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 :	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	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. A gas occupies 100.0 mL at 50°C and 1 atm pressure. The gas is cooled at constant pressure so that volume is reduced to 50.0 mL. What is the final temperature of the gas.

A-2. A sample of gas at 27ºC and 1.00 atm pressure occupies 2.50 L. What temperature is required to adjust the pressure of that gas to 1.50 atm after it has been transferred to a 2.00 L container?

A-3. Assuming the same pressure in each case, calculate the mass of hydrogen required to inflate a balloon to a certain volume V at 127ºC if 8 g helium is required to inflate the balloon to half the volume, 0.50 V, at 27ºC.

A-4. A quantity of an ideal gas is collected in a graduated tube over the mercury in a barometer type arrangement. The volume of gas at 20ºC is 50 ml and the level of mercury is 100 mm above the outside of the mercury level. The atmospheric pressure is 750 mm. Volume of gas at STP is : (Take R = 0.083 lt. atm/K/mole)

A-5. 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-6. An open vessel at 27ºC is heated until $(3/5)^{th}$ of the air in it has been expelled. Assuming that the volume of the vessel remain s constant. Find out.
(a) The temperature at which vessel was heated.
(b) Volume of the air (measured at 300 K) escaped out if vessel is heated to 900 K.
(c) The temperature at which half of the air escapes out.

A-7. 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)

Section (B) : Daltons law of partial pressures

Commit to memory :

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

$P_1 = \frac{n_1RT}{v}$; $P_2 = \frac{n_2RT}{v}$; $P_2 = \frac{n_3RT}{v}$ P_1, P_2 & P_3 are partial pressure of gases

P_{Total} = Total pressure of Gaseous mixture

B-1. 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 ?

B-2. What will be pressure exerted by a mixture of 3.2 g of methane and 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. 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.

B-5. 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.

B-6. 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) ?

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 P is connected with a 3 litre of another flask of O_2 at the same temperature and 100 cm P. 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. 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-2. 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)

D-3. 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 ?

D-4. A gaseous mixture contains oxygen and another unknown gas in the molar ratio of 4 : 1 diffuses through a porous plug in 245 seconds. Under similar conditions same volume of oxygen takes 220 sec to diffuse. Find the molecular mass of the unknown 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. 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.

E-2. 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-3. At what temperature would the most probable speed of CO_2 molecules be twice that at 127ºC.

E-4. 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. 40 ml of ammonia gas, taken in an eudiometer tube, was subjected to sparks till the volume did not further change. The volume was found to increase by 40 ml. 40 ml of oxygen gas then mixed and the mixture was further exploded. The gases remained were 30 ml. Deduce the formula of ammonia. (Ammonia contain N and H only).

F-3. 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-4. 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-5. 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]

F-6. 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.

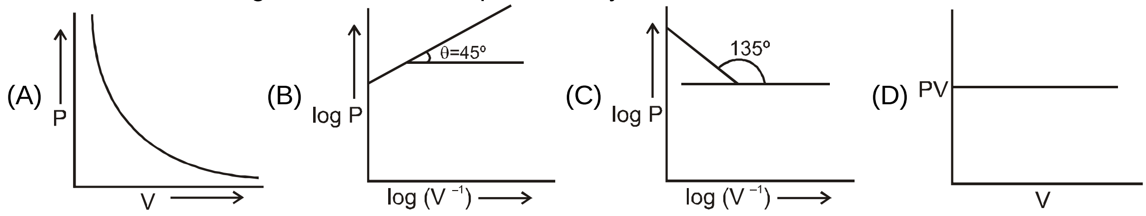
PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Ideal gas equation & gas laws

Commit to memory :

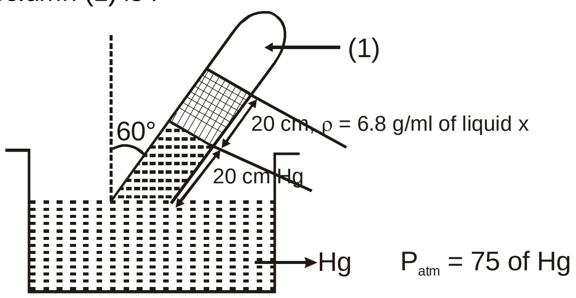
Boyle's law :	$P_1V_1 = P_2V_2$	P_1 & P_2 are pressure of gas
Charles law :	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	V_1 & V_2 are Volume of gas
Gay-lussac's law :	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	T_1 & T_2 are Temperature of gas
Ideal Gas Equation :	$PV = nRT$	n = number of moles of gas

A-1. Which of the following curve does not represent Boyle's law?



