(EXERCISE O-I)

1. A container when is empty weighs 50 gm. After certain liquid of density 25 gm/dm^3 is filled its mass becomes equal to 100 gm. The volume of the container will be :

(A) 0.25 dm^3 (B) 0.5 dm^3 (C) 1 dm^3 (D) 2 dm^3

2. 10 g of a gas at 1 atm, 273 K occupies 5 litres. The temperature at which the volume becomes double for the same mass of gas at the same pressure is ?

(A) 273K (B) –273^{0}C (C) 273^{0}C (D) 546^{0}C

3. The density of gas A is twice that of B at the same temperature the molecular weight of gas B is thrice that of A. The ratio of pressure of gas A and gas B will be

(A) 1 : 6 (B) 7 : 8 (C) 6 : 1 (D) 1 : 4

4. 4.0 g of argon has pressure P and temperature T K in a vessel. On keeping the vessel at 50° higher temperature, 0.8 g of argon was given out to maintain the pressure P. The original temperature was :

(A) 73 K (B) 100 K (C) 200 K (D) 510 K

5. A rigid container containing 10 gm gas at some pressure and temperature. The gas has been allowed to escape from the container due to which pressure of the gas becomes half of its initial pressure and temperature become (2/3)rd of its initial. The mass of gas (in gm) escaped is

(A) 7.5 (B) 1.5 (C) 2.5 (D) 3.5

6. 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

7. 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) $\frac{1}{4}$

8. The total pressure exerted by a number nonreacting gases is equal to the sum of partial pressure of the gases under the same conditions is known as :

(A) Boyle's law (B) Charle's law (C) Avogadro's law (D) Dalton's law

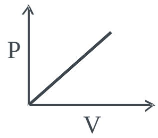
9. Dalton's law cannot be applied for which gaseous mixture at normal temperatures:

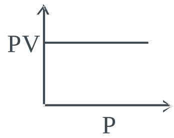
(A) O_2 and N_2 (B) NH_3 and HCl (C) He and N_2 (D) CO_2 and O_2

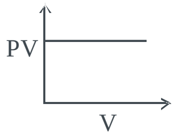
10. A closed vessel contains helium and ozone at a pressure of P atm. The ratio of He and oxygen atoms is 1 : 1. If helium is removed from the vessel, the pressure of the system will reduce to :

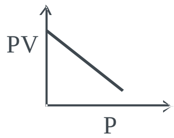
(A) 0.5 P atm (B) 0.75 P atm (C) 0.25 P atm (D) 0.33 P atm

11. Which of the following graphs represent boyle's law :

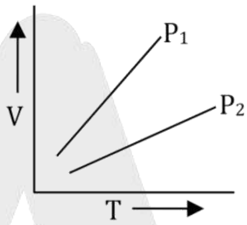
(A) 

(B) 

(C) 

(D) 

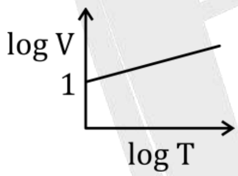
12. V versus T curves at constant pressure P_1 and P_2 for an ideal gas are shown in Fig. Which is correct



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

13. At constant pressure of 0.821 atm ; log V vs log T is plotted as shown in-

Then number of moles present in experiment -

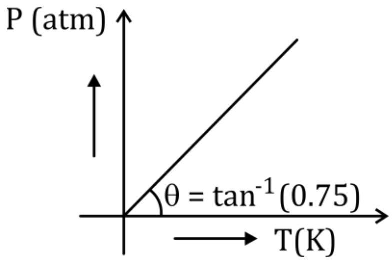


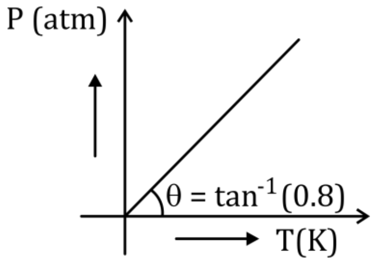
(A) 1 (B) 10 (C) 100 (D) 0.1

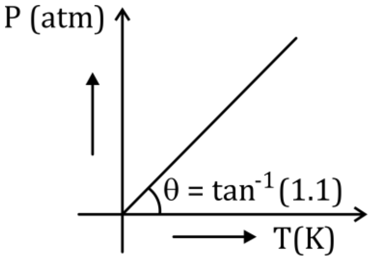
14. Gas A (1 mol) dissociates in a closed rigid container of volume 0.16 lit. as per following reaction.

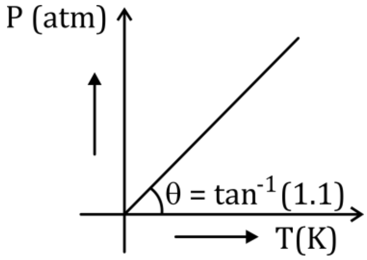
$$2A\,(g) \longrightarrow 3B\,(g) + 2C\,(g)$$

If degree of dissociation of A is 0.4 and remains constant in entire range of temperature, then the correct P vs T graph is [Given R = 0.08 lit-atm/mol/K]

(A) 

(B) 

(C) 

(D) 

15. A gaseous reaction,

$$3A \longrightarrow 2B$$

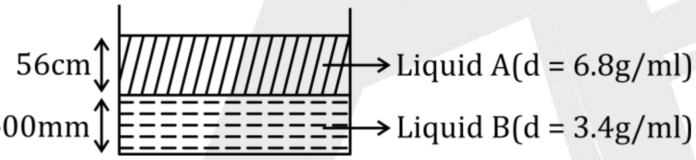
is carried out in a 0.0821 litre closed container initially containing 1 mole of gas A.
After sufficient time a curve of P (atm) vs T (K) is plotted and the angle with x-axis was found to be 42.95°. The degree of association of gas A is [Given : tan 42.95 = 0.8]

(A) 0.4 (B) 0.6 (C) 0.5 (D) 0.8

16. If saturated vapours are compressed slowly (temperature remaining constant) to half the initial volume, the vapour pressure will :

(A) Become four times (B) become doubled

(C) Remain unchanged (D) Become half

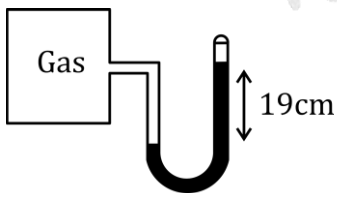
17. 

Total pressure at point (A) is

(A) 0.5 atm (B) 1 atm (C) 1.8 atm (D) 1.5 atm

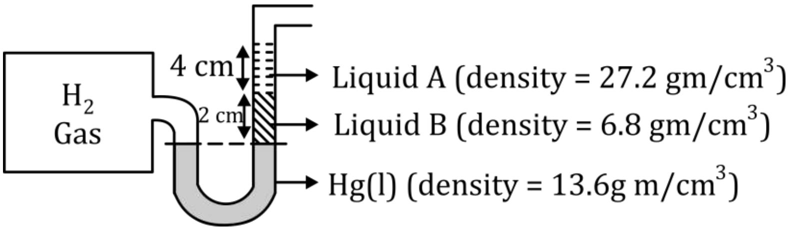
18. A gas A_x having mass of 100 g is confined in a container of volume 16 L maintained at 300 K and a manometer is attached as shown, value of x is :

(R = 0.08 atm-L/mole-K) (Atomic mass of A = 24)



(A) 2 (B) 8 (C) 4 (D) 5

19. A container of volume 2 litre contains H_2 gas at 300K as shown (P_{atm} = 76 cm of Hg)



The pressure (in cm Hg) of H_2 in the container is -

(A) 82 cm (B) 85 cm (C) 80 cm (D) 81 cm

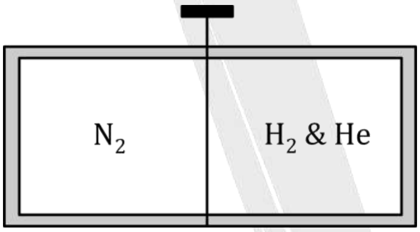
20. A box of 1L capacity is divided into two equal compartments by a thin partition which are filled with 2g H_2 and 16g CH_4 respectively. The pressure in each compartment is recorded as P atm. The total pressure when partition is removed will be:

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

21. Two vessels of volume 2V and 3V contain two gases A and B separately at 1.5 and 4 atm respectively. If the vessels are connected through a tube (negligible volume) at constant temperature, the total pressure of gaseous mixture is –

(A) 3 atm (B) 15/2 atm (C) 5 atm (D) 6 atm

22. A vessel of uniform cross-section of length 500 as shown figure is divided in two parts by a weightless & frictionless piston one part contains 5 moles of N_2 (g) and other part contains 2 moles of H_2(g) & 1 mole of He (g) gaseous mixture at the same temperature and pressure.

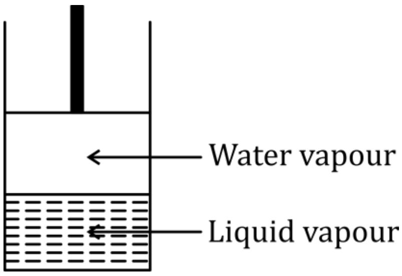


What is the length of N_2 compartment ?

(Assume volume of piston to be negligible)

(A) 187.5 cm (B) 300 cm (C) 312.5 cm (D) None of these

23. At 20°C, the vapour pressure of water is recorded as 22.57 mbar. What will be vapour pressure of water in the apparatus shown after the piston is lowered, thereby decreasing the volume of the gas above liquid to half of the original volume



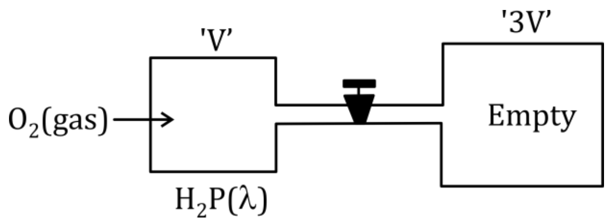
(A) 45.14 mbar

(B) 22.57 mbar

(C) 11.28 mbar

(D) between 11.28 and 22.57 mbar

24. Two containers at same temperature are connected through a nozzle as shown, if one container have O_2 gas and some liquid H_2O at total pressure of 840 mm at 27ºC.



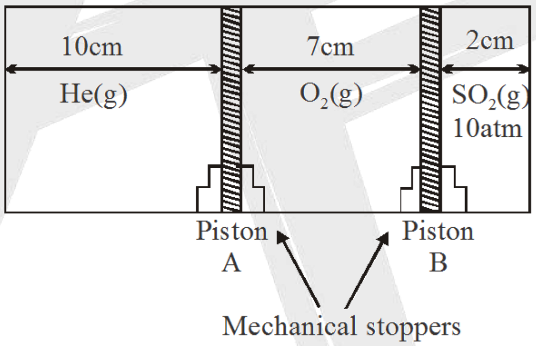
Find pressure when valve between two containers is opened.

