IDEAL GAS

CONTENTS

JEE(ADVANCED) SYLLABUS

Gaseous and liquid states : Absolute scale of temperature, ideal gas equation; Deviation from ideality, van der Waals equation; Kinetic theory of gases, average, root mean square and most probable velocities and their relation with temperature; Law of partial pressures; Vapour pressure; Diffusion of gases, Graham's Law.

JEE(MAIN) SYLLABUS

Three states of matter, gaseous state, gas laws (Boyle's Law and Charles Law), Avogadro's Law, Grahams' Law of diffusion, Dalton's law of partial pressure, ideal gas equation, Kinetic theory of gases, real gases and deviation from ideal behaviour, vander Waals' equation, liquefaction of gases and critical points, Intermolecular forces; liquids and solids.

IDEAL GAS

1. INTRODUCTION

Matter, as we know, broadly exist in three states - solid, liquid and gas.

There are always two opposite tendencies between particles of matter which determine the state of matter :

- Intermolecular forces.
- The molecular motion / random motion (energy of particles)

Intermolecular forces tend to keep the molecules together but thermal energy of the molecules tends to keep them apart. Three states of matter are the result of balance between intermolecular forces and the thermal energy of the molecules.

2. GENERAL CHARACTERISTICS OF SOLID, LIQUID & GAS

Each physical state of matter possesses characteristics properties of its own. For example,

Matter

Properties	Solid state	Liquid state	Gaseous state
Attractive force	• large	• Smaller	• Almost zero
Thermal motion	• Almost zero	• Greater	• Random motion
Volume	• Fixed volume	• Fixed volume	• varies with container
Geometry	• Definite	• Not definite	• Not definite

3. MEASURABLE PROPERTIES OF GASES

The characteristics of gases are described fully in terms of four parameters or measurable properties :

(I) Amount of the gas (i.e., mass or number of moles). (II) Volume (V) of the gas.

(III) Temperature (T) (IV) Pressure (P)

I. Amount of the gas :

(i) The mass of a gas can be determined by weighing the container in which the gas is enclosed and again weighing the container after removing the gas. The difference between the two masses gives the mass of the gas.

Mass of gas (m) = Mass of filled container – mass of empty container

(ii) The mass of the gas is related to the number of moles of the gas as

Moles of gas (n) = Mass in grams / Molar mass = m/M

(iii) Mass is expressed in gram or kg.

II. Gas volume :

(i) Since gases occupy the entire space available to them, the measurement of volume of a gas only requires a measurement of the container confining the gas.

(ii) Volume is expressed in litres (L), millilitres (mL) or cubic centimeters (cm^3) or cubic meters (m^3).

(iii) $1\ L = 1000\ mL$; $1\ L = 1\ dm^3 = 10^{-3}\ m^3$

$1\ m^3 = 10^3\ dm^3 = 10^6\ cm^3 = 10^6\ mL = 10^3\ L$

$1\ mL$ or $1\ cc = 1\ cm^3$

III. Temperature :

(i) Gases expand on increasing the temperature.

(ii) Temperature is measured in degree centigrade (°C) or Celsius degree with the help of thermometers. Temperature is also measured in degree Fahrenheit (°F).

(iii) S.I. unit of temperature is kelvin (K) or absolute degree

$K = °C + 273$

(iv) Relation between °F and °C is

$°C/5 = (°F - 32) / 9$

IV. Pressure :

Force exerted by the gas per unit area of the walls of the container in all directions. Thus,

Pressure (P) = Force(F) / Area(A)

Atmospheric pressure :

The pressure exerted by atmosphere on earth's surface at sea level is called atmospheric pressure. Generally its unit is atm.

Pressure(P) = Force(F) / Area(A)

= Mass(m) × Acceleration(g) / Area(a)

= Volume × density × Acceleration(g) / Area(a)

= Area (a) × height (h) × density (ρ) × Acceleration(g) / Area(a)

Pressure(P) = hρg

where h = Height of mercury column in the barometer.

ρ = Density of mercury.

g = Acceleration due to gravity.

Pressure does not depend on the cross section of tube, but only on the vertical height of the Hg. If area is doubled, volume also gets doubled and mass will also gets doubled. Now it will rest on twice area but pressure exerted remains same.

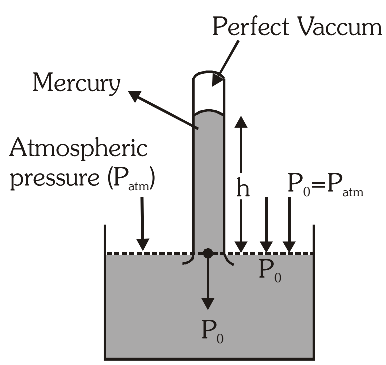
1 atm = 1.013 bar = 1.013×10^5 N/m^2 = 1.013×10^5 Pa

1 atm = 76 cm of Hg = 760 mm of Hg = 760 torr

PRESSURE MEASURING DEVICES

Generally, the instruments used for the calculation of pressure of a gas are **barometer** and **manometer.**

(i) Barometer : A barometer is an instrument that is used for the measurement of atmospheric pressure. The construction of the barometer is as follows -



A thin narrow calibrated capillary tube is filled up to the brim, with a liquid such as mercury, and is inverted into a trough filled with the same fluid. Now depending on the external atmospheric pressure, the level of the mercury inside the tube will adjust itself, the reading of which can be monitored. When the mercury column inside the capillary comes to rest, then the net forces on the column should be balanced.

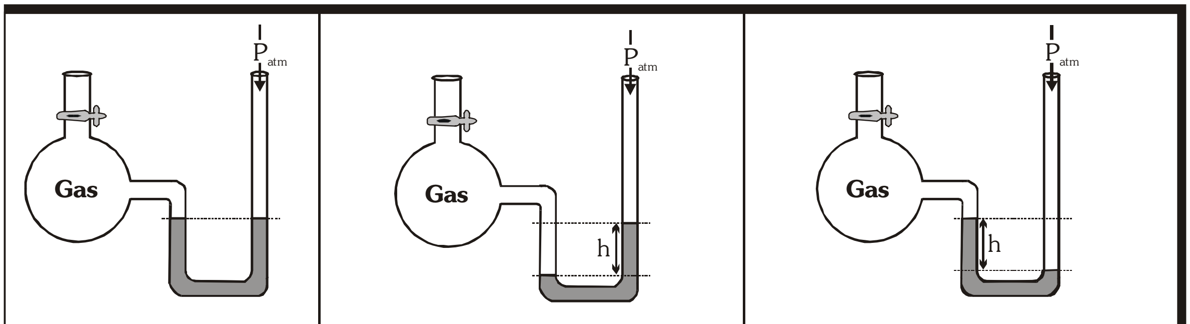
$\Rightarrow$ $P_0 \times A = \rho A \times gh$

$\Rightarrow$ $\boxed{P_0 = \rho gh}$; where ρ is the density of the fluid.

(ii) Manometer :

(a) Open end manometer :

It consists of a U-shaped tube partially filled with mercury. One limb of the tube is shorter than the other. The shorter limb is connected to the vessel containing the gas whereas the longer limb is open as shown in fig. The mercury in the longer tube is subjected to the atmospheric pressure while mercury in the shorter tube is subjected to the pressure of the gas.



(i) Gas pressure = P_{atm} | (ii) Gas pressure =(P_{atm}+h) cm of Hg | (iii) Gas pressure=(P_{atm}–h) cm of Hg

Fig : Measurement of gas pressure

Where P_{atm} = 76 cm of Hg and h = Height in cm of Hg

There are three possibilities as described below :

(i) If the level of Hg in the two limbs is same, then gas pressure = atmospheric pressure (P_{atm}).

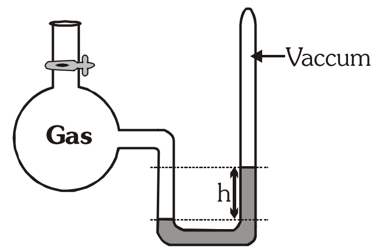
(ii) If the level of Hg in the longer limbs is higher, gas pressure
= P_{atm} + (difference between the two levels) = P_{atm} + h.

(iii) If the level of Hg in the shorter limb is higher, then gas pressure
= P_{atm} – (difference between the two levels)
= P_{atm} – h.

(b) Closed end manometer :

This is generally used to measure low gas pressure.

It also consists of U-tube with one limb shorter than the other and partially filled with mercury as shown in fig. The space above mercury on the closed end is completely evacuated. The shorter limb is connected to the vessel containing gas. The gas exerts pressure on the mercury in the shorter limb and forces its level down.



Closed end manometer

Gas pressure = [Difference in the Hg level in two limbs]

Solved Examples

Ex.1 Why mercury is used in the barometer tube?

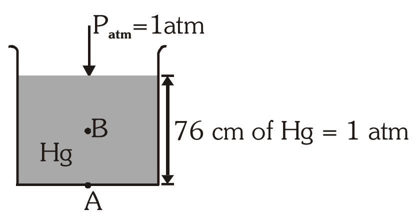
Sol. Mercury, a liquid with very high density, is normally used in the barometer because it does not stick to the surface of the glass tube. Mercury is also non-volatile at room temperature. Therefore, there are hardly any vapours of mercury above the liquid column and their pressure, if any , can be neglected. Due to high density of mercury, height of mercury column will be small and can be easily measured.

Ex.2 An open tank is filled with Hg upto a height of 76cm.
Find the pressure at the

(a) Bottom (A) of the tank

(b) Middle (B) of the tank.

(If atmospheric pressure is 1 atm)



Sol. **(a)** At bottom,

$P_A = P_{atm} + P_{Hg}$

$= 1 + 1 = 2$ atm

(b) At middle,

$P_B = P_{atm} + P_{Hg}$

$= 1 + \frac{1}{2} = 1.5$ atm

Ex.3 Find the height of water upto which water must be filled to create the same pressure at the bottom, as in above problem.

Given that $d_w = 1\ gm/cm^3$, $d_{Hg} = 13.6\ gm/cm^3$, $h_{Hg} = 76$ cm

Sol. $P_{water} = P_{Hg}$

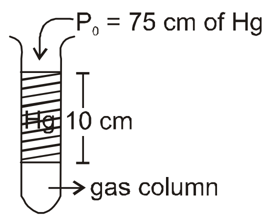
$h_w d_w\ g = h_{Hg} d_{Hg}\ g$

$h_w d_w = h_{Hg} d_{Hg}$

$h_w \times 1\ g/cm^3 = 76\ cm \times 13.6\ g/cm^3$

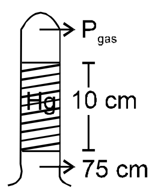
$h_w = 1033.6$ cm

Ex.4 In each of the following examples, find the pressure of the trapped gas.



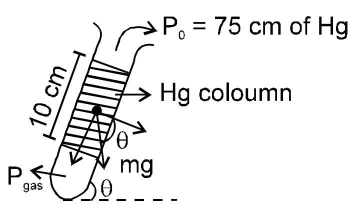
Sol. Total pressure of gas column = 75 + 10 = 85 cm of Hg.

Ex.5



Sol. P_{gas} = 65 cm of Hg.

Ex.6



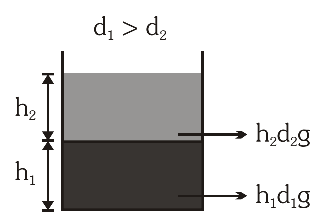
$P_g = 75 + 10 \cos \theta$.

Sol. From the above problem, it can be generalised that, applying force balance every single time is not necessary. If we are moving up in a fluid, then substract the vertical length, and while moving down add the vertical length.

Ex.7 What will be the pressure if two immiscible fluid is filled according to given diagram.

(a) Find the pressure at the bottom of tank.

(b) Find the pressure at the middle point of bottom layer.

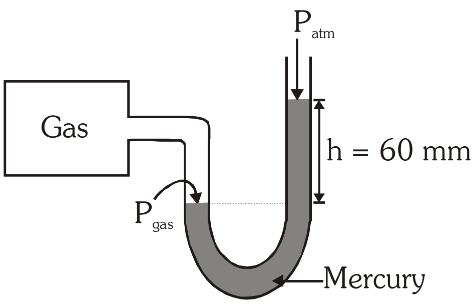


Sol. (a) $P_{atm} + h_2d_2g + h_1d_1g$;

(b) $P_{atm} + h_2d_2g + \frac{h_1}{2} d_1g$

Ex.8 Find the pressure of the gas inside a container if the open manometer attached to the container shows a difference of 60 mm.

Sol. **Case-I** : $P_{atm} < P_{gas}$

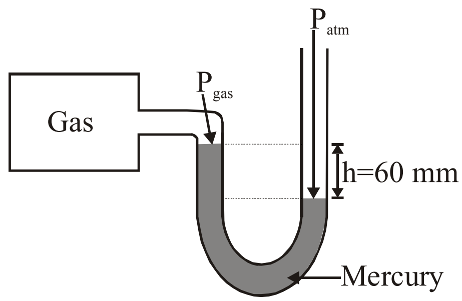


P_{gas} = P_{atm} + 60 mm

= 760 mm + 60 mm

= 820 mm of Hg

Case-II : $P_{atm} > P_{gas}$



P_{atm} = P_{gas} + 60 mm

760 mm = P_{gas} + 60

P_{gas} = 700 mm

4. GAS LAWS

The behaviour of the gases is governed by same general laws, which were discovered as a result of their experimental studies. These laws are relationships between measurable properties of gases. Some of these properties like pressure, volume, temperature and mass are very important because relationships between these variables describe state of the gas.

The first reliable measurement on properties of gases was made by Anglo-Irish scientist Robert Boyle in 1662. The law which he formulated is known as ***Boyle's Law***. Later on attempts to fly in air with the help of hot air balloons motivated Jaccques Charles and Joseph Lewis Gay Lussac to discover additional gas laws. Contribution from *Avogadro* and others provided lot of information about gaseous state.

4.1 Boyle's Law :

For a fixed amount of gas at constant temperature, the volume occupied by the gas is inversely proportional to the pressure applied on the gas or pressure of the gas.

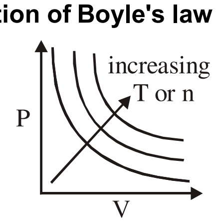
$\Rightarrow$ $V \propto \dfrac{1}{P}$

$\Rightarrow$ Hence , PV = const. (K)

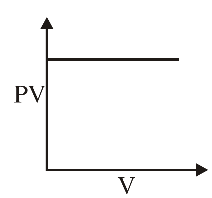
$\Rightarrow$ $\boxed{P_1V_1 = P_2V_2}$

Graphical representation of Boyle's law :

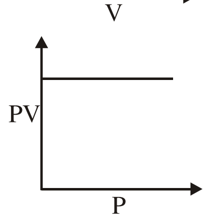
(i) **P v/s V :**



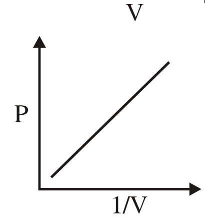
(ii) **PV v/s V :**



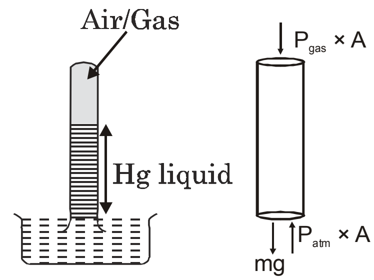
(iii) **PV v/s P :**



(iv) **P v/s 1/V :**



Faulty Barometer : An ideal barometer will show a correct reading only if the space above the mercury column is vacuum, but in case if some gas column is trapped in the space above the mercury column, then the barometer is classified as a faulty barometer. The reading of such a barometer will be less than the true pressure.



For such a faulty barometer

$$P_0A = Mg + P_{gas}A$$

$$P_0 = \rho gh + P_{gas} \qquad \text{or} \qquad \rho gh = P_0 - P_{gas}$$

4.2. Charle's Law :

For a fixed amount of gas at constant pressure, volume occupied by the gas is directly proportional to temperature of the gas on absolute scale of temperature.

$\Rightarrow \quad V \alpha T$

$\Rightarrow \quad V = KT$

$$\boxed{\frac{V}{T} = \text{constant (K)}}$$

T = Temperature on absolute scale, kelvin scale or ideal gas scale.

$$\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$$

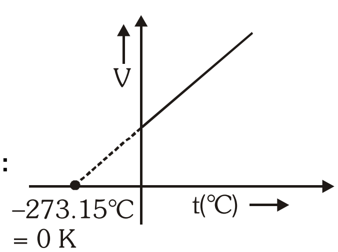
$$\boxed{V = V_0 + bt} \qquad \boxed{V = b'T}$$

t = temperature on centigrade scale. T = absolute temperature (K)

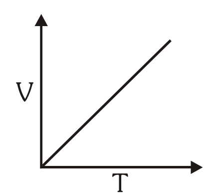
V_0 = volume of gas at 0°C. b, b' = constants

Graphical representation of Charle's Law :

(i) V v/s t (°C) :



(ii) V v/s T :



Important Points :

- Since volume is proportional to absolute temperature, the volume of a gas should be theoretically zero at absolute zero temperature.
- In fact, no substance exists as gas at a temperature near absolute zero, though the straight line plots can be inter polated to zero volume. Absolute zero can never be attained practically though it can be approached only.
- By considering –273.15°C as the lowest approachable limit, Kelvin developed temperature scale which is known as absolute scale.

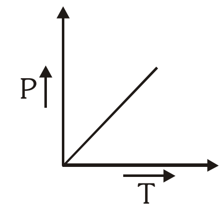
4.3. Gay-lussac's law :

For a fixed amount of gas at constant volume, pressure of the gas is directly proportional to temperature of the gas on absolute scale of temperature.

$\Rightarrow \quad P \propto T$

$\frac{P}{T}$ = constant (K)

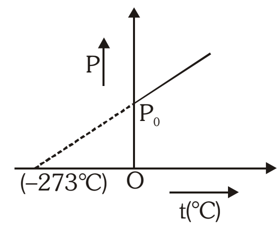
$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ Temperature on absolute scale, kelvin scale or ideal gas scale.



Note: Originally, the law was developed on the centigrade scale, where it was found that pressure is a linear function of temperature $\Rightarrow \boxed{P = P_0 + bt}$,

where 'b' is a constant and 'P_0' is pressure at zero degree centigrade.

But for kelvin scale : $\boxed{P = b''T}$ where T is in K.



4.4. Avogadro's law :

Equal volumes of all the gases under similar conditions of temperature and pressure contains equal number of molecules or moles of molecules (not atoms).

$V \propto N$ (Temperature and pressure constant)

$V \propto n$ (Temperature and pressure constant)

Where, N = number of molecules, n = number of moles of molecules

$$\boxed{\frac{V_1}{N_1} = \frac{V_2}{N_2} \text{ or } \frac{V_1}{n_1} = \frac{V_2}{n_2}}$$

Since volume of a gas is directly proportional to the number of moles; one mole of each gas at standard temperature and pressure (STP) will have same volume.

Standard temperature and pressure means 273.15 K (0°C) temperature and 1 bar (i.e., exactly 10^5 pascal) pressure. At STP, molar volume of an ideal gas or a combination of ideal gases is 22.71098 L mol^{-1}.

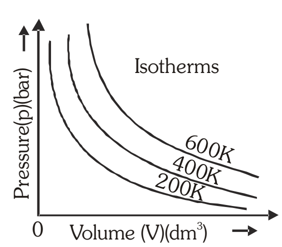
Molar volume in litres per mole of some gases at 273.15 K and 1 bar (STP).

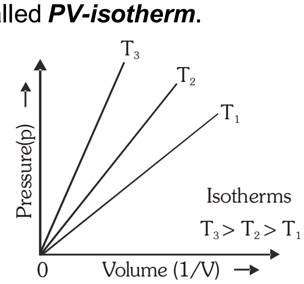
Argon	22.37
Carbon dioxide	22.54
Dinitrogen	22.69
Dioxygen	22.69
Dihydrogen	22.72
Ideal gas	22.71

Solved Examples

Ex.9 What is a pressure-volume isotherm ?

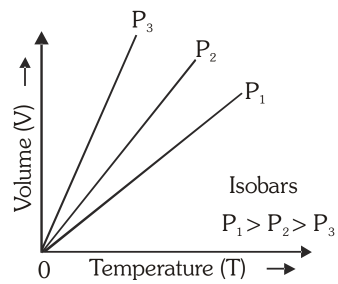
Sol. Graph between P & V at constant temperature is called ***PV-isotherm***.





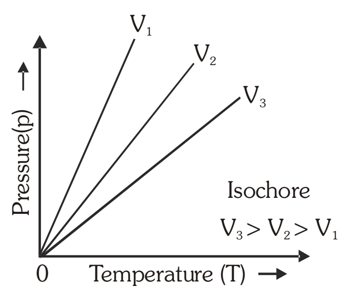
Ex. 10 What is Isobar ?

Sol. Graph plotted at constant pressure is called isobar. Graph between V & T at constant pressure is called VT-isobar.



Ex. 11 What is Isochore ?

Sol. Graph plotted at constant volume is called isochore. Graph between P & T at constant volume is called PT-isochore.



5. IDEAL GAS EQUATION

A single equation which is combination of Boyle's, Charle's & Avogadro's Law is known as ***Ideal gas equation***. Or we can say a single equation which describe the simultaneous effects of the change in temperature & pressure on volume of the given amount of the gas is called the ***Ideal gas equation.***

PV = nRT

According to Boyle's law, $V \propto \frac{1}{P}$ (at constant T and n)

According to Charle's law, $V \propto T$ (at constant P and n)

According to Avogadro's law, $V \propto n$ (at constant T and P)

According to the three laws, $V \propto \frac{nT}{P}$ or $PV \propto nT$

or PV = nRT [Equation of state or combined gas law]

Where R is a constant called ***Universal gas constant***, which does not depend on variables (P, V, n, T) and nature of gas.

- Molar volume is the volume of 1 mole of gas.

Molar volume $(V_m) = \frac{\text{Volume}}{\text{mole}}$

$PV_m = RT$

Volume of 1 mole of an ideal gas under STP conditions (273.15 K and 1 bar pressure) is 22.7 L mol^{-1}.

- **Dimension of R :**

$$R = \frac{PV}{nT} = \frac{\text{Pressure} \times \text{Volume}}{\text{Mole} \times \text{Temperature}} = \frac{(\text{Force / Area}) \times (\text{Area} \times \text{Length})}{\text{Mole} \times \text{Temperature (K)}}$$

$$= \frac{\text{Force} \times \text{Length}}{\text{Mole} \times \text{Temperature(K)}} = \frac{\text{Work or energy}}{\text{Mole} \times \text{Temperature (K)}}$$

- **Physical significance of R :**
  The dimensions of R are energy per mole per kelvin and hence it represents the amount of work (or energy) that can be obtained from one mole of a gas when its temperature is raised by 1 K isobarically.
- **Units of R :**

(i) In lit-atm $R = \dfrac{1\,\text{atm} \times 22.4\,\text{lit.}}{1\,\text{mol} \times 273\text{ K}}$ **= 0.0821 lit-atm mol^{-1}K^{-1}**

(ii) In C.G.S system $R = \dfrac{1 \times 76 \times 13.6 \times 980\ \text{dyne}\,\text{cm}^{-2} \times 22400\,\text{cm}^3}{1\,\text{mol} \times 273\text{ K}}$

= 8.314 × 10^7 erg mole^{-1} K^{-1}.

(iii) In M.K.S.system (SI units) R **= 8.314 Joule mole^{-1} K^{-1}.** [10^7 erg = 1 joule]

(iv) In calories, $R = \dfrac{8.314 \times 10^7\ \text{erg}\,\text{mole}^{-1}\text{K}^{-1}}{4.184 \times 10^7\,\text{erg}}$

= 1.987 ≈ **2 calorie mol^{-1} K^{-1}.**

Solved Examples

Ex.12 A sample of gas occupies 100 dm^3 at 1 bar pressure and at T °C. If the volume of the gas is reduced to 5 dm^3 at the same temperature, what additional pressure must be applied ?

Sol. From the given data :

P_1 = 1 bar P_2 = ?

V_1 = 100 dm^3 V_2 = 5 dm^3

Since the temperature is constant, Boyle's law can be applied

$$P_1V_1 = P_2V_2 = P_2 = \frac{P_1V_1}{V_2}$$

$$P_2 = \frac{(1\,\text{bar}) \times (100\,\text{dm}^3)}{(5\,\text{dm}^3)} = 20\,\text{bar}$$

∴ Additional pressure applied = 20 – 1 **= 19 bar**

Ex.13 A certain amount of a gas at 27°C and 1 bar pressure occupies a volume of 25 m^3. If the pressure is kept constant and the temperature is raised to 77°C, what will be the volume of the gas ?