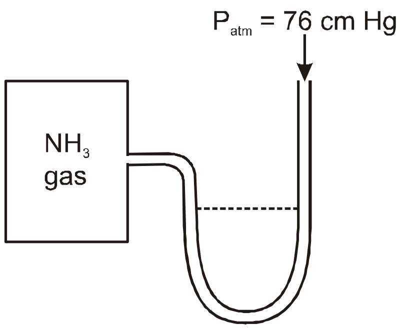
A-2. The density of liquid gallium at 30ºC is 6.095 g/mL. Because of its wide liquid range (30 to 2400ºC), gallium could be used as a barometer fluid at high temperature. What height (in cm) of gallium will be supported on a day when the mercury barometer reads 740 torr? (The density of mercury is 13.6 g/mL).
(A) 322 (B) 285 (C) 165 (D) 210

A-3. 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-4. 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

A-5. A gas is heated from 0°C to 100°C at 1.0 atm pressure. If the initial volume of the gas is 10.0 L, its final volume would be :
(A) 7.32 L (B) 10.00 L (C) 13.66 L (D) 20.00 L

A-6. 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-7. 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

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. 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

A-10. SO_2 at STP contained in a flask was replaced by O_2 under identical conditions of pressure, temperature and volume. Then the weight of O_2 will be _______ of SO_2.
(A) half (B) one fourth (C) twice (D) four times.

A-11. Under what conditions will a pure sample of an ideal gas not only exhibit a pressure of 1 atm but also a concentration of 1 mol litre $^{-1}$. [R = 0.082 litre atm mol^{-1} K^{-1}]
(A) at S.T.P. (B) when V = 22.42 L
(C) when T = 12 K (D) impossible under any condition

A-12. An amount of 1.00 g of a gaseous compound of boron and hydrogen occupies 0.820 liter at 1.00 atm and at 3ºC. 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-13. 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 exerted by gases is :
(A) $\frac{P_A}{P_B} = 2$ (B) $\frac{P_A}{P_B} = 1$ (C) $\frac{P_A}{P_B} = 4$ (D) $\frac{P_A}{P_B} = 3$

A-14. 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

A-15. The density of neon will be highest at :
(A) STP (B) 0°C, 2 atm (C) 273°C. 1 atm (D) 273°C. 2 atm

A-16. 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

Section (B) : Daltons law of partial pressures

Commit to memory :

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

$P_1 = \frac{n_1RT}{v}$; $P_2 = \frac{n_2RT}{v}$; $P_2 = \frac{n_3RT}{v}$ P_1, P_2 & P_3 are partial pressure of gases

P_{Total} = Total pressure of Gaseous mixture

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

B-2. A mixture of hydrogen and oxygen at one bar pressure contains 20% by weight of hydrogen. Partial pressure of hydrogen will be
(A) 0.2 bar (B) 0.4 bar (C) 0.6 bar (D) 0.8 bar

B-3. A compound exists in the gaseous phase both as monomer (A) and dimer (A_2). The atomic mass of A is 48 and molecular mass of A_2 is 96. In an experiment 96 g of the compound was confined in a vessel of volume 33.6 litre and heated to 273ºC. The pressure developed if the compound exists as dimer to the extent of 50% by weight under these conditions will be :
(A) 1 atm (B) 2 atm (C) 1.5 atm (D) 4 atm

B-4. The total pressure of a mixture of oxygen and hydrogen is 1.0 atm. The mixture is ignited and the water is removed. The remaining gas is pure hydrogen and exerts a pressure of 0.40 atm when measured at the same values of T and V as the original mixture. What was the composition of the original mixture in mole percent ?
(A) $x_{O_2} = 0.2;\ x_{H_2} = 0.8$ (B) $x_{O_2} = 0.4;\ x_{H_2} = 0.6$
(C) $x_{O_2} = 0.6;\ x_{H_2} = 0.4$ (D) $x_{O_2} = 0.8;\ x_{H_2} = 0.2$

Section (C) : Mixing of Gases

Commit to memory :
On mixing of gases $n_{final} = n_1 + n_2 + n_3 + ...$

C-1. 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-2. Two glass bulbs A (of 100 mL capacity), and B (of 150 mL capacity) containing same gas are connected by a small tube of negligible volume. At particular temperature the pressure in A was found to be 20 times more than that in bulb B. The stopcock is opened without changing the temperature. The pressure in A will :
(A) drop by 75% (B) drop 57% (C) drop by 25% (D) will remain same

C-3. 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

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

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

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

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

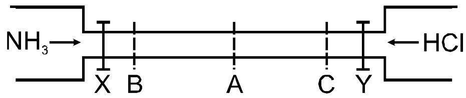
r = pressure change rate = $\frac{dp}{dt}$

