - BV^n$, where A and B depend only on temperature and -
(1) m = –c and n = –1 (2) m = c and n = 1

(3) m = –c and n = 1 (4) m = c and n = –1

Q.46 The root mean square and most probable speed of the molecules in a gas are-
(1) same
(2) different
(3) cannot say
(4) depends on nature of the gas

Q.47 In vanderwall's gas equation if pressure is increase to large extent then what will be effect on volume ?
(1) zero
(2) arbitrary reduces to low value
(3) become non zero constant
(4) none

Q.48 Which of the following will be same if temperature of two ideal gas is equal ?
(1) v_{rms} (2) Heat
(3) P (4) V

Q.49 Three perfect gases at absolute temperatures T_1,T_2 and T_3 are mixed. The masses of molecules are m_1, m_2 and m_3 and the number of molecules are n_1, n_2 and n_3 respectively. Assuming no loss of energy, the final temperature of the mixture is :
(1) $\frac{(T_1+T_2+T_3)}{3}$
(2) $\frac{n_1T_1+n_2T_2+n_3T_3}{n_1+n_2+n_3}$
(3) $\frac{n_1T_1^2+n_2T_2^2+n_3T_3^2}{n_1T_1+n_2T_2+n_3T_3}$
(4) $\frac{n_1^2T_1^2+n_2^2T_2^2+n_3^2T_3^2}{n_1T_1+n_2T_2+n_3T_3}$

Q.50 A diatomic molecule has
(1) 1 degree of freedom
(2) 3 degrees of freedom
(3) 5 degrees of freedom
(4) 6 degrees of freedom

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 5

These questions of two statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.
(1) If both Assertion & Reason are true & the Reason is a correct explanation of the Assertion.
(2) If both Assertion and Reason are true but Reason is not a correct explanation of the Assertion.
(3) If Assertion is true but the Reason is false.
(4) If Assertion & Reason both are false.

Q.1 **Assertion :** The average kinetic energy of the molecules in one mole of all ideal gases, at the same temperature is the same.

Reason : The average kinetic energy of one mole of any ideal gas is given by $\vec{E}=\frac{1}{2}RT$.

(1) A (2) B (3) C (4) D

Q.2 **Assertion :** Internal energy of a gas must increases when its temperature is increased.
Reason : Internal energy of a gas is proportional to the velocity of the vessel in which gas is contained.

(1) A (2) B (3) C (4) D

Q.3 **Assertion :** A real gas behaves as an ideal gas at high temperature and low pressure.
Reason : Liquid state of an ideal gas is impossible.
(1) A (2) B (3) C (4) D

Q.4 **Assertion :** Total kinetic energy or internal energy or total energy does not determine the direction of flow of heat.
Reason : Systems are in thermal equilibrium, when their temperature are same or average kinetic energy per molecule is same.
(1) A (2) B (3) C (4) D

Q.5 **Assertion :** State variables (P, V and T) of any gas at low densities obey the equation PV = nRT.
Reason : Real gases are good approximation of an ideal gas at low density.
(1) A (2) B (3) C (4) D

Q.6 **Assertion :** Vanderwall's gas equation is $\left(P+\frac{a}{V^2}\right)(V-b)=RT$

Reason : $P_{real} = \frac{RT}{V-b}-\frac{a}{V^2}$ and $V_{real} = V - b$.
(1) A (2) B (3) C (4) D

Q.7 **Assertion :** The Maxwell speed distribution graph is symmetric about the most probable speed.
Reason : The root mean square speed of an ideal gas depends on the type of gas (monatomic, diatomic or polyatomic).
(1) A (2) B (3) C (4) D

Q.8 **Assertion :** Potential energy of an ideal gas is zero.
Reason : The molecules are continuously doing random motion.
(1) A (2) B (3) C (4) D

Q.9 **Assertion :** In Maxwell's speed distribution graph, for a given amount of gas, the area under the graph increases as the temperature of the gas increases.
Reason : Increase in temperature broadening the curve.
(1) A (2) B (3) C (4) D

Q.10 **Assertion :** The root mean square and most probable speeds of the molecules in a gas are the same.

Reason : The Maxwell distribution for the speed of molecules in a gas is symmetrical.
(1) A (2) B (3) C (4) D

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 1 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	2	4	2	1	4	1	4	3	1	1	2	1	1	3	4	4	3	3	1	3
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	4	3	4	3	4	4	1	1	2	3	3	1	1	3	2	2	4	3	2	2
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	1	4	2	2	4	1	4	1	1	3	2	3	4	3	1	2	4	1	2	2
Q.No.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	
Ans.	4	4	3	4	4	1	2	4	2	2	1	2	3	4	2	1	1	4	3	

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 2 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	2	4	1	4	1	3	2	2	2	1	2	2	1	2	1	1	1	4	4
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	2	1	4	3	2	4	2	4	4	3	1	4	4	2	4	2	3	1	3

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 3 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ans.	3	3	2	1	4	4	4	2	3	3	2	4	3	4	4	2	2	2
Q.No.	19	20	21	22	23	24	25	26										
Ans.	1	4	3	3	3	3	4	2										

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 4 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	3	2	2	3	3	4	4	3	1	2	3	1	2	2	3	1	1	4	4	1
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	1	3	4	1	4	1	2	4	2	4	3	2	4	1	4	3	4	1	3
Q.No.	41	42	43	44	45	46	47	48	49	50										
Ans.	3	3	1	3	1	2	2	2	2	3										

IMPORTANT PRACTICE QUESTION SERIES FOR IIT-JEE EXAM – 5 (ANSWERS)

Q.No.	1	2	3	4	5	6	7	8	9	10
Ans.	3	3	2	2	1	1	4	2	4	4