(Volume of liquid is negligible)

(Vapour pressure of H_2O = 40 mm Hg at 27ºC)

(A) 210 mm (B) 200 mm (C) 240 mm (D) 800 mm

25. Equal mass of three gases He, O_2 & SO_2 are present in a container initially as shown -



If mechanical stoppers are removed and movable pistons are allowed to attain equilibrium -

Choose the correct statement -

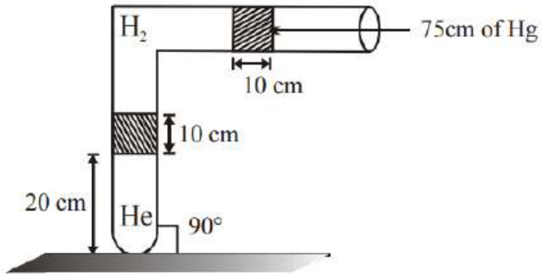
(A) Position of piston A from the left end of the container is 15 cm

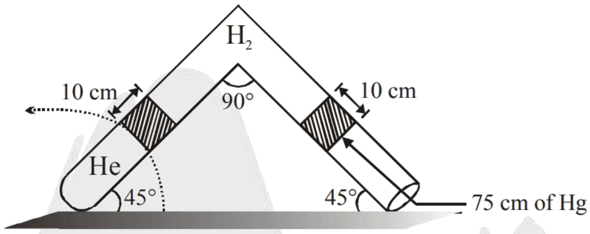
(B) Position of piston B from the left end of the container is 7cm

(C) Final pressure of O_2 gas is 10 atm

(D) Final pressure of He gas is 20 atm.

26. Find length of column having He gas if it is kept in the following manner at same T





(A) $\frac{65\times20}{75}$ cm

(B) $\frac{85\times20}{75}$ cm

(C) $\frac{85\times20}{\left(75-\frac{10}{\sqrt{2}}\right)}$ cm

(D) $\frac{85\times20}{\left(75+\frac{10}{\sqrt{2}}\right)}$ cm

Graham's Law of Diffusion and Effusion

27. Rate of diffusion of a gas is :

(A) directly proportional to its density

(B) directly proportional to its molecular weight

(C) directly proportional to the square of its molecular weight

(D) inversely proportional to the square root of its molecular weight

28. Since the atomic weights of carbon, nitrogen and oxygen are 12, 14 and 16 respectively, among the following pairs of gases, the pair that will diffuse at the same rate is :

(A) CO_2 and N_2O (B) CO_2 and N_2O_3 (C) CO_2 and CO (D) CO_2 and NO

29. The increasing order of effusion among the gases, H_2, O_2, NH_3 and CO_2 is –

(A) H_2, CO_2, NH_3, O_2 (B) H_2, NH_3, O_2, CO_2

(C) H_2, O_2, NH_3, CO_2 (D) CO_2, O_2, NH_3, H_2

30. Consider the following pairs of gases A and B.

	A	B
(a)	CO	N_2
(b)	O_2	O_3
(c)	$^{235}UF_6$	$^{238}UF_6$

Relative rates of effusion of gases A to B under similar condition is in the order:

(A) a < b < c (B) a < c < b (C) a > b > c (D) a > c > b

31. The rate of diffusion of hydrogen is about–

(A) $\frac{1}{2}$ that of Helium (B) 1.4 times that of Helium

(C) twice that of Hydrogen atom (D) Four times that of Helium

32. 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 2 : 1 (C) 1 : 2 2 (D) 4 : 1

33. The rate of diffusion of methane at a given temperature is twice that of a gas X. The molecular weight of X is :

(A) 64 (B) 32 (C) 4.0 (D) 8.0

34. 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

35. A gas X diffuses three times faster than another gas Y the ratio of their vapour densities i.e., D_x : D_y is

(A) 1/3 (B) 1/9 (C) 1/6 (D)1/12

36. Calculate the ratio of rate of effusion of O_2 and H_2 from a container containing 16gm O_2 and 2gm H_2

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

37. 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

38. 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.

(A) 3.125 % (B) 31.25 % (C) 6.25 % (D) 62.5 %

Kinetic Theory of Gaseous

39. Which of the following is not a postulate of kinetic molecular theory of gases :

(A)The actual volume of gas particles is negligible in comparison to the empty space between them

(B) Particles of gas are in constant random motion and move in all possible directions in straight line

(C) Particle collide with each other and with container wall and the total energy of particles before and after the collision remains same

(D) Different particles travel with different speeds which remains constant with time

40. Which is not one of the postulates of the kinetic molecular theory

(A) At a constant temp. all of the particle have the same speed

(B) There are no force of attraction between molecules

(C) Gas particles move in a straight line between collisions

(D) The molecules are in a state of constant random motion

41. If a gas is 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

42. 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) $E/\sqrt{2}$

43. The total KE of an ideal monoatomic gas at 27^0C is

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

44. 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

45. At what temperature will be total kinetic energy (KE) of 0.30 mole of He be the same as the total KE of 0.40 mole of Ar at 400 K :

(A) 400 K (B) 373 K (C) 533 K (D) 300 K

Maxwell Distribution of Speeds

46. Most probable speed, average speed and RMS speed are related as :

(A) 1 : 1.128 : 1.224 (B) 1 : 1.128 : 1.424

(C) 1 : 2.128 : 1.224 (D) 1 : 1.428 : 1.442

47. 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

48. A flask has 10 molecules out of which four molecules are moving at 7ms^{-1} & the remaining are moving at same speed of X ms^{-1}. If Urms of the gas is 5 ms^{-1}. The value of 'X' will be

(A) 5 (B) 3 (C) 9 (D) 16

49. At STP, the order of root mean square speed of molecules 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) $N_2 > O_2 > H_2 > HBr$

50. Which one of the following gases would have the highest R.M.S. velocity at 25^{0}C ?

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

51. If the average velocity of N_2 molecules is 0.3 m/sec. at 27^{0}C, then the velocity of 0.6 m/sec will take place at :

(A) 273 K (B) 927 K (C) 1000 K (D) 1200 K

52. Which of the following expression does not give root mean square velocity –

(A) $\left(\frac{3RT}{M_w}\right)^{\frac{1}{2}}$ (B) $\left(\frac{3P}{DM_w}\right)^{\frac{1}{2}}$ (C) $\left(\frac{3P}{D}\right)^{\frac{1}{2}}$ (D) $\left(\frac{3PV}{nM_w}\right)^{\frac{1}{2}}$

53. At what temperature would the rms speed of a gas molecule have twice its value at 100°C ?

(A) 4192 K (B) 1492 K (C) 9142 K (D) 2491 K

54. Temperature at which most probable speed of O_2 becomes equal to root mean square speed of N_2 is [Given : N_2 at 427°C]

(A) 732 K (B) 1200 K (C) 927 K (D) 800 K

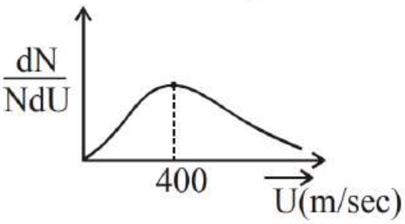
55. Two flasks X and Y have capacity 1L and 2L respectively and each of them contains 1 mole of a gas. The temperature of the flask are so adjusted that average speed of molecules in X is twice as those in Y. The pressure in flask X would be

(A) same as that in Y (B) half of that in Y (C) twice of that in Y (D) 8 times of that in Y

56. 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

57. For ideal gas observation as per Maxwell distribution



(A) $U_{rms} = \sqrt{1.5} \times 400\, m/sec$

(B) Fraction of molecules moving between 400 to 401 m / sec are equal with fraction of molecules moving between 452 to 453 m/ sec

(C) $U_{rms} = \sqrt{20} \times 400\, m/sec$

(D) $U_{avg} = 1.5\, U_{mps}$

58. The ratio of fraction of molecules present in the range $U_{mps} \pm 0.02$ (m/sec.) for N_2 at 100 K & C_4H_8 at 200 K is

(A) Greater than 1 (B) less than 1 (C) 1 (D) None of these

Collisions Among Gaseous Molecules

59. A vessel contains mono atomic 'He' at 1 bar and 300 K, determine its number density -

(A) $2.4 \times 10^{25}\ m^{-3}$ (B) $6.8 \times 10^{23}\ m^{-3}$

(C) $4.8 \times 10^{26}\ m^{-3}$ (D) $9.2 \times 10^{27}\ m^{-3}$

60. At constant volume Z_{11} is directly proportional to -

(A) P (B) P (C) T^2 (D) T

61. Which of the following changes will double the mean free path of gas in closed container

(A) Increasing temperature two times at constant volume

(B) Increasing temperature four times at constant volume

(C) Increasing temperature two times at constant pressure

(D) Increasing temperature four times at constant pressure

(EXERCISE S-I)

1. A fix amount of gas by absorbing heat volume increases two times & pressure also increases to 4 times. How many times absolute temperature of gas would increase.

2. 3.6 gm of an ideal gas was injected into a bulb of internal volume of 8.21 L at pressure P atm and temp T-K. The bulb was then placed in a thermostat maintained at (T+ 15) K.0.6 gm of the gas was let off to keep the original pressure. Find P and T if mol weight of gas is 36.

3. A toy balloon originally held 1.0 gm of He gas and had a radius 10 cm. During the night, 0.875 gm of the gas effused from the balloon. Assuming ideal gas behaviour, under these constant P and T conditions, what was the radius of the balloon the next morning.

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

5. While resting, the average human male use 0.2 dm^3 of O_2 per hour at 1 atm & 300 K for each kg of body mass. Assume that all this O_2 is used to produce energy by oxidising glucose in the body. What is the mass of glucose required per hour by a resting male having mass 60 kg.

What volume, at 1 atm & 300 K of CO_2 would be produced (R = 0.08 $\frac{L-atm}{mol-K}$)

6. Automobile air bags are inflated with N_2 gas which is formed by the decomposition of solid sodium azide (NaN_3). The other product is Na - metal. Calculate the volume of N_2 gas at 27°C and 1atm formed by the decomposing of 130 gm of sod azide.

7. 1.0×10^{-2} kg of hydrogen and 6.4×10^{-2} kg of oxygen are contained in a 10×10^{-3} m^3 flask at 473 K. Calculate the total pressure of the mixture. If a spark ignities the mixture. What will be the final pressure.

8. Calculate the mole fraction of N_2 gas in a mixture of N_2 and O_2. If the partial pressure of O_2 is 63 cm of Hg and the total pressure of the mixture is 90 cm of Hg.

9. A polythene bag of 3 litre capacity is filled by Helium gas (Occupying 1L at 0.3 atm & 300K). Subsequently enough Ne gas is filled to make total pressure 0.4 atm at 300K. Calculate ratio of moles of Ne to He in container.

10. 16 gm of O_2 was filled in a container of capacity 8.21 lit. at 300 K. Calculate

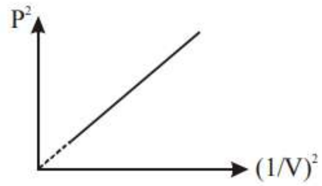
(i) Pressure exerted by O_2

(ii) Partial pressure of O_2 and O_3 if 50 % of oxygen is converted into ozone at same temperature.

(iii) Total pressure exerted by gases if 50% of oxygen is converted into ozone (O_3) at temperature 50 K.

11. An ideal gas is at a temperature of 200 K & at a pressure of 8.21 atm. It is subjected to change in volume by changing amount of the gas & a graph of n^2 vs V^2 (litre^2) is plotted. Is slope constant? If yes, calculate its value else justify why it is not constant.