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

D-1. The rates of diffusion of SO_3, CO_2, PCl_3 and SO_2 are in the following order :
(A) $PCl_3 > SO_3 > SO_2 > CO_2$ (B) $CO_2 > SO_2 > PCl_3 > SO_3$
(C) $SO_2 > SO_3 > PCl_3 > CO_2$ (D) $CO_2 > SO_2 > SO_3 > PCl_3$

D-2. 20 ℓ of SO_2 diffuses through a porous partition in 60 seconds. Volume of O_2 diffuse under similar conditions in 30 seconds will be :
(A) 12.14 ℓ (B) 14.14 ℓ (C) 18.14 ℓ (D) 28.14 ℓ

D-3. 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

D-4. X ml of H_2 gas effuses through a hole in a container in 5 sec. The time taken for the effusion of the same volume of the gas specified below under identical conditions is :
(A) 10 sec. He (B) 20 sec. O_2 (C) 25 sec. CO_2 (D) 55 sec. CO_2

D-5. 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) $\left(1:\sqrt{14}\ :\ \sqrt{7}\right)$ (B) $\left(\sqrt{14}\ :\ \sqrt{7}:1\right)$ (C) $\left(\sqrt{7}:1\ :\ \sqrt{14}\right)$ (D) $\left(1:\sqrt{7}\ :\ \sqrt{14}\right)$

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. 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-2. 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}

E-3. 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

E-4. The kinetic energy of N molecules of O_2 is x joule at –123ºC. Another sample of O_2 at 27ºC has a kinetic energy of 2 x. The latter sample contains _______ molecules of O_2.
(A) N (B) N/2 (C) 2 N (D) 3 N

E-5. 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

E-6. 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.

E-7. 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

E-8. The ratio between the r.m.s. velocity of H_2 at 50 K and that of O_2 at 800 K is:
(A) 4 (B) 2 (C) 1 (D) 1/4

E-9. Which of the following expression correctly represents the relationship between the average kinetic energy of CO and N_2 molecules at the same temperature.
(A) $\bar{E}(CO) > \bar{E}(N_2)$ (B) $\bar{E}(CO) < \bar{E}(N_2)$ (C) $\bar{E}(CO) = \bar{E}(N_2)$
(D) Cannot be predicted unless volumes of the gases are given

E-10. Helium atom is two times heavier than a hydrogen molecule. At 298 K, the average kinetic energy of a helium atom is
(A) two times that of a hydrogen molecules (B) same as that of a hydrogen molecules
(C) four times that of a hydrogen molecules (D) half that of a hydrogen molecules

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. 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-2. 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-3. 15 ml of a gaseous hydrocarbon was required for complete combustion in 357ml of air (21% of oxygen by volume) and the gaseous products occupied 327 ml (all volumes being measured at NTP). What is the formula of the hydrocarbon ?
(A) C_3H_8 (B) C_4H_8 (C) C_5H_{10} (D) C_4H_{10}

F-4. 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-5. A gaseous alkane is exploded with oxygen. The volume of O_2 for complete combustion to CO_2 formed is in the ratio 7/4. The molecular formula of alkane is :
(A) C_2H_4 (B) C_2H_6 (C) CH_4 (D) C_4H_{12}

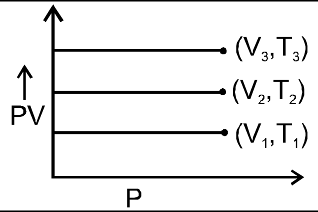
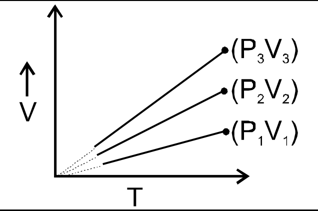
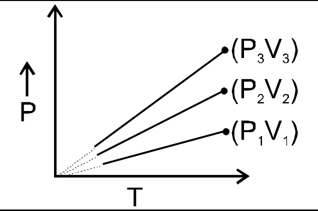
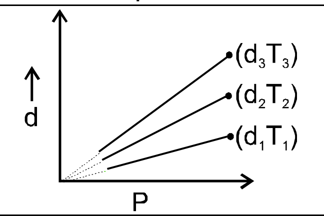
F-6. LPG is a mixture of n-butane & iso-butane. The volume of oxygen needed to burn 1 kg of LPG at NTP would be :
(A) 2240 Lt. (B) 2510 Lt. (C) 1000 Lt. (D) 500 Lt.