Sol. From the available data :

V_1 = 25 m^3 T_1 = 27 + 273 = 300 K

V_2 = ? T_2 = 77 + 273 = 350 K

Since the pressure of the gas is constant, Charles law is applicable

$$\frac{V_1}{V_2} = \frac{T_1}{T_2}$$

or $$V_2 = \frac{V_1 \times T_2}{T_1}$$

$$V_2 = \frac{(25\text{m}^3) \times (350\text{K})}{(300\text{K})}$$ **= 29.17 m^3**

Ex. 14 The density of a gas is found to be 1.56 g dm^{-3} at 0.98 bar pressure and 65°C. Calculate the molar mass of the gas. **Use R = 0.083 dm^3 bar K^{-1} mol^{-1}**

Sol. We know that :

$$M = \frac{dRT}{P} = \frac{(1.56\,g\,dm^{-3}) \times (0.083\,dm^3\,bar\,K^{-1}\,mol^{-1}) \times 338K}{(0.98\,bar)} = \mathbf{44.66\ g\ mol^{-1}}$$

Ex. 15 A glass bulb of 2 L capacity is filled by helium gas at 10 atm pressure. Due to a leakage the gas leaks out. What is the volume of gas leaked if the final pressure in container is 1 atm.

Sol. $P_1 \times 2\,L = P_2 \times V$

$\Rightarrow$ $10 \times 2 = 1 \times V$

$\Rightarrow$ $20 = V$

$V = V' + 2\,L$

$20 = V' + 2\,L$

V' **= 18 L**

$\Rightarrow$ total volume of gas leaked

Ex. 16 LPG is a mixture of n-butane & iso-butane. What is the volume of oxygen needed to burn 1 kg of LPG at 1 atm, 273 K ?

Sol. During the burning of LPG following reaction takes place -

$$C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5\,H_2O$$

Now, for complete combustion of 1 mole of LPG $\longrightarrow \frac{13}{2}$ moles of O_2 are required.

$\therefore$ for $\frac{1000}{58}$ moles of LPG $\longrightarrow \frac{13}{2} \times \frac{1000}{58}$ moles of O_2 are required.

Thus, the volume of oxygen needed to burn 1 kg of LPG at 1 atm & 273K would be

Vol. of O_2 = Moles of O_2 × 22.4 L = $\frac{13}{2} \times \frac{1000}{58} \times 22.4$ = **2510 L**

Ex. 17 The best vacuum so far attained in laboratory is 10^{-10} mm of Hg. What is the number of molecules of gas remain per cm^3 at 20°C in this vacuum ?

Sol. Given conditions -

$P = 10^{-10}$ mmHg $= \frac{10^{-10}}{760}$ atm ; $V = 1\ cm^3 = \frac{1}{1000}$ L ; T = 20°C = 293 K

No. of molecules, N = ?

Now, applying

$PV = nRT$

$\therefore$ number of molecules per cm^3, $N = \frac{N_A \times P \times V}{RT}$

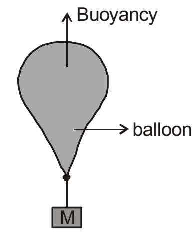
$$\Rightarrow \quad N = \frac{6.023 \times 10^{23} \times (10^{-10}/760) \times (1/1000)}{(0.0821)(293)}$$

N = 3.29 × 10^6 molecules

5.1 Calculation of pay load :

Pay load is defined as the maximum weight that can be lifted by a gas filled balloon.

For maximum weight that can be lifted, applying force balance



$F_{buoyancy} = M_{balloon} \times g + M_{pay\,load} \times g$

$\Rightarrow \quad \rho_{air}$ v.g. = ρ_{gas} v.g + Mg + mg.

mass of balloon = m

volume of balloon = v

density of air = ρ_{air}

density of gas inside the balloon = ρ_{gas}

net force on balloon = 0 (at equilibrium / when balloon is incoming with constant speed)

Solved Examples

Ex.18 A balloon of diameter 20 m weights 100 kg. Calculate its pay-load, if it is filled with He at 1.0 atm and 27ºC. Density of air is 1.2 kg m^{-3}. [R = 0.0082 dm^3 atm K^{-1} mol^{-1}]

Solution : Weight of balloon = 100 kg = 10 × 10^4 g

Volume of balloon = $\frac{4}{3}\pi r^3 = \frac{4}{3}\times\frac{22}{7}\times\left(\frac{20}{2}\times 100\right)^3$ = 4190 × 10^6 cm^3 = 4190 × 10^3 litre

Weight of gas (He) in balloon = $\frac{PVM}{RT} = \frac{1\times 4190\times 10^3\times 4}{0.082\times 300}$ = 68.13 × 10^4 g $\left(\because \; PV = \frac{w}{M}RT\right)$

$\therefore$ Total weight of gas and balloon = 68.13 × 10^4 + 10 × 10^4 = 78.13 × 10^4 g

Weight of air displaced = $\frac{1.2\times 4190\times 10^6}{10^3}$ = 502.8 × 10^4 g

$\therefore$ Pay load = wt. of air displaced – (wt. of balloon + wt. of gas)

$\therefore$ Pay load = 502.8 × 10^4 – 78.13 × 10^4 = **424.67 × 10^4 g**

5.2 Analysis of gaseous mixture :

Vapour Density : Vapour density of any gas is defined as the density of any gas with respect to density of the H_2 gas under identical conditions of temperature T and pressure P.

$$\text{Vapour Density} = \frac{\text{density of gas at T\&P}}{\text{density of } H_2 \text{ under same P \& T}}$$

$$P = \frac{m}{V}.\frac{RT}{M} \quad \Rightarrow \quad P = \rho\frac{RT}{M} \quad \Rightarrow \quad \rho = \frac{PM}{RT}$$

$$\text{Vapour Density} = \frac{PM_{gas}RT}{RT\,PM_{H_2}} = \frac{M_{gas}}{M_{H_2}} = \frac{M_{gas}}{2}$$

M_{gas} = 2 × vapour density

Average molecular mass of gaseous mixture :

total mass of the mixture divided by total no. of moles in the mixture

$$M_{mix} = \frac{\text{Total mass of mixture}}{\text{Total no. of moles in mixture}}$$

If we have 'n_1', 'n_2' and 'n_3' are moles of three different gases having of molar mass 'M_1', 'M_2' and 'M_3' respectively.

$$M_{min} = \frac{n_1M_1 + n_2M_2 + n_3M_3}{n_1 + n_2 + n_3}$$

Ex.19 Calculate the mean molar mass of a mixture of gases having 7 g of Nitrogen, 22 g of CO_2 and 5.6 litres of CO at STP.

Sol. Moles of N_2 = 7/28 = 1/4 Moles of CO_2 = 22/44 = 1/2 Moles of CO = 5.6 / 22.4 = 1/4

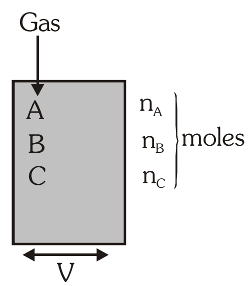
mean molar mass = $M_{min} = \dfrac{n_1M_1 + n_2M_2 + n_3M_3}{n_1 + n_2 + n_3}$ = (7 + 7 + 22) / 1 = 36

6. DALTON'S LAW OF PARTIAL PRESSURES

6.1 Partial pressure :

In a mixture of non-reacting gases, partial pressure of any component gas is defined as the pressure exerted by the individual gas if whole of the volume of mixture had been occupied by this component only.

Partial pressure of component gases are -



$P_A = \dfrac{n_A RT}{V}$ = partial pressure of A

$P_B = \dfrac{n_B RT}{V}$ = partial pressure of B

$P_C = \dfrac{n_C RT}{V}$ = partial pressure of C

6.2 Dalton's Law :

Dalton's law of partial pressure states "at a given temperature, the total pressure exerted by two or more non-reacting gases occupying a definite volume is equal to the sum of the partial pressures of the component gases."

$P_{Total} = p_1 + p_2 + p_3 + ...$ (At constant V and T)

$$= \left(\frac{n_1}{V} + \frac{n_2}{V} + \frac{n_3}{V} + ...\right)RT = (n_1 + n_2 + n_3 + ...)\frac{RT}{V} = \frac{nRT}{V}$$

Where $n = n_1 + n_2 + n_3 + ...$ = Total moles, V = Total volume

$$P_{Total} = \sum p_i = \frac{RT}{V}\sum n_i$$

- **Dalton's law of partial pressure is applicable only to non-reacting gases.**
  If the two non-reacting gases A and B having n_A and n_B number of moles respectively are filled in a vessel of volume V at temperature T, then

$$\frac{p_A}{P} = \frac{n_A RT/V}{(n_A + n_B)RT/V} = \frac{n_A}{n_A + n_B} = x_A \text{ (mole fraction of A)}$$

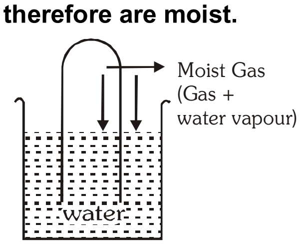
$p_A = x_A \times P$, Similarly $p_B = x_B \times P$

Partial pressure of a component = Mole fraction × total pressure.

6.3 It has been observed that gases are generally collected over water and therefore are moist.

$P_{dry\ gas} = P_{moist\ gas} - P_{water\ vapour}$

or Pressure of dry gas = Pressure of moist gas – aqueous tension



The pressure exerted by water vapour is constant when it is in equilibrium with liquid water at a particular temperature. It is called vapour pressure of water or ***aqueous tension***, which varies with the temperature and becomes 760 mm at 100°C.

6.4 Relative Humidity (RH) = $\dfrac{\text{Partial pressure of water in air}}{\text{Vapour pressure of water (aq.tension)}}$

Solved Examples

Ex.20 (a) Find the total pressure and partial pressure of each component if a container of volume 8.21 lit. contains 2 moles of A and 3 mole of B at 300K.

(b) What will be the final pressure and partial pressure of each component if 5 moles of C is also added to the container at same temperature.

Sol. (a) $P_A = \frac{n_A RT}{V} = \frac{2 \times 0.821 \times 300}{8.21} = 6\,\text{atm}$

$P_B = \frac{n_B RT}{V} = \frac{3 \times 0.821 \times 300}{8.21} = 9\,\text{atm}$

Total pressure $P_T = P_A + P_B = 6 + 9 = 15$ atm

(b) $P_C = \frac{n_C RT}{V} = \frac{5 \times 0.821 \times 300}{8.21} = 15\,\text{atm}$

Note: If we add or remove a non reacting gas partial pressure of other gases remains unchanged.

$P_T = P_A + P_B + P_C = 6 + 9 + 15 = 30$ atm

Ex. 21 2 moles of NH_3(g) and 1 mole of HCl(g) are taken in a container of capacity 8.21 lit at 300K to produce NH_4Cl(s). Find the total pressure after the reaction.

Sol.

	$NH_3(g)$	+ $HCl(g)$	$\longrightarrow NH_4Cl(s)$
initial	2	1	
after rxn	1	0	

In this reaction HCl is L.R. so it will be completely consumed. We don't consider pressure due to solid.

$\therefore$ $P_T = \frac{nRT}{V} = \frac{1 \times 0.821 \times 300}{8.21} = 3\,\text{atm}$

Ex. 22 A closed container containing O_2 and some liquid water was found to exert 740 mm pressure at 27°C.

(a) Then calculate the pressure exerted by O_2 if aqueous tension at 27°C is 20 mm.

(b) What will be the final pressure if volume is reduced to half.
(consider volume of liquid water negligible)

(c) What will be the final pressure if volume is doubled.

Sol. (a) $P_T = P_{\text{dry gas}} + P_{\text{aq. tension}}$

$740 = P_{O_2} + 20$

$P_{O_2} = 740 - 20 = 720$ mm

(b) $\left(P_{O_2} V_{O_2}\right)_{\text{initial}} = \left(P_{O_2} V_{O_2}\right)_{\text{final}}$ (Boyle's law)

$720 \times V = P_{O_2} \times \frac{V}{2}$

$P_{O_2} = 1440\,\text{mm}$

$P_T = P_T = P_{O_2} + P_{\text{aq.}}$

$= 1440 + 20 = 1460$ mm

(c) $\left(P_{O_2} V_{O_2}\right)_{\text{initial}} = \left(P_{O_2} V_{O_2}\right)_{\text{final}}$

$720 \times V = P_{O_2} \times 2V$

$P_{O_2} = 360$ mm

$P_T = P_{O_2} + P_{\text{aq.}}$

$= 360 + 20$ **= 380 mm**

7. PROBLEM RELATED WITH DIFFERENT TYPE OF CONTAINERS

I. Closed Container :

In this case gas can neither go outside nor it can come inside. So number of moles of gas is always constant. Closed container can be of following types -

(a) Closed rigid container : In this case number of moles constant, volume constant.

At this condition :

Initial Final

$$\frac{P_1}{T_2} = \frac{P_2}{T_2}$$

Example : Gas cylinder

(b) Closed non rigid container : (fitted with freely movable piston)

In this kind of container inside pressure is always equal to outside pressure, i.e., atmospheric pressure so that n = constant , p = constant

Ex: Balloon, Water bubble

Initial Final

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Solved Examples

Ex.23 A balloon is inflated to $\frac{7}{8}$ of its maximum volume at 27°C then calculate the minimum temperature above which it will burst.

Sol. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\qquad$ $\frac{7V}{8 \times 300} = \frac{V}{T}$

T = 342.8 K

Ex.24 A gas cylinder containing cooking gas can with stand a pressure of 18 atm. The pressure gauge of cylinder indicates 12 atm at 27°C. Due to sudden fire in building the temperature start rising at what temperature will the cylinder explode.

Sol. $\frac{P_1}{T_2} = \frac{P_2}{T_2}$

$$\frac{12}{300} = \frac{18}{T}$$

T = 450 K

II. Tyre tube/bolloon type container :

In this case temperature is always constant. Initially on adding gas volume of tube will increase and pressure of tube will remain constant until it will gain maximum volume.

$\because$ $V \propto n$

Initial Final

$$\frac{V_1}{n_2} = \frac{V_2}{n_2}$$

after attaining maximum volume on adding gas pressure reach to a maximum possible pressure.

Hence at this condition volume constant or temperature constant.

V = constant T = constant

$P \propto n$

$$\frac{P_1}{n_1} = \frac{P_2}{n_2}$$

Solved Examples

Ex.25 A tyre tube of maximum volume 8.21 lit. can withstand a pressure of 10 atm. Initially the tube is empty.

(i) Calculate the number of moles required to inflate completely the tube upto a pressure of 1 atm & 300 K temperature.

(ii) Calculate the minimum number of moles required to burst the tyre tube at 300 K.

Sol. **(i)** PV = nRT

$1 \times 8.21 = n_1 \times 0.0821 \times 300$

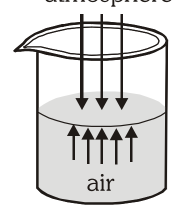
$n_1 = \frac{1}{3}$

(ii) PV = nRT

$10 \times 8.21 = n_2 \times 0.0821 \times 300$

$n_2 = \frac{10}{3}$

III. **Open rigid container :** When air is heated in an open vessel , pressure is always atmospheric pressure i.e., constant and volume is also constant.



At this condition

Initial Final

$n_1 T_1 = n_2 T_2$

n_1 = initial number of moles

n_2 = final number of moles

$\mathbf{n_{initial} = n_{final} + n_{removed.}}$

Ex.26 An open flask contains air at 27°C. Calculate the temperature at which it should be heated so that

(a) 1/3rd of air measured in the container at 27°C escape out.

(b) 1/3rd of air measured in the container at final temperature escape out.

Sol. **(a)** $\mathbf{n_{initial} - n_{final} = n_{expelled}}$

$$\frac{PV}{R\times 300} - \frac{PV}{R\times T} = \frac{1}{3}\times\frac{PV}{R\times 300} \;=\; \frac{1}{300} - \frac{1}{T} = \frac{1}{900}$$

$$\frac{1}{T} = \frac{1}{300} - \frac{1}{900} = \frac{3-1}{900} = \frac{2}{900} \Rightarrow \quad T = 450\text{ K} = 177°\text{C}$$

(b) $\mathbf{n_{initial} - n_{final} = n_{expelled}}$

$$\frac{PV}{R\times 300} - \frac{PV}{R\times T} = \frac{1}{3}\times\frac{PV}{R\times T}$$

$$\frac{1}{300} - \frac{1}{T} = \frac{1}{3\times T}$$

$\Rightarrow$ T = 400 K = 127°C

Ex.27 A bulb of unknown volume containing air is heated from 27°C to 227°C at constant pressure. The expelled air is measured at different temperature of determine volume of container. What will be volume of container if -

(a) 200 ml of air measured at 227°C was expelled.

(b) 200 ml of air measured at 27°C was expelled.

(c) 200 ml of air measured at 127°C was expelled.

Sol. **(a)** $\mathbf{n_{initial} - n_{final} = n_{expelled}}$

$$\frac{PV}{R\times 300} - \frac{PV}{R\times 500} = \frac{P\times 200}{R\times 500}$$

$$\frac{V}{3} - \frac{V}{5} = \frac{200}{5}$$

$$\frac{5V-3V}{15} = \frac{200}{5}$$

$\Rightarrow \quad 2V = \dfrac{200 \times 15}{5} \quad \Rightarrow \quad V = 300$ ml

(b) $\dfrac{PV}{R \times 300} - \dfrac{PV}{R \times 500} = \dfrac{P \times 200}{R \times 300} = \dfrac{2V}{15} = \dfrac{200}{3} \Rightarrow V = \dfrac{100 \times 15}{2 \times 3} = 500\text{ml}$

(c) $\dfrac{PV}{R \times 300} - \dfrac{PV}{R \times 500} = \dfrac{P \times 200}{R \times 400}$

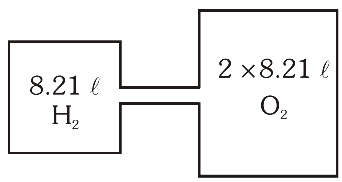
$\dfrac{2V}{15} = \dfrac{200}{4} \quad \Rightarrow \quad V = \dfrac{200 \times 15}{2 \times 4} = 375\text{ml}$

IV. Connected Container :

If containers are connected for substantial time then gases move from one container to another container till partial pressure of each component of mixtures becomes equal in all connected containers (irrespective whether containers have same or different temperature and volumes)

Solved Examples

Ex.28 A container of 8.21 lit. capacity is filled with 1 mole of H_2 at 300 K and it is connected to another container of capacity 2 × 8.21 lit. containing 4 moles of O_2 at 300 K, then find the final pressure & partial pressure of each gas.



Sol. $P_f V_f = n_f RT$

$P_f (3 \times 8.21) = 5 \times 0.0821 \times 300$

$P_f = 5$ atm

$P_{H_2} = x_{H_2} P_f = \dfrac{1}{1+4} \times 5 = 1\text{atm}$

$P_{O_2} = x_{O_2} P_f = \dfrac{4}{1+4} \times 5 = 4\text{atm}$

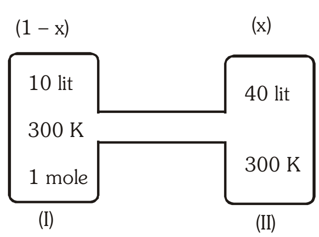
Ex.29 A 10 litre container consist of 1 mole of gas at 300 K. It is connected to another container having volume 40 litre and is initially at 300 K. The nozzle connecting two containers is opened for a long time and once the movement of gas stopped, the larger container was heated to a temperature of 600 K. Calculate

(a) Moles and pressure of gas in both the containers before heating.

(b) Moles and pressure in two containers after heating.

(Assume that initially the larger container is completely evacuated.)

Sol. **(a)** Before heating :



$P_I = P_{II}$

$\dfrac{(1-x)R \times 300}{10} = \dfrac{x \times R \times 300}{40}$

x = 0.8 moles

$n_I = 1 - x = 0.2$ mole

$n_{II} = x = 0.8$ mole

Pressure $= \dfrac{x \times R \times T}{V} = \dfrac{0.8 \times R \times 300}{40} = 0.492$ atm

(b) After heating :

$$\frac{(1-x_1)R \times 300}{10} = \frac{x_1 \times R \times 600}{40}$$

x_1 = 0.67 moles, Given T_1 = 600 K

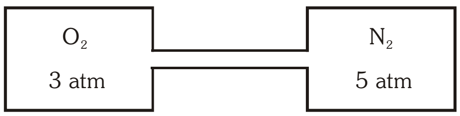
Pressure $= \frac{x_1 \times R \times T_1}{V} = \frac{0.67 \times .0821 \times 600}{40}$ = 0.821 atm

8. GRAHAM'S LAW OF DIFFUSION & EFFUSION

8.1 Diffusion :

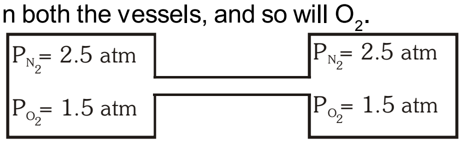
The ***diffusion*** is the process of gradual mixing of molecules of one gas with molecules of another gas due to their molecular motion (kinetic energy). The diffusion always proceeds from a region of high concentration to a region of lower concentration (or high partial pressure to low partial pressure). For example, when a bottle of perfume is opened at one end of the room, the person sitting at the other end of the room can smell the perfume because of the diffusion process of perfume molecules.

Note : Initially



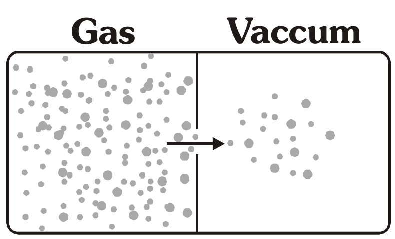
When stop cock is removed flow will be from both sides, N_2 will try to equalise its partial pressure in both the vessels, and so will O_2.

Finally



8.2 Effusion :

The effusion is the process of forcing a gas through a pin hole or small orifice from one compartment to another empty (vacuum) compartment.



8.3 Graham's Law :

Under similar condition of pressure (partial pressure) and temperature, the rate of diffusion of different gases is inversely proportional to square root of their density.

$\Rightarrow$ rate of diffusion, $\boxed{r \propto \frac{1}{\sqrt{d}}}$

$$\Rightarrow \quad \frac{r_1}{r_2} = \frac{\sqrt{d_2}}{\sqrt{d_1}} = \frac{\sqrt{M_2}}{\sqrt{M_1}} = \frac{\sqrt{V.D_2}}{\sqrt{V.D_1}}$$

where, d = density of gas

V.D = vapour density

M = molar mass of gas

- The general form of the grahams law of diffusion can be stated as follows, when one or all of the parameters are varied.

$$\text{rate} \propto \frac{P}{\sqrt{TM}} A$$

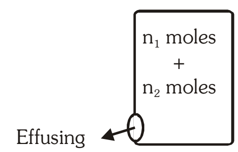
P – Pressure, A – area of hole, T – Temp. , M – mol. wt.

- **Under conditions of same temperature but different pressure, we have -**

$$\boxed{r \propto \frac{P}{\sqrt{M}}}$$

$$\boxed{\frac{r_1}{r_2} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}}}$$

If both gases are present in the same container at same temperature.



$$P \propto n$$

$$\Rightarrow \quad \frac{r_1}{r_2} = \frac{n_1}{n_2}\sqrt{\frac{M_2}{M_1}}$$

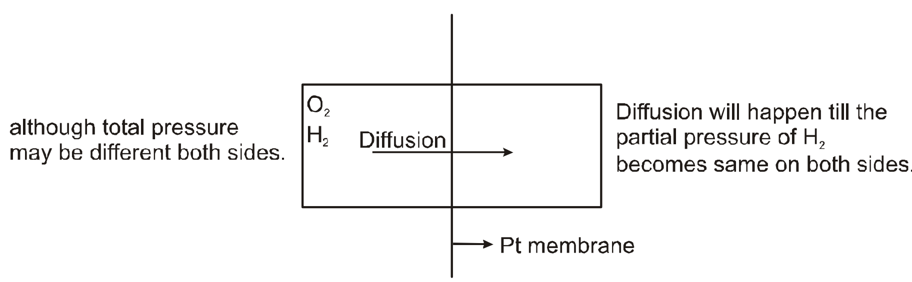
Rate of diffusion/effusion can be expressed as -

$$r = \frac{\text{volume diffused}}{\text{time taken}} \text{ or } \frac{\text{moles diffused}}{\text{time taken}} \text{ or } \frac{\text{pressure dropped}}{\text{time taken}}$$

or $$\frac{\text{distance travelled in horizontal tube of uniform cross} - \text{section}}{\text{time taken}}$$

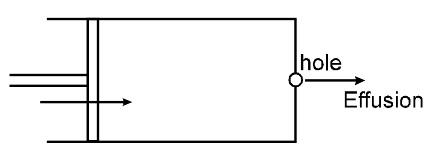
Selective diffusion :

If one or more than one components of a mixture are allowed to diffuse and others are not allowed then it is selective diffusion of those components.



☞ **Platinum allows only H_2 gas to pass through**

Effusion : (forced diffusion) a gas is made to diffuse through a hole by the application of external pressure.



Solved Examples

Ex. 30 32 ml of He effuses through a fine orifice in 1 minute. Then what volume of CH_4 will diffuse in 1 minute under the similar condition.