12. Consider the following graph

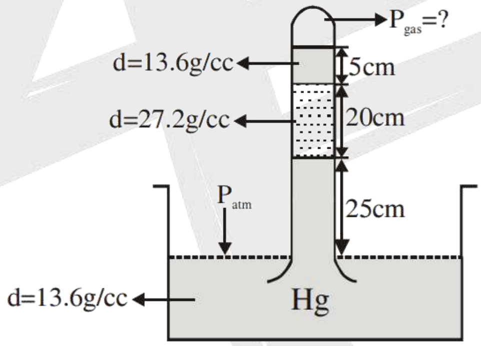


Graph is plotted for 1 mol of gas at 400K, find slope of curve. [Take : $R=0.08\dfrac{L-atm}{mol-K}$]

(A) $(32)^2$ (B) $(16)^2$ (C) $(8)^2$ (D) $(D)^2$

13. In the following arrangement find the pressure of gas (in cm of Hg).

(Assume that atmospheric pressure P_{atm} = 75 cm of Hg)



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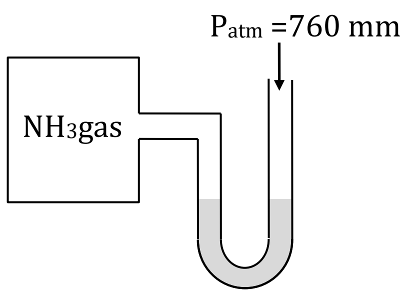
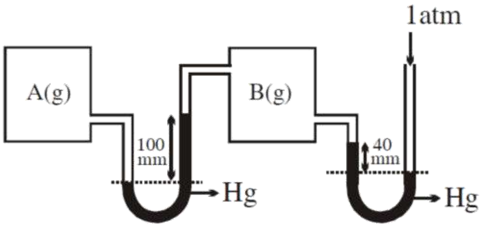
14. A manometer attached to a flask contains NH_3 gas have no difference in mercury level initially as shown in diagram. After the sparking into the flask, it have difference of 19 cm in mercury level in two columns. Calculate % dissociation of ammonia.



15. At 300, two gases are filled in two equal sized containers as given.

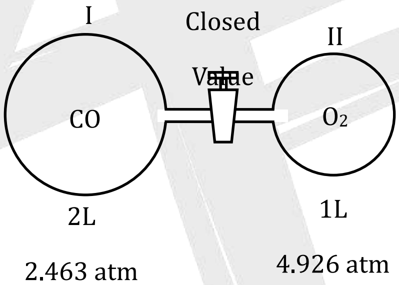


What will be the pressure of A(g) (in mm of Hg).

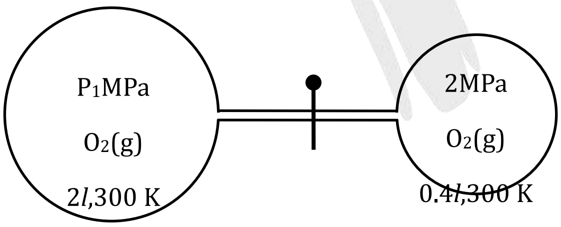
16. An iron cylinder contains helium at a pressure of 250 k pa and 27°C. The cylinder can withstand a pressure of 1×10^6 pa . The room in which cylinder is placed catches fire. Predict whether the cylinder will blow up before it metls or not. [melting point of cylinder = 1800 k]

17. Two glass bulbs A and B are connected by a very small tube having a stop cock. Bulb A has a volume of 100 ml and contained the gas, while bulb B was empty on opening the stop cock, the pressure fell down to 40% at constant temperature. Find out the volume of bulb B in mL.

18. Determine final pressure after the valve is left opened for a long time in the apparatus represented in figure. Assume that the temperature is fixed at 300 K. Under the given conditions assume no reaction of CO & O_2.



19. If in below diagram after opening valve, final pressure is $\frac{7}{6}$ MPa, than calculate P_1 (in MPa)



20. There are n connected container having volume V, 2V, 3V, ..., nV separated by stopcock. All container have same moles of gas at same temperature. If pressure of first container is P, then final pressure when all stop cocks are opened is -

21. A vertical cylinder closed from both ends is equipped with an easily moving piston dividing the volume into two parts, each containing one mole of air. In equilibrium at 320 K, the volume of the upper part is 4.0 times greater than that of the lower part. At what temperature (in kelvin) the volume of upper part becomes 3.0 times than that of lower part?

Graham's Law of Diffusion and Effusion

22. 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.

23 A gas mixture contains equal number of molecules of N_2 and SF_6, some of it is passed through a gaseous effusion apparatus. Calculate how many molecules of N_2 are present in the product gas for every 100 molecules of SF_6.

24. One litre of gaseous mixture of CH_4 and H_2 effuses in 200 seconds while one litre of gas 'X' take 10 minutes to effuse in identical conditions. If molar ratio of $CH_4 : H_2$ in mixture is 1 : 2. Find molar mass of gas 'X' in (g mol^{-1}) units ?

25. Pure O_2 diffuses through an aperture in 224 sec, whereas mixture of O_2 and another gas containing 75 % O_2 Takes 336 sec to effuse out same volume What is molecular weight of the gas?

26. Two gases NO and O_2 were introduced at the two ends of a one meter long tube simultaneously (tube of uniform cross- section). At what distance from NO gas end , Brown fumes will be seen.

27. At 20ºC two balloons of equal volume and porosity are filled to a pressure of 2 atm, one with 14 kg N_2 & other with 1 kg H_2 . The N_2 balloon leaks to a pressure of $\frac{1}{2}$ atm in one hour. How long will it take for H_2 balloon to leaks to a pressure of $\frac{1}{2}$ atm.

28. Calculate relative rate of effusion of SO_2 to CH_4 under given condition

(i) Under similar condition of pressure & temperature

(ii) Through a container containing SO_2 and CH_4 in 3:2 mass ratio

(iii) If the mixture obtained by effusing out a mixture (n_{SO_2} / n_{CH_4} = 8/1) after three effusing steps.

29. Find the number of diffusion steps required to separate the isotopic mixture initially containing some amount of H_2 gas and 1 mol of D_2 gas in a container of 3 lit capacity maintained at 24.6 atm & 27 °C to the final mass ratio $\left(\frac{W_{D_2}}{W_{H_2}}\right)$ equal to $\frac{1}{4}$.

Kinetic Theory of Gaseous

30. Average translational kinetic energy of an ideal gas molecule at 27ºC is 3.88×10^{-x} eV. Hence x is

Maxwell Distribution of Speeds

31. At what temperature in °C, the U_{rms} of SO_2 is equal to the average velocity of O_2 at 27°C.

32. Calculate the root mean square speed of H_2 molecules under following conditions.

(a) 2 mole of H_2 at 27ºC

(b) 3 mole of H_2 in a 5 L container at 10^5 Pa

(c) 4 mole of H_2 at the density of 1g/ml at 10^5 Pa

33. Calculate U_{rms} of molecules of H_2 at 1 atm if density of H_2 is 3×10^{-4} g/cc. (1 atm = 10^5 Pa)

34. Three ideal gases H_2, CH_4 and SO_2 are filled in three rigid containers A, B and C respectively.

A	B	C
$W_{H_2} = 64gm$	$W_{CH_4} = 64gm$	$W_{SO_2} = 128gm$
$V = 2L$	$V = 1L$	$V = 2L$
$T = 200K$	$T = 400K$	$T = 1600K$

the ratio of most probable speeds of molecules in all containers is $\boxed{x : y : z}$ then calculate the value of $\left(\frac{x+y}{z}\right)$.

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

Collisions Among Gaseous Molecules

36. If the mean free path is 10 cm at one bar pressure then its value at 5 bar pressure, if temperature is kept constant.

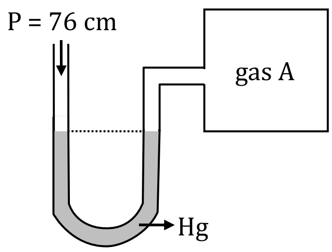
37. Calculate the mean free path in CO_2 at 27°C and a pressure of 10^{-6} mm Hg.

(molecular diameter = 460 pm)

38. 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

(EXERCISE O-II)

1. 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)

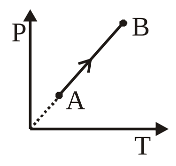
(A) total pressure increased by 1.3 atm

(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.

2. Select the correct option for an ideal gas undergoing a process as shown in diagram.



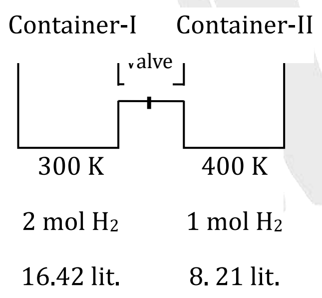
(A) If 'n' is changing, 'V' must also be changing.

(B) If 'n' is constant, 'V' must be constant.

(C) If 'n' is constant, 'V' must be changing.

(D) If 'n' is changing, 'V' must be constant.

3. Select the correct option(s):



(A) Pressure in container-I is 3 atm before opening the valve.

(B) Pressure after opening the valve is 3.57 atm.

(C) Moles in each compartment are same after opening the valve.

(D) Pressure in each compartment are same after opening the valve.

4. When an equimolar mixture of two gases A and B [$M_A > M_B$] is allowed to effuse through a Pin hole-

(A) B comes out at a faster rate

(B) Relative rate of effusion of A increases with time

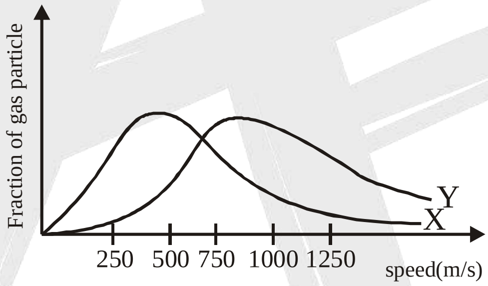
(C) Rate of effusion of B will always be greater

(D) Initially, with equal molar ratio rate of effusion of B is greater than rate of effusion of A.

5. A closed vessel at temperature T contain a mixture of two diatomic gases A and B. Molar mass of A is 16 times that of B and mass of gas A contained in the vessel is 2 times that of B.
Which of the following statements are correct-
(A) Average kinetic energy per molecule of A is equal to that of B.
(B) Root mean square velocity of B is four times that of A
(C) Pressure exerted by B is eight time of that exerted by A
(D) Number of molecules of B, in the cylinder, is eight time that of A

6. Choose the correct statement(s) among the following
(A) Average molecular speed of gases increases with decrease in fraction of molecules moving slowly
(B) Rate of effusion of gases increases with increase in collision frequency at constant volume.
(C) Rate of effusion is proportional to molecular weight of gas
(D) Mean free path does not change with change in temperature at constant pressure

7. 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 any 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

8. Identify the correct statements when a fixed amount of ideal gas is heated in a container fitted with a movable piston always operating at constant pressure.
(A)Average distance travelled between successive collisions will decreases.
(B) Collisions frequency increases since speed of the molecules increases with increase in temperature.
(C) Average relative speed of approach remains unaffected.
(D)Average angle of approach remains unaffected.

9. Select the correct option(s) for an ideal gas

(A) Most probable speed increases with increase in temperature

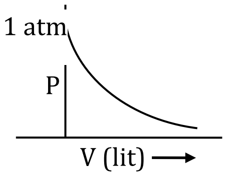
(B) Fraction of particles moving with most probable speed increases with increase in temperature

(C) Fraction of particles moving with most probable speed are more for Cl_2 than H_2 under similar condition of T, P & V.