F-7. If in an experiment 100 ml of ozonised oxygen was reduced in volume to 40 ml (at the same temperature and pressure) when treated with turpentine, what would be the increase in volume if the original sample was heated until no further change occurred and then brought back to the same temerature and pressure ?
(A) 20 ml (B) 30 ml (C) 40 ml (D) 10 ml

F-8. 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 :

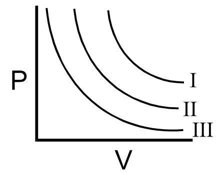
	Column – I		**Column - II**
(A)	$P_1V_1 = P_2V_2 = P_3V_3 = \ldots\ldots\ldots\ldots$	(p)	Kinetic equation of ideal gases.
(B)	$\frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V_3}{T_3} = \ldots$ at constant pressure.	(q)	Boyle's law
(C)	$r \propto \sqrt{\frac{1}{d}}$	(r)	Dalton's law of partial pressures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

Exercise-2

✍ **Marked questions are recommended for Revision.**

PART - I : ONLY ONE OPTION CORRECT TYPE

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) $T_1 > T_2 = T_3$

2.✍ A 40 ml of a mixture of H_2 and O_2 at 18ºC 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

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. 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

9. Pure O_2 diffuses through an aperture in 224 second, whereas mixture of O_2 and another gas containing 80% O_2 diffuses from the same in 234 second. The molecular mass of gas will be:
(A) 51.5 (B) 48.6 (C) 55 (D) 46.6

10. A straight glass tube as shown, has 2 inlets X & Y at the two ends of 200 cm long tube. HCl gas through inlet X and NH_3 gas through inlet Y are allowed to enter in the tube at the same time and under the identical conditions. At a point P inside the tube both the gases meet first. The distance of point P from X is :
(A) 118.9 cm (B) 81.1 cm (C) 91.1 cm (D) 108.9 cm

11. 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

12. 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 is :
(A) 53 (B) 35 (C) 71 (D) 120

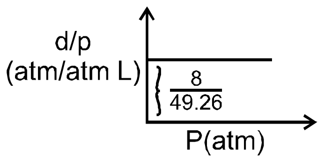
13. A sample of an ideal gas was heated from 30ºC to 60ºC at constant pressure. Which of the following statement(s) is/are true.
(A) Kinetic energy of the gas is doubled (B) Boyle's law will apply
(C) Volume of the gas will be doubled (D) None of the above

14. 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

15. 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

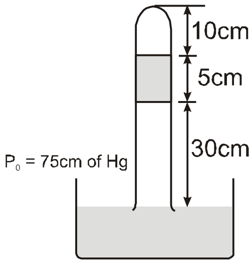
PART - II : NUMERICAL VALUE QUESTIONS

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

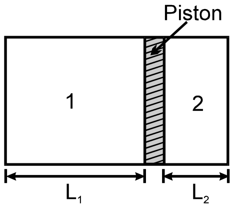


2. 10 moles of an ideal gas is subjected to an isochoric process (volume const.) and a graph of log (p) v/s log (T) is plotted where p is in (atm) & T is in kelvin. If volume of the container is 82.1 ml then calculate the sume of a, b & c where a = slope of graph, b = x intercept of graph, c = y intercept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

3. A tube of length 45 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).

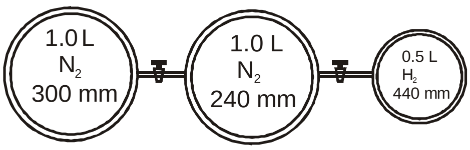


5. A spherical balloon of 21 cm diameter is to be filled up with hydrogen at NTP, from a cylinder containing the gas at 20 atm at 27°C. If the cylinder can hold 2.82 litre of water, calculate the number of balloons that can be filled up.

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. A column of Hg of 100 mm in length is contained in the middle of a narrow tube 1 m long which is closed at both ends. Both the halves of the tube contained air at a pressure of 760 mm of Hg. By what distance (in mm) will the column of Hg lie displaced if the tube is held vertical. Assume decrease in length of mercury column to be negligible, also take the process at constant temperature. (Isothermal process).

8. 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)

9. 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) ?

10. At 20ºC, two balloons of equal volume and porosity are filled to a pressure of 2 atm, one with 14 kg N_2 and other with 1 kg of H_2. The N_2 balloon leaks to a pressure of 1/2 atm in 1 hr. How long will it take for H_2 balloon to reach a pressure of 1/2 atm ?

11. 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 -

12. 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 combusion. Calculate the volume of air required for complete combution of a mixture (50 ml) having ratio b : a. (Report your answer divide by 25).

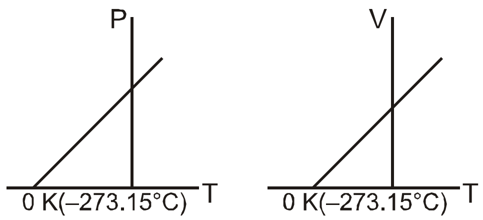
13. 10 ml of a mixture of CH_4, C_2H_4 and CO_2 was exploded with excess of air. After explosion there was a contraction of 17 ml and after treatment with KOH, there was further reduction of 14ml. Find volume of CO_2 in 20 mL of original mixture (in mL).