Sol. $\because$ $r \propto \frac{1}{\sqrt{M}}$

$r = \frac{\text{volume diffused}}{\text{time}}$

$\because$ time is same so

$$\frac{V_{CH_4}}{V_{He}} = \sqrt{\frac{M_{He}}{M_{CH_4}}}$$

$$\frac{V_{CH_4}}{32} = \sqrt{\frac{4}{16}}$$

$$V_{CH_4} = \frac{1}{2} \times 32 = 16\,\text{mL}$$

Ex. 31 20 dm^3 of Ne diffuse through a porous partition in 60 seconds. What volume of SO_3 will diffuse under similar conditions in 30 sec. (Atomic wt. of Ne = 20, S = 32)

Sol. $\frac{r_{N_e}}{r_{SO_3}} = \sqrt{\frac{M_{SO_3}}{M_{Ne}}} \Rightarrow \frac{V_{Ne}/t_{Ne}}{V_{SO_3}/t_{SO_3}} = \sqrt{\frac{M_{SO_3}}{M_{Ne}}}$

$\Rightarrow$ $V_{SO_3} = \frac{V_{Ne} \times t_{SO_3}}{t_{Ne}} \times \sqrt{\frac{M_{Ne}}{M_{SO_3}}} = \frac{20 \times 30}{60} \times \sqrt{\frac{20}{80}} = \frac{10}{2} = 5\ dm^3$

Ex. 32 A gaseous mixture of O_2 and X containing 20% (mole %) of X, diffused through a small hole in 234 seconds while pure O_2 takes 224 seconds to diffuse through the same hole. Molecular weight of X is :

Sol. $\frac{t_{mix}}{t_{O_2}} = \sqrt{\frac{M_{mix}}{M_{O_2}}}$

$\frac{234}{224} = \sqrt{\frac{M_{mix}}{32}}$

$\therefore$ $M_{mix} = 34.921.$

As the mixture contains 20% (mole %) of X, the molar ratio of O_2 and X may be represented as 0.8n : 0.2n, n being the total no. of moles.

$\therefore$ $M_{mix} = \frac{32 \times 0.8n + M_x \times 0.2n}{n} = 34.921$

$\therefore$ M_x (mol. wt. of X) = 46.6

Ex.33 At 1200ºC, mixture of Cl_2 and Cl atoms (both in gaseous state) effuses 1.16 times as fast as krypton effuses under identical conditions. Calculate the fraction of chlorine molecules dissociated into atoms. M (Kr) = 83.8 g mol^{-1}.

Sol. $Cl_2 \rightleftharpoons 2Cl$

$$\frac{r(Cl_2 \text{ and } Cl \text{ mix})}{r(Kr)} = 1.16\sqrt{\frac{M(Kr)}{M_{av}(Cl_2 + Cl)}} = \sqrt{\frac{83.8}{M_{av}}}$$

$\therefore$ $M_{av} = \dfrac{83.8}{(1.16)^2} = 62.28$ g mol^{-1}

	Cl_2	$\rightleftharpoons$	$2Cl$
Initial mole	1		0
After dissociation	(1 – x)		2x

(x = degree of dissociation)

Total moles after dissociation = 1 – x + 2x = (1 + x)

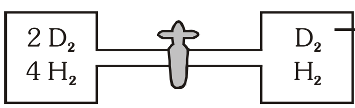
$$\therefore \quad \frac{(1-x)M(Cl_2)+2x\,M(Cl)}{(1+x)} = 62.28 \Rightarrow \frac{(1-x)\times 71+2x\times 35.5}{1+x} = 62.28$$

x = 0.14

$\therefore$ % dissociation = 14%

Ex.34 A mixture containing 2 moles of D_2 and 4 moles of H_2 is taken inside a container which is connected to another empty container through a nozzle. The nozzle is opened for certain time and then closed. The second bulb was found to contain 4 gm D_2. Then find % by moles of the lighter gases in second container.

Sol. I II



$w_{D_2} = 4$ gm

$n_{D_2} = \dfrac{4}{4} = 1$

lighter gas = H_2

$$\frac{r_{H_2}}{r_{D_2}} = \frac{n_{H_2}}{n_{D_2}}\sqrt{\frac{M_{D_2}}{M_{H_2}}} = \frac{n'_{H_2}/t}{n'_{D_2}/t}$$

$$(\%\text{ mole of } H_2)_{II} = \left(\frac{n'_{H_2}}{n'_{H_2} + n'_{D_2}}\right)\times 100$$

$$\therefore \quad \frac{n_{H_2}}{n_{D_2}}\sqrt{\frac{M_{D_2}}{M_{H_2}}} = \frac{n'_{H_2}}{n'_{D_2}} \quad \Rightarrow \quad \frac{4}{2}\sqrt{\frac{4}{2}} = \frac{n'_{H_2}}{1}$$

$$\Rightarrow \quad n'_{H_2} = 2\sqrt{2} \quad \Rightarrow \quad n'_{D_2} = 1$$

$$(\%\text{ mole of } H_2)_{II} = \frac{(2\sqrt{2})}{(2\sqrt{2}+1)}\times 100$$

$$= \frac{2\times 1.44}{[(2\times 1.44)+1]}\times 100 = \frac{(2.8)}{(2.8+1)}\times 100 = \frac{(2.8)}{(2.8+1)}\times 100$$

= 73.87%

9. KINETIC THEORY OF GASES

This is a theoretical model for ideal gas which can correlate the experimental facts (like Boyle's law, Charle's law& Avogadro's law etc.). It was presented by ***Bernoulli in 1738*** and developed in 1860 by ***Clausius, Maxwell, Kroning*** *and* ***Boltzmann***. Postulates of kinetic theory of gases are :

(i) All the gases consist of very small molecules or atoms whose volume is negligible compared to volume of container.
(ii) There are no attractive or repulsive forces between the molecules.
(iii) The gaseous molecules are under a continuous state of motion which is unaffected by gravity (the random straight line motion is known as brownian motion)
(iv) Due to the continuous motion, collision between gaseous molecules and with the wall of container occurs. The collision with the wall of container are responsible for pressure exerted by the gas on the wall of container.
(v) The molecule moves with different speed, however the speed of each molecule keep on changing as the collision occur.
(vi) Collision among gas particles molecules is perfectly elastic, i.e., there is no loss in kinetic energy and moment during such collision.
(vii) The average kinetic energy of gas particles will depends on absolute temperature only.

9.1 Kinetic gas equation :

$\therefore$ $PV = \frac{1}{3} mN u_{rms}^2$; ***This equation is called kinetic gas equation.***

P = **Pressure of gas**

V = **Volume of gas**

m = **Mass of gas molecule**

N = **Number of gas molecules**

u_{rms} = **Root mean square speed**

9.2 Kinetic energy of gas molecules :

Total translational K.E. of molecules

$$= \frac{1}{2} mN.u_{rms}^2 = \frac{3}{2}PV = \frac{3}{2}nRT$$

$\therefore$ Average translational K.E. per mole $= \frac{3}{2}RT$

and $(K.E.)_{per\ molecule} = \frac{3}{2}\left(\frac{R}{N_A}\right)T = \frac{3}{2}kT$

Where k = Boltzman constant $= \frac{R}{N_A} = \frac{8.314 J/molK}{6.02 \times 10^{23}} = 1.3806 \times 10^{-23}\ J\ K^{-1}$

• $(K.E.)_{per\ molecule}$ and $(K.E.)_{per\ mol}$ is only depend on absolute temperature. It is does not depend on the nature of gas. This conclusion is known as ***"Maxwell's Generalisation"***.

Ex.35 Calculate the kinetic energy of 8 gram methane (CH_4) at 27°C temperature.

Sol. $n = \frac{8}{16} = \frac{1}{2}$, T = (27° + 273) = 300 K, R = 8.314 J $mol^{-1} K^{-1}$

$(K.E.)_{n\ mol} = n \times \frac{3}{2}RT = \frac{1}{2} \times \frac{3}{2} \times 8.314 \times 300 = 1870.65$ J

Ex.36 Calculate the pressure exerted by 10^{23} gas molecules, each of mass 10^{-25} kg, in a container of volume $1 \times 10^{-3}\ m^3$ and having root mean square velocity of $10^3\ ms^{-1}$. Also calculate total kinetic energy and Temperature of the gas.

Sol. By kinetic theory

$$P = \frac{1}{3}\frac{mNu^2}{V} = \frac{1\times10^{-25}\times10^{23}\times(10^3)^2}{3\times10^{-3}} = 3.33 \times 10^6\ N\ m^{-2}$$

$$\text{Total KE} = \left(\frac{1}{2}mu_{rms}^2\right) \times N = \frac{1}{2} \times 10^{-25} \times (10^3)^2 \times 10^{23} = \frac{1}{2} \times 10^4 = 0.5 \times 10^4\ J$$

Also total KE = $\frac{3}{2}$ nRT, where n (mole)= $\frac{10^{23}}{N_A} = \frac{10^{23}}{6.023\times10^{23}}$

$$0.5 \times 10^4 = \frac{3}{2}\times\frac{10^{23}}{6.023\times10^{23}}\times 8.314\times T$$

$$\therefore \quad T = \frac{0.5\times10^4\times2\times6.023}{3\times8.314} = 2415\ K$$

9.3 Root Mean Square Velocity (u_{rms}) by kinetic gas equation :

$$PV = \frac{1}{3} mN\,u_{rms}^2$$

$$\therefore \quad u_{rms} = \sqrt{\frac{3PV}{mN}} = \sqrt{\frac{3P}{d}} = \sqrt{\frac{3RT}{M}}$$

9.4 Diffrent kind of speed of molecules :

(i) Average or mean speed, $u_{av} = \frac{u_1 + u_2 + \ldots\ldots.. + u_N}{N} = \sqrt{\frac{8RT}{\pi M}}$

(ii) Root mean square speed, $u_{rms} = \sqrt{\frac{u_1^2 + u_2^2 + \ldots\ldots.. + u_N^2}{N}} = \sqrt{\frac{3RT}{M}}$

(iii) Most probable speed, $u_{mp} = \sqrt{\frac{2RT}{M}}$

It is the speed at which maximum fraction of molecules are travelling

❖ **Ratio of speeds :**

$$U_{rms} : U_{avg} : U_{mps} = \sqrt{\frac{3RT}{M}} : \sqrt{\frac{8RT}{\pi M}} : \sqrt{\frac{2RT}{M}}$$

$= \sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$ = 1.22 : 1.13 : 1 : 00 = 1.00 : 0.92 : 0.816

10. MAXWELL'S DISTRIBUTION OF SPEEDS

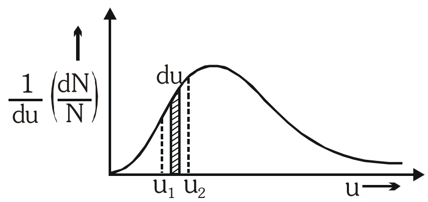
It has already been pointed out that a gas is a collection of tiny particles separated from one another by large empty spaces and moving rapidly at random in all directions. In the course of their motion, they collide with one another and also with the walls of the container. Due to frequent collisions, the speeds and directions of motion of the molecules keep on changing. Thus, all the molecules in a sample of gas do not have same speed. Although it is not possible to find out the speeds of individual molecule , yet from probability considerations it has become possible to work out the distribution of molecules in different speed intervals. This distribution is referred to as the Maxwell-Boltzmann distribution in honour of the scientists who developed it. It may be noted that the distribution of speeds remains constant at a particular temperature although individual speeds of molecules may change.

N = Total number of molecules.
M = Molar mass of gas (kg/mol)
u = Root mean square velocity
du = Velocity interval
dN = Number of molecules having speeds between u and u + du.
dN / N = fraction of molecules having speeds between u and u + du.

and $\frac{1}{N}\left(\frac{dN}{du}\right)$ = fraction of molecules having speed between u to u + du per unit interval of speed.
= Maxwell distribution function.

10.1 Properties of Maxwell's graph :

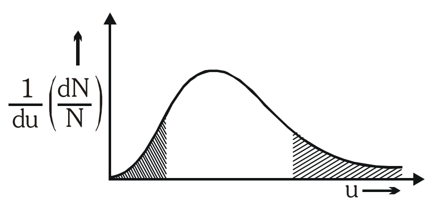
I.



Area between u_1 and u_2 = $\int_{u_1}^{u_2} \frac{1}{du}\left(\frac{dN}{N}\right)du = \int_{u_1}^{u_2}\left(\frac{dN}{N}\right)$

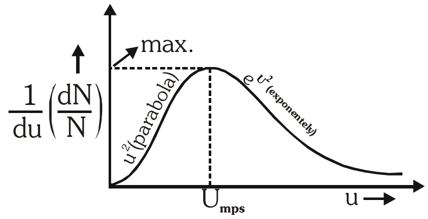
Hence, total fraction of particles with speed between u_1 and u_2
= Area under the curve represents fraction of molecules.

II.



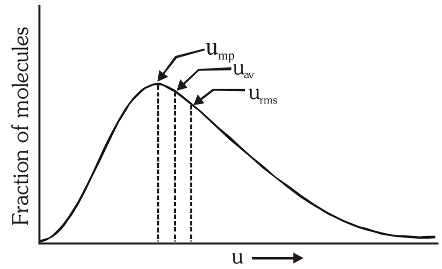
It can be seen from the above figure, that the fraction of molecules having either very low speeds or very high speeds are small in numbers.

III.



The most probable speed is the speed possessed by the maximum fraction of the molecules.

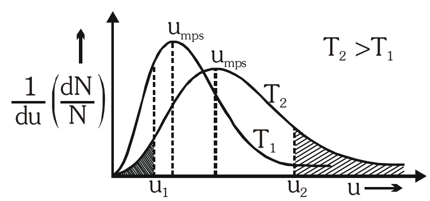
IV. Graph between fraction of molecules vs molecular speeds :



$$U_{rms} : U_{avg} : U_{mps} = \sqrt{\frac{3RT}{M}} : \sqrt{\frac{8RT}{\pi M}} : \sqrt{\frac{2RT}{M}}$$

$$= \sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2} = 1.22 : 1.13 : 1 : 00 = 1.00 : 0.92 : 0.816$$

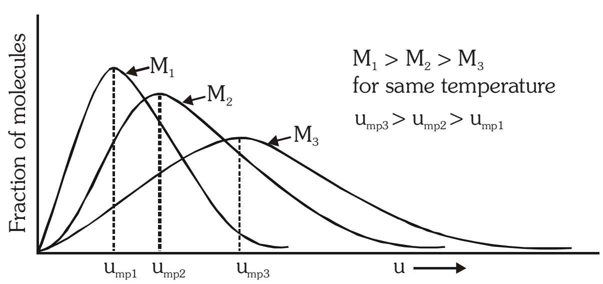
V.



Total area under the curve will be constant and will be unity at all temperatures. The above figure illustrates the distribution of speeds at two temperatures T_1 and T_2. Since the total no. of molecules is same at both temperatures, increase in the K.E. of the molecules results decrease in fraction of molecules having lower speed range and increase in fraction of molecules having higher speed range on increasing the temperature. On increasing temperature the value of u_{mps}(most probable speed) will increase. Also the curve at the higher temperature T_2 has its u_{mps} shifted to a higher value compared with that for T_1, whereas corresponding fraction of molecules has decreased. But at the same time, the curve near u_{mps} has become broader at the higher temperature indicating the more molecules possess speeds near to most probable speed.

- The area under the curve will denote fraction of molecules having speeds between zero and infinity
- Total area under the curve will be constant and will be unity at all temperatures.
- Area under the curve between zero and u_1 will give fraction of molecules racing speed between 0 to u_1 . This fraction is more at T_1 and is less at T_2 .
- The peak corresponds to most probable speed.
- At higher temperature, fraction of molecules having speed less than a particular value decreases.

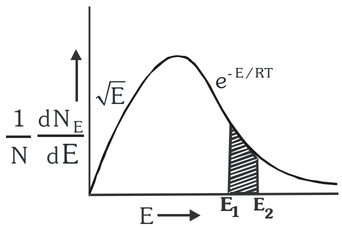
VI. For Gases with different molar masses will have following graph at a given temperature.



At a given temperature u_{mps} will be more for lighter gas (M_3) but fraction of molecules moving with u_{mps} will be more for heavier gas (M_1).

Note : Effect of M and T are opposite.

10.2 Maxwell Distribution of kinetic energy :



The shaded area of this graph indicate the fraction of particles having energy between E_1 and E_2

Solved Examples

Ex. 37 Four particles have speed 2, 3, 4 and 5 cm/s respectively. Find their avg. & rms speed :

Sol. $U_{avg.} = \frac{U_1 + U_2 + U_3 + ...U_N}{N}$

$U_{avg.} = \frac{2+3+4+5}{4} = 3.5\,cm/s$

$U_{r.m.s.} = \sqrt{\frac{U_1^2 + U_2^2 + U_3^2 + ...}{N}}$

$u_{rms} = \sqrt{\frac{2^2 + 3^2 + 4^2 + 5^2}{4}} = \frac{\sqrt{54}}{2}\,cm/s$

Ex.38 At what temperature do the average speed of $CH_{4(g)}$ molecule equal the average speed of O_2 molecule at 300 K ?

Sol. $(U_{avg})_{CH_4} = (U_{avg})_{O_2}$

$\sqrt{\frac{8RT}{\pi \times 16}} = \sqrt{\frac{8 \times R \times 300}{\pi \times 32}}$

T = 150 K

Ex.39 At 27°C find the ratio of root mean square speeds of ozone to oxygen :-

Sol. $\frac{U_{rms}(O_3)}{U_{rms}(O_2)} = \sqrt{\frac{\frac{3RT}{M.W_{O_3}}}{\frac{3RT}{M.W_{O_2}}}} = \sqrt{\frac{M.W_{O_2}}{M.W_{O_3}}} = \sqrt{\frac{32}{48}} = \sqrt{\frac{2}{3}}$

Ex.40 The temperature at which U_{rms} of He becomes equal to U_{mp} of CH_4 at 500 K.

Sol. $(U_{rms})_{He} = (U_{mp})_{CH_4}$

$\sqrt{\frac{3RT_{He}}{M_{He}}} = \sqrt{\frac{2RT_{CH_4}}{M_{CH_4}}}$

$\frac{3T}{4} = \frac{2 \times 500}{16}$

$T = \frac{250}{3}K$

MISCELLANEOUS PREVIOUS YEARS QUESTION

1. Calculate the total pressure in a 10 litre cylinder which contains 0.4 g He, 1.6 g oxygen and 1.4 g of nitrogen at 27ºC. Also calculate the partial pressure of He gas in the cylinder. Assume ideal behavious for gases.

Ans. **0.492 atmp ; 0.246 atmp**

Sol. Given, V = 10 litre, T = 27 + 273 = 300K

Mole of He = $\frac{0.4}{4}$ = 0.1 ; mole of O_2 = $\frac{1.6}{32} = 0.05$;

Mole of N_2 = $\frac{1.4}{28} = 0.05$

$\therefore$ Total moles = 0.1 + 0.05 + 0.05 = 0.20

$P_M = \frac{nRT}{V} = \frac{0.2 \times 0.082 \times 300}{100} = 0.492\text{atm}$

$\therefore$ P'_{He} = P_M × Mole fraction of He = 0.492 × $\frac{0.05}{0.2}$ = 0.246 atm

P'_{O_2} = P_M × Mole fraction of O_2 = 0.492 × $\frac{0.05}{0.2}$ = 0.0123 atm

P'_{N_2} = P_M × Mole fraction of N_2 = 0.492 × $\frac{0.05}{0.2}$ = 0.0123 atm

2. According to Graham's law , at a given temperature the ratio of the rates of diffusion $\frac{r_A}{r_B}$ of gases A and B is given by :

(A) $\frac{P_A}{P_B}\left(\frac{M_A}{M_B}\right)^{1/2}$ (B) $\left(\frac{M_A}{M_B}\right)\left(\frac{P_A}{P_B}\right)^{1/2}$ (C) $\frac{P_A}{P_B}\left(\frac{M_B}{M_A}\right)^{1/2}$ (D) $\frac{M_A}{M_B}\left(\frac{P_B}{P_A}\right)^{1/2}$

Ans. **(C)**

3. An evacuated glass vessel weighs 50.0 g when empty, 148.0 gm when filled with a liquid of density 0.98 g /mL and 50.5 g when filled with an ideal gas at 760 mm Hg at 300 k . Determine the molecular weight of the gas .

Ans. **123**

Sol. Weight of liquid = 148 – 50 = 98 g

Volume of liquid = $\frac{98}{0.98} = 100\text{mL}$ = volume of vessel

Thus, vessel of 100 ml contains ideal gas at 760 mm of Hg at 300K.

Weight of gas = 50.5 – 50 = 0.5 g

Using PV = nRT

$\frac{760}{760} \times \frac{100}{1000} \times \frac{0.5}{m} = 0.0821 \times 300$

$\therefore$ Molecular weight of gas (m) = 123

4. The pressure exerted by 12 g of an ideal gas at temperature t ºC in a vessel of volume V is one atmp. When the temperature is increased by 10 degrees at the same volume, the pressure increases by 10 %. Calculate the temperature 't' and volume 'V'. [molecular weight of gas = 120]

Ans. **–173°C , 0.82 L**

Sol. P_1 = 1 = 1 atm, T_1 = t + 273

$P_2 = 1 + \frac{10}{100}$ = 1.1 atm, T_2 = t + 283

$$\frac{1\times V}{1.1\times V} = \frac{\frac{12}{M}\times R(t+273)}{\frac{12}{M}\times R(t+283)}$$

t = –173ºC = 100K

$1 \times V = \frac{12}{120}\times 0.082\times 100$

V = 0.82 lite

5. One mole of N_2 gas at 0.8 atmp takes 38 sec to diffuse through a pin hole, whereas one mole of an unknown compound of Xenon with F at 1.6 atmp takes 57 sec. to diffuse through the same hole . Calculate the molecular formula of the compound. (At. wt. Xe = 138, F = 19)

Ans. **XeF_6**

Sol. $$\frac{r_1}{r_2} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}}$$

$$\frac{n_1}{t_1}\times\frac{t_2}{n_2} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}}$$

$$\frac{1}{38}\times\frac{57}{1} = \frac{0.8}{1.6}\sqrt{\frac{M}{28}}$$

M = 252

138 + 19 × n = 252 $\Rightarrow$ n = 6 $\Rightarrow$ XeF_6

6. The r.m.s. velocity of hydrogen is $\sqrt{7}$ times the r.m.s. velocity of nitrogen. If T is the temperature of the gas :

(A) $T(H_2) = T(N_2)$ (B) $T(H_2) > T(N_2)$ (C) $T(H_2) < T(N_2)$ (D) $T(H_2) = \sqrt{7}\ T(N_2)$

Ans. **(C)**

Sol. $(u_{rms})_{H_2} = \sqrt{7} \times (u_{rms})_{N_2}$

$$\sqrt{\frac{3RT_1}{2}} = \sqrt{7}\times\sqrt{\frac{3RT_2}{28}}$$

$$\frac{3RT_1}{2} = \frac{7\times 3RT_2}{28}$$

$2T_1 = T_2 \Rightarrow T_{N_2} > T_{H_2}$

7. The root mean square velocity of an ideal gas at constant pressure varies with density as

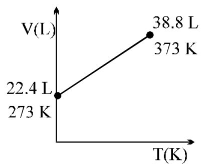
(A) d^2 (B) d (C) $d^{1/2}$ (D) $1/d^{1/2}$

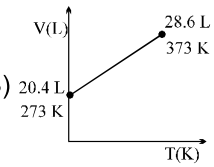
Ans. **(D)**

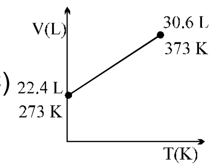
Sol. $u_{rms} = \sqrt{\frac{3P}{d}}$

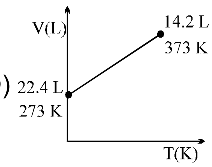
$u_{rms} \propto \frac{1}{d^{1/2}}$

8. Which one of the following V, T plots represents the behaviour of one mole of an ideal gas at one atmp?

(A) 

(B) 

(C) 

(D) 

Ans. **(C)**

Sol. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{22.4}{273} = \frac{30.6}{373}$

9. The average velocity of gas molecules is 400 m/sec. Calculate its (rms) velocity at the same temperature.

Ans. **434.17 m/sec**

Sol. $u_{rms} = \sqrt{\frac{3\pi}{8}} \times u_{avg}$

$= \sqrt{\frac{3 \times 3.14}{8}} \times 400 = 434\,m/s$

10. The ratio of the rate of diffusion of helium and methane under identical condition of pressure and temperature will be

(A) 4 (B) 2 (C) 1 (D) 0.5

Ans. **(B)**

Sol. $\frac{r_{He}}{r_{CH_4}} = \sqrt{\frac{16}{4}} = 2$

11. At 400 K, the root mean square (rms) speed of a gas X (molecular weight = 40) is equal to the most probable speed of gas Y at 60 K. The molecular weight of the gas Y is

Ans. 4

Sol. $(u_{rms})_x = (u_{mp})_y$

$\frac{\sqrt{3RT_x}}{M_x} = \frac{\sqrt{2RT_x}}{M_Y}$

$\frac{3 \times 400}{40} = \frac{2 \times 60}{M_y}$

$M_y = \frac{2 \times 60 \times 40}{3 \times 400} = 4$

Exercise-1

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Ideal gas equation & gas laws

Commit to memory :

Boyle's law : $P_1V_1 = P_2V_2$ — P_1 & P_2 are pressure of gas

Charles law : — V_1 & V_2 are Volume of gas

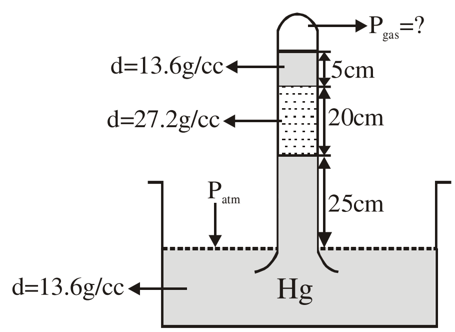
Gay-lussac's law : $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ — T_1 & T_2 are Temperature of gas

Ideal Gas Equation : PV = nRT — n = number of moles of gas

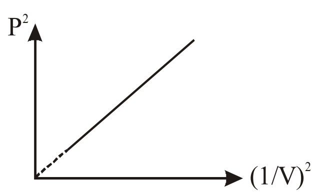
A-1. A certain amount of a gas at 27°C and 1 bar pressure occupies a volume of 25 m^3. If the pressure is kept constant and the temperature is raised to 77°C, what will be the volume of the gas ?