(D) Most probable speed is more for Cl_2 than H_2 at same temperature

Paragraph for Question 10 to 12

On the recently discovered 10th planet it has been found that the gases follow the relationship $\mathbf{Pe^{V/2} = nCT}$ where C is constant other notation are as usual (V in lit., P in atm and T in Kelvin).



A curve is plotted

between P and V at 500 K & 2 moles of gas as shown in figure

10. The value of constant C is

(A) 0.01 (B) 0.001 (C) 0.005 (D) 0.002

11. Find the slope of the curve plotted between P Vs T for closed container of volume 2 lit. having same moles of gas

(A) $\frac{e}{2000}$ (B) 2000 e (C) 500 e (D) $\frac{e}{1000e}$

12. If a closed container of volume 200 lit. of O_2 gas (ideal gas) at 1 atm & 200 K is taken to planet. Find the pressure of oxygen gas at the planet at 821 K in same container

(A) $\frac{10}{e^{100}}$ (B) $\frac{20}{e^{50}}$ (C) 1 atm (D) 2 atm

Paragraph for Question 13 to 15

The constant motion and high velocities of gas particles lead to some important practical consequences. One such consequence is that as minimum rapidly when they come in contact. The mixing of different gases by random molecular motion and with frequent collisions is called diffusion A similar process in which gas molecules escape through a tiny hole into a vacuum is called effusion.

13. Helium gas at 1 atm and SO_2 at 2 atm pressure, temperature being the same, are released separately at the same moment into 1 m long evacuated tubes of equal diameters. If helium reaches the other end of the tube in t sec, what distance SO_2 would traverse in the same time interval in the other tube ?

(A) 25 cm (B) 50 cm (C) 60 cm (D) 75 cm

14. 4 g of H_2 effused through a pinhole in 10 sec at constant temperature and pressure. The amount of oxygen effused in the same time interval and at the same conditions of temperature and pressure would be :

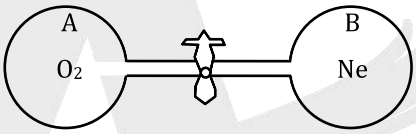
(A) 4 g (B) 8 g (C) 16 g (D) 32 g

15. For 10 min. each at 27°C, from two identical bulbs helium and an unknown gas X at equal pressures are leaked into a common vessel of 3 L capacity. The resulting pressure is 4.1 atm and the mixture contains 0.4 mol of helium. The molar mass of gas X is :

(A) 16 (B) 32 (C) 64 (D) 80

Paragraph for Question 16 to 17

Initially, flask A contained oxygen gas at 27°C and 950 mm of Hg, and flask B contained neon gas at 27°C and 900 mm. Finally, the two flasks were joined by means of a narrow tube of negligible volume equipped with a stopcork and gases were allowed to mixup freely. The final pressure in the combined system was found to be 910 mm of Hg.



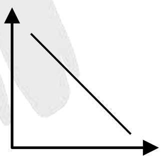
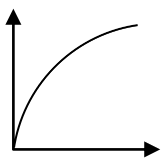
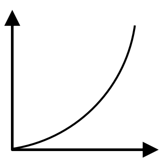
16. What is the correct relationship between volumes of the two flasks ?

(A) $V_B = 3V_A$ (B) $V_B = 4V_A$ (C) $V_B = 5V_A$ (D) $V_B = 4.5V_A$

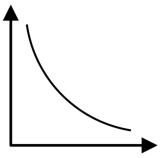
17. How many moles of gas are present in flask A in the final condition, if volume of flask B is 304 L? (R = 0.08 atm L mol^{-1} K^{-1})

(A) 7.58 (B) 3.79 (C) 15.16 (D) None of these

18. Match the entries in column I with entries in Column II and then pick out correct options.

	Column I		Column II
(A)	$\frac{1}{V^2}$ vs P for ideal gas at constant T and n.	(P)	
(B)	V $\frac{1}{T}$ vs for ideal gas at constant P and n	(Q)	
(C)	log P vs log V for ideal gas	(R)	

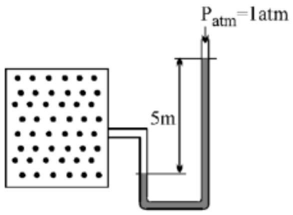
at constant T and n.

(D) V vs $\frac{1}{P^2}$ for ideal gas (S) 

at constant T and n.

EXERCISE (S-II)

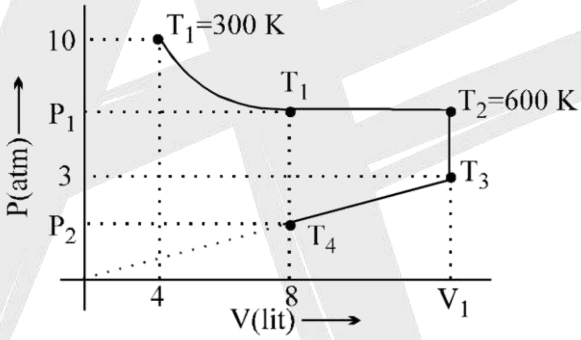
1. One mole of an ideal gas is subjected to a process in which $P = \frac{1}{8.21}V$ where P is in atm & V in litre. If the process is operating from 1 atm to finally 10 atm (no higher pressure achieved during the process) then what would be the maximum temperature obtained.



2. Calculate the number of moles of gas present in the container of volume 10 L at 300 K. If the manometer containing glycerin shows 5m difference in level as shown in diagram.

Given: $d_{glycerin}$ = 2.72 g/ml, $d_{mercury}$ = 13.6 g/ml.

3. Fixed mass of a gas is subjected to the changes as shown is diagram, calculate T_3, T_4, P_1, P_2 and V_1 as shown is diagram. Considering gas obeys PV = nRT equation.



4. A balloon containing 1 mole air at 1 atm initially is filled further with air till pressure increases to 3 atm. The initial diameter of the balloon is 1 m and the pressure at each state is proportion to diameter of the balloon. Calculate

(a) No. of moles of air added to change the pressure from 1 atm to 3 atm.

(b) balloon will burst if either pressure increases to 7 atm or volume increases to $36\pi m^3$. Calculate the number of moles of air that must be added after initial condition to burst the balloon.

5. The composition of the equilibrium mixture ($Cl_2 \rightleftharpoons 2Cl$) which is attained at 1200ºC is determined by measuring the rate of effusion through a pin hole. It is observed that at 1.8 mm Hg pressure, the mixture effuses 1.16 times as fast as Kr effuses under the same conditions. Calculate the fraction of chlorine molecules dissociated into atoms. [Kr = 84 a. m. u.]

6. One mole of NH_4Cl (s) is kept in an open container & then covered with a lid. The container is now heated to 600 K where all NH_4Cl (s) dissociates into NH_3 & HCl(g). If volume of the container is 24.63 L, calculate what will be the final pressure of gases inside the container. Also find whether the lid would stay or bounce off if it can withstand a pressure difference of 4.5 atm. Assume that outside air is at 300 K and 1 atm pressure.

7. A compound exists in the gaseous state both as a monomer (A) and dimer (A_2). The molecular weight of the monomer is 48. In an experiment, 96 g of the compound was confined in a vessel of volume 33.6 litres and heated to 273° C. Calculate the pressure developed, if the compound exists as a dimer to the extent of 50 per cent by weight, under these conditions. (R = 0.082)

8. H_2 gas is kept inside a container A and container B, each having volume 2 litre under different conditions which are described below. Determining the missing values with proper unit.

[R = 8 J mol^{-1} K^{-1} and NA = 6×10^{23} , N = No. of molecules]

Parameter	Container A	Container B
P	(i) -----	1 atm
T	300 K	600 K
N	6×10^{20}	(ii) -----
Total Average KE	(iii) -----	(iv) -----
Ratio U_{mps}	(v) ---------------------	
Ratio Z_{11}	(vi) ---------------------	

9. The mean free path of the molecule of a certain gas at 300 K is 2.6×10^{-5} m. The collision diameter of the molecule is 0.23 nm. Calculate

(a) Pressure of the gas, and

(b) number of molecules per unit volume of the gas.

EXERCISE (JEE-MAINS)

1. According to the kinetic theory of gases, in an ideal gas, between two successive collisions a gas molecule travels **[AIEEE-2003]**

(A) In a straight line path (B) with an accelerated velocity

(C) In a circular path (D) In a wavy path

2. What volume of hydrogen gas, at 273K and 1 atm, pressure will be consumed in obtaining 21.6g of elemental boron (atomic mass = 10.8) from the reduction of boron trichloride by hydrogen ? **[AIEEE-2003]**

(A) 44.8 L (B) 22.4 L (C) 89.6 L (D) 67.2 L

3. As the temperature is raised from 20°C to 40°C, the average kinetic energy of neon atoms changes by factor of which of the following ? **[AIEEE-2004]**

(A) 1/2 (B) $\sqrt{(313/293)}$ (C) 313/298 (D) 2

4. Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is - **[AIEEE-2008]**

(A) 2/3 (B) $\frac{1}{3}\times\frac{273}{298}\times$ (C) $\frac{1}{3}$ (D) $\frac{1}{2}$

5. The molecular velocity of any gas is :- **[AIEEE-2011]**

(A) inversely proportional to the square root of temperature

(B) inversely proportional to absolute temperature

(C) directly proportional to square of temperature

(D) directly proportional to square root of temperature

6. a, v and u represent most probable velocity, average velocity and root mean square velocity respectively of a gas at a particular temperature. The correct order among the following is

[JEE(Main)-2012]

(A) a > u > v (B) v > u > a (C) u > v > a (D) u > a > v

7. An open vessel at 300 K is heated till $\frac{2}{5}$ th of the air in it is expelled. Assuming that the volume of the vessel remains constant, the temperature to which the vessel is heated is:

[JEE(Main-online)-2012]

(A) 750 K (B) 400 K (C) 500 K (D) 1500K

8. For 1 mol of an ideal gas at constant temperature T, the plot of (log P) against(log V) is a (P : Pressure, V : Volume) : **[JEE(Main-online)-2012]**

(A) Straight line parallel to x-axis (B) Curve starting at origin

(C) Straight line with a negative slope (D) Straight line passing through origin

9. The relationship among most probable velocity, average velocity and root mean square velocity is respectively :- **[JEE(Main-online)-2012]**

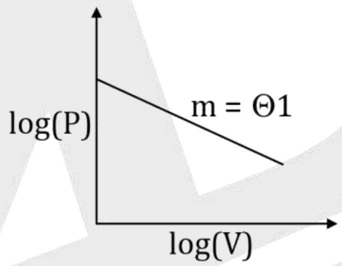
(A) $\sqrt{2}:\sqrt{8/\pi}:\sqrt{3}$

(B) $\sqrt{2}:\sqrt{3}:\sqrt{8/\pi}$

(C) $\sqrt{3}:\sqrt{8/\pi}:\sqrt{2}$

(D) $\sqrt{8/\pi}:\sqrt{3}:\sqrt{2}$

10. Which one of the following is the wrong assumption of kinetic theory of gases ? **[JEE(Main-online)-2013]**



(A) All the molecules move in straight line between collision and with same velocity.

(B) Molecules are separated by great distances compared to their sizes.

(C) Pressure is the result of elastic collision of molecules with the container's wall.

(D) Momentum and energy always remain conserved.