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



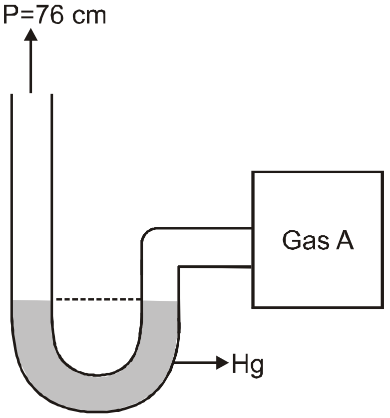
(A) As the temperature is reduced, the volume as well as the pressure increase

(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

3. 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

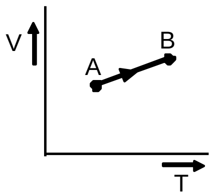
(D) difference in mercury level is 228 mm.

4. 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

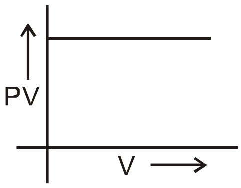
(B) At constant pressure, for a definite quantity of an ideal gas graph of VT v/s T will be parabolic

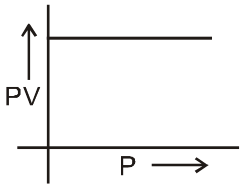
(C) In going from A to B for definite quantity of an ideal gas pressure increase

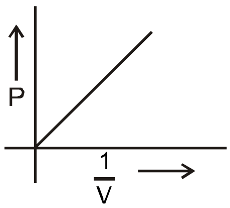


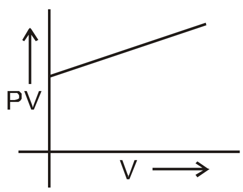
(D) At constant volume, for a definite quantity of an ideal gas graph of $\frac{p}{T}$ v/s T^2 will be straight line.

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

(A) 

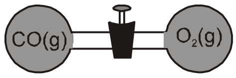
(B) 

(C) 

(D) 

6. 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.

7. 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.

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. 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

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 M_x is completely changed to another gaseous allotrope having molecular formula M_y 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

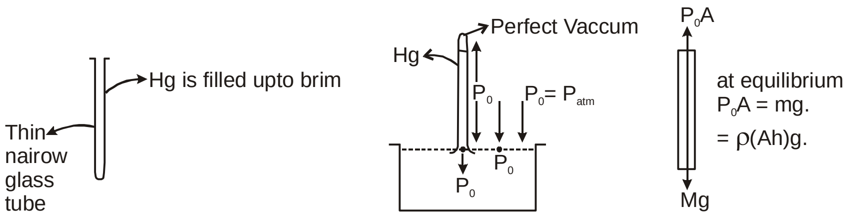
PART - IV : COMPREHENSION

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,

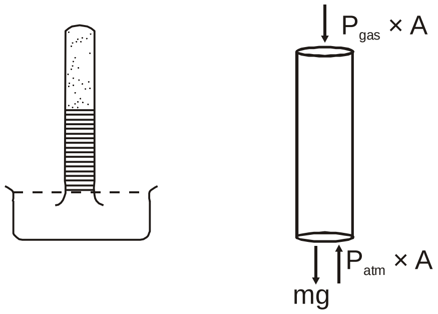
$P_{atm} \times A = m \times g$ ('A' is the cross-sectional area of the capillary tube)

If 'ρ' is the density of the fluid, then m = ρ × g × 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.

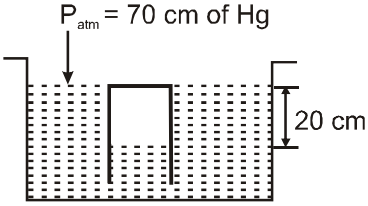
For such a faulty barometer



$P_0A = mg + P_{gas} A$

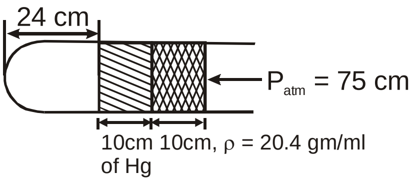
$P_0 = \rho gh + P_{gas}$ or $\rho gh = P_0 - P_{gas}$

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)



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

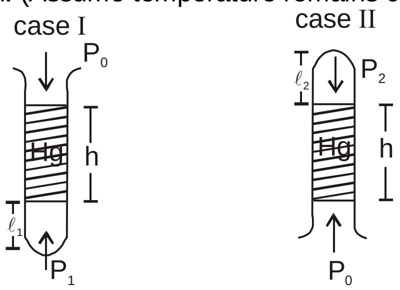
2.