A-2. A gas at a pressure of 5.0 bar is heated from 0°C to 546°C and simultaneously compressed to one third of its original volume. What will be the final pressure ?

A-3. In the following arrangement find the pressure of gas (in cm of Hg).
(Assume that atmospheric pressure P_{atm} = 75 cm of Hg)



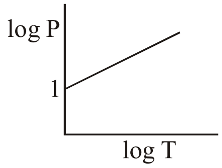
A-4. Consider the following graph



Graph is plotted for 1 mol of gas at 400K, find slope of curve.

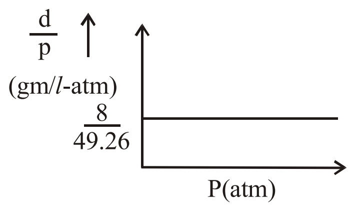
[Take : R = 0.08 $\frac{L-atm}{mol-K}$]

A-5. In constant volume container of 0.821 litre, log P vs log T is plotted as shown in graph. Calculate number of moles of ideal gas present in container :



A-6. For an ideal gas, the following graph is obtained at constant temperature of 300K.

The molar mass of gas (in gm/mol) is - **[R = 0.0821L-atm/mol-K]**



A-7. Density of ideal gas at 2.46 atm and 300 K is 0.8 gm/l. Hence gm-molar mass of gas is **[R = 0.082L-atm/mol-K]**

A-8. The density of phosphorus vapours at 327ºC and 1 atm is 2.52 gm/lit. If molecular formula of phosphorus is P_X, then calculate 'X' **(Atomic weight of : P = 31)**

A-9. A quantity of hydrogen is confined in a chamber of constant volume. When the chamber is immersed in a bath of melting ice, the pressure of the gas is 1000 torr. (a) What is the Celsius temperature when the pressure manometer indicates an absolute pressure of 400 torr ? (b) What pressure will be indicated when the chamber in brought to 100ºC ?

A-10. At the top of a mountain the thermometer reads –23ºC and the barometer reads 700 mm Hg. At the bottom of the mountain the temperature is 27ºC and the pressure is 750 mm Hg. Compare the density of the air at the top with that at the bottom.

Section (B) : Daltons law of partial pressures

Commit to memory :

Daltons law : $P_{Total} = P_1 + P_2 + P_3 = \frac{(n_1 + n_2 + n_3)RT}{v}$

$P_1 = \frac{n_1 RT}{v}$; $P_2 = \frac{n_2 RT}{v}$; $P_3 = \frac{n_3 RT}{v}$

P_1, P_2 & P_3 are partial pressure of gases

P_{Total} = Total pressure of Gaseous mixture

B-1. Equal masses of ethane and hydrogen are mixed in an empty container at 25ºC. The fraction of the total pressure exerted by hydrogen is.

B-2. What will be pressure exerted by a mixture of 3.2 g of methane of 4.4 g of carbon dioxide contained in a 9 dm^3 flask at 27°C ?

B-3. Oxygen and cyclopropane at partial pressures of 570 torr and 170 torr respectively are mixed in a gas cylinder. What is the ratio of the number of moles of cyclopropane to the number of moles of oxygen?

B-4. A container holds 22.4 litre of a gas at 1 atmospheric pressure and at 0ºC. The gas consists of a mixture of argon, oxygen and sulphur dioxide in which :

(a) Partial pressure of SO_2 = (Partial pressure O_2) + (Partial pressure of Ar)

(b) Partial pressure of O_2 = 2 × partial pressure of Ar

Calculate the density of the gas mixture under these conditions.

Section (C) : Mixing of Gases

Commit to memory :

On mixing of gases $n_{final} = n_1 + n_2 + n_3 + ...$

C-1. A volume V of a gas at a temperature T_1 and a pressure p is enclosed in a sphere. It is connected to another sphere of volume $\frac{V}{2}$ by a tube and stopcock. The second sphere is initially evacuated and the stopcock is closed. If the stopcock is opened the temperature of the gas in the second sphere becomes T_2. The first sphere is maintained at a temperature T_1. What is the final pressure p_1 within the apparatus ?

C-2. If a 2 litre flask of N_2 at 20°C and 70 cm Hg pressure is connected with a 3 litre of another flask of O_2 at the same temperature and 100 cmHg pressure. What will be the final pressure after the gases have throughly mixed at the same temperature as before ? Also calculate the mole % of each gas in the resulting mixture. The volume of stopcock may be neglected.

C-3. Two flask of equal volume have been joined by a narrow tube of negligible volume. Initially both flasks are at 300 K containing 0.60 mole of O_2 gas at 0.5 atm pressure. One of the flask is then placed in a thermostat at 600 K. Calculate final pressure and the number of O_2 gas in each flask.

Section (D) : Graham's law of diffusion

Commit to memory :

$$\frac{r_1}{r_2} = \frac{\sqrt{d_2}}{\sqrt{d_1}} = \frac{\sqrt{M_2}}{\sqrt{M_1}} = \sqrt{\frac{V.D_2}{V.D_1}}$$ V.D is vapour density

Rate $\propto \frac{P}{\sqrt{TM}} A$

r = volume flow rate $= \frac{dV_{out}}{dt}$

P – Pressure,

r = moles flow rate $= \frac{dn_{out}}{dt}$

A – area of hole,

r = distance travelled by gaseous molecules per unit time $= \frac{dx}{dt}$

T – Temp. , M – mol. wt.

r = pressure change rate $= \frac{dp}{dt}$

D-1. If helium and methane are allowed to diffuse out of the container under the similar conditions of temperature and pressure, then the ratio of rate of diffusion of helium to methane is.

D-2. H_2 and O_2 are kept in mass ratio 1 : 8 respectively at 6 atm. If small orifice is made then relative rate of effusion of H_2 with respect to O_2 initially is.

D-3. The rates of diffusion of two gases A and B are in the ratio 1 : 4. If the ratio of their masses present in the mixture is 2 : 3. The ratio of their mole fraction is : ($9^{1/3} = 2.08$)

D-4. The pressure in a vessel that contained pure oxygen dropped from 2000 torr to 1500 torr in 40 min as the oxygen leaked through a small hole into a vacuum. When the same vessel was filled with another gas, the pressure dropped from 2000 torr to 1500 torr in 80 min. What is the molecular weight of the second gas ?

Section (E) : Kinetic theory of gases

Commit to memory :

$PV = \frac{1}{3} mN \overline{U^2}$ Kinetic equation of gases

$U_{rms} = \sqrt{\frac{3RT}{M}}$ M = molar mass

$U_{av} = \sqrt{\frac{8RT}{\pi M}}$

$U_{MPS} = \sqrt{\frac{2RT}{M}}$ T = Temperature

E-1. Root mean square speed of an unknown gas at 727ºC is 10^5 cm/second. Calculate molar mass of unknown gas (in gram/mole) [Take R = $\frac{25}{3}$ J/mole-K].

E-2. When the temperature of an ideal gas is increased from 27°C to 927°C the kinetic energy will be increased by x times. Find the value of x ?

E-3. The root mean square speed of gas molecules at a temperature 27 K and pressure 1.5 bar is 1×10^4 cm/sec. If both temperature and pressure are raised three times, calculate the new rms speed of gas molecules.

E-4. At what temperature would the most probable speed of CO_2 molecules be twice that at 127ºC

E-5. At what temperature will hydrogen molecules have the same root mean square speed as nitrogen molecules have at 35ºC ?

Section (F) : Eudiometry

Commit to memory :

Some Common Facts :

- If a hydrocarbon is burnt, gases liberated will be CO_2 & H_2O. [H_2O is seperated out by cooling the mixture & CO_2 by absorption by aqueous KOH]
- If organic compound contains S or P, then these are converted into SO_2 & P_4O_{10} by burning the organic compound.
- If nitrogen is present, then it is converted into N_2.
  [The only exception : if organic compound contains – NO_2 group then NO_2 is liberated]
- If mixture contains N_2 gas & this is exploded with O_2 gas, do not assume any oxide formation unless specified.
- Ozone is absorbed in turpentine oil and oxygen in alkaline pyragallol.

F-1. 1 litre of a mixture of CO and CO_2 is taken. This mixture is passed through a tube containing red hot charcoal. The volume now becomes 1.6 litres. The volumes are measured under the same conditions. Find the composition of the mixture by volume.

F-2. When 100 ml of a $O_2 – O_3$ mixture was passed through turpentine, there was reduction of volume by 20 ml. If 100 ml of such a mixture is heated, what will be the increase in volume? **[Hint:** O_3 is absorbed by turpentine**]**

F-3. 60 ml of a mixture of nitrous oxide (N_2O) and nitric oxide (NO) was exploded with excess of hydrogen. If 38 ml of N_2 was formed, calculate the volume of each gas in the mixture.

F-4. A sample of a gaseous hydrocarbon occupying 1.12 litres at NTP when completely burnt in air produced 2.2 g of CO_2 and 1.8 g of H_2O. Calculate the weight of the compound taken and the volume of O_2 at NTP required for its burning. Find the molecular formula of the hydrocarbon.

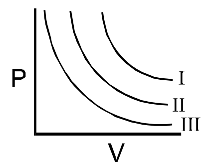
PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Ideal gas equation & gas laws

Commit to memory :

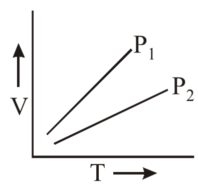
Boyle's law : $P_1V_1 = P_2V_2$	P_1 & P_2 are pressure of gas
Charles law : $\frac{V_1}{T_1} = \frac{V_2}{T_2}$	V_1 & V_2 are Volume of gas
Gay-lussac's law : $\frac{P_1}{T_1} = \frac{P_2}{T_2}$	T_1 & T_2 are Temperature of gas
Ideal Gas Equation : PV = nRT	n = number of moles of gas

A-1. I, II, III are three isotherms respectively at T_1, T_2 and T_3 as shown in graph. Temperature will be in order :



(A) $T_1 = T_2 = T_3$ (B) $T_1 < T_2 < T_3$ (C) $T_1 > T_2 > T_3$ (D) $T_1 > T_2 = T_3$

A-2. V versus T curves at constant pressure P_1 and P_2 for an ideal gas are shown in Fig. Which is correct

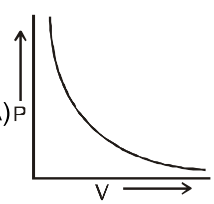


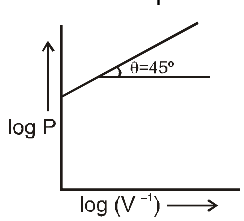
(A) $P_1 > P_2$ (B) $P_1 < P_2$ (C) $P_1 = P_2$ (D) All

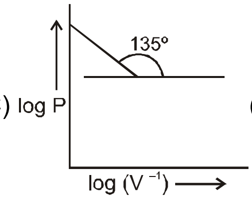
A-3. In a rigid container NH_3 is kept at certain temperature, if on doubling the temperature it is completely dissociated into N_2 and H_2. Find final pressure to initial pressure ratio :

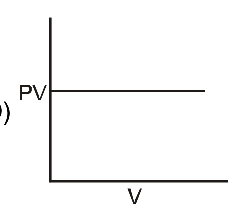
(A) 4 (B) 2 (C) $\frac{1}{2}$ (D) $\frac{1}{4}$

A-4. Which of the following curve does not represent Boyle's law?

(A) 

(B) 

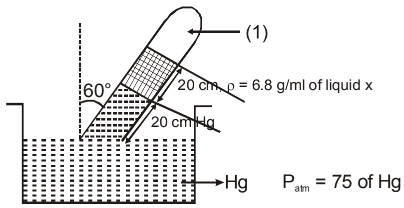
(C) 

(D) 

A-5. The density of liquid gallium at 30ºC is 6.095 g/mL. Because of its wide liquid range (30 to 2400ºC), gallium could be used as a barometer fluid at high temperature. What height (in cm) of gallium will be supported on a day when the mercury barometer reads 740 torr? (The density of mercury is 13.6 g/mL).

(A) 322 (B) 285 (C) 165 (D) 210

A-6. Pressure of the gas in column (1) is :



(A) 60 cm of Hg (B) 55 cm of Hg (C) 50 cm of Hg (D) 45 cm of Hg

A-7. If the pressure of a gas contained in a closed vessel is increased by 0.4 % when heated by 1ºC its initial temperature must be :
(A) 250 K (B) 250ºC (C) 25ºC (D) 25 K

A-8. A balloon weighing 50 kg is filled with 685 kg of helium at 1 atm pressure and 25°C. What will be its pay load if it displaced 5108 kg of air ?
(A) 4373 kg (B) 4423 kg (C) 5793 kg (D) none of these

A-9. An amount of 1.00 g of a gaseous compound of boron and hydrogen occupies 0.820 liter at 1.00 atm and at 3^0C. The compound is (R = 0.0820 liter atm $mole^{-1} K^{-1}$; at. wt: H = 1.0, B = 10.8)
(A) BH_3 (B) B_4H_{10} (C) B_2H_6 (D) B_3H_{12}

A-10. A and B are two identical vessels. A contains 15 g ethane at 1atm and 298 K. The vessel B contains 75 g of a gas X_2 at same temperature and pressure. The vapour density of X_2 is :
(A) 75 (B) 150 (C) 37.5 (D) 45

Section (B) : Daltons law of partial pressures

Commit to memory :

Daltons law : $P_{Total} = P_1 + P_2 + P_3 = \frac{(n_1 + n_2 + n_3)RT}{v}$

$P_1 = \frac{n_1 RT}{v}$; $P_2 = \frac{n_2 RT}{v}$; $P_3 = \frac{n_3 RT}{v}$ P_1, P_2 & P_3 are partial pressure of gases

P_{Total} = Total pressure of Gaseous mixture

B-1. Dalton's law cannot be applied for which gaseous mixture at normal temperatures:
(A) O_2 and N_2 (B) NH_3 and HCl (C) He and N_2 (D) CO_2 and O_2

B-2. A closed vessel contains helium and ozone at a pressure of P atm. The ratio of He and oxygen atoms is 1 : 1. If helium is removed from the vessel, the pressure of the system will reduce to :
(A) 0.5 P atm (B) 0.75 P atm (C) 0.25 P atm (D) 0.33 P atm

B-3. Equal weights of ethane & hydrogen are mixed in an empty container at 25º C, the fraction of the total pressure exerted by hydrogen is:
(A) 1: 2 (B) 1: 1 (C) 1: 16 (D) 15: 16

Section (C) : Mixing of Gases

Commit to memory :

On mixing of gases $n_{final} = n_1 + n_2 + n_3 + ...$

C-1. At constant temperature 200 cm^3 of N_2 at 720 mm and 400 cm^3 of O_2 at 750 mm pressure are put together in a one litre flask. The final pressure of mixture is

(A) 111 mm (B) 222 mm (C) 333 mm (D) 444 mm

C-2. A box of 1L capacity is divided into two equal compartments by a thin partiion which are filled with 2g H_2 and 16g CH_4 respectively. The pressure in each compartment is recorded as P atm. The total pressure when partition is removed will be :

(A) P (B) 2P (C) P/2 (D) P/4

C-3. Two glass bulbs A and B are connected by a very small tube having a stop cock. Bulb A has a volume of 100 cm^3 and contained the gas , while bulb B was empty . On opening the stop cock , the pressure fell down to 40 % . The volume of the bulb B must be :

(A) 75 cm^3 (B) 125 cm^3 (C) 150 cm^3 (D) 250 cm^3

C-4. A 100 ml vessel containing $O_2(g)$ at 1.0 atm and 400 K is connected to a 300 ml vessel containing NO(g) at 1.5 atm and 400 K by means of a narrow tube of negligible volume where gases react to form NO_2 . Final pressure of mixture will be –

(A) 1.125 atm (B) 0.125 atm (C) 1 atm (D) 1.5 atm

Section (D) : Graham's law of diffusion

Commit to memory :

$$\frac{r_1}{r_2} = \frac{\sqrt{d_2}}{\sqrt{d_1}} = \frac{\sqrt{M_2}}{\sqrt{M_1}} = \sqrt{\frac{V.D_2}{V.D_1}}$$ V.D is vapour density

$$\text{Rate} \propto \frac{P}{\sqrt{TM}} A$$

r = volume flow rate $= \frac{dV_{out}}{dt}$

P – Pressure,

r = moles flow rate $= \frac{dn_{out}}{dt}$

A – area of hole,

r = distance travelled by gaseous molecules per unit time $= \frac{dx}{dt}$

T – Temp. , M – mol. wt.

r = pressure change rate $= \frac{dp}{dt}$

D-1. A football bladder contains equimolar proportions of H_2 and O_2. The composition by mass of the mixture effusing out of punctured football is in the ratio ($H_2 : O_2$)

(A) 1 : 4 (B) $2\sqrt{2} : 1$ (C) $1 : 2\sqrt{2}$ (D) 4 : 1

D-2. Three identical footballs are respectively filled with nitrogen , hydrogen and helium at same pressure. If the leaking of the gas occurs with time from the filling hole, then the ratio of the rate of leaking of gases $(r_{N_2} : r_{H_2} : r_{He})$ from three footballs under identical conditions (in equal time interval) is :

(A) $(1 : \sqrt{14} : \sqrt{7})$ (B) $(\sqrt{14} : \sqrt{7} : 1)$ (C) $(\sqrt{7} : 1 : \sqrt{14})$ (D) $(1 : \sqrt{7} : \sqrt{14})$

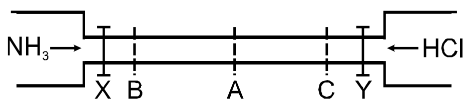
D-3. The rate of diffusion of two gases A and B is in the ratio of 1 : 4 and that of B and C in the ratio of 1 : 3 the rate of diffusion of C with respect to A is -

(A) $\frac{1}{12}$ (B) 12 (C) 6 (D) 4

D-4. A 4 : 1 molar mixture of He & CH_4 kept in a vessel at 20 bar pressure. Due to a hole in the vessel, gas mixture leaks out. What is the composition of mixture effusing out initially -

(A) 8 : 1 (B) 4 : 1 (C) 1 : 4 (D) 4 : 3

D-5. See the figure-1 :



The valves of X and Y are opened simultaneously. The white fumes of NH_4Cl will first form at:

(A) A (B) B (C) C (D) A, B and C simultaneously

Section (E) : Kinetic theory of gases

Commit to memory :

$PV = \frac{1}{3} mN\,\overline{U^2}$ Kinetic equation of gases

$U_{rms} = \sqrt{\frac{3RT}{M}}$ M = molar mass

$U_{av} = \sqrt{\frac{8RT}{\pi M}}$

$U_{MPS} = \sqrt{\frac{2RT}{M}}$ T = Temperature

E-1. A sample of an ideal gas was heated from 30^0C to 60^0C at constant pressure. Which of the following statement(s) is/are true.

(A) Kinetic energy of the gas is doubled (B) Boyle's law will apply

(C) Volume of the gas will be doubled (D) None of the above

E-2. Four particles have speed 2, 3, 4 and 5 cm/s respectively. Their rms speed is :

(A) 3.5 cm/s (B) $\left(\frac{27}{2}\right)$ cm/s (C) $\sqrt{54}$ cm/s (D) $\left(\frac{\sqrt{54}}{2}\right)$ cm/s

E-3. Which one of the following gases would have the highest R.M.S. velocity at 25^0C ?

(A) Oxygen (B) Carbon dioxide (C) Sulphur dioxide (D) Carbon monoxide

E-4. The density ratio of O_2 and H_2 is 16 : 1. The ratio of their U_{rms} is :-

(A) 4 : 1 (B) 16 : 1 (C) 1 : 4 (D) 1 : 16

E-5. Which of the gas have highest fraction of molecules at 27ºC in most probable speed region -

(A) H_2 (B) N_2 (C) O_2 (D) CO_2

E-6. The av. K.E./mole of an ideal monoatomic gas at 27^0C is

(A) 900 cal (B) 1800 cal (C) 300 cal (D) None

E-7. Average K.E. of CO_2 at 27^0C is E. The average kinetic energy of N_2 at the same temperature will be
(A) E (B) 22E (C) E/22 (D) $E/\sqrt{2}$

E-8. If a gas expands at constant temperature then :
(A) No. of gaseous molecule decreases (B) kinetic energy of molecule decreases
(C) K.E. remain same (D) K.E. increases

E-9. Temperature at which r.m.s. speed of O_2 is equal to that of neon at 300 K is :
(A) 280 K (B) 480 K (C) 680 K (D) 180 K

E-10. The R.M.S. speed of the molecules of a gas of density 4 kg m^{-3} and pressure 1.2×10^5 N m^{-2} is :
(A) 120 m s^{-1} (B) 300 m s^{-1} (C) 600 m s^{-1} (D) 900 m s^{-1}

Section (F) : Eudiometry

Commit to memory :

Some Common Facts :

- If a hydrocarbon is burnt, gases liberated will be CO_2 & H_2O. [H_2O is seperated out by cooling the mixture & CO_2 by absorption by aqueous KOH]
- If organic compound contains S or P, then these are converted into SO_2 & P_4O_{10} by burning the organic compound.
- If nitrogen is present, then it is converted into N_2.
  [The only exception : if organic compound contains – NO_2 group then NO_2 is liberated]
- If mixture contains N_2 gas & this is exploded with O_2 gas, do not assume any oxide formation unless specified.
- Ozone is absorbed in turpentine oil and oxygen in alkaline pyragallol.

F-1. 10 ml of a gaseous hydrocarbon was exploded with excess of O_2. On cooling the reaction mixture volume was reduced by 10 ml while on adding KOH volume was reduced by 20 ml. Molecular formula of hydrocarbon is :
(A) CH_4 (B) C_4H_6 (C) C_2H_4 (D) C_2H_2

F-2. A mixture of methane, propane and carbon monoxide contain 36.5% propane by volume. If its 200 ml are burnt in excess of O_2, the volume of CO_2 formed is :
(A) 173 ml (B) 346 ml (C) 200 ml (D) 519 ml

F-3. The volume of CO_2 produced by the combustion of 40 ml of gaseous acetone in excess of oxygen is :
(A) 40 ml (B) 80 ml (C) 60 ml (D) 120 ml

F-4. 500 ml of a hydrocarbon gas burnt in excess of oxygen yields 2500 ml of CO_2 and 3 lts of water vapours. All volume being measured at the same temperature and pressure. The formula of the hydrocarbon is
(A) C_5H_{10} (B) C_5H_{12} (C) C_4H_{10} (D) C_4H_8

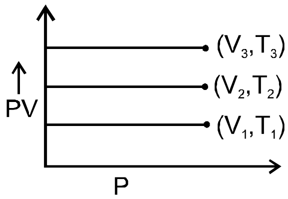
F-5. 7.5 ml of a gaseous hydrocarbon was exploded with 36 ml of oxygen. The volume of gases on cooling was found to be 28.5 ml, 15 ml of which was absorbed by KOH and the rest was absorbed in a solution of alkaline pyrogallol. If all volumes are measured under same conditions, the formula of hydrocarbon is
(A) C_3H_4 (B) C_2H_4 (C) C_2H_6 (D) C_3H_6

F-6. A mixture of methane and carbon monoxide requires 1.7 times its volume of oxygen for complete combustion. What is the ratio of CH_4 : CO by volume in the mixture ? [All volume are measured at the same temperature and pressure]
(A) 1 : 1 (B) 1 : 2 (C) 2 : 1 (D) 4 : 1

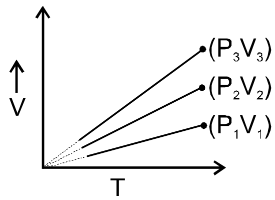
PART - III : MATCH THE COLUMN

1. For a fixed amount of the gas match the two column :

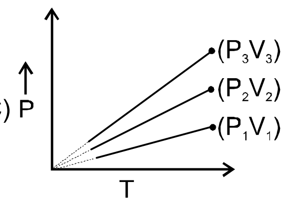
Column-I | **Column-II**

(A) 

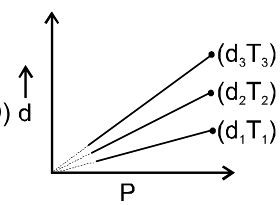
(p) $T_1 > T_2 > T_3$

(B) 

(q) $P_1 > P_2 > P_3$

(C) 

(r) $V_1 > V_2 > V_3$

(D) 

(s) $d_1 > d_2 > d_3$

2. Single option match maxtix :

Column-I	**Column-II**
(A) $P_1V_1 = P_2V_2 = P_3V_3 =$	(p) Kinetic equation of ideal gases.
(B) $\frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V_3}{T_3} =$ .... at constant pressure.	(q) Boyle's law
(C) $r \propto \sqrt{\frac{1}{d}}$	(r) Dalton's law of partial pressures at constant temperature
(D) $P = P_1 + P_2 + P_3 +$............	(s) Graham's law
(E) $PV = \frac{1}{3} mnc^2$	(t) Charles' law

Exercise-2

✍ **Marked Questions may have for Revision Questions.**

PART - I : ONLY ONE OPTION CORRECT TYPE

1. A small bubble rises from the bottom of a lake, where the temperature and pressure are 8°C and 6.0 atm,to the water's surface,where the temperature is 25°C and pressure is 1.0 atm. Calculate the final volume of the bubble if its initial volume was 2 mL.