11. By how many folds the temperature of a gas would increase when the root mean square velocity of the gas molecules in a container of fixed volume is increased from 5×10^4 cm/s to 10×10^4 cm/s ? **[JEE(Main-online)-2013]**

(A) Four (B) three (C) Two (D) Six

12. For gaseous state, if most probable speed is denoted by C, average speed by C and mean square speed by C, then for a large number of molecules the ratios of these speeds are :-

[JEE(Main-offline)-2013]

(A) C : $\overline{C}$: C = 1.225 : 1.128 : 1 (B) C : $\overline{C}$: C = 1.128 : 1.225 : 1

(C) C : $\overline{C}$: C = 1 : 1.128 : 1.225 (D) C : $\overline{C}$: C = 1 : 1.225 : 1.128

13. A gaseous compound of nitrogen and hydrogen contains 12.5%(by mass) of hydrogen. The density of the compound relative to hydrogen is 16. The molecular formula of the compound is:

[JEE(Main-online)-2014]

(A) NH_2 (B) NH_3 (C) N_3H (D) N_2H_4

14. 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-online)-2014]

(A)1.750 L (B) 7.50 L (C) 3.60 L (D) 4.032 L

15. 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-online)-2014]**

(A) 1200 K (B) 600 K (3) 300 K (4) 2400 K

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

[JEE-Mains (online)-2015]

(A) Gas particles have negligible volume.

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

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

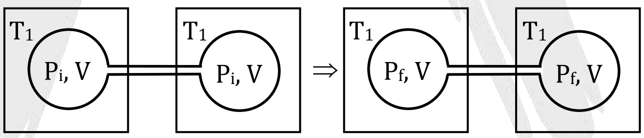
(D) Collisions of gas particles are perfectly elastic.

17. 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-online)-2016]**

(A) u/2 (B) 4u (C) 14u (4) 2u

18. 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]



(A) $2p_i$ $2p_i\left(\frac{T_1T_2}{T_1+T_2}\right)$ (B) $p_i\left(\frac{T_1T_2}{T_1+T_2}\right)$ (C) $2p_i\left(\frac{T_1}{T_1+T_2}\right)$ (D) $2p_i\left(\frac{T_2}{T_1+T_2}\right)$

19. 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 (Jan)]**

(A) 500°C (B) 500 K (C) 750° C (D) 750 K

20. The volume of gas A is twice than that of gas B. The compressibility factor of gas A is thrice than that of gas B at same temperature. The pressures of the gases for equal number of moles are : **[JEE-Mains-2019 (Jan.)]**

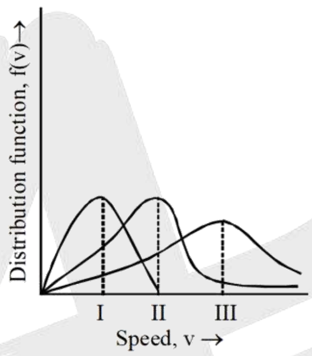
(A) $P_A = 3P_B$ (B) $3P_A = 2P_B$ (C) $2P_A = 3P_B$ (D) $P_A = 2P_B$

21. 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 (Jan.)]**

(A) $\frac{2R}{4+12}$ (B) $\frac{2R}{4-12}$ (C) $\frac{4-R}{2R}$ (D) $\frac{4+R}{2R}$

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

[JEE-Mains-2019 (Apr.)]



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

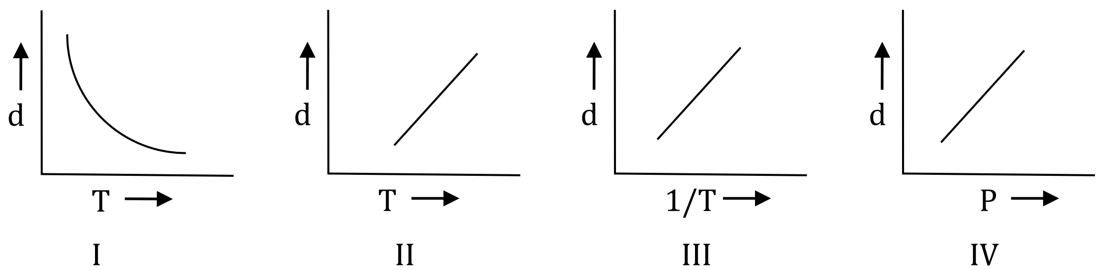
(B) V_{mp} of N_2 (300 K) ; V_{mp} of H_2 (300 K); V_{mp} of O_2 (400 K)

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

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

23. A spherical balloon of radius 3 cm containing helium gas has a pressure of 48 × 10^{-3} bar. At the same temperature, the pressure, of a spherical balloon of radius 12 cm containing the same amount of gas will be .... ×10^{-6} bar. **[JEE Main, 2020]**

24. Which one of the following graphs is not correct for ideal gas ? **[JEE Main, 2020]**



d = Density, P = Pressure, T = Temperature

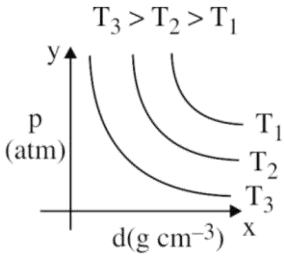
(A) IV (B) II (C) III (D) I

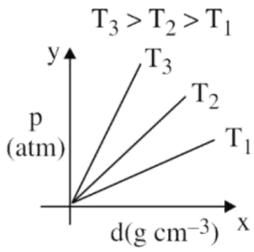
25. Geraniol, a volatile organic compound, is a component of rose oil. The density of the vapour is 0.46 gL^{-1} at 257°C and 100 mm Hg. The molar mass of geraniol is __________ (Nearest Integer)

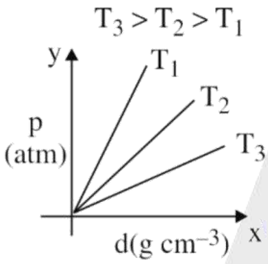
[Given R = 0.082 L atm K^{-1} mol^{-1}]

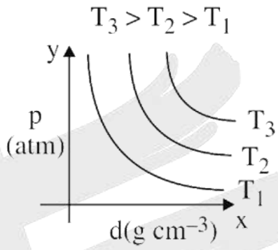
[JEE Main, June 2022]

26. Which amongst the given plots is the correct plot for pressure (p) vs density (d) for an ideal gas? **[JEE Main, June 2022]**

(A) 

(B) 

(C) 

(D) 

27. 'x' g of molecular oxygen (O_2) is mixed with 200 g of neon (Ne). The total pressure of the nonreactive mixture of O_2 and Ne in the cylinder is 25 bar. The partial pressure of Ne is 20 bar at the same temperature and volume. The value of 'x' is

[Given: Molar mass of O_2 = 32 g mol^{-1}. Molar mass of Ne = 20 g mol^{-1}]

[JEE Main, July 2022]

EXERCISE (JEE-ADVANCED)

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. **[JEE 1997]**

2. According to Graham's law, at a given temperature the ratio of the rates of diffusion $\frac{r_A}{r_B}$ of ga gases A and B is given by : **[JEE 1998]**

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

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 . **[JEE 1998]**

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] **[JEE 1999]**

5. One mole of N_2 gas at 0.8 atm takes 38 sec to diffuse through a pin hole, whereas one mole of an unknown compound of Xenon with F at 1.6 atm takes 57 sec to diffuse through the same hole. Calculate the molecular formula of the compound.(At. wt. Xe = 138, F = 19) **[JEE 1999]**

6. The rms velocity of hydrogen is $\sqrt{7}$ times the r. m. s. velocity of nitrogen. If T is the temperature of the gas : **[JEE 2000]**

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

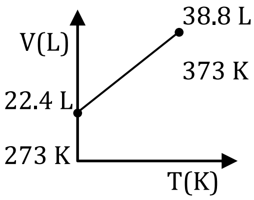
7. **Statement-1 :** The pressure of a fixed amount of an ideal gas is proportional to its temperature.

Statement-2 : Frequency of collision and their impact both increase in proportion to the square root of temperature. True / False. **[JEE 2000]**

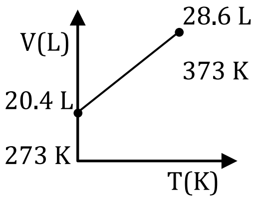
8. The root mean square velocity of an ideal gas at constant pressure varies with density as **[JEE 2001]**

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

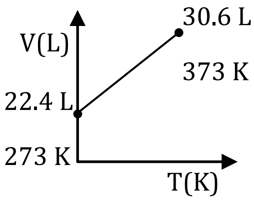
9. Which one of the following V, T plots represents the behaviour of one mole of an ideal gas at one atmp? **[JEE 2002]**



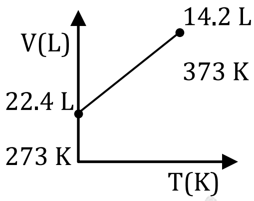
(A)



(B)



(C)



(D)

10. The average velocity of gas molecules is 400 m/sec. Calculate its (rms) velocity at the same temperature. **[JEE 2003]**

11. The root mean square velocity of one mole of a monoatomic gas having molar mass M is u_{rms}. The relation between the average kinetic energy (E) of the gas and u_{rms} is **[JEE-2004]**

(A) $u_{rms} = \sqrt{\frac{3E}{2M}}$ (B) $u_{rms} = \sqrt{\frac{2E}{3M}}$ (C) $u_{rms} = \sqrt{\frac{2E}{M}}$ (D) $u_{rms} = \sqrt{\frac{E}{3M}}$

12. 20% surface sites have adsorbed N_2. On heating N_2 gas evolved from sites and were collected at 0.001 atm and 298 K in a container of volume is 2.46 cm^3. Density of surface sites is $6.023\times10^{14}/\ cm^2$ and surface area is 1000 cm^2, find out the no. of surface sites occupied per molecule of N_2. **[JEE 2005]**

13. The ratio of the rate of diffusion of helium and methane under identical condition of pressure and temperature will be **[JEE 2005]**

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

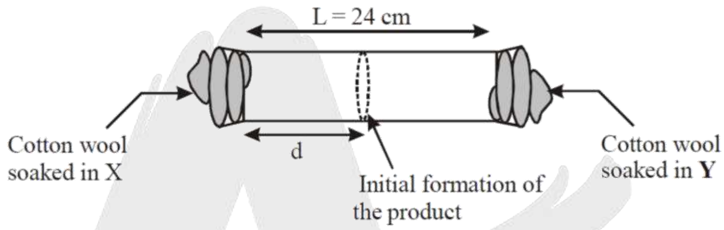
14. At 400 K, the root mean square (rms) speed of a gas X (molecular weight = 40) is equal to the most probable speed of gas Y at 60 K. The molecular weight of the gas Y is **[JEE 2009]**

15. 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 0°C) are introduced. Considering the ideal gas behaviour, the total volume (in litre) of the gases at 0°C is close to

[JEE 2011]

Paragraph for Question 16 & 17

X and Y are two volatile liquids with molar weights of 10g mol^{-1} and 40g 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 300K. 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. **[JEE 2014]**



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

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

17. The experimental value of d is found to be smaller than the estimate obtained using Graham's law. This is due to -

(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

18. 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. As a result, the diffusion coefficient of this gas increases x times. The value of x is **[JEE-2016]**