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.). Find atmospheric pressure in terms of height of Hg column. (Assume temperature remains constant)



(A) $\frac{h(\ell_1+\ell_2)}{(\ell_2-\ell_1)}$ (B) $\frac{h(\ell_2-\ell_1)}{(\ell_1+\ell_2)}$ (C) $\frac{(\ell_1+\ell_2)}{h(\ell_2-\ell_1)}$ (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

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

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

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

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. 4) 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

Comprehension # 3

Answer Q.7, Q.8 and Q.9 by appropriately matching the information given in the three columns of the following table.

In following questions :
M_A & M_B = Molar masses of ideal gases A & B, P = Pressure of gas, A = Area of hole of container
T_A & T_B = Temp of gases A & B in kelvin, n_A & n_B = Moles of gases A & B in container
r_A & r_B = rate of effusion of gas A & B

Column-1		Column-2		Column-3	
(I)	$\frac{M_A}{M_B} = \frac{1}{4}$	(i)	Under similar conditions of P, A, T	(P)	$\frac{r_A}{r_B} = \frac{1}{3}$
(II)	$\frac{M_A}{M_B} = \frac{4}{1}$	(ii)	Under similar conditions of T & P $\frac{A_A}{A_B} = \frac{20}{10}$	(Q)	$\frac{r_A}{r_B} = \frac{4}{3}$
(III)	$\frac{M_A}{M_B} = \frac{4}{9}$	(iii)	Under similar conditions of A & T $\frac{n_A}{n_B} = \frac{2}{3}$	(R)	$\frac{r_A}{r_B} = \frac{2}{1}$
(IV)	$\frac{M_A}{M_B} = \frac{9}{4}$	(iv)	Under similar conditions of P & A $\frac{T_A}{T_B} = \frac{800}{200}$	(S)	$\frac{r_A}{r_B} = \frac{3}{4}$

7. Select correct combination.
(A) I (iv) R (B) I (iii) Q (C) II (ii) Q (D) IV (iii) S

8. Select incorrect combination.
(A) I (i) R (B) iii (iv) S (C) IV (iv) P (D) III (iii) P

9. Select correct combination.
(A) II (iii) P (B) I (ii) Q (C) III (ii) S (D) iv (iii) P

Exercise-3

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

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

1. The average velocity of gas molecules is 400 m/sec calculate its r.m.s. velocity at the same temperature. **[JEE-2003(M), 2/60]**

2. For one mole of gas the average kinetic energy is given as E. The U_{rms} of gas is : **[JEE-2004(S), 3/84]**
(A) $\sqrt{\frac{2E}{M}}$ (B) $\sqrt{\frac{3E}{M}}$ (C) $\sqrt{\frac{2E}{3M}}$ (D) $\sqrt{\frac{3E}{2M}}$

3. Ratio of rates of diffusion of He and CH_4 (under identical conditions). **[JEE-2005(S), 3/84]**
(A) $\frac{1}{2}$ (B) 3 (C) $\frac{1}{3}$ (D) 2

4. 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]**

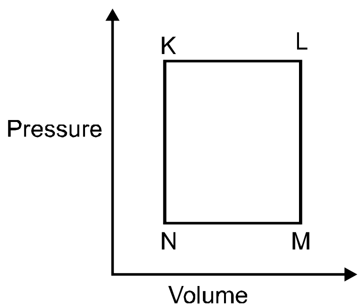
5. To an evacuated vessel with movable piston under external pressure of 1 atm., 0.1 mol of He and 1.0 mol of an unknown compound (vapour pressure 0.68 atm. at 0ºC) are introduced. Considering the ideal gas behaviour, the total volume (in litre) of the gases at 0°C is close to

6.* According to kinetic theory gases **[JEE-2011, 4/180]**
(A) collisions are always elastic
(B) heavier molecules transfer more momentum to the wall 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.

7. 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 –73ºC is "M" times that of the de Broglie wavelength of Ne at 727ºC. M is **[JEE(ADVANCED)-2013, 4/120]**

Paragraph for Questions 8 to 9

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



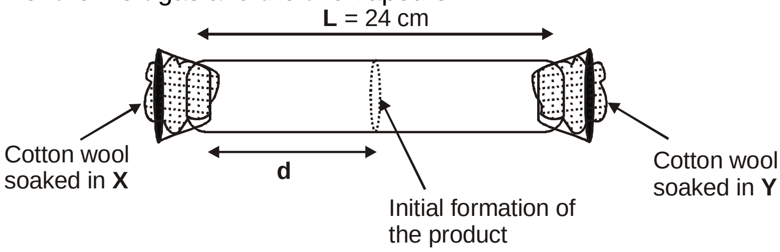
8. The succeeding operations that enable this transformation of states are : **[JEE(Advanced)-2013, 3/120]**
(A) Heating, cooling, heating, cooling (B) Cooling, heating, cooling, heating
(C) Heating, cooling, cooling, heating (D) Cooling, heating, heating, cooling

9. 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

10. If the value of Avogadro number is 6.023×10^{23} mol^{-1} and the value of Boltzmann constant is 1.380×10^{-23} J K^{-1}, then the number of significant digits in the calculated value of the universal gas constant is **[JEE(Advanced)-2014, 4/120]**

Paragraph for questions 11 and 12

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.