(A) 14 mL (B) 12.72 mL (C) 11.31 mL (D) 15 mL

2.✍ A 40 ml of a mixture of H_2 and O_2 at 18 ºC and 1 atm pressure was sparked so that the formation of water was complete. The remaining pure gas had a volume of 10 ml at 18ºC and 1 atm pressure. If the remaining gas was H_2, the mole fraction of H_2 in the 40 ml mixture is :

(A) 0.75 (B) 0.5 (C) 0.65 (D) 0.85

3. On the surface of the earth at 1 atm pressure, a balloon filled with H_2 gas occupies 500 mL. This volume is 5/6 of its maximum capacity. The balloon is left in air. It starts rising. The height above which the balloon will burst if temperature of the atmosphere remains constant and the pressure decreases 1 mm for every 100 cm rise of height is

(A) 120 m (B) 136.67 m (C) 126.67 m (D) 100 m

Section (B) : Daltons law of partial pressures

4. A vessel of volume 5 litre contains 1.4 g of nitrogen at a temperature 1800 K. The pressure of the gas if 30% of its molecules are dissociated into atoms at this temperature is :

(A) 4.05 atm (B) 2.025 atm (C) 3.84 atm (D) 1.92 atm

5.✍ Two closed vessel A and B of equal volume containing air at pressure P_1 and temperature T_1 are connected to each other through a narrow open tube. If the temperature of one is now maintained at T_1 and other at T_2 (where $T_1 > T_2$) then that what will be the final pressure ?

(A) $\frac{T_i}{2P_1T_2}$ (B) $\frac{2P_1T_2}{T_1+T_2}$ (C) $\frac{2P_1T_1}{T_1-T_2}$ (D) $\frac{2P_1}{T_1+T_2}$

6. Two flasks of equal volume are connected by a narrow tube (of negligible volume) all at 27ºC and contain 0.70 mole of H_2 at 0.5 atm. One of the flask is then immersed into a bath kept at 127ºC, while the other remains at 27ºC. The final pressure in each flask is :

(A) Final pressure = 0.5714 atm (B) Final pressure = 1.5714 atm

(C) Final pressure = 0.5824 atm (D) None of these

7. Two flasks of equal volume are connected by a narrow tube (of negligible volume) all at 27ºC and contain 0.70 moles of H_2 at 0.5 atm. One of the flask is then immersed into a bath kept at 127ºC, while the other remains at 27ºC. The number of moles of H_2 in flask 1 and flask 2 are :

(A) Moles in flask 1 = 0.4, Moles in flask 2 = 0.3

(B) Moles in flask 1 = 0.2, Moles in flask 2 = 0.3

(C) Moles in flask 1 = 0.3, Moles in flask 2 = 0.2

(D) Moles in flask 1 = 0.4, Moles in flask 2 = 0.2

8. Under identical conditions of pressure and temperature. 4 L of gaseous mixture (H_2 and CH_4) effuses through a hole in 5min whereas 4 L of a gas X of molecular mass 36 takes to 10 min to effuse through the same hole. The mole ratio of $H_2 : CH_4$, in the mixture is -

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

9. One litre of a gaseous mixture of two gases effuses in 311 seconds while 2 litres of oxygen takes 20 minutes. The vapour density of gaseous mixture containing CH_4 and H_2 is

(A) 4 (B) 4.3 (C) 3.4 (D) 5

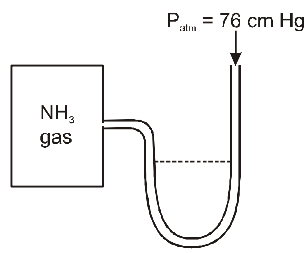
10. The mass of molecule A is twice that of molecule B. The root mean square velocity of molecule A is twice that of molecule B. If two containers of equal volume have same number of molecules, the ratio of pressure P_A/P_B will be :

(A) 8 : 1 (B) 1 : 8 (C) 4 : 1 (D) 1 : 4

11. LPG is a mixture of n-butane & iso-butane. The volume of oxygen needed to burn 1 kg of LPG at NTP would be :

(A) 2240 ℓt (B) 2510 ℓt (C) 1000 ℓt (D) 500 ℓt

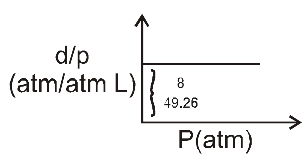
12. A manometer attached to a flask contains with ammonia gas have no difference in mercury level initially as shown in diagram. After sparking into the flask, ammonia is partially dissociated as $2NH_3\,(g) \longrightarrow N_2\,(g) + 3H_2\,(g)$ now it have difference of 6 cm in mercury level in two columns, what is partial pressure of H_2 (g) at equilibrium?



(A) 9 cm Hg (B) 18 cm Hg (C) 27 cm Hg (D) None of these

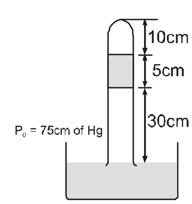
PART - II : SINGLE OR DOUBLE INTEGER TYPE

1. From the graph of $\frac{d}{p}$ vs p at a constant tempreture of 300K calculate molar mass of gas.

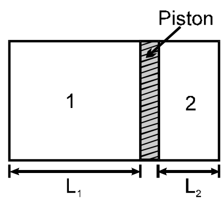


2. 10 moles of an ideal gas is subjected to an isochoric process (volume const.) and a graph of log (p) v/s log (T) is plotted where p is in (atm) & T is in kelvin. if volume of the container is 82.1 ml then calculate the sume of a, b & c where a = slope of graph, b = x intercept of graph, c = y intercept of graph.

3. A tube of length 50 cm is containing a gas in two sections separated by a mercury column of length 5 cm as shown in figure. The open end of tube is just inside the Hg surface in container find pressure differance of gases in two sections. [Assume atmospheric pressure = 75 cm of Hg column]



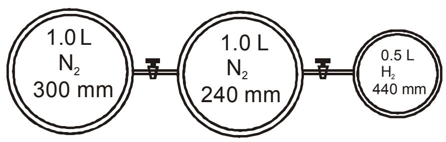
4. The closed cylinder shown in figure has a freely moving piston separating chambers 1 and 2. Chamber 1 contains 280 mg of N_2 gas, and chamber 2 contains 200 mg of helium gas. When equilibrium is established, what will be the ratio L_2/L_1 ? (Molecular weights of N_2 and He are 28 and 4).



5. A spherical balloon of 21 cm diameter is to be filled up with hydrogen at NTP, from a cylinder containing the gas at 20 atm at 27°C. If the cylinder can hold 2.82 litre of water, calculate the number of balloons that can be filled up.

6. A closed container of volume 0.02 m^3 contains a mixture of neon and argon gases, at a temperature of 27°C and pressure of 1×10^5 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 x and y in the container, assuming them to be ideal. (Universal gas constant R = 8.314 J/mole K) Give your answer as x + y.

7. Consider the arrangment of bulbs shown below.



If the pressure of the system when all the stopcocks are opened is x (in atm) then find 100 x ?
(760 mm = 1 atm)

8. Two vessels whose volumes are in the ratio 2 : 1 contain nitrogen and oxygen at 2500 mm and 1000 mm pressures respectively when they are connected together what will be the pressure of the resulting mixture (in meters of Hg) ?

9. Two flask A & B have capacity of 1 litre and 2 litre respectively. Each of them contain 1 mole of a gas. The temperature of the flask are so adjusted that average speed of molecules in "A" is twice that in "B" & pressure in flask "A" is x times of that in "B". Then value of x is -

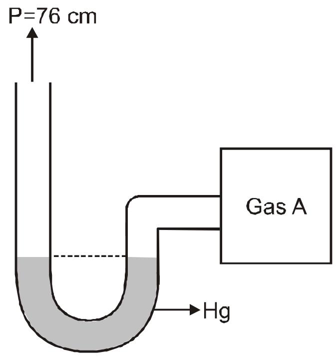
10. A mixture of formic acid and oxalic acid is heated with concentrated H_2SO_4. The gases produced are collected and on its treatment with KOH solution the volume of the gas decreased by one-sixth. Calculate the molar ratio of the two acids in the original mixture. [**Hint :** H_2SO_4 is a dehydrating agent. HCOOH produces H_2O and CO; $H_2C_2O_4$ produces H_2O, CO_2 and CO]

PART - III : ONE OR MORE THAN ONE OPTION CORRECT TYPE

1. A gas cylinder containing cooking gas can withstand a pressure of 14.9 atmosphere. The pressure guaze of cylinder indicates 12 atmosphere *at 27* ºC. Due to sudden fire in the building temperature starts rising. The temperature at which cylinder will explode is :

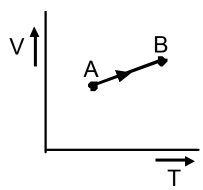
(A) 372.5 K (B) 99.5 ºC (C) 199 ºC (D) 472.5 k

2. A open ended mercury manometer is used to measure the pressure exerted by a trapped gas as shown in the figure. Initially manometer shows no difference in mercury level in both columns as shown in diagram.
After sparking 'A' dissociates according to following reaction
$A(g) \longrightarrow B(g) + 3C(g)$
If pressure of Gas "A" decrease to 0.9 atm. Then :
(Assume temperature to be constant and is 300 K)



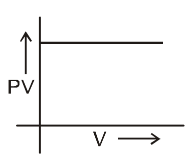
(A) total pressure increased to 1.3 atm
(B) total pressure increased by 0.3 atm
(C) total pressure increased by 22.3 cm fo Hg
(D) difference in mercury level is 228 mm.

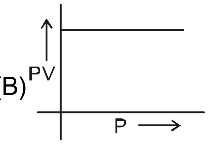
3. Which of the following is/are correct ?
(A) At constant volume, for a definite quantity of an ideal gas graph of PT v/s T^2 will be parabolic
(B) At constant pressure, for a definite quantity of an ideal gas graph of VT v/s T will be parabolic
(C) In going from A to B for definite quantity of an ideal gas pressure increase

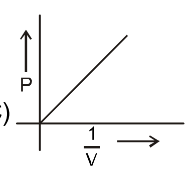


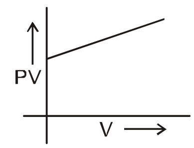
(D) At constant volume, for a definite quantity of an ideal gas graph of $\frac{p}{T}$ v/s T^2 will be straight line.

4. For gaseous state at constant temperature which of the following plot is correct ?

(A) 

(B) 

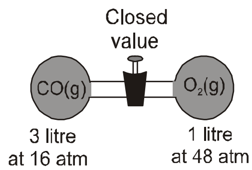
(C) 

(D) 

5. In a closed rigid container, 3 mol of gas A and 1 mol of gas B are mixed at constant temperature. If 1mol of another gas C at same temperature is introduced and all gases are considered to be non reacting, then
(A) Partial pressure of gases A and B remain unaffected due to introduction of gas C.
(B) Ratio of total pressure before and after mixing of gas 'C' is $\frac{3}{5}$.
(C) If the total pressure of gas mixture before introducing gas 'C' is 20atm, then the total gas pressure after mixing 'C' will be 25 atm.
(D) If data of option'C' are used, then partial pressure of gas 'C' will be 5 atm.

6. Carbon mono oxide (CO) and oxygen O_2 react according to :

$$2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$$



Assuming that the reaction takes place and goes to completion, after the valve is opened in the apparatus represented in the accompanying figure. Also assume that the temperature is fixed at 300 K. (Take R = 0.08 atm L/mole K)

(A) Partial Pressure of O_2 = 6 atm.
(B) Number of moles of CO_2 formed = 2
(C) Number of moles of O_2 left = 1
(D) Partial Pressure of O_2 = 3 atm.

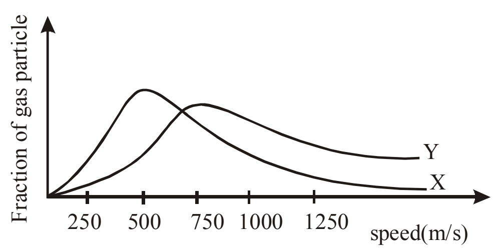
7. The rate of diffusion of 2 gases 'A' and 'B' are in the ratio 16: 3. If the ratio of their masses present in the mixture is 2 : 3. Then

(A) The ratio of their molar masses is 16 : 1
(B) The ratio of their molar masses is 1 : 4
(C) The ratio of their moles present inside the container is 1 : 24
(D) The ratio of their moles present inside the container is 8 : 3

8. Which statement is/are correct for postulates of kinetics theory of gases -

(A) Gases are composed of molecules whose size is negligible compared with the average distance between them
(B) Molecules moves randomly in straight lines in all directions and at various speeds.
(C) When molecules collide with one another the collisions are elastic. In an elastic collision the loss of kinetic energy takes place
(D) The average kinetic energy of a molecule is proportional to the absolute temperature.

9. The graph below shows the distribution of molecular speed of two ideal gases X and Y at 200K.
on the basis of the below graph identify the correct statements -



(A) If gas X is methane, then gas Y can be CO_2
(B) Fraction of molecules of X must be greater than Y in a particular range of speed at 200K
(C) Under identical conditions rate of effusion of Y is greater than that of X
(D) The molar kinetic energy of gas X at 200K is equal to the molar kinetic energy of Y at 200K

10. If a gas is allowed to expand at constant tempeature then which of the following does not hold true :

(A) the kinetic energy of the gas molecules decreases
(B) the kinetic energy of the gas molecules increases
(C) the kinetic energy of the gas molecules remains the same
(D) Can not be predicted

11. Precisely 1 mol of helium and 1 mol of neon are placed in a container. Indicate the correct statements about the system.
(A) Molecules of the two gases strike the wall of the container with same frequency.
(B) Molecules of helium strike the wall more frequently.
(C) Molecules of helium have greater average molecular speed.
(D) Helium exerts larger pressure.

12. Indicate the correct statement for equal volumes of N_2(g) and CO_2(g) at 25ºC and 1 atm.
(A) The average translational KE per molecule is the same for N_2 and CO_2
(B) The rms speed remains same for both N_2 and CO_2
(C) The density of N_2 is less than that of CO_2
(D) The total translational KE of both N_2 and CO_2 is the same

13. A hypothetical gaseous element having molecular formula Mx may be changed to another gaseous allotrope having molecular formula My at 310 K. In this act volume of the gas is contracted by 12 ml to a volume of 8 ml. The simplest possible molecular formulae of the two allotropes are
(A) M_2 (B) M_3 (C) M_4 (D) M_5

14. A 100 ml mixture of CO and CO_2 is passed through a tube containing red hot charcoal. The volume now becomes 160 ml. The volumes are measured under the same conditions of temperature and pressure. Amongst the following, select the correct statement(s) :
(A) Mole percent of CO_2 in the mixture is 60.
(B) Mole fraction of CO in the mixture is 0.40
(C) The mixture contains 40 ml of CO_2
(D) The mixture contains 40 ml of CO

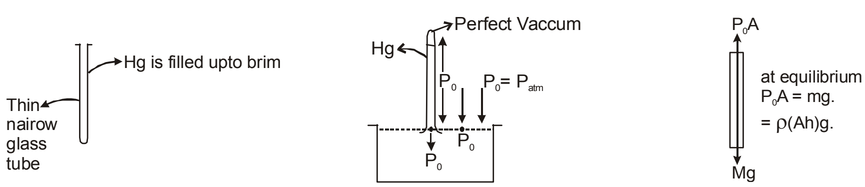
PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

MEASUREMENT OF PRESSURE

Barometer : A barometer is an instrument that is used for the measurement of pressure. The construction of the barometer is as follows



Cross sectional view of the capillary column

A thin narrow calibrated capillary tube is filled to the brim, with a liquid such as mercury, and is inverted into a trough filled with the same fluid. Now depending on the external atmospheric pressure, the level of the mercury inside the tube will adjust itself, the reading of which can be monitored. When the mercury column inside the capillary comes to rest, then the net forces on the column should be balanced.
Applying force balance, we get,
$P_{atm} \times A = m \times g$ ('A' is the cross-sectional area of the capillary tube)
If 'ρ' is the density of the fluid, then $m = \rho \times g \times h$ ('h' is the height to which mercury has risen in the capillary)
hence, $P_{atm} \times A = (\rho \times g \times h) \times A$
or, $P_{atm} = \rho gh$

Faulty Barometer :

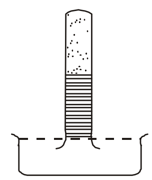
An ideal barometer will show a correct reading only if the space above the mercury column is vacuum, but in case if some gas column is trapped in the space above the mercury column, then the barometer is classified as a faulty barometer. The reading of such a barometer will be less than the true pressure.

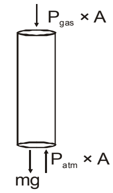
For such a faulty barometer

$$P_0A = mg + P_{gas}A$$

$$P_0 = \rho gh + P_{gas}$$

or $$\rho gh = P_0 - P_{gas}$$





1. A tube closed at one end is dipped in mercury as shown in figure-3 such that the closed surface coincides with the mercury level in the container. By how much length of the tube should be extended such that the level of Hg in the tube is 5 cm below the mercury level inside the container. (assume temperature remains constant)

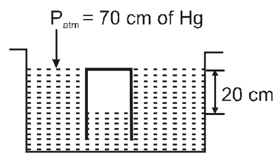
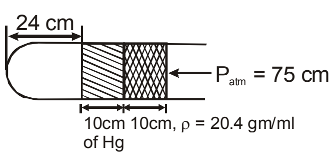


Fig.-3

(A) 18 cm (B) 19 cm (C) 24 cm (D) 30 cm

2. If above tube is placed vertically with the open end upward then the length of the air column will be (assume temperature remains constant)



(A) 20 cm (B) 36 cm (C) 18 cm (D) 15 cm

3. A gas column is trapped between closed end of a tube and a mercury column of length (h) when this tube is placed with its open end upwards the length of gas column is (ℓ_1) the length of gas column becomes (ℓ_2) when open end of tube is held downwards (as shown in fig.-4). Find atmospheric pressure in terms of height of Hg column.

(assume temperature remains constant)

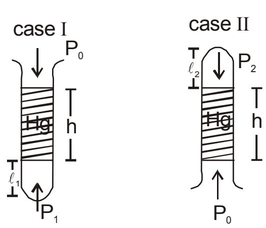


Fig.-4

(A) $\dfrac{h(\ell_1+\ell_2)}{(\ell_2-\ell_1)}$ (B) $\dfrac{h(\ell_2-\ell_1)}{(\ell_1+\ell_2)}$ (C) $\dfrac{(\ell_1+\ell_2)}{h(\ell_2-\ell_1)}$ (D) $(h_1\ell_1 + h_2\ell_2)$

Comprehension # 2

Dalton's Law : Suppose a mixture of two ideal gases, A and B, is contained in a volume V at a temperature T. Then, since each gas is ideal, we can write

$$P_A = n_A \frac{RT}{V}, \quad P_B = n_B \frac{RT}{V}$$

That is, in the mixture each gas exerts a pressure that is the same as it would exert if it were present alone, and this pressure is proportional to the number of moles of the gas present. The quantities P_A and P_B are called the partial pressures of A and B respectively. According to Dalton's law of partial pressures, the total pressure, P_t, exerted on the walls of the vessel is the sum of the partial pressures of the two gases :

$$P_t = P_A + P_B = (n_A + n_B)\left(\frac{RT}{V}\right).$$

The expression can be generalised so as to apply to a mixture of any number of gases. The result is

$$P_t = \sum_i P_i = \frac{RT}{V} \sum_i n_i, \qquad ...(1)$$

where ' i ' is an index that identifies each component in the mixture and the symbol Σ_i stands for the operation of adding all the indexed quantities together. Another useful expression of the law of partial pressures is obtained by writing

$$P_A = n_A \frac{RT}{V}, \quad P_t = \frac{RT}{V} \sum_i n_i, \quad \frac{P_A}{P_t} = \frac{n_A}{\sum_i n_i}, \quad P_A = P_t\left(\frac{n_A}{\sum_i n_i}\right). \qquad ....(2)$$

The quantity $\frac{n_A}{\sum_i n_i}$, is called the mole fraction of component A, and equation (2) says that the partial pressure of any component , such as component A, is the total pressure of the mixture multiplied by $\frac{n_A}{\sum_i n_i}$, the fraction of the total moles which are component A.

4. A closed container of volume 30 litre contains a mixture of nitrogen and oxygen gases, at a temperature of 27°C and pressure of 4 atm. The total mass of the mixture is 148 gm. The moles of individual gases in the container are (Take R = 0.08 litre atm/moleK)

(A) n_{N_2} = 2 moles, n_{O_2} = 3 mole
(B) n_{N_2} = 3 mole, n_{O_2} = 2 mole
(C) n_{N_2} = 4 mole, n_{O_2} = 1 mole
(D) n_{N_2} = 2.5 mole, n_{O_2} = 2.5 mole

5. If the whole mixture (of above problem) is transferred to a 5 litre vessel at same temperature, then choose the correct one :

(A) Total pressure in the container remains same.
(B) mole fraction of gases will change by $\frac{1}{2}$ unit.
(C) Partial pressure of each gases will be 6 times.
(D) Total pressure in the container becomes half of the initial pressure.

6. If the original mixture (as in Q.No. 16) is allowed to react at this temperature to form NO gas, then the total pressure in the container after the reaction is :

(A) 2 atm (B) 8 atm (C) 4 atm (D) None of these

Exercise-3

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

1. At 400 K, the root mean square (rms) speed of a gas **X** (molecular weight = 40) is equal to the most probable speed of gas **Y** at 60 K. The molecular weight of the gas **Y** is. **[JEE-2009, 4/160]**

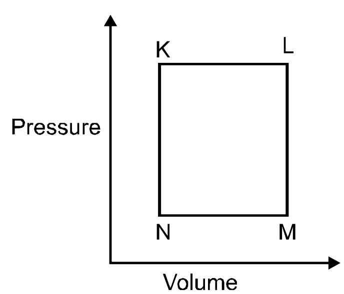
2.* According to kinetic theory gases **[JEE-2011, 4/180]**
(A) collisions are always elastic
(B) heavier molecules transfer more momentum to the waal of the container
(C) only a small number of molecules have very high velocity
(D) between collisions, the molecules move in straight lines with constant velocities.

3. To an evacuated vessel with movable piston under external pressure of 1 atm., 0.1 mol of He and 1.0 mol of an unknown compound (vapour pressure 0.68 atm. at 0ºC) are introduced. Considering the ideal gas behaviour, the total volume (in litre) of the gases at 0°C is close to **[JEE-2011, 4/180]**

4. The atomic masses of He and Ne are 4 and 20 a.m.u., respectively. The value of the de Broglie wavelength of He gas at –73°C is "M" times that of the de Broglie wavelength of Ne at 727°C. M is **[JEE(ADVANCED)-2013, 4/120]**

Paragraph for Questions 5 to 6

A fixed mass 'm' of a gas is subjected to transormation of states from K to L to M to N and back to K as shown in the figure

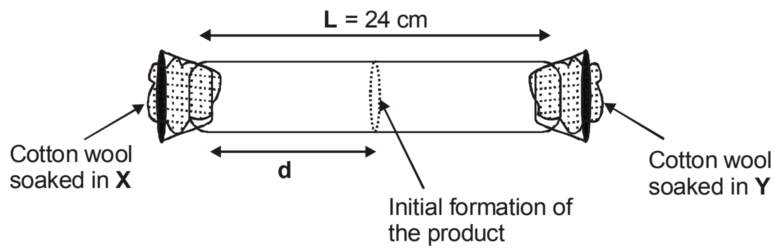


5. The succeeding operations that enable this transformation of states are **[JEE(Advanced)-2013, 3/120]**
(A) Heating, cooling, heating, cooling
(B) Cooling, heating, cooling, heating
(C) Heating, cooling, cooling, heating
(D) Cooling, heating, heating, cooling

6. The pair of isochoric processes among the transormation of states is **[JEE(Advanced)-2013, 3/120]**
(A) K to L and L to M (B) L to M and N to K
(C) L to M and M to N (D) M to N and N to K

Paragraph for questions 7 and 8

X and **Y** are two volatile liquids with molar weights of 10 g mol^{-1} and 40 g mol^{-1} respectively. Two cotton plugs, one soaked in **X** and the other soaked in **Y**, are simultaneously placed at the ends of a tube of length **L** = 24 cm, as shown in the figure. The tube is filled with an inert gas at 1 atmosphere pressure and a temperature of 300 K. Vapours of **X** and **Y** react to form a product which is first observed at a distance **d** cm from the plug soaked in **X**. Take **X** and **Y** to have equal molecular diameters and assume ideal behaviour for the inert gas and the two vapours.