19. 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 Advance 2018]**

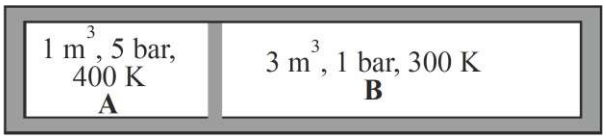


Figure 1

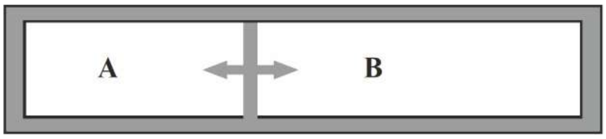


Figure 2

20. 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 Advance 2019]

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

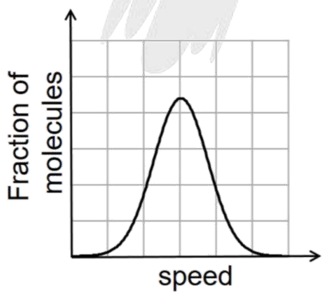
(B) U_{rms} is doubled when its temperature is increased four times

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

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

21. If the distribution of molecular speeds of gas is as per the figure shown below, then the ratio of the most probable, the average, and the root mean square speeds, respectively, is

[JEE Advance 2020]



a) 1 : 1 : 1
b) 1 : 1 : 1.224
c) 1 : 1.128 : 1.224
d) 1 : 1.128 : 1

Answer key

(EXERCISE O-I)

1.	(D)	2.	(C)	3.	(C)	4.	(C)	5.	(C)	6.	(D)	7.	(A)
8.	(D)	9.	(B)	10.	(C)	11.	(B)	12.	(B)	13.	(C)	14.	(B)
15.	(B)	16.	(C)	17.	(D)	18.	(D)	19.	(B)	20.	(A)	21.	(A)
22.	(C)	24.	(C)	25.	(D)	26.	(B)	27.	(D)	28.	(A)	29.	(D)
30.	(B)	31.	(B)	32.	(A)	33.	(A)	34.	(A)	35.	(B)	36.	(A)
37.	(C)	38.	(C)	39.	(D)	40.	(A)	41.	(C)	42.	(A)	43.	(A)
44.	(B)	45.	(C)	46.	(A)	47.	(D)	48.	(B)	49.	(A)	50.	(D)
51.	(D)	52.	(B)	53.	(B)	54.	(B)	55.	(D)	56.	(D)	57.	(A)
58.	(C)	59.	(A)	60.	(A)	61.	(C)						

(EXERCISE S-I)

1. (8)　2. (P=0.075 atm, T=75 K)　3. (5 cm)　4. (8)

5. (15 gm ; 12 dm^3)　6. (73.9 litre)

7. (P_{total} = 27.54 ×10^5 N/m^2 , P_{final} = 19.66 ×10^5N/m^2)

8. (0.3)　9. (3)　10. ((i) 1.5 atm; (ii) O_2=0.75 atm, O_3 = 0.5 atm; (iii) 0.208 atm)

11. ($\frac{1}{6}$)　12. $(32)^2$　13. (5)　14. (25 %)

15. (820)　16. (Yes)　17. (150)　18. (3.284 atm)　19. (1 MPa)　20. ($\frac{2P}{(n+1)}$)

21. (450)　22. (8)　23. (228)　24. (60)　25. (192)

26. (50.8 cm)　27. (16 min)　28. ((i) $\frac{1}{2}$; (ii) $\frac{3}{16}$, (iii) $\frac{1}{2}$)

29. (4)　30. (2)　31. (236.3°C)

32. ((a) 1934.24 m/sec , (b) 500 m/sec , (c) 17.32 m/sec.)

33. (1000 m/sec)　34. (3)　35. (25)　36. (2 cm)　37. (3.3 × 10^3)　38. (2)

(EXERCISE O-II)

1.	(B,D)	2.	(A,B)	3.	(A,D)	4.	(A,B,D)	5.	(A,B,C,D)	6.	(A,B)
7.	(C.D)	8.	(D)	9.	(A,C)	10.	(B)	11.	(D)	12.	(A)
13.	(B)	14.	(C)	15.	(C)	16.	(B)	17.	(B)		

18. ((A)$\rightarrow$R, (B)$\rightarrow$S, (C)$\rightarrow$P, (D)$\rightarrow$Q)

(EXERCISE S-II)

1. (10,000 K) 2. (0.94 mole)

3. ((i) P_1 = 5 atm; (ii) T_3 = 360 K; (iii) V_1 = 16 lit.; (iv) P_2 = 1.5 atm ; (v) T_4 = 90 K)

4. ($P \propto d$; P= kd & k = $\frac{1\text{atm}}{1\text{meter}}$; (a) 80; (b) 1295 moles) 5. (0.137)

6. (6 atm, will bounce) 7. (2 atm)

8. ((i) 0.012 atm; (ii) 2.5 $\times 10^{22}$; (iii) 3.6 J; (iv) 300 J; (v) $\frac{1}{\sqrt{2}}$; (vi) 0.4 × 10–3 : 1)

9. ((a) 530.6 Pa, (b) 1281 × 10^{20} m^{-3})

(EXERCISE JEE-MAIN)

1.	(A)	2.	(D)	3.	(C)	4.	(C)	5.	(D)	6.	(C)	7.	(C)
8.	(C)	9.	(A)	10.	(A)	11.	(A)	12.	(C)	13.	(D)	14.	(A)
15.	(D)	16.	(C)	17.	(D)	18.	(D)	19.	(B)	20.	(C)	21.	(C)
22.	(D)	23.	(750)	24.	(2)	25.	(152)	26.	(B)	27.	(80)		

(EXERCISE JEE-ADVANCED)

1. (0.492 atm; 0.246 atm) 2. (C) 3. (123) 4. (-173°C, 0.82 litre)

5. (XeF_6) 6. (C) 7. (Both statement are correct) 8. (D) 9. (C)

10. (434.17 m/sec) 11. (C) 12. (2) 13. (B) 14. (4)

15. (7) 16. (C) 17. (D) 18. (4) 19. (2.22 or 2.23) 20. (B,C,D)

21. (B)

SOLUTION

EXERCISE # O-I

1. Mass of liquid = 50 gm

$\Rightarrow$ volume of container = $\frac{50}{25}$ = 2 dm^3

2. By equation of state, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$$\Rightarrow \frac{P \cdot V_1}{273} = \frac{P \cdot 2V_1}{T_2}$$

$\Rightarrow$ T_2 = 546 K or 273°C

3. $d_A = 2d_B$ & $M_B = 3M_A$

As, $P = \frac{dRT}{M}$

$$\Rightarrow P_A = \frac{d_A RT}{M_A} \quad .....(1)$$

$$\& \quad P_B = \frac{d_B RT}{M_B} \quad .....(2)$$

(1) ÷ (2)

$$\frac{P_A}{P_B} = \frac{d_A}{d_B} \times \frac{M_B}{M_A}$$

$$= \frac{2d_B}{d_B} \times \frac{3M_A}{M_A} = 6 \quad \Rightarrow \quad P_A : P_B = 6 : 1$$

4. $(nRT)_1 = (nRT)_2$

$$\frac{4}{18} \times R \times T = \frac{3.2}{18} \times R \times (T+50)$$

$\Rightarrow$ T = 200K

5. Assuming volume remaining constant

$$\frac{W_1T_1}{P_1} = \frac{W_2T_2}{P_2}$$

$\Rightarrow \quad \dfrac{10 \times T}{P} = \dfrac{W_2 \times 2T \times 2}{3 \times P}$

$\Rightarrow \quad W_2 = 7.5$ gm

$\Rightarrow \quad$ mass of gas escaped = $W_1 - W_2$

= 10 – 7.5 = 2.5 gm

6. $P_{(final)} = \dfrac{P_1V_1 + P_2V_2}{V_T}$

$= \left(\dfrac{720 \times 200 + 750 \times 400}{1000}\right) = \left(\dfrac{444000}{1000}\right)$

= 444 mm

7. $2NH_3 \longrightarrow N_2 + 3H_2$

	$2NH_3$	N_2	$3H_2$
At. T→	P	0	0
At. 2T→	2P	0	0
	–	P	3P

$\Rightarrow \quad$ Ratio of final pressure to initial pressure = $\dfrac{4P}{P}$

i.e. 4

8. This statement is in accordance to Dalton's Law.

9. $NH_3 + HCl \longrightarrow NH_4Cl$

Dalton's Law is applicable for non-reacting gas.

10.

	He	:	0
Number of ratio of atoms	1	:	1
Ratio of mole of atoms	$\dfrac{1}{N_A}$	:	$\dfrac{1}{N_A}$
Ratio of mole of molecules	$\dfrac{1}{N_A}$	:	$\dfrac{1}{3N_A}$

Now, $\dfrac{1}{N_A} + \dfrac{1}{3N_A} = P$

$\Rightarrow \quad \dfrac{4}{3N_A} = P \quad \Rightarrow \quad \dfrac{1}{N_A} = \dfrac{3P}{4}$

If Helium is removed from the vessel,

Let pressure of system be P'

$\Rightarrow \quad P' = \frac{1}{3N_A} \quad = \frac{1}{3}\times\frac{3P}{4}$

$\Rightarrow \quad P' = \frac{P}{4}$ or 0.25 P

12. At constant temperature, $P \propto \frac{1}{V}$

$\Rightarrow \quad P_1 < P_2$

13. PV = nRT

$V = \frac{nR}{P}\times T$

$\log V = \log\frac{nR}{P} + \log T$

Intercept of the given graph = $\log\frac{nR}{P} = 1$

$\frac{nR}{P} = 10$

$\frac{n\times.0821}{.821} = 10$

n = 100

14. $2A_{(g)} \longrightarrow 3B_{(g)} + 2C_{(g)}$

1 0 0

$(1-0.4)$ $\quad \frac{0.4\times3}{2}$ $\quad \frac{0.4\times2}{2}$

= 0.6 = 0.6 = 0.4

$P = \frac{nR}{V}\times T$

$\Rightarrow \quad \text{Slope} = \tan\theta = \frac{nR}{V} = \frac{1.6\times0.08}{0.16} = 0.8$

$\Rightarrow \quad \theta = \tan^{-1}(0.8)$

15. $3A \longrightarrow 2B$

1 0

$1-\propto \qquad \frac{2\propto}{3}$

$n_T = 1 - \propto + \frac{2\propto}{3} = 0.8$

$\Rightarrow \qquad \propto = 0.6$

16. Vapour pressure depends on temperature only, so, as the temperature remains constant, V.P. will remain unchanged

20. As $M_{Avg.}$ remains same

$\Rightarrow$ Total pressure will remain same

22. $V \propto n$ due to same T & P in each compartment

$\therefore$ Length of N_2 compartment $\frac{5}{5+3} \times 500 \Rightarrow 312.5$ cm

23. Vapour pressure depends only on temperature.

Graham's Law of Diffusion and Effusion

27. Rate of diffusion of gas is inversely proportional to the square root of its molecular weight.

28. rate $\propto \frac{1}{\sqrt{M}}$

29. rate $\propto \frac{1}{\sqrt{M}}$

Increasing order of effusion is ($CO_2 < O_2 < NH_3 < H_2$)

30. As, $\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_2}}$

$\Rightarrow$ Relative rates of effusion are, a < c < b.