11. 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

12. 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.

13. 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]**

14. The diffusion coefficient of an ideal gas is proportional to its mean free path and mean speed. The absolute temperature of an ideal gas is increased 4 times and its pressure is increased 2 times. As a result, the diffusion coefficient of this gas increases x times. The value of x is **[JEE(Advanced)-2016, 3/124]**

15. 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(Advanced)-2018, 3/120]**

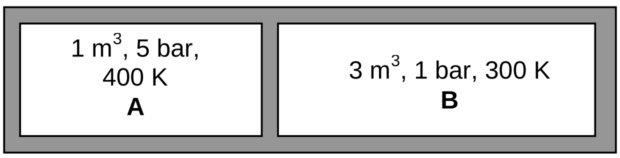


Figure 1

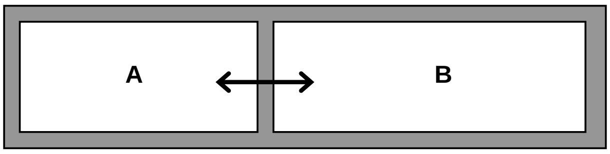


Figure 2

16. 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(Advanced)-2019, 4/124]**
(1) U_{rms} is inversely proportional to the square root of its molecular mass
(2) ε_{av} is doubled when its temperature is increased four times.
(3) U_{rms} is doubled when its temperature is increased four times.
(4) ε_{av} at a given temperature does not depend on its molecular mass.

PART - II : JEE (MAIN) ONLINE PROBLEMS (PREVIOUS YEARS)

1. The temperature at which oxygen molecules have the same root mean square speed as helium atoms have at 300 K is : (Atomic masses : He = 4 u, O = 16 u) **[JEE(Main) 2014 Online (09-04-14), 4/120]**
(1) 300 K (2) 600 K (3) 1200 K (4) 2400 K

2. The initial volume of a gas cylinder is 750.0 mL. If the pressure of gas inside the cylinder changes from 840.0 mm Hg to 360.0 mm Hg, the final volume the gas will be :
[JEE(Main) 2014 Online (11-04-14), 4/120]
(1) 1.750 L (2) 3.60 L (3) 4.032 L (4) 7.50 L

3. Sulphur dioxide and oxygen were allowed to diffuse through a porpus partition. 20 dm^3 of SO_2 diffuses through the porous partition is 60 seconds. The volume of O_2 in dm^3 which diffuses under the similar condition in 30 seconds will be (atomic mass of sulphur = 32 u) :
[JEE(Main) 2014 Online (19-04-14), 4/120]
(1) 7.09 (2) 14.1 (3) 10.0 (4) 28.2

4. Which of the following is not an assumption of the kinetic theory of gases ?
[JEE(Main) 2015 Online (10-04-15), 4/120]
(1) Gas particles have negligible volume
(2) A gas consists of many identical particels which are in continual motion
(3) At high pressure, gas particles are difficult to compress
(4) Collisions of gas particles are perfectly elastic

5. Initially, the root mean square (rms) velocity of N_2 molecules at certain temperature is u. If this temperature is doubled and all the nitrogen molecules dissociate into nitrogen atoms, then the new *rms* velocity will be : **[JEE(Main) 2016 Online (10-04-16), 4/120]**
(1) 2 u (2) 14 u (3) u / 2 (4) 4 u

6. 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(Main) 2017 Online (09-04-17), 4/120]**
(1) 56 g mol^{-1} (2) 112 g mol^{-1} (3) 224 g mol^{-1} (4) 28 g mol^{-1}

7. Assuming ideal gas behaviour, the ratio of density of ammonia to that of hydrogen chlroide at same temperature and pressure is : (Atomic wt. of Cl 35.5 u) **[JEE(Main) 2018 Online (16-04-18), 4/120]**

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

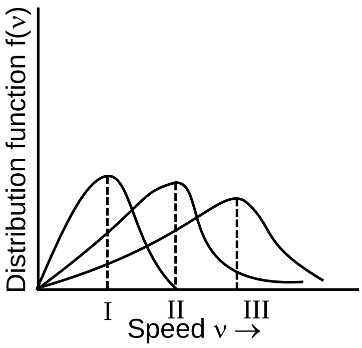
8. 0.5 moles of gas A and x moles of gas B exert a pressure of 200 Pa in a container of volume 10 m^3 at 1000 K. Given R is the gas constant in JK^{-1} mol^{-1}, x is : **[JEE(Main) 2019 Online (09-01-19), 4/120]**