7. The value of **d** in cm (shown in the figure), as estimated from Graham's law, is :

[JEE(Advanced)-2014, 3/120]

(A) 8 (B) 12 (C) 16 (D) 20

8. The experimental value of **d** is found to be smaller than the estimate obtained using Graham's law. This is due to **[JEE(Advanced)-2014, 3/120]**

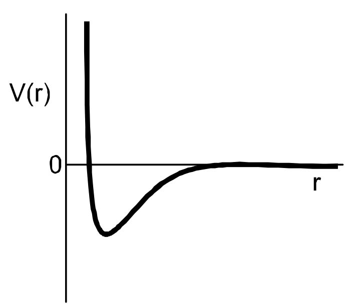
(A) larger mean free path for **X** as compared to that of **Y**.
(B) larger mean free path for **Y** as compared to that of **X**.
(C) increased collision frequency of **Y** with the inert gas as compared to that of **X** with the inert gas.
(D) increased collision frequency of **X** with the inert gas as compared to that of **Y** with the inert gas.

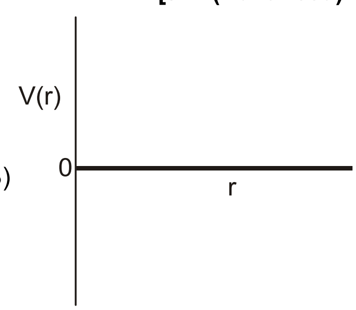
9. A closed vessel with rigid walls contains 1 mol of $^{238}_{92}U$ and 1 mol of air at 298 K. Considering complete decay of $^{238}_{92}U$ to $^{206}_{82}Pb$, the ratio of the final pressure to the initial pressure of the system at 298 K is

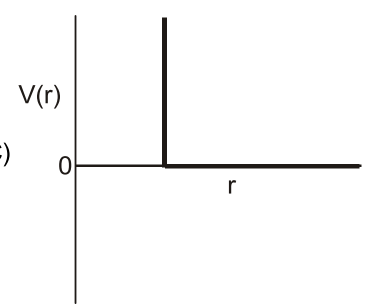
[JEE(Advanced)-2015, 4/168]

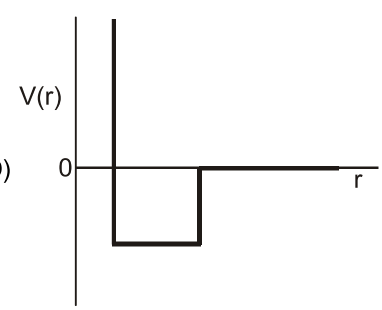
10. One mole of a monoatomic real gas satisfies the equation p(V – b) = RT where b is a constant. The relationship of interatomic potential V(r) and interatomic distance r for the gas is given by

[JEE(Advanced)-2015, 4/168]

(A)


(B)


(C)


(D)


11. A closed tank has two compartments A and B, both filled with oxygen (assumed to be ideal gas). The partition separating the two compartments is fixed and is a perfect heat insulator (Figure 1). If the old partition is replaced by a new partition which can slide and conduct heat but does NOT allow the gas to leak across (Figure 2), the volume (in m^3) of the compartment A after the system attains equilibrium is____. **[JEE 2018]**

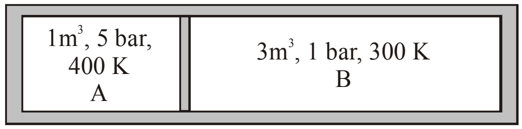


Figure 1

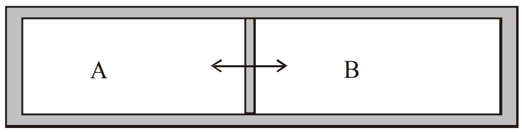


Figure 2

12. Which of the following statement(s) is (are) correct regarding the root mean square speed (U_{rms}) and average translational kinetic energy (ε_{av}) of a molecule in a gas at equilibrium ? **[JEE 2019]**

(A) U_{rms} is doubled when its temperature is increased four times

(B) ε_{av} at a given temperature does not depend on its molecular mass

(C) U_{rms} is inversely proportional to the square root of its molecular mass

(D) ε_{av} is doubled when its temperature is increased four times

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. When r, P and M represent rate of diffusion, pressure and molecular mass, respectively, then the ratio of the rates of diffusion (r_A/r_B) of two gases A and B, is given as: **[AIEEE 2011, 4/120]**

(1) $(P_A/P_B)\,(M_B/M_A)^{1/2}$ (2) $(P_A/P_B)^{1/2}\,(M_B/M_A)$ (3) $(P_A/P_B)\,(M_A/M_B)^{1/2}$ (4) $(P_A/P_B)^{1/2}\,(M_A/M_B)$

2. The molecular velocity of any gas is: **[AIEEE 2011, 4/120]**

(1) inversely proportional to absolute temperature.

(2) directly proportional to square of temperature.

(3) directly proportional to square root of temperature.

(4) inversely proportional to the square root of temperature.

3. A gaseous hydrocarbon gives upon combustion 0.72 g of water and 3.08 g. of CO_2. The empirical formula of the hydrocarbon is : **[JEE(Main) 2013, 4/120]**

(1) C_2H_4 (2) C_3H_4 (3) C_6H_5 (4) C_7H_8

4. For gaseous state, if most probable speed is denoted by C*, average speed by $\overline{C}$ and mean square speed by C, then for a large number of molecules the ratios of these speeds are : **[JEE(Main) 2013, 4/120]**

(1) $C^* : \overline{C} : C = 1.225 : 1.128 : 1$ (2) $C^* : \overline{C} : C = 1.128 : 1.225 : 1$

(3) $C^* : \overline{C} : C = 1 : 1.128 : 1.225$ (4) $C^* : \overline{C} : C = 1 : 1.225 : 1.128$

5. If Z is a compressibility factor, vander Waals equation at low pressure can be written as : **[JEE(Main) 2014, 4/120]**

(1) $Z = 1 + \dfrac{RT}{Pb}$ (2) $Z = 1 - \dfrac{a}{VRT}$ (3) $Z = 1 - \dfrac{Pb}{RT}$ (4) $Z = 1 + \dfrac{Pb}{RT}$

6. Which of the following is not an assumption of the kinetic theory of gases ?

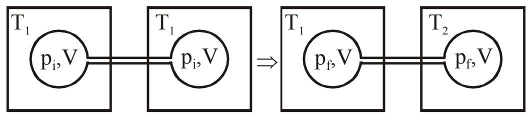
(1) Gas particles have negligible volume. **[JEE-Mains (online)-2015]**

(2) A gas consists of many identical particles which are in continual motion.

(3) At high pressure, gas particles are difficult to compress.

(4) Collisions of gas particles are perfectly elastic.

7. Two closed bulbs of equal volume(V) containing an ideal gas initially at pressure p_i and temperature T_1 are connected through a narrow tube of negligible volume as shown in the figure below. The temperature of one of the bulbs is then raised to T_2. The final pressure p_f is :- **[JEE-Mains-2016]**



(1) $2p_i\left(\frac{T_1T_2}{T_1+T_2}\right)$ (2) $p_i\left(\frac{T_1T_2}{T_1+T_2}\right)$ (3) $2p_i\left(\frac{T_1}{T_1+T_2}\right)$ (4) $2p_i\left(\frac{T_2}{T_1+T_2}\right)$

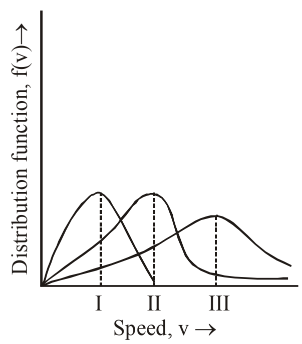
8. At 300 K, the density of a certain gaseous molecule at 2 bar is double to that of dinitrogen (N_2) at 4 bar. The molar mass of gaseous molecule is:- **[JEE-Mains-2017(ONLINE)]**

(1) 28 g mol^{-1} (2) 56 g mol^{-1} (3) 224 g mol^{-1} (4) 112 g mol^{-1}

9. Assuming ideal gas behaviour, the ratio of density of ammonia to that of hydrogen chloride at same temperature and pressure is : (Atomic wt. of Cl = 35.5 u) **[JEE-Mains-2018(ONLINE)]**

(1) 0.64 (2) 1.64 (3) 1.46 (4) 0.46

10. Points I, II and III in the following plot respectively correspond to (V_{mp} : most probable velocity) **[JEE-Mains-2019(ONLINE)]**



(1) V_{mp} of N_2 (300K); V_{mp} of H_2(300K); V_{mp} of O_2(400K)

(2) V_{mp} of H_2 (300K); V_{mp} of N_2(300K); V_{mp} of O_2(400K)

(3) V_{mp} of O_2 (400K); V_{mp} of N_2(300K); V_{mp} of H_2(300K)

(4) V_{mp} of N_2 (300K); V_{mp} of O_2(400K); V_{mp} of H_2(300K)

Points I, II and III in the following plot respectively correspond to (V_{mp} : most probable velocity)

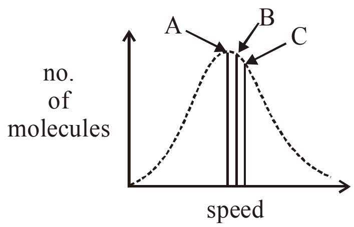
11. 0.5 moles of gas A and x moles of gas B exert a pressure of 200 Pa in a container of volume 10 m^3 at 1000 K. Given R is the gas constant in JK^{-1} mol^{-1}, x is : **[JEE-Mains-2019(ONLINE)]**

(1) $\frac{2R}{4+12}$ (2) $\frac{2R}{4-R}$ (3) $\frac{4-R}{2R}$ (4) $\frac{4+R}{2R}$

12. An open vessel at 27°C is heated until two fifth of the air (assumed as an ideal gas) in it has escaped from the vessel. Assuming that the volume of the vessel remains constant, the temperature at which the vessel has been heated is : **[JEE-Mains-2019(ONLINE)]**

(1) 750°C (2) 500°C (3) 750 K (4) 500 K

13. Identify the correct labels of A, B and C in the following graph from the options given below:



[JEE(Main-online)Jan.-2020]

Root mean square speed (V_{rms}) ; most probable speed (V_{mp}) ; Average speed ($V_{av.}$)

(1) A – V_{rms} ; B –V_{mp} ; C – V_{av} (2) A – V_{av} ; B –V_{rms} ; C – V_{mp}

(3) A – V_{mp} ; B –V_{rms} ; C – V_{av} (4) A – V_{mp} ; B –V_{av} ; C – V_{rms}

ANSWER KEY

EXERCISE # 1

PART - I

A-1. 29.17 m^3 **A-2.** 45 bar **A-3.** 5 **A-4.** 1024 **A-5.** 100

A-6. 4 **A-7.** 8 **A-8.** 4

A-9. (a) t = – 163.8ºC, (b) P = 1.37 × 10^3 torr

A-10. 1.12 : 1 **B-1.** 15:16 **B-2.** 8.32 × 10^4 Pa.

B-3. $\frac{170}{570} = 0.30$ **B-4.** 2.201 g/L **C-1.** $\frac{2pT_2}{2T_2 + T_1}$

C-2. P_T = 1.16 atm, 68.18% O_2 , 31.82% N_2

C-3. 0.66 atm, $n_{O_2} = 0.4$ (300 K), $n_{O_2} = 0.2$ (600 K)

D-1. 2 : 1 **D-2.** 8 **D-3.** 0.347 **D-4.** M = 128 g/mol

E-1. 25 **E-2.** 4 **E-3.** 1.73 x 10^4 cm/sec

E-4. 1327ºC **E-5.** T = 22.0 K

F-1. CO_2 = 0.6 lt, CO = 0.4 lt **F-2.** 10 ml

F-3. NO = 44 ml ; N_2O = 16 ml **F-4.** 0.8 g, O_2 = 2.24 Ltr, CH_4.

PART - II

A-1.	(C)	**A-2.**	(B)	**A-3.**	(A)	**A-4.**	(C)	**A-5.**	(C)
A-6.	(A)	**A-7.**	(A)	**A-8.**	(A)	**A-9.**	(C)	**A-10.**	(A)
B-1.	(B)	**B-2.**	(C)	**B-3.**	(D)	**C-1.**	(D)	**C-2.**	(A)
C-3.	(C)	**C-4.**	(A)	**D-1.**	(A)	**D-2.**	(A)	**D-3.**	(B)
D-4.	(A)	**D-5.**	(C)	**E-1.**	(D)	**E-2.**	(D)	**E-3.**	(D)
E-4.	(C)	**E-5.**	(D)	**E-6.**	(A)	**E-7.**	(A)	**E-8.**	(C)
E-9.	(B)	**E-10.**	(B)	**F-1.**	(D)	**F-2.**	(B)	**F-3.**	(D)
F-4.	(B)	**F-5.**	(B)	**F-6.**	(D)				

PART - III

1.	(A - s) ; (B - q, s) ; (C - r) ; (D - p, r)	**2.**	(A-q), (B-t), (C-s),(D-r), (E-p)

EXERCISE # 2

PART - I

1.	(B)	**2.**	(A)	**3.**	(C)	**4.**	(D)	**5.**	(B)
6.	(A)	**7.**	(A)	**8.**	(D)	**9.**	(B)	**10.**	(A)
11.	(B)	**12.**	(A)						

PART - II

1.	4	**2.**	1	**3.**	5	**4.**	5	**5.**	10
6.	28 (m_{Ar} = 24 + m_{Ne} = 4)			**7.**	40 atm				
8.	2 m	**9.**	8	**10.**	4 : 1				

PART - III

1.	(AB)	**2.**	(ABD)	**3.**	(BCD)	**4.**	(ABC)	**5.**	(ACD)
6.	(ABC)	**7.**	(BD)	**8.**	(ABD)	**9.**	(CD)	**10.**	(ABD)
11.	(BC)	**12.**	(ACD)	**13.**	(AD)	**14.**	(ABD)		

PART - IV

1.	(B)	**2.**	(C)	**3.**	(A)	**4.**	(B)	**5.**	(C)
6.	(C)								

EXERCISE # 3

PART - I

1.	M_Y = 4.	**2.**	(ABCD)	**3.**	7	**4.**	5	**5.**	(C)
6.	(B)	**7.**	(C)	**8.**	(D)	**9.**	9	**10.**	(C)
11.	(2.22)	**12.**	(ABC)						

PART - II

1.	(1)	**2.**	(3)	**3.**	(4)	**4.**	(3)	**5.**	(2)
6.	(3)	**7.**	(4)	**8.**	(4)	**9.**	(4)	**10.**	(4)
11.	(3)	**12.**	(4)	**13.**	(4)				

Reliable Ranker Problems

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.

Self Assessment Test

PART- 1 : PAPER JEE (MAIN) PATTERN

SECTION–I : (Maximum Marks : 80)

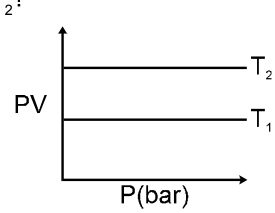
- This section contains **TWENTY** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :
  Full Marks : +4If only the bubble corresponding to the correct option is darkened.
  Zero Marks : 0 If none of the bubbles is darkened.
  Negative Marks : –1 In all other cases

1. 2.5 L of a sample of a gas at 27°C and 1 bar pressure is compressed to a volume of 500 mL keeping the temperature constant, the percentage increase in pressure is
(A) 100 % (B) 400 % (C) 500% (D) 80%

2. For two gases, A and B with molecular weights M_A and M_B, it is observed that at a certain temperature, T, the mean velocity of A is equal to the root mean square velocity of B. Thus the mean velocity of A can be made equal to the mean velocity of B, if
(A) A is at temperature, T_1 and B at T_2 $T_1 > T_2$
(B) A is lowered to a temperature $T_2 < T$ while B is at T
(C) Both A and B are raised to a higher temperature
(D) Both A and B are lowered in temperature.

3. At what temperature, the average speed of gas molecules be double of that at temperature, 27ºC?
(A) 120ºC (B) 108ºC (C) 927ºC (D) 300ºC

4. The product of PV is plotted against P at two temperatures T_1 and T_2 and the 'result is shown in figure. What is correct about T_1 and T_2?



(A) $T_1 > T_2$ (B) $T_2 > T_1$ (C) $T_1 = T_2$ (D) $T_1 + T_2 = 1$

5. Match of following (where U_{rms} = root mean square speed, U_{av} = average speed, U_{mp} = most probable speed)

	List I		List II
(a)	U_{rms} / U_{av}	(i)	1.22
(b)	U_{av} / U_{mp}	(ii)	1.13
(c)	U_{rms} / U_{mp}	(iii)	1.08

(A) (a)-(iii), (b)-(ii), (c)-(i) (B) (a)-(i), (b)-(ii), (c)-(iii)
(C) (a)-(iii), (b)-(i), (c)-(ii) (D) (a)-(ii), (b)-(iii), (c)-(i).

6. When CO_2 under high pressure is released from a fire extinguisher, particles of solid CO_2 are formed, despite the low sublimation temperature (– 77ºC) of CO_2 at 1.0 atm. It is
(A) the gas does work pushing back the atmosphere using KE of molecules and thus lowering the temperature
(B) volume of the gas is decreased rapidly hence, temperature is lowered
(C) both (A) and (B)
(D) None of the above

7. The volume of a gas increases by a factor of 2 while the pressure decreases by a factor of 3. Given that the number of moles is unaffected, the factor by which the temperature changes is :

(A) $\frac{3}{2}$ (B) 3×2 (C) $\frac{2}{3}$ (D) $\frac{1}{2} \times 3$

8. If V_0 is the volume of a given mass of gas at 273 K at constant pressure , then according to Charle's law , the volume at 10 ºC will be :

(A) $10\ V_0$ (B) $\frac{2}{273}(V_0 + 10)$ (C) $V_0 + \frac{10}{273}$ (D) $\frac{283}{273} V_0$

9. When a gas is compressed at constant temperature :
(A) the speeds of the molecules increase
(B) the collisions between the molecules increase
(C) the speeds of the molecules decrease
(D) the collisions between the molecules decrease

10. Helium atom is two times heavier than a hydrogen molecule at 298 k , the average kinetic energy of helium is :
(A) two times that of hydrogen molecule
(B) same as that of the hydrogen molecule
(C) four times that of a hydrogen molecule
(D) half that of a hydrogen molecule

11. If equal weights of oxygen and nitrogen are placed in separate containers of equal volume at the same temperature, which one of the following statements is true?
(mol wt: N_2 = 28, O_2 = 32)
(A) Both flasks contain the same number of molecules.
(B) The pressure in the nitrogen flask is greater than the one in the oxygen flask.
(C) More molecules are present in the oxygen flask.
(D) Molecules in the oxygen flask are moving faster on the average than the ones in the nitrogen flask.

12. At what temperature root mean square speed of N_2 gas is equal to that of propane gas at S.T.P. conditions.
(A) 173.7°C (B) 173.7 K (C) S.T.P. (D) – 40°C

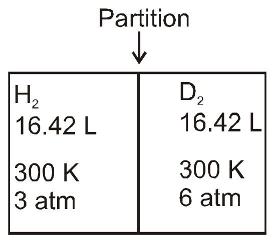
13. 10 L of O_2 gas is reacted with 30 L of CO (g) at STP. The volume of each gas present at the end of the reaction are :
(A) O_2 = 10 L, CO_2 = 20 L
(B) CO = 10 L, CO_2 = 20 L
(C) CO = 20 L, CO_2 = 10 L
(D) CO = 15 L, CO_2 = 15 L

14. 1 mol of a gaseous aliphahatic compound $C_nH_{3n}O_m$ is completely burnt in an excess of oxygen. The contraction in volume is (assume water get condensed out)

(A) $\left(1+\frac{1}{2}n-\frac{3}{4}m\right)$ (B) $\left(1+\frac{3}{4}n-\frac{1}{4}m\right)$ (C) $\left(1-\frac{1}{2}n-\frac{3}{4}m\right)$ (D) $\left(1+\frac{3}{4}n-\frac{1}{2}m\right)$

15. At STP the order of mean square velocity of molecules of H_2, N_2, O_2 and HBr is -
(A) $H_2 > N_2 > O_2 > HBr$
(B) $HBr > O_2 > N_2 > H_2$
(C) $HBr > H_2 > O_2 > N_2$
(D) $N_2 > O_2 > H_2 > HBr$

16.



If the partition is removed the average molar mass of the sample will be (Assume ideal behaviour).

(A) $\frac{5}{3}$ g/mol (B) $\frac{10}{3}$ g/mol (C) $\frac{3}{2}$ g/mol (D) 3 g/mol

17. If all the oxygen atoms present in 4 mole H_2SO_4, 2 mole P_4O_{10} & 2mole NO_2 are collected for the formation of O_2 gas molecules then calculate volume of O_2 gas formed at 2 atm pressure & 273 K temperature.

(A) 224 L (B) 448 L (C) 336 L (D) 112 L

18. At what temperature will the total KE of 0.3 mol of He be the same as the total KE of 0.40 mol of Ar at 400 K ?

(A) 533 K (B) 400 K (C) 346 K (D) 300 K

19. Potassium hydroxide solutions are used to absorb CO_2. How many litres of CO_2 at 1.00 atm and 22ºC would be absorbed by an aqueous solution containing 15.0 g of KOH ? (Take R = $\frac{1}{12}$ ℓ atm / K/mole)

$$2KOH + CO_2 \longrightarrow K_2CO_3 + H_2O$$

(A) 3.24 L (B) 1.62 L (C) 6.48 L (D) 0.324 L

20. A quantity of gas is collected in a graduated tube over the mercury. The volume of gas at 18 ºC is 50 ml and the level of mercury in the tube is 100 mm above the outside mercury level. The barometer reads 750 torr. Hence, volume at S.T.P. is approximately :

(A) 22 ml (B) 40 ml (C) 20 ml (D) 44 ml

SECTION-II

Instructions.

1. This section contains Five (05) questions. The answer to each question is Numerical Value with two digit integer and decimal upto one digit.
2. If the numerical value has more than two decimal places Truncate/Round-off the value upto Two decimal places.
   Full Marks : +4 If Only the correct option is chosen.
   Zero Marks : - 0 in all other cases

21. Two flasks A and B have equal volumes. A is maintained at 300 K and B at 600 K, while A contains H_2 gas, B has an equal mass of CO_2 gas. Find the ratio of total K.E. of gases in flask A to that of B.

22. If two moles of an ideal gas at 546 K occupies a volume of 44.8 litres, the pressure (in atm) must be -

23. What is the total pressure (in atm) exerted by the mixture of 7.0 g of N_2 , 2g of hydrogen and 8.0 g of sulphur dioxide gases in a vessel of 6 L capacity that has been kept in a reservoir at 27°C?

24. Two glass bulbs A and B at same temperature are connected by a very small tube having a stop-corck. Bulb A has a volume of 100 cm^3 and contained the gas while bulb B was empty. On opening the stop-corck, the pressure fell down to 20%. The volume of the bulb B (in Ltr.) is :

25. 2 litres of moist hydrogen were collected over water at 26^{0}C at a total pressure of one atmosphere. On analysis, it was found that the quantity of H_2 collected was 0.0788 mole. What is the mole % of H_2 in the moist gas :

PART 2 : PAPER JEE (ADVANCED) PATTERN

SECTION-I : (Maximum Marks : 12)

- This section contains **FOUR** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is correct.
- For each question, darken the bubble corresponding to the correct option in the ORS.
- For each question, marks will be awarded in one of the following categories :

Full Marks	:	+3	If only the bubble corresponding to the correct option is darkened.
Zero Marks	:	0	If none of the bubbles is darkened.
Negative Marks	:	–1	In all other cases

1. Correct expression for density of an ideal gas mixture of two gases 1 and 2, where m_1 and m_2 are masses and n_1 and n_2 are moles and M_1 and M_2 are molar masses.