31. Rate of diffusion of Hydrogen is about

$$\frac{r_{H_2}}{r_{H_e}} = \sqrt{\frac{M_{He}}{M_{H_2}}} = \sqrt{2} = 1.4$$

$\Rightarrow \qquad r_{H_2} = 1.4 \times r_{He}$

32. $\frac{W_{H_2}}{W_{O_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}}$

$= \sqrt{\frac{2}{32}} \qquad = \sqrt{\frac{1}{16}} = \frac{1}{4}$

33. $\frac{r_{CH_4}}{r_X} = \sqrt{\frac{M_X}{M_{CH_4}}}$

$1 = \sqrt{\frac{MX}{16}}$

$4 \times 16 = M_X$

$\Rightarrow \quad M_X = 64 \text{ gm}$

34. $\frac{n'_{He}}{n'_{CH_4}} = \frac{4}{1} \times \sqrt{\frac{16}{4}} \quad = 8 : 1$

35. $\frac{r_x}{r_y} = 3 = \sqrt{\frac{D_y}{D_x}}$

$\frac{D_y}{D_x} = \frac{9}{1}$

$\Rightarrow \quad D_x : D_y = 1 : 9$

36. $\frac{r_{O_2}}{r_{H_2}} = \frac{16\times 2}{32\times 2} \sqrt{\frac{2}{32}}$

$= \frac{1}{2}\times\frac{1}{4} = \frac{1}{8}$

37. $\frac{\left(\frac{n_A}{n_B}\right)_f}{\left(\frac{n_B}{n_B}\right)_i} = \left(\frac{M_B}{M_A}\right)^{n/2}$

$\frac{3072}{20}\times\frac{1600}{240} = \left(\frac{32}{2}\right)^{n/2}$

$(4)^5 = (4)^n$

$\Rightarrow \quad n = 5$

38. $\frac{r_{mix}}{r_{SO_2}} = \sqrt{\frac{M_{SO_2}}{M_{mix}}}$

$2 = \sqrt{\dfrac{64}{M_{mix}}}$

$\Rightarrow \quad M_{max.} = 16$

Now, $\quad 16 = \dfrac{17}{1+\propto}$

$\Rightarrow \quad \propto = 6.25\%$

Kinetic Theory of Gaseous

41. K.E depends on Temperature only

So, K.E. remain same

42. As, K.E depends on T only

$\Rightarrow$ It will remain same

43. K.E $= \dfrac{3}{2}RT$

$= \dfrac{3}{2} \times 2 \times 300$

$= 900$ cal/mole

44. K.E $= \dfrac{3}{2}KT$

$= \dfrac{3}{2} \times 1.3807 \times 10^{-23} \times 298$

$= 6.17 \times 10^{-21}$ J

45. $(K.E)_{He}$ at TK $=$ $(K.E.)_{Ar}$ at 400 K

$\Rightarrow \dfrac{3}{2} \times 0.30 \times R \times T = \dfrac{3}{2} \times 0.40 \times R \times 400$

$\Rightarrow \quad T = \dfrac{1600}{3} = 533$ K

Maxwell Distribution of Speeds

46. $U_{m.p.s} : U_{Avg} : U_{r.m.s}$

$\sqrt{\dfrac{2RT}{M}} : \sqrt{\dfrac{8RT}{\pi - M}} : \sqrt{\dfrac{3RT}{M}}$

$\sqrt{2}$: $\sqrt{\frac{8}{\pi}}$: $\sqrt{3}$

OR, 1 : 1.128 : 1.224

47. $U_{r.m.s} = \sqrt{\frac{V_1^2 + V_2^2 + V_3^2 + V_4^2}{4}}$

$= \sqrt{\frac{4+9+16+25}{4}} = \frac{\sqrt{54}}{2}\,cm/s$

48. $S = \sqrt{\frac{(7)^2 \times 4 + 6 \times x^2}{10}}$

$2S = \frac{49 \times 4 + 6x^2}{10} \Rightarrow x = 3$

49. $U_{r.m.s} \propto \frac{1}{\sqrt{M}}$

50. $U_{r.m.s} \propto \frac{1}{\sqrt{M}}$

51. $(V_{Avg.})_{N2} = 0.3$ m/s at 27°C

$\sqrt{\frac{8RT}{\pi M}} = 0.3$

$\Rightarrow \frac{8R}{\pi M} = \frac{(0.3)^2}{300}$ .....(1)

Now, $\sqrt{\frac{8RT}{\pi M}} = 0.6$

$\frac{8R}{\pi M} \times T = 0.6 \times 0.6$

$\Rightarrow T = \frac{0.6 \times 0.6 \times 300}{(0.3)^2}$

$\Rightarrow T = 1200$ K

52. $U_{r.m.s} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{nM}} = \sqrt{\frac{3P}{D}}$

53. $(U_{r.m.s})_T = 2 \times (U_{r.m.s})_{373k}$

$\Rightarrow \quad \frac{3RT}{M} = 4 \times \frac{3R \times 373}{M}$

$\Rightarrow \quad T = 4 \times 373$

$\Rightarrow \quad T = 1492$ K

54. $(U_{m.p.s})_{O_2} = (U_{r.m.s})_{N_2}$

$\left(\sqrt{\frac{2RT}{M}}\right)_{O_2} = \left(\sqrt{\frac{3RT}{M}}\right)_{N_2}$

$\frac{2 \times T}{32} = \frac{3 \times 700}{28}$

$\Rightarrow \quad T = 1200$ K

55. $(U_{avg.})_X = 2(U_{avg.})_Y$

$\left(\sqrt{\frac{8PV}{\pi M}}\right)_X = 2\left(\sqrt{\frac{8PV}{\pi M}}\right)_Y$

$\Rightarrow \quad P_XV_X = 4 \times P_YV_Y$

$\Rightarrow \quad \frac{P_X}{P_Y} = \frac{4 \times 2}{1}$

$\Rightarrow \quad P_X = 8P_Y$

56. $\frac{1}{N}\left(\frac{dN}{dU}\right) \propto M$

57. $U_{rms} = \sqrt{1.5 \times 400}$

<u>Collisions Among Gaseous Molecules</u>

59. As, $N^* = \frac{P}{KT}$

$= \frac{10^5}{1.38 \times 10^{-23} \times 300}$

$\Rightarrow \quad N^* = 2.4 \times 10^{25}\ m^{-3}$

60. At. Constant volume,

$Z_{11} \propto \sqrt{P} \quad \Rightarrow$ Correct option is (A)

EXERCISE S-1

1. By using equation of state,

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\Rightarrow \quad \frac{P\cdot V}{T_1} = \frac{4P\times 2V}{T_2}$$

$$\Rightarrow \quad \boxed{T_2 = 8T_1}$$

2. Case-I : $P.V. = \frac{3.6}{36} \times 0.0821 \times T$ ...(1)

Case-II : $P.V. = \frac{3}{36} \times 0.0821 \times (T + 15)$ ...(2)

Equating (1) & (2),

We get, $\boxed{T = 75k}$

From equation (1)

$$P \times 8.21 = \frac{3.6}{36} \times 0.0821 \times 75$$

$$\Rightarrow \quad P = 0.075 \text{ atm}$$

3. $P\cdot V_1 = \frac{1}{4}RT$ ...(1)

$P\cdot V_2 = \frac{0.125}{4}RT$ ...(2)

Now, (1) ÷ (2),

$$\frac{V_1}{V_2} = 8 \quad \Rightarrow \quad V_2 = \frac{1}{8}V_1$$

$$\text{or} \quad \frac{4}{3}\pi r_2^3 = \frac{1}{8}\times\frac{4}{3}\pi r_1^3$$

$$\Rightarrow \quad r_2^3 = \left(\frac{10}{2}\right)^3$$

$$\Rightarrow \quad \boxed{r_1 = 5 \text{ cm}}$$

4. As, $M = \frac{dRT}{P}$

$\Rightarrow$ $M = \dfrac{0.8 \times 0.082 \times 300}{2.46}$

$\Rightarrow$ M = 8 gm/mole

5. $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

$n_{O_2} = \dfrac{1 \times 0.2 \times 10^{-3}}{0.08 \times 300}$

$\simeq 8.3 \times 10^{-6}$ mole

$\therefore$ mass of glucose required for hour by a resting mole having mass 60 kg

$\simeq \dfrac{8.3 \times 10^{-6}}{6} \times 180 \times 60$

$\simeq$ 15 gm.

Also, volume of CO_2 product = $\dfrac{8.3 \times 10^{-6} \times 0.08 \times 300}{1} \times 60$

$\simeq 12\ dm^3$.

6. $2NaN_3 \longrightarrow 2Na + 3N_2$

Mole : 2 3

Volume of N_2 formed = $\dfrac{3 \times 0.0821 \times 300}{1}$ = 73.9 lits.

7. Total pressure of mixture = $P_{H_2} + P_{O_2}$

$\Rightarrow$ $P_T = \dfrac{10^{-2} \times 10^3 \times 0.0821 \times 473}{2 \times 10} + \dfrac{6.4 \times 10^{-2} \times 10^3 \times 0.0821 \times 473}{32 \times 10}$

$\Rightarrow$ $P_T \simeq 27.17$ atm

or

$27.54 \times 10^5\ N/m^2$

Where spark ignites the mixture,

$H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O(g)$

mole : 5 2 0

1 0 4

$\Rightarrow$ moles total $\simeq$ 5

$\Rightarrow$ $P_{(final)} = \left(\frac{5 \times 0.0821 \times 473}{10} \times 1.013 \times 10^5\right)$

$= 19.66 \times 10^5$ N/m^2

8. $P_T = P_{N_2} + P_{O_2}$

$\Rightarrow$ $P_{N_2} = 90 - 63$

i.e. $P_{N_2} = 27$ mm of Hg

Now, $P_{N_2} = x_{N_2} \times P_T$

$\Rightarrow$ $x_{N_2} = \frac{27}{90}$. $\Rightarrow$ $x_{N_2} = 0.3$

$\Rightarrow$ Answer is (0.3×10) i.e. 3

9. $n_{He} = \frac{0.3 \times 1}{0.0821 \times 300}$

$= 0.012$

Now, $\frac{0.4 \times 3}{0.0821 \times 300} = n_T$

$\Rightarrow$ $n_T = 0.048$

$\Rightarrow$ $n_{Ne} = 0.048 - 0.012$

$= 0.036$

$\Rightarrow$ $\frac{n_{He}}{n_{He}} = \frac{0.036}{0.012}$

$\simeq 3$

10. (i) $P = \frac{nRT}{V}$

$= \frac{16 \times 0.0821 \times 300}{32 \times 8.21}$

$= 1.5$

(ii) $3O_2 \longrightarrow 2O_3$

mole : $.5$ $\quad$ 0

$0.5 - .25$ $\quad$ $0.25 \times \frac{2}{3}$

Now, $P_{O_2} = x_O \times P_T$

$= \frac{0\cdot25}{\cdot5} \times 1\cdot5$

$\simeq 0\cdot75$

& $P_{O_3} = \frac{0\cdot16}{\cdot5} \times 1\cdot5$

$\simeq 0\cdot50$

(iii) $P_T = \frac{n_T \times RT}{V}$

$= \frac{0\cdot42 \times 0\cdot0821 \times 50}{8\cdot21}$

$\simeq 0\cdot208$ atm.