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

9. 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(Main) 2019 Online (12-01-19), 4/120]**

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

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



[JEE(Main) 2019 Online (10-04-19)S2, 4/120]

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

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

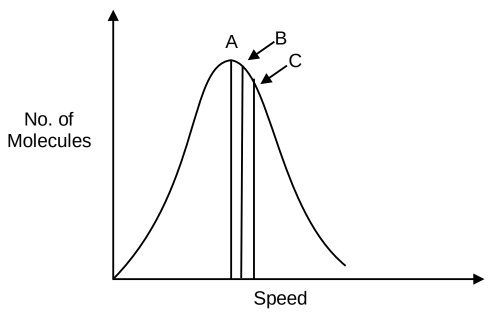
(3) V_{mp} of N_2 (300 K) ; V_{mp} of H_2 (300 K) ; V_{mp} of O_2 (400 K)

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

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

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

[JEE(Main) 2020 Online (07-01-20)S2, 4/120]



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

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

Answers

EXERCISE – 1

PART – I

A-1. – 111.5°C **A-2.** Final temperature = 360, Increase in temperature is 60 K.

A-3. 6 g **A-4.** 40.3 mL **A-5.** (a) t = – 163.8ºC, (b) P = 1.37×10^3 torr

A-6. (a) 477ºC, (b) 2/3, (c) 327ºC **A-7.** 310.4 g escaped.

B-1. P_{N_2} = 418 torr, P_{O_2} = 190 torr, P_{CO_2} = 152 torr, total pressure = 760.

B-2. 8.32×10^4 Pa. **B-3.** $\frac{170}{570}$ = 0.30 **B-4.** 1.12 : 1 **B-5.** 2.201 g/L

B-6. (a) 1.98% (b) 10.156 litres **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. 0.347 **D-2.** 448 g mol^{-1} **D-3.** M = 128 g/mol **D-4.** 133

E-1. 2.16×10^4 cm/sec. **E-2.** 1.73×10^4 cm/sec **E-3.** 1327ºC

E-4. T = 22.0 K **F-1.** CO_2 = 0.6 lt, CO = 0.4 lt **F-2.** NH_3

F-3. 10 mL **F-4.** NO = 44 ml ; N_2O = 16 ml **F-5.** 4 : 1

F-6. 0.8 g, O_2 = 2.24 Ltr, CH_4.

PART – II

A-1.	(C)	**A-2.**	(C)	**A-3.**	(A)	**A-4.**	(A)	**A-5.**	(C)
A-6.	(A)	**A-7.**	(C)	**A-8.**	(A)	**A-9.**	(C)	**A-10.**	(A)
A-11.	(C)	**A-12.**	(C)	**A-13.**	(C)	**A-14.**	(A)	**A-15.**	(B)
A-16.	(B)	**B-1.**	(D)	**B-2.**	(D)	**B-3.**	(B)	**B-4.**	(A)
C-1.	(C)	**C-2.**	(B)	**C-3.**	(A)	**D-1.**	(D)	**D-2.**	(B)
D-3.	(C)	**D-4.**	(B)	**D-5.**	(A)	**E-1.**	(B)	**E-2.**	(B)
E-3.	(A)	**E-4.**	(A)	**E-5.**	(B)	**E-6.**	(D)	**E-7.**	(B)
E-8.	(C)	**E-9.**	(C)	**E-10.**	(B)	**F-1.**	(D)	**F-2.**	(B)
F-3.	(A)	**F-4.**	(B)	**F-5.**	(B)	**F-6.**	(B)	**F-7.**	(B)
F-8.	(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.	(C)	**2.**	(A)	**3.**	(C)	**4.**	(D)	**5.**	(B)
6.	(A)	**7.**	(A)	**8.**	(B)	**9.**	(A)	**10.**	(B)
11.	(C)	**12.**	(C)	**13.**	(D)	**14.**	(D)	**15.**	(B)

PART – II

1.	4	**2.**	1	**3.**	5	**4.**	5	**5.**	10
6.	28 (m_{Ar} = 24 + m_{Ne} = 4)			**7.**	30 mm	**8.**	40 atm	**9.**	2 m
10.	16 Minutes	**11.**	8	**12.**	27	**13.**	3		

PART – III

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

PART – IV

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

EXERCISE – 3

PART – I

1.	434 m/s	**2.**	(A)	**3.**	(D)	**4.**	M_Y = 4.	**5.**	7
6.	(ACD)	**7.**	5	**8.**	(C)	**9.**	(B)	**10.**	4
11.	(C)	**12.**	(D)	**13.**	9	**14.**	4	**15.**	2.22
16.	(1, 3 & 4)								

PART – II

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