(A) $d = \frac{(m_1 + m_2)}{(M_1 + M_2)}$ (B) $d = \frac{(m_1 + m_2)}{(n_1 + n_2)}\frac{P}{RT}$

(C) $d = \frac{(n_1 + n_2)}{(m_1 + m_2)} \times \frac{P}{RT}$ (D) None of these

2. A balloon filled with ethyne is pricked with a sharp point and quickly dropped in a tank of H_2 gas under identical conditions. After a while the balloon will :
(A) Shrink (B) Enlarge
(C) Completely collapse (D) Remain unchanged in size

3. 10 ml of gaseous hydrcarbon is exploded with 100 ml O_2. The residual gas on cooling is found to measure 95 ml of which 20 ml is abosrbed by KOH and the reminder by alkaline pyrogallol. The formula of the hydrocarbon is :
(A) CH_4 (B) C_2H_6 (C) C_2H_4 (D) C_2H_2

4. A teacher enters a classroom from front door while a student from back door. There are 13 equidistant rows of benches in the classroom. The teacher releases N_2O, the laughing gas, from the first bench while the student releases the weeping gas ($C_6H_{11}OBr$) from the last bench. At which row will the students starts laughing and weeping simultaneously
(A) 7 (B) 10 (C) 9 (D) 8

SECTION-II : (Maximum Marks: 32)

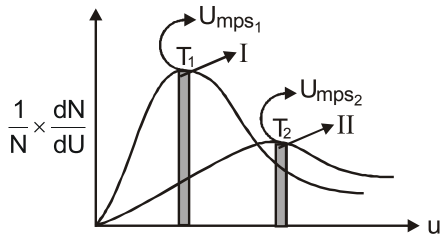
- This section contains **EIGHT** questions.
- Each question has **FOUR** options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s).
- For each question, choose the correct option(s) to answer the question.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks	:	+4	If only (all) the correct option(s) is (are) chosen.
Partial Marks	:	+3	If all the four options are correct but ONLY three options are chosen.
Partial Marks	:	+2	If three or more options are correct but ONLY two options are chosen, both of which are correct options.
Partial Marks	:	+1	If two or more options are correct but ONLY one option is chosen and it is a correct option.
Zero Marks	:	0	If none of the options is chosen (i.e. the question is unanswered).
Negative Marks	:	–1	In all other cases.

- **For Example :** If first, third and fourth are the **ONLY** three correct options for a question with second option being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in –1 marks.

5. The Ne atom has 10 times the mass of H_2. Which of the following statements are true?
(A) Ten moles of H_2 would have the same volume as 1 mole of Ne.
(B) One mole of Ne exerts the same pressure as one mole of H_2 at STP
(C) A H_2 molecule travels 10 times faster than an Ne atom.
(D) At STP, one litre of Ne has 10 times the density of 1 litre of H_2.

6. Following represent the Maxwell distribution curve for an ideal gas at two temperature T_1 and T_2. Which of the following option(s) are true ?

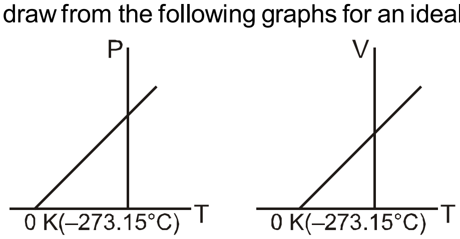


(A) Total area under the two curves is independent of moles of gas
(B) U_{mps} decreases as temperature decreases
(C) $T_1 > T_2$ and hence higher the temperature, sharper the curve
(D) The fraction of molecules having speed = U_{mps} decreases as temperature increases

7. If for two gases of molecular weights M_A and M_B at temperature T_A and T_B, respectively, $T_AM_B = T_BM_A$, then which property has the same magnitude for both the gases ?
(A) PV if mass of gases taken are same (B) Pressure
(C) KE per mole (D) V_{rms}

8. Which of the following statements are correct ?
(A) Helium diffuses at a rate 8.65 times as much as CO does.
(B) Helium escapes at a rate 2.65 times as fast as CO does.
(C) Helium escapes at a rate 4 times as fast as CO_2 does.
(D) Helium escapes at a rate 4 times as fast as SO_2 does.

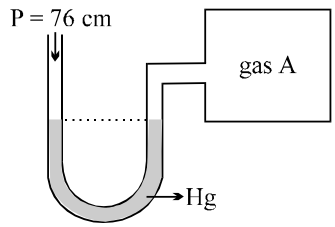
9. What conculsion would you draw from the following graphs for an ideal gas ?



(A) As the temperature is reduced, the volume as well as the pressure increase
(B) As the temperature is reduced, the volume becomes zero and the pressure reaches infinity
(C) As the temperature is reduced, the pressure derease
(D) A point is reached where, theoretically, the volume become zero

10. Select the correct statement for an ideal gas
(A) If all gas molecules are assumed to be rigid sphere of negligible volume, the only possible molecular motion is translation
(B) When temperature increases at constant pressure, collision frequency increases
(C) Mean free path increases by increasing temperature at constant pressure
(D) Kinetic energy decreases by increasing pressure at constant temperature

11. An open ended mercury manometer is used to measure the pressure exerted by a trapped gas as shown in the figure. Initially manometer shows no difference in mercury level in both columns as shown in diagram.



After sparking 'A' dissociates according to following reaction

$$2A(g) \longrightarrow 3B(g) + 2C(g)$$

If pressure of Gas "A" decreases to 0.8 atm. Then (Assume temperature to be constant and is 300 K)
(A) total pressure increased by 1.3 atm
(B) total pressure increased by 0.3 atm
(C) total pressure increased by 22.3 cm of Hg
(D) difference in mercury level is 228 mm.

12. Two non reacting gas A & B having mole ratio of 3:5 in a container exerts a pressure of 8 atm. If B is removed what would be pressure of ‘A’ only, If A is removed what would be pressure of ‘B’ only, temperature remaining constant.
(A) 3 atm (B) 4 atm (C) 5 atm (D) None of these

SECTION-III : (Maximum Marks: 18)

- This section contains **SIX** questions.
- The answer to each question is a **NUMERICAL VALUE**.
- For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the **second decimal place**; e.g. 6.25, 7.00, –0.33, –.30, 30.27, –127.30, if answer is 11.36777..... then both 11.36 and 11.37 will be correct) by darken the corresponding bubbles in the ORS.
For Example : If answer is –77.25, 5.2 then fill the bubbles as follows.
- Answer to each question will be evaluated according to the following marking scheme:
Full Marks : +3 If ONLY the correct numerical value is entered as answer.
Zero Marks : 0 In all other cases.

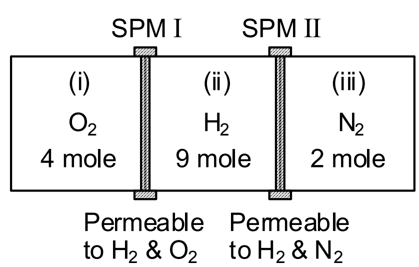
13.✍ A container is divided into 3 identical parts by fixed semipermeable membrane as shown below.

In compartment (i) 4 moles of O_2 are taken

In compartment (ii) 9 moles of H_2 are taken

In compartment (iii) 2 moles of N_2 are taken

Calculate the ratio of total pressure in the three compartments after a sufficient long time. Assume temperature constant throughout. If ratio is a : b : c (simplest ratio) then express your answer as
a + b + c.



14. The density of a gas filled in an electric lamp is 0.75 kg/m^3. When lamp is switched on, the pressure in it increases from 4 Pa to 25 Pa, then what is increase in u_{rms} in m/sec.

15. 0.75 mole of solid X_4 and 2 mole of O_2 are heated to completely react in a closed rigid container to form only one gaseous compound (no reactant left behind). Find the ratio of final pressure at 327ºC to the initial pressure at 27ºC in the flask. Fill your answer as x, where ratio is x : 1.

16. For the reaction

$$2NH_3(g) \longrightarrow N_2(g) + 3H_2(g),$$

what is the % of NH_3 converted if the mixture diffuses twice as fast as that of SO_2 under similar conditions.

17. The density of gas A is twice that of B at the same temperature the molecular weight of gas B is twice that of A. The ratio of pressure of gas A and B will be :

18. Two vessels connected by a valve of negligible volume. One container (I) has 2.8 of N_2 at temperature T_1(K). The other container (II) is completely evacuated. The container (I) is heated to T_2 (K) while container (II) is maintained at $T_2/3$ (K). Volume of vessel (I) is half that of vessel (II). If the valve is opened then what is the weight ratio of N_2 in both vessel (W_{II}/W_I) ?

PART - 3 : OLYMPIAD (PREVIOUS YEARS)

1. How many moles of air are there in the lungs of an average adult with a lung capacity of 3.8 L . (Assume that the person is at 1.0 atm pressure and has normal body temperature at 37°C). **[NSEC-2002]**

(A) 0.15 mol (B) 0.25 mol (C) 1.15 mol (D) 2.25 mol.

2. The root mean square velocity of SO_2 is equal to that of oxygen at 27°C when the temperature is : **[NSEC-2008]**

(A) 327°C (B) 127°C (C) 227°C (D) 600°C

3. The temperature of a sample of sulfur dioxide is increased from 27°C to 327°C. The average kinetic energy of the gas molecules **[NSEC-2008]**

(A) is doubled (B) increases by the factor 327/27
(C) is halved (D) remains same

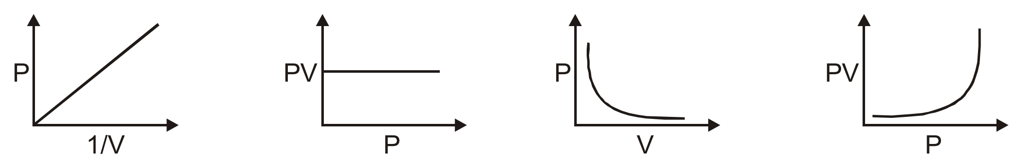
4. The vapour density of gas A is four times that of B. If the molecular mass of B is M then molecular mass of A is: **[NSEC-2012]**

(A) M (B) 4M (C) M/4 (D) 2M

5. A gas shows positive Joule-Thomson Effect below its **[NSEC-2013]**

(A) Boyls Temperature (B) Critical Temperature
(C) Inversion Temperaute (D) Transition Temperate

6. The graph that wrongly represents the Boyle's law of an ideal gas is **[NSEC-2014]**



(i) (ii) (iii) (iv)

(A) II (B) I (C) IV (D) III

7. In an experiment, it was found that for a gas at constant temperature, PV = C. The value of C depends on **[NSEC-2015]**

(A) atmospheric pressure (B) quantity of gas
(C) molecular weight of gas (D) volume of chamber

8. The quantity that does not change for a sample of a gas in a seled rigid container when it is cooled from 120ºC to 90ºC at constant volume is **[NSEC-2015]**

(A) average energy of the molecule (B) pressure of the gas
(C) density of the gas (D) Average speed of the molecules

9. Equal masses of ethane and hydrogen gas are present in a container at 25ºC. The fraction of the total pressure exerted by ethane gas is : **[NSEC-2016]**

(A) 1/2 (B) 1/16 (C) 15/16 (D) 1/8

10. The volume of nitrogen evolved on complete reaction of 9 g of ethylamine with a mixture of $NaNO_2$ and HCl at 273ºC and 1 atm pressure is : **[NSEC-2016]**
(A) 11.2 dm^3 (B) 5.6 cm^3 (C) 4.48 dm^3 (D) 22.4 cm^3

11. Which of the following will not give a straight line plot for an ideal gas ? **[NSEC-2017]**
(A) V vs T (B) V vs P (C) V vs 1/P (D) V vs 1/T

12. When a sample of gas kept at 20ºC and 4.0 atm is heated to 40ºC at constant volume ? **[NSEC-2017]**
(A) average speed of the gas molecules will decrease.
(B) number of collisions between the gas molecules per second will remain the same.
(C) average kinetic energy of the gas will increase
(D) pressure of the gas will become 8 atm.

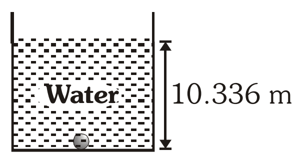
13. The pressure inside two gas cylinders of volume 25 m^3 and 50m^3 are 10 kP and 20 kP respectively. The cylinders are kept at the same temperature and separated by a value. What is the pressure in the combined system when the value is opened? **[NSEC-2018]**
(A) 30 kPa (B) 15 kPa (C) 16.7 kPa (D) 2.5 kPa

14. Density of CO_2 gas at 0ºC and 2.00 atm pressure can be expressed as? **[NSEC-2018]**
(A) 2 gm^{-3} (B) 4 gm^{-3} (C) 4×10^3 kgm^{-3} (D) All are incorrect

PART - 4 : ADDITIONAL PROBLEMS

SUBJECTIVE QUESTIONS

1. **(a)** Radius of a bubble at the bottom of the tank shown below was found to be 1 cm, then find the radius of the bubble at the surface of water considering the temperature at the surface & bottom being same.



(b) If absolute temperature at the surface is 4 times that at the bottom, then find radius of bubble at the surface.

2. Find the ratio of moles of SO_2 to CH_4 after fifth diffusion steps if their initially mole ratio is 8 : 1.

3. A human adult breathes in approximately 0.50 dm^3 of air at 1.00 bar with each breath. If an air tank holds 100 dm^3 of air at 200 bar, how many breathes the tank will supply ?

4. For 10 minute each, at 0ºC, from two identical holes nitrogen and an unknown gas are leaked into a common vessel of 4 litre capacity. The resulting pressure is 2.8 atm and the mixture contains 0.4 mole of nitrogen. What is the molar mass of unknown gas? (Use R = 0.082 L-atm/mol-K)

5. A gas cylinder contains 320 g oxygen gas at 24.6 atm pressure and 27ºC. What mass of oxygen would escape if first the cylinder were heated to 133ºC and then the valve were held open until the gas pressure was 1.00 atm, the temperature being maintained at 133ºC ? (R = 0.0821 L. atm/K/mole)

6. A mixture of hydrogen and oxygen at one bar pressure contains 20% , by weight of hydrogen. The partial pressure of hydrogen will be.

7. Suppose a gas sample in all have 6×10^{23} molecules. Each 1/3 rd of the molecules have rms speed 10^4 cm/sec, 2×10^4 cm/sec and 3×10^4 cm/sec. Calculate the rms speed of gas molecules in sample.

8. A closed vessel contains equal number of nitrogen and oxygen molecules at pressure of P mm. If nitrogen is removed from the system, then the pressure will be.

9. A mixture of gases at 760 torr contains 55.0% nitrogen, 25.0% oxygen and 20.0% carbon dioxide by mole. What is the partial pressure of each gas in torr ?

10. A mixture of nitrogen and water vapours is admitted to a flask which contains a solid drying agent. Immediately after admission, the pressure of the flask is 760 mm. After some hours the pressure reached a steady value of 745 mm.
(a) Calculate the composition, in mol and per cent of original mixture.
(b) If the experiment is done at 20ºC and the drying agent increases in weight by 0.15 g, what is the volume of the flask ? (the volume occupied by the drying agent may be ignored) ?

ONLY ONE OPTION CORRECT TYPE

11. According to the kinetic theory of gases, in an ideal gas, between two successive collisions a gas molecule travels -
(A) In a straight line path (B) with an accelerated velocity
(C) In a circular path (D) In a wavy path

12. The following gases are present under similar condition of T, P & V. The longest mean free path stands for
(A) H_2 (B) N_2 (C) O_2 (D) Cl_2

13. If a mixture containing 3 moles of hydrogen and 1 mole of nitrogen is converted completely into ammonia, the ratio of initial and final volume under the same temperature and pressure would be :
(A) 3 : 1 (B) 1 : 3 (C) 2 : 1 (D) 1 : 2

14. According to kinetic theory of gases, for a diatomic molecule :
(A) The pressure exerted by the gas is proportional to the mean velocity of the molecule.
(B) The pressure exerted by the gas is proportional to the r.m.s. velocity of the molecule.
(C) The r.m.s. velocity of the molecule is inversely proportional to the temperature.
(D) The mean translational K.E. of the molecule is proportional to the absolute temperature.

15. The average kinetic energy (in joules of) molecules in 8.0 g of methane at 27º C is :
(A) 6.21×10^{-20} J/molecule (B) 6.21×10^{-21} J/molecule
(C) 6.21×10^{-22} J/molecule (D) 3.1×10^{-22} J/molecule

16. The temperature of an ideal gas is increased from 120 K to 480 K. If at 120 K the root-mean-square velocity of the gas molecules is v, at 480 K it becomes :
(A) 4v (B) 2v (C) v/2 (D) v/4

17. A thin balloon filled with air at 47ºC has a volume of 3 litre. If on placing it in a cooled room its volume becomes 2.7 litre , the temperature of room is :
(A) 42ºC (B) 100ºC (C) 15ºC (D) 200ºC

18. 10 moles of an ideal gas present in 8.21 litre container at constant temperature. The intercept on y-axis and slope of curve plotted between P/T vs T.
(A) 0.01, 0 (B) 0.1, 1 (C) 0.1, 0 (D) 10, 1

19. $N_2 + 3H_2 \longrightarrow 2NH_3$. 1 mol N_2 and 4 mol H_2 are taken in 15 L flask at 27°C. After complete conversion of N_2 into NH_3, 5 L of H_2O is added. Pressure set up in the flask is :

(A) $\frac{3 \times 0.0821 \times 300}{15}$ atm (B) $\frac{2 \times 0.0821 \times 300}{10}$ atm

(C) $\frac{1 \times 0.0821 \times 300}{15}$ atm (D) $\frac{1 \times 0.0821 \times 300}{10}$ atm

20. Which of the following is not the correct set of pressure and volume at constant temperature and constant moles of gas ?

	P	V		P	V
(A)	1 atm	200 ml	(B)	760 mm	0.2 L
(C)	0.5 atm	100 L	(D)	2 atm	100 mL

21. The number of effusion steps required to convert a mixture of H_2 and O_2 from 240 : 1600 (by mass) to 3072 : 20 (by mass) is

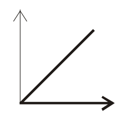
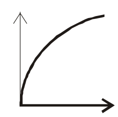
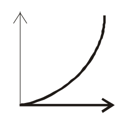
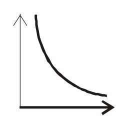
(A) 2 (B) 4 (C) 5 (D) 6

22. The average kinetic energy of an ideal gas per molecule in SI units at 25^0C will be :

(A) 6.17×10^{-21} kJ (B) 6.17×10^{-21} J (C) 6.17×10^{-20} J (D) 7.16×10^{-20} J

PART - III : MATCH THE COLUMN

23. Match each List-I with an appropriate pair from List-II and select the correct answer using the code given below the lists.

	List-I		List-II
P.	$\frac{1}{V^2}$ vs. P for ideal gas at constant T and n.	1.	
Q.	V vs. $\frac{1}{T}$ for ideal gas at constant P and n	2.	
R.	PT vs. T^2 for ideal gas at constant T and n.	3.	
S.	V vs. $\frac{1}{P^2}$ for ideal gas at constant T and n.	4.	

Code :

	P	Q	R	S		P	Q	R	S
(A)	3	4	1	2	(B)	1	2	4	3
(C)	3	1	2	4	(D)	2	3	1	4

SINGLE AND DOUBLE VALUE INTEGER TYPE

24. Two flask A and B have equal volume at 100K and 200K and have pressure 4 atm and 1 atm respectively. The flask A contains H_2 gas and B contains CH_4 gas. The collision diameter of CH_4 is twice that of H_2. Calculate ratio of mean free path of CH_4 to H_2.

25. If the mean free path is 10 cm at one bar pressure then its value at 5 bar pressure, if temperature is kept constant.

26. 10 ml of a mixture of CH_4, C_2H_4 and CO_2 was exploded with excess of air. After explosion there was a contraction of 17 ml and after treatment with KOH, there was further reduction of 14ml. What was the composition of the mixture? Report your answer as $V_{CH_4} + V_{C_2H_4} + V_{CO_2}$.

27. A mixture of N_2 and H_2 has initially mass ratio of 196 : 1 then find after how many steps we can obtain a mixture containing 1 : 14 mole ratio of N_2 and H_2.

28. 50 ml of gaseous mixture of acetylene and ethylene is taken in a ratio of a : b requires 700 ml of air containing 20% by volume O_2 for complete combustion. Calculate the volume of air required for complete combution of a mixture (50 ml) having ratio b : a. (Report your answer divide by 25).

29. A certain volume of argon gas (Mol. Wt. = 40) requires 45 s to effuse through a hole at a certain pressure and temperature. The same volume of another gas of unknown molecular weight requires 60 s to pass through the same hole under the same conditions of temperature and pressure. The molecular weight of the gas (in amu) is :

30. A 0.5 dm^3 flask contains gas A and 1 dm^3 flask contains gas B at the same temperature. If density of A = 3 g/dm^3 and that of B = 1.5 g/dm^3 and the molar mass of A = 1/2 of B, the ratio of pressure ($\frac{P_A}{P_B}$) exerted by gases is :

31. An open flask containing air is heated from 300 K to 500 K. What percentage of air will be escaped to the atmosphere, if pressure is keeping constant?

32. A gaseous mixture of three gases A, B and C has a pressure of 10 atm. The total number of moles of all the gases is 10. If the partial pressure of A and B are 3.0 and 1.0 atm respectively and if C has mol. wt. of 2.0, what is the weight of C in g present in the mixture ?

33. A glass bulb of 2 L capacity is filled by helium gas at 10 atm pressure. Due to a leakage the gas leaks out. What is the volume of gas (in ltr.) leaked if the final pressure in container is 1 atm.

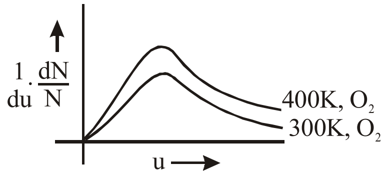
ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

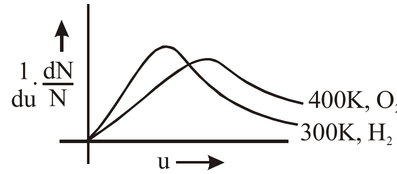
34. Which of the following quantities is the same for all ideal gases at the same temperature :

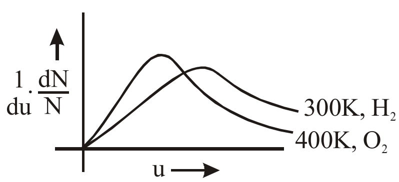
(A) The kinetic energy of 1 mol (B) The kinetic energy of 1 g

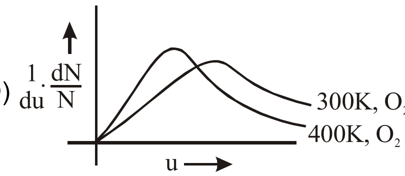
(C) The number of molecules in 1 mol (D) The number of molecules in 1 g

35. Which of the following graph is/are correct according to maxwell distribution law ?

(A) 

(B) 

(C) 

(D) 

36. Select correct statement -

(A) Fraction of molecules at U_{rms} for an ideal gas is less than that of at U_{mp}

(B) Real gas can behave like an ideal at high pressure and low temperature

(C) If a real gas is above boyle temperature it can not be liquified.

(D) When z < 1 ; real gas is more compressible than ideal gas

37. In a certain sample of gas at 25^0 C the number of molecules having speeds between 4 km sec^{-1} and 4.1 kmsec^{-1} is N. If the total number of gas molecules at the same temperature are doubled what will happen ?
(A) Value of most probable velocity will remains same
(B) Area under the Maxwell's curve for distribution of speeds will increase by four times
(C) No. of molecules between 4 km sec^{-1} and 4.1 km sec^{-1} will become 2 N
(D) No. of molecules between 4 km sec^{-1} and 4.1 km sec^{-1} will remain same.

38. Which among the following has rate of effusion more than moist air
(A) Dry air (B) He (C) NH_3 (D) O_2

39. Select the correct statement(s) for an ideal gas -
(A) All the molecules move with same speed
(B) Kinetic energy of a molecule remains unchanged due to collision with other molecule
(C) Kinetic energy of molecules depends only on temperature
(D) Speed of molecules depend on both molecular mass & temperature

40. Two identical vessels are connected by a narrow tube of negligible volume. Initially, the vessels were containing a total of 0.7 mole of an ideal gas at 27ºC and 1.05 bar. Now, one vessel is heated to 227ºC and other is cooled to –73ºC. Which of the following is/are correct information(s) ? (R = 0.083 litre-bar/K-mol)
(A) Volume of each vessel is 8.3 litre.
(B) Final pressure of gas in both vessel is 1.0 bar.
(C) Final mole of gas in the vessel at 227ºC is 0.5.
(D) Initial mole of gas in each vessel was 0.35.

41. The temperature of a sample of an ideal gas is increased at constant volume. Which of the following perameter of gas will not change ?
(A) Density
(B) Mean free path
(C) Average speed of molecules
(D) Total force applied by molecules on a wall

42. A vessel contains equimolar mixture of CH_4 and C_2H_6 gases. If a pin-hole is made in the vessel, then the correct information(s) is/are -
(A) More molecules of CH_4 will come out relative to C_2H_6 molecules.
(B) The vapour density of gaseous mixture remained in the vesssel will increase with time.
(C) The average molecular mass of gaseous mixture remained in the vessel may be 20, at any time.
(D) Initial rate of effusion of the both gases is same.

43. 400 ml N_2 gas is collected over water at 785 torr and 27ºC. The vapour pressure of water at 27ºC is 25 torr. The correct infromation(s) is / are
(A) The pressure exerted by dry N_2 gas = 1 atm
(B) The molar ratio of N_2 gas and water vapour above liquid water = 30.4 : 1
(C) The partial volume of dry N_2 gas = 400 ml
(D) The minimum mass of liquid water finally present in the vessel = $\frac{150}{19\times 821}$ gm

RRP ANSWER KEY

PART - 1

1.	(B)	**2.**	(B)	**3.**	(C)	**4.**	(B)	**5.**	(A)
6.	(A)	**7.**	(C)	**8.**	(D)	**9.**	(B)	**10.**	(B)
11.	(B)	**12.**	(B)	**13.**	(B)	**14.**	(D)	**15.**	(A)
16.	(B)	**17.**	(A)	**18.**	(A)	**19.**	(A)	**20.**	(B)
21.	11	**22.**	2 atm	**23.**	5.64 bar	**24.**	0.4 L	**25.**	96.7

PART - 2

1.	(B)	**2.**	(B)	**3.**	(D)	**4.**	(C)	**5.**	(BD)
6.	(ABD)	**7.**	(AD)	**8.**	(BD)	**9.**	(CD)	**10.**	(AC)
11.	(BD)	**12.**	(AC)	**13.**	15	**14.**	6	**15.**	1
16.	6.25%	**17.**	4	**18.**	6				

PART - 3

1.	(A)	**2.**	(A)	**3.**	(A)	**4.**	(B)	**5.**	(C)
6.	(C)	**7.**	(B)	**8.**	(C)	**9.**	(B)	**10.**	(C)
11.	(D)	**12.**	(C)	**13.**	(C)	**14.**	(D)		

PART - 4

1.	(a) $2^{1/3}$ cm ; (b) 2 cm	**2.**	1/4	**3.**	40,000 breaths
4.	448 g mol^{-1}	**5.**	310.4 g escaped.	**6 .**	0.8 bar
7.	2.16 x 10^4 cm/sec.	**8.**	(0.5 P mm)		

9. P_{N_2} = 418 torr, P_{O_2} = 190 torr, P_{CO_2} = .152 torr, total pressure = 760.

10. (a) 1.98% (b) 10.156 litres

11.	(A)	**12.**	(A)	**13.**	(C)	**14.**	(D)	**15.**	(B)
16.	(B)	**17.**	(C)	**18.**	(C)	**19.**	(D)	**20.**	(C)
21.	(C)	**22.**	(B)	**23.**	(A)	**24.**	2	**25.**	2
26.	10	**27.**	n = 4	**28.**	27	**29.**	71	**30.**	4
31.	40	**32.**	12	**33.**	**18**	**34.**	(AC)	**35.**	(ACD)
37.	(AC)	**38.**	(BC)	**39.**	(CD)	**40.**	(ABD)	**41.**	(AB)
42.	(AB)	**43.**	(AB)						

RRP SOLUTIONS

PART- 1

1. Using $p_1V_1 = P_2V_2$ $1 \times 2.5 = 0.5 \times P_2 = 5$ bar.

$\therefore$ % increase in pressure = $\dfrac{(5-1)\text{bar}}{1\text{bar}} \times 100\% = 400\ \%$.

2. Given $\sqrt{\dfrac{8RT}{\pi M_A}} = \sqrt{\dfrac{3RT}{M_B}}$ $\Rightarrow 8M_B = 3\pi\, M_A$

& $\sqrt{\dfrac{3RT_A}{M_A}} = \sqrt{\dfrac{3RT_B}{M_B}}$ $\Rightarrow \dfrac{T_A}{M_A} = \dfrac{T_B}{M_B}$ $\Rightarrow M_B \,.\, T_A = M_A \,.\, T_B$

$\Rightarrow \dfrac{3\pi}{8}\, M_A \,.\, T_A = M_A \,.\, T_B$ $\Rightarrow T_B > T_A$ Hence (B)

3. $\sqrt{\dfrac{8RT}{\pi M}} = 2\sqrt{\dfrac{8 \times R \times 300}{\pi\ M}}$ $\Rightarrow T = 1200\text{ K} = 927^\circ\text{C}$

4. $PV \propto T$

5. $U_{MPS} = \sqrt{\dfrac{2RT}{M}}$; $U_{RMS} = \sqrt{\dfrac{3RT}{M}}$; $U_{av} = \sqrt{\dfrac{8RT}{\pi M}}$

6. K.E. $\propto$ Temperature

7. $PV = nRT$

$\dfrac{P}{3} \times 2V = nRT$

$T' = \dfrac{2}{3}\, T$

8. $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$

$\dfrac{V_0}{273} = \dfrac{V_2}{283}$ $\Rightarrow$ $V_2 = \dfrac{283}{273} V_0$

9. (B) Frequency of collision will increase.

10. Average K.E. = $\dfrac{3}{2}$RT and T is constant 298 K

$\therefore$ K.E. is same for all gases at same Temperature.

11. $n_{N_2} > n_{O_2}$ where 'n' is no of moles of gases.

$\Rightarrow$ $P_{N_2} > P_{O_2}$ because $P_{gas} \alpha$ n.

12. Let Temp (T) where V_{rms} of N_2 = V_{rms} of C_3H_8 at STP

$$= \sqrt{\frac{3RT_1}{M_{N2}}} = \sqrt{\frac{3RT_2}{M_{C_3H_8}}} = \sqrt{\frac{3\times 8.314\times 273}{44\times 10^{-3}}}$$

$$= \sqrt{\frac{3RT_1}{M_{N2}}} = 393.38$$

T_1 = 173.72 K

13.

$$2CO \quad + \quad O_2 \longrightarrow 2CO_2$$

	$2CO$	O_2	$2CO_2$
	30/22.4	10/22.4	
O_2 is limiting reagent	10/22.4	0	20/22.4

$\therefore$ at the end of reaction CO_2 = 20 L

CO = 10 L

14. $C_nH_{3n}O_m + yO_2 \longrightarrow nCo_2(g) + \frac{3n}{2} H_2O\,(l)$

Contraction in volume = Contraction in moles of gas = $1 + \frac{3n}{4} - \frac{m}{2}$

$= 1 + \frac{3n}{4} - \frac{m}{2}$

$\Rightarrow \quad \left(2n+\frac{3n}{2}-m\right) \times \frac{1}{2}$ **= y** $\quad \Rightarrow \quad$ $\mathbf{n + \frac{3n}{4} - \frac{m}{2} = y}$

15. $V_{rms} \propto \frac{1}{\sqrt{M}}$ 'M' is Molecular wt.

order of M.wt. = $H_2 < N_2 < O_2 <$ HBr

$\therefore$ order of $V_{rms} = H_2 > N_2 > O_2 >$ HBr.

16. mole of H_2 = $\frac{3\times 16.42}{0.0821\times 300}$ = 2

mole of D_2 = $\frac{6\times 16.42}{0.0821\times 300}$ = 4

average molecular weight = $\frac{2\times 2+4\times 4}{4+2} = \frac{10}{3}$

17. moles of O_2 in 4 mole (H_2SO_4) = 4 × 2
moles of O_2 in 2 mole (P_4O_{10}) = 10
moles of O_2 in 2 mole (NO_2) = 2
$\therefore$ total moles of O_2 = 20 mole
$\because$ volume of 20 mole at 1 atm = 22.4 × 20 L

$\therefore$ at 2 atm = $\frac{1}{2}\times 22.4\times 20$ = 224 L

18. $\left[\frac{3}{2}nRT\right]_{He} = \frac{3}{2}\,nRT$

0.3 T = 0.4 × 400
T = 533 K

19. $V = \frac{15}{56} \times \frac{1}{2} \times \frac{0.0821 \times 295}{1} = 3.24$ L

20. Net pressure of gas = P_{gas} P_{gas} = 650 mm.

$\frac{P_1V_1}{T_1} = \left(\frac{P_2V_2}{T_2}\right)_{STP}$ $\frac{650 \times 50}{291} = \frac{760 \times V_2}{273}$

V_2 = 40.11 ml P_1 = 9 atm P_2 = 6 atm

$V_1 = 5\ell$ $V_2 = 10\ \ell$

21. $\frac{n_A T_A}{n_B T_B} = \frac{m}{2} \times \frac{44}{m} \times \frac{300}{600} = 11$

22. $P = \frac{nRT}{V} = \frac{2 \times 0.0821 \times 546}{44.8} = 2$ atm

23. No. of moles of $N_2 = \frac{7}{28} = \frac{1}{4}$

No. of moles of H_2 = 1 Mole Total moles = $\frac{1}{4} + 1 + \frac{1}{8}$

No. of moles of $SO_2 = \frac{1}{8}$ moles $= \frac{1}{8}(2+8+1) = \frac{11}{8}$

$P = \frac{nRT}{V} = \frac{11}{8} \times \frac{0.0821 \times 300}{6} = 5.64$

24. 100 P = 0.2 P × 100 + 0.2 P × V

$\frac{1000}{2} = 100 + V$

V = 400 ml

25. $n_{Total} = \frac{PV}{RT} = \frac{1 \times 2}{0.0821 \times 299} = 0.081$ moles $X_{H_2} = \frac{n_{H_2}}{n_{total}} = \frac{0.0788}{\frac{0.0821}{2} \times 299} = 0.967$

PART- 2

2. H_2 gas is greater than diffuses into balloon because rate of diffusion of H_2 is greater than the rate of diffusion of ethyne. Hence, it is enlarged.

3. Volume of CO_2 = 20 ml (absorbed gas by KOH)

Volume of air unreacted = 95 – 20 = 75 (gas abosrbed by pyrogallol)

$\therefore$ O_2 reacted = 100 + 75 = 25 ml

$\because$ 10 ml hydrocarbon libarates 20 ml CO_2.

$\therefore$ 2 atoms of 'C' are present in the compound.

$\therefore$ $C_2H_x + yO_2 \longrightarrow 2CO_2 + H_2O$

	C_2H_x	O_2	CO_2	H_2O
initial	10 ml	25 ml		
final	0	0	20	10 ml

volume of water vapours = (25 – 20) × 2 = 10 ml

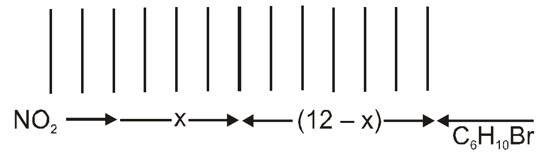
$\because$ 10 ml hydrocarbon gives 10 ml water vapours.

$\therefore$ No. of Hydrogen atoms in compounds are 2.

$\therefore$ Compound will be C_2H_2.

4. Let both gases meet at n^{th} row

$$\frac{r_{NO_2}}{r_{C_6H_{10}Br}} = \frac{x}{12-x} = \sqrt{\frac{179}{44}} = 2$$



$x = 24 - 2x$
$3x = 24$
$x = 8 = n - 1$
$n = 9^{th}$ Row

7. When $\frac{T_A}{M_A} = \frac{T_B}{M_B}$ or $T_AM_B = T_BM_A$

$(PV)_A = nRT$ or $\frac{W_A}{M_A}RT_A$

and $(PV)_B = \frac{W_B}{M_B}RT_B$

$\therefore$ When $W_A = W_B$

$(PV)_A = (PV)_B$

$U_{rms} = \sqrt{\frac{3RT}{M}}$

$\therefore U_A = \sqrt{\frac{3RT_A}{M_A}}$

$U_B = \sqrt{\frac{3RT_B}{M_B}}$

$\therefore U_A = U_B \qquad \left(\frac{T_A}{M_A} = \frac{T_B}{M_B}\right)$

8. $r \propto \frac{1}{\sqrt{M}}$

12. $P_T = X_AP°_A + X_BP°_B$

$8 = \frac{3}{8}P_A + \frac{5}{8}P_B$

$\frac{P_A}{P_B} = \frac{3}{5} \quad \Rightarrow \therefore \; P_A = 3$ atm ; $P_B = 5$ atm

13. After a very long time

$\Rightarrow$ P_{H_2} will be same in all the compartments

$\Rightarrow$ P_{O_2} will be same in (i) & (ii) compartment

$\Rightarrow$ P_{N_2} will be same in (ii) & (iii) comportment

Compartment	(i)	(ii)	(iii)
	O_2 = 2 mole	H_2 = 3 mole	H_2 = 3 mole
	H_2 = 3 mole	O_2 = 2 mole	N_2 = 1 mole
		N_2 = 1 mole	

Ratio of Pressure = Ratio of moles = 5 : 6 : 4 $\qquad$ ($\because$ V & T is same)
a + b + c = 5 + 6 + 4 = 15

14. $u_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{d}} \qquad d = \frac{PM}{RT}$

$\Delta u_{rms} = \sqrt{\frac{3}{d}}(\sqrt{P_2} - \sqrt{P_1}) = 2 \times 3 = 6$ m/sec.

15. Mole atoms of X = 0.75 × 4 = 3

Mole atoms of O = 2 × 2 = 4

Hence the product is X_3O_4 (g)

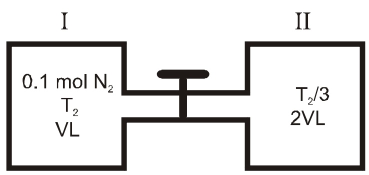
Initial moles of gaseous reactants, n_1 = 2 (oxygen only)

Final moles of gaseous product, n_2 = 1 (X_3O_4)

Hence, $\frac{P_2}{P_1} = \frac{n_2T_2}{n_1T_1} = \frac{1\times 600}{2\times 300} = 1$ or $P_2 : P_1 : 1 : 1$

17. $d_A = 2d_B$; $3M_A = M_B$; $PM = dRT$

$= \frac{P_A}{P_B} \times \frac{M_A}{M_B} = \frac{d_A}{d_B} \times \frac{RT}{RT} = \frac{P_A}{P_B} \times \frac{1}{2} = 2$ $\frac{P_A}{P_B} = \frac{4}{1}$

18. 

Let x moe of N_2 present into vessel II and P is final pressure of N_2

$P(2V) = xR(T_2/3)$ and $P(V) = (0.1 - x)RT_2$

$\Rightarrow \quad 2 = \frac{x}{3(0.1 - x)}$

$\Rightarrow \quad x = 0.6/7$ mole,

$\frac{0.6}{7} \times 2.8 \Rightarrow 2.4$ g N_2

II has 2.4 g N_2 and I has 0.4 g of N_2 ;

$\frac{W_I}{W_{II}} = \frac{0.4}{2.4} \Rightarrow 1 : 6$

PART - 3

4. $VD_A = 4VD_B$

or $\frac{M_A}{2} = 4 \times \frac{M_B}{2}$, or $M_A = 4M_B$

14. All options are incorrect)

PART - 4

4. $\frac{n_{N_2}}{n_x} = \sqrt{\frac{m_x}{M_{N_2}}}$ ....(i)

$P_T V_T = n_T RT$ ....(ii)

Here $n_T = \frac{2.8\times 4}{0.0821\times 273} = 0.5$ and $n_x + n_{N_2} = 0.5$ $\Rightarrow$ $n_x = 0.1$

From (1)

$\frac{0.4}{0.1} = \sqrt{\frac{M_x}{28}}$ $\Rightarrow$ $M_x = 448$.

5. $\frac{n_1T_1}{P_1} = \frac{n_2T_2}{P_2}$ $\therefore$ $\frac{10 \times 300}{24.6} = \frac{n_2 \times 400}{1}$

$\therefore$ $n_2 = 0.3$

$\therefore$ Mass of oxygen left = 0.3 × 32 = 9 g

$\therefore$ Mass of oxygen escaped = 320 – 9.6 = 310.4 g.

7. $u_{rms} = \sqrt{\frac{\Sigma n_1 u_1^2}{\Sigma n}} = \sqrt{\frac{u_1^2 \text{ x } n_1 + u_2^2 \text{ x } n_2 + u_3^2 \text{ x } n_3}{n_1 + n_2 + n_3}}$

$\therefore u_{rms} = \sqrt{\frac{2 \text{ x } 10^{23} \text{ x } (10^4)^2 + 2 \text{ x } 10^{23} \text{ x } (2 \text{ x } 10^4)^2 + 2 \text{ x } 10^{23} \text{ x } (3 \text{ x } 10^4)^2}{6 \text{ x } 10^{23}}}$ = 2.16 x 10^4 cm/sec

9. Let total moles of gas mixture be 100.

$P_{N_2} = \left(\frac{n_{N_2}}{n_T}\right) \times P_T = \frac{55}{100} \times 760 = 418$ torr.

$P_{O_2} = \left(\frac{n_{O_2}}{n_T}\right) \times P_T = \frac{25}{100} \times 760 = 190$ torr.

$P_{CO_2} = (760 - 418 - 190) = 152$ torr.

10. (a) By Dalton's partial pressure

$P_{N_2} + P_{H_2O} = 760$ mm

From given data $P_{N_2} = 745$ mm

So $P_{H_2O} = 760 - 745 = 15$ mm

% Mole of N_2 = % of pressure of N_2 = $\frac{745}{760} \times 100 = 98.02$

$\therefore$ Mole % of H_2O = 100 – 98.02 = **1.98%** **Ans.**

(b) Increase weight of drying agent due to absorption of water (H_2O).

Hence, Wt. of H_2O = 0.15 g

$\therefore$ Mole of $H_2O = \frac{0.15}{18}$

Pressure of $H_2O(P_{N_2})$ = 15 mm = $\frac{15}{760}$ atm

From gas equation PV = nRT

$\frac{15}{760} \times V = \frac{0.15}{18} \times 0.0821 \times (273 + 20)$

V = **10.156 litres** **Ans.**

$P_{N_2} = \left(\frac{n_{N_2}}{n_T}\right) \times P_T = \frac{55}{100} \times 760 = 418$ torr.

$P_{O_2} = \left(\frac{n_{O_2}}{n_T}\right) \times P_T = \frac{25}{100} \times 760 = 190$ torr.

$P_{CO_2} = (760 - 418 - 190) = 152$ torr.

13. Initial $N_2 + 3H_2 \longrightarrow 2NH_3$

1 3

final – – 2

ratio = $\frac{4}{2} = \frac{2}{1}$.

14. K.E. = $\frac{3}{2}$nRT

15. Average KE = $\frac{3}{2} \times \frac{8.314 \times 300}{6.023 \times 10^{23}} = 6.21 \times 10^{-21}$ J/molecule.

16. $v \propto \sqrt{T}$

17. $\frac{V_1}{V_2} = \frac{T_1}{T_2}$

18. Intercept on y-axis = $\log_{10}\frac{nR}{V} = \log_{10}\frac{10 \times 0.821}{8.21} = -10$

$\frac{P}{T}$ v/s curve $\frac{P}{T} = \frac{nR}{V}$

Intercept = $\frac{nR}{V} = \frac{10 \times 0.821}{8.21} = 0.1$, slope = 0

19.

	N_2	+	$3H_2$	$\longrightarrow$	$2NH_3$
t = 0	1 mole		4 mole		0
$t = t_{final}$	0		1 mole		2 mole

NH_3 will absorb by water and volume will be 15 – 5 = 10 L

P = $\frac{nRT}{V} = \frac{1 \times 0.0821 \times 300}{10}$ atm

20. (1) Total moles = $\frac{1 \times 0.2}{RT}$

(2) Total moles = $\frac{1 \times 0.2}{RT}$

(3) Total moles = $\frac{0.5 \times 100}{RT}$

(4) Total moles = $\frac{2 \times 0.1}{RT}$

23. $y = \frac{1}{V^2}$ or $\sqrt{y} = \frac{1}{V}$

P = x and P = $\frac{\text{constant}}{V}$

(A) x = (k) $\sqrt{y} \Rightarrow y = k^1x^2$

(B) V = kT; y = V & $\frac{1}{T} = x \therefore y = \frac{k}{x}$

(C) P = kT; PT = kT^2 or y = kx

(D) $v = \frac{c}{p} \Rightarrow y = c\sqrt{x}$; $y^2 = cx$

26. Volume of H_2O produced = 17 mL; Volume of CO_2 produced = 14 mL
Total volume of CO_2 = volume of CO_2 initially + volume of CO_2 produced = 14 ml
suppose volume of CH_4 and C_2H_4 in the mixture x and y ml respectively
volume of CO_2 produced on explosion = 14 – (10 – x – y) = (4 + x + y) ml
POAC for C, H and O
for C, $1 \times$ mole of CH_4 + $2 \times$ mole of C_2H_4 = $1 \times$ mole of CO_2
$x + 2y = 4 + x + y \qquad y = 4$
for H, $4x + 4y = 2 \times$ mole of H_2O .... (i)
for O, $2 \times$ mole of O_2 = $2 \times (4 + x + y)$ + mole of H_2O .... (ii)
for equation (i) and (ii)
mole of $O_2 = (4 + 2x + 2y)$ (use in explosion)
in explosion reaction
volume of reactant – volume of product = 17 ml
$(x + y) + (4 + 2x + 2y) – (4 + x + y) = 17$
$2x + 2y = 17$ .... (iii)
from equation (i) and (iii)
volume of CH_4 = 4.5, volume of C_2H_4 = 4 ml, volume of CO_2 = 4 ml

28. Let volume of C_2H_2 = x ml (since gases are assume ideal, therefore moles $\propto$ volume)
$\therefore$ value of $C_2H_4 = 50 – x$

$$\underset{x}{C_2H_2} + \underset{\frac{5}{2}x}{\frac{5}{2}O_2} \longrightarrow 2CO_2 + H_2O$$

$$\underset{50-x}{C_2H_4} + \underset{3(50-x)}{3O_2} \longrightarrow 2CO_2 + 2H_2O$$

Total volume of $O_2 = \frac{5}{2}x + 3(50 – x) = 700 \times \frac{20}{100}$

$\Rightarrow$ x = 20 ml
$\therefore$ volume of C_2H_2 = 20 ml
$\therefore$ volume of C_2H_4 = 30 ml
In new conditions
$\therefore$ volume of C_2H_2 = 30 ml
$\therefore$ volume of C_2H_4 = 20 ml

$$\underset{30}{C_2H_2} + \underset{\left(\frac{5}{2}\times 30\right)x}{\frac{5}{2}O_2} \longrightarrow 2CO_2 + H_2O$$

$$\underset{20}{C_2H_4} + \underset{3(20)\text{ ml}}{3O_2} \longrightarrow 2CO_2 + 2H_2O$$

Total volume of $O_2 = \left(\frac{5}{2}\times 30\right) + 3(20) = 135$

$\therefore$ Total volume of air $= \frac{135}{0.2} = 675$ ml

29. $r \propto \frac{1}{\sqrt{M}}$

30. $P_A = \frac{3RT}{M_A}$; $P_B = \frac{1.5RT}{M_B}$

$\frac{P_A}{P_B} = \frac{2M_B}{M_A} = \frac{2 \times 2M_A}{M_A} = 4.$

31. $V_1 = V$, $T_1 = 300$ K, $T_2 = 500$ K, $V_2 = ?$
At constant pressure $V_1T_2 = V_2T_1$

$\therefore\ V_2 = \frac{P_1T_2}{T_1} = \frac{V \times 500}{300} = \frac{5V}{3}$

$\therefore$ Volume of air escaped = final volume – initial volume

$= \frac{5V}{3} - V\ \frac{2V}{3}$

$\therefore$ % of air escaped = $\frac{2V/3}{5V/3} \times 100 = 40\%$

32. Pressure of Total mixture = 10 atm

$P_A + P_B + P_C = 10$

$3 + 1 + P_C = 10 \quad \Rightarrow \quad P_C = 6$ atm

Total moles of mixture = 10

$n_A + n_B + n_C = 10$

$\frac{P_A}{P_B} = \frac{n_A}{n_B} = \frac{3}{1} \quad \Rightarrow \quad \frac{P_B}{P_C} = \frac{n_B}{n_C} = \frac{1}{6}$

Let $n_A = K \Rightarrow n_B = \frac{K}{3}$ $\quad n_C = \frac{1}{6}$ $\quad n_B = 2K$

$\Rightarrow \quad K + \frac{K}{3} + 2K = 10 \quad \Rightarrow \quad \frac{K}{3} = \frac{n_C}{6} \quad \Rightarrow n_C = 2K$

$\Rightarrow \quad K\left(\frac{10}{3}\right) = 10 \quad K = 3, \quad \Rightarrow \quad n_A = 3$

$n_B = 1$
$n_C = 6$

$\therefore$ weight of 'C' in mixture = $2 \times 6 = 12$.

39. All molecules move with different speeds and due to molecular collision, kinetic energy of molecules will change.

40. Initial condition : $PV = nRT$
or, $1.05 \times 2V = 0.7 \times 0.083 \times 300 \Rightarrow V = 8.3$ L
Final condition : $n_1 \times R \times 500 = n_2 \times R \times 200$
and $n_1 + n_2 = 0.7$
Hence, $n_1 = 0.2$, $n_2 = 0.5$

and $P = \frac{n_1 \times R \times 500}{V} = 1.0\text{bar}$

42. $\frac{r_{CH_4}}{r_{C_2H_6}} = \sqrt{\frac{30}{16}} > 1$

As more CH_4 will come out, the % of C_2H_6 and hence M_{av} of gaseous mixture remained will will increase.