11. $n^2 = \left(\frac{P}{RT}\right)^2 \times V^2$

$\Rightarrow$ slope $= \left(\frac{P}{RT}\right)^2$

$\Rightarrow$ slope $= \frac{(8\cdot21)^2}{(0\cdot0821 \times 200)^2}$

$\simeq 0\cdot25$

or $\frac{1}{4}$

12. For 1 mole of gas at 400k, P^2 vs $\frac{1}{V_2}$ graph is plotted.

Using $PV = nRT \Rightarrow P = nRT \times \frac{1}{V}$

On squaring both sides, we get $P^2 = (nRT)^2 \times \frac{1}{V^2}$

For P^2 vs $\frac{1}{V^2}$ graph, slope = $(nRT)^2$

Slope = $(1 \times .08 \times 400)^2 = (32)^2$

14. $2NH_3 \longrightarrow N_2 + 3H_2$

76	0	0
$76 - x$	$\frac{x}{2}$	$\frac{3x}{2}$

As, $x = 19$

$\Rightarrow$ % dissociation = $\frac{19}{76} \times 100$

= 25%

16. As, $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\Rightarrow \frac{250 \times 10^3}{300} = \frac{10^6}{T_2}$

$\Rightarrow T_2 = 1200k$

Yes, the cylinder will blow up.

17. $P_f(100 + V) = (n_1 + n_2)RT$ ...(1)

$P_A(100) = n_3 \cdot RT$ ...(2)

Now, (1) ÷ (2),

$$\frac{P_f}{P_A} \times \frac{100+V}{100} = \frac{(n_1+n_2)RT}{n_3 RT} \quad \left(\frac{P_f}{P_A} = \frac{40}{100} \;\&\; n_1 + n_2 = n_3\right)$$

$\Rightarrow V = 150$ ml

18. $n_1 = \frac{2.463 \times 2}{25}$ & $n_2 = \frac{4.926 \times 1}{25}$

$\Rightarrow P_f \times 3 = \frac{9.852}{25} \times 25$

$\Rightarrow P_f = 3.284$ atm

19. $P_f . V_f = n_T . R \times T$

$\Rightarrow \frac{7}{6} \times 10 \times 2.4 = n_T \times 25$

$\Rightarrow n_T = 1.12$

Now, $n_T = n_1 + n_2$

As, $n_2 = \frac{20 \times .4}{25} = \frac{8}{25}$

$\Rightarrow n_1 = 1.12 - \frac{8}{25}$ = 0.8

Now, $n_1 = \frac{P_1 V_1}{RT}$

$\Rightarrow$ $P_1 = \dfrac{.8 \times 25}{2}$

$\Rightarrow$ P_1 = 10 atm or 1 MPa

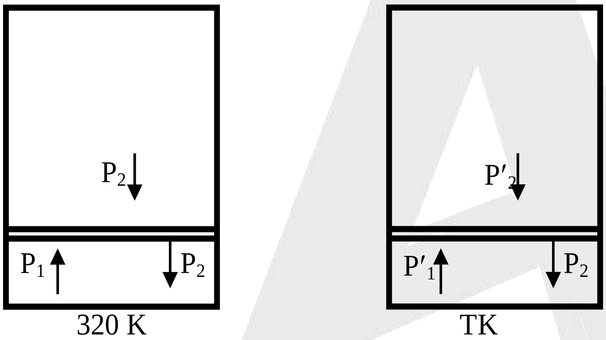
20. As, $n_i = n_f$

$$\Rightarrow \quad \frac{(P.V)\times n}{RT} = \frac{P_f \times V(1+2+3......n)}{RT}$$

$$\Rightarrow \quad P = \frac{P_f\,(n+1)}{2}$$

$$\Rightarrow \quad P_f = \left(\frac{2P}{n+1}\right)$$

21.



$$P_2 + P_0 = P_1 \qquad\qquad P_2' + P_0 = P_1'$$

$$P_0 = P_1 - P_2 = P_1' - P_2'$$

or,

$$\frac{n\times R\times 320}{\left(\frac{V}{5}\right)} - \frac{n\times R\times 320}{\left(\frac{4V}{5}\right)} = \frac{n\times R\times T}{\left(\frac{V}{4}\right)} - \frac{n\times R\times T}{\left(\frac{3V}{4}\right)}$$

$$\therefore T = 450\,K$$

Graham's Law of Diffusion and Effusion

22. $$\frac{r_{H_2}}{r_{O_2}} = \frac{P_{H_2}}{P_{O_2}}\sqrt{\frac{M_{O_2}}{M_{H_2}}}$$

$$= \frac{1\times 32}{2\times 8}\sqrt{\frac{32}{2}}$$

= 8

23. $\dfrac{r_{N_2}}{r_{SF_6}} = \sqrt{\dfrac{M_{SF_6}}{M_{N_2}}}$

$(dn)_{N_2} = \sqrt{\dfrac{146}{28}} \times (dn)_{SF_6}$

$= 2{\cdot}28 \times 100$

$= 228$

No. of molecules of N_2 present in the product gas for every 100 molecules of SF_6 is 228.

24. $\dfrac{r_{mix}}{r_x} = \sqrt{\dfrac{M_x}{M_{mix}}}$

$\dfrac{600}{200} = \sqrt{\dfrac{M_x}{20/3}}$

$9 = \dfrac{M_x}{20/3}$

$M_x = 9 \times \dfrac{20}{3}$

$M_x = 60g$

25. $\dfrac{r_{O_2}}{r_{mix.}} = \sqrt{\dfrac{M_{mix}}{M_{O_2}}}$

$\dfrac{336}{224} = \sqrt{\dfrac{M_{mix}}{32}} \Rightarrow \quad M_{mix.} = 72$

Now, Let molecular weight of unknown gas be x g

$\Rightarrow \quad 72 = \dfrac{3}{4} \times 32 + \dfrac{1}{4} \times x$

$\Rightarrow \quad x = 192$ gm

26. No $\rightarrow$ |$\longleftarrow$ x $\longrightarrow$|$\longleftarrow$ 100–x $\longrightarrow$| $\leftarrow O_2$

$\dfrac{r_{NO_2}}{r_{O_2}} = \sqrt{\dfrac{M_{O_2}}{M_{NO}}}$

$\dfrac{x}{100-x} = \sqrt{\dfrac{32}{30}}$

$\Rightarrow \quad x = 50{\cdot}8$ cm

27. At constant volume & temperature

$$P \propto W$$

Thus, for N_2 : P_1 = 2 atm, P_2 = 1/2 atm. at t = 1 hr.

$$\frac{P_1}{P_2} = \frac{W_1}{W_2}$$

$\Rightarrow$ $W_2 = \dfrac{14 \times 1/2}{2}$

$\Rightarrow$ $W_2 = \dfrac{14}{4}$

$\therefore$ wt. of N_2 diffused = $14 - \dfrac{14}{4}$

$= \dfrac{21}{4}$ kg.

For H_2 : P_1 = 2 atm, $P_2 = \dfrac{1}{2}$ at t = t hrs.

w_1 = 1 kg $w_2 \rightarrow$?

$\Rightarrow$ $w_2 = \dfrac{1}{4}$ kg

Hence, wt. of H_2 diffused = $1 - \dfrac{1}{4} = \dfrac{3}{4}$ kg.

Now, $\dfrac{r_A}{r_B} = \dfrac{\rho_B}{\rho_4}$

or, $\dfrac{V_A \times t_B}{V_B \times t_A} = \dfrac{\rho_B}{\rho_A}\sqrt{\dfrac{\rho_A}{\rho_B}}$

$$\frac{W_A \times t_B}{W_B \times t_A} = \frac{\rho_B}{\rho_A}\sqrt{\frac{\rho_A}{\rho_B}}$$

For our problem,

$$\frac{W_{H_2} \times t_{N_2}}{W_{N_2} \times t_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{N_2}}}$$

$$\frac{\frac{3}{4} \times 1}{\frac{21}{2} \times t} = \sqrt{\frac{2}{28}}$$

$\Rightarrow t = \frac{60}{14}$ mins

$\Rightarrow t = 16$ mins

28. (i) $\frac{r_{SO_2}}{r_{CH_4}} = \sqrt{\frac{M_{CH_4}}{M_{SO_2}}} = \sqrt{\frac{16}{64}}$

$\Rightarrow \frac{r_{SO_2}}{r_{CH_4}} = \frac{1}{2}$

(ii) $\frac{r_{SO_2}}{r_{CH_4}} = \frac{3\times16}{64\times2}\sqrt{\frac{1}{4}}$

$= \frac{3}{16}$

(iii) $\frac{r_{SO_2}}{r_{CH_4}} = 1\times\sqrt{\frac{1}{4}}$

$\Rightarrow \frac{r_{SO_2}}{r_{CH_4}} = 1$

29. using, Pv = nRT

$n_T = \frac{24.6\times3}{0.0821\times300}$

$\Rightarrow n_T = 3$

$\Rightarrow n_{H_2} = 2$ & $n_{D_2} = 1$

Now,

$$\frac{\left(\frac{n_{H_2}}{n_{B_2}}\right)_f}{\left(\frac{n_{H_2}}{n_{D_2}}\right)_i} = \left(\frac{M_{D_2}}{M_{H_2}}\right)^{\frac{n}{2}} \Rightarrow \frac{\left(\frac{1\times4}{4\times2}\right)}{\left(\frac{2}{1}\right)} = \left(\frac{1}{2}\right)^{\frac{n}{2}}$$

$\Rightarrow \frac{1}{4} = \left(\frac{1}{2}\right)^{\frac{n}{2}}$ $\Rightarrow \frac{1}{16} = \left(\frac{1}{2}\right)^{n}$

$\Rightarrow \left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^n$ $\Rightarrow n = 4$

Kinetic Theory of Gaseous

30. As, K.E = $\frac{3}{2}$ KT

$= \frac{3}{2} \times \frac{1.38 \times 10^{-23} \times 300}{1.6 \times 10^{-19}}$ ev

$= 3.88 \times 10^{-2}$ ev

$\Rightarrow x = 2$

Maxwell Distribution of Speeds

31. $(U_{r.m.s})_{SO_2}$ at TK = $(U_{Arg.})_{O_2}$ at 300K

$\left(\sqrt{\frac{3RT}{M}}\right)_{SO_2} = \left(\sqrt{\frac{8RT}{\pi M}}\right)_{O_2}$ at 300 K

$\Rightarrow \frac{3 \times T}{64} = \frac{8 \times 300}{\pi \times 32}$

$\Rightarrow$ T = 509.554 K Or 236.3°C.

32. (a) $m_{rms} = \sqrt{\frac{3RT}{M}}$

$= \sqrt{\frac{3 \times 8.314 \times 300}{2 \times 10^{-3}}}$ = 1934.24 ms^{-1}

(b) $\mu_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{nM}}$

$= \sqrt{\frac{3 \times 10^5 \times 5 \times 10^{-3}}{3 \times 2 \times 10^{-3}}}$ = 500 m/sec

(c) $\mu_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{d}}$

$= \sqrt{\frac{3 \times 10^5}{10^3}}$

$= \sqrt{300}$ = 17.32 m/sec

33. $U_{r.m.s} = \sqrt{\frac{3P}{P}}$

$$= \sqrt{\frac{3\times10^5\times10^{-6}}{3\times10^{-4}\times10^{-3}}}$$

$$= \sqrt{10^6} \qquad = 1000 \text{ m/s}$$

Collisions Among Gaseous Molecules

36. $\lambda = \dfrac{1}{\sqrt{2}\pi r^2 N^+}$ or $\dfrac{1\times KT}{\sqrt{2}\pi r^2\times P}$

$\Rightarrow \quad \dfrac{\lambda_2}{\lambda_1} = \dfrac{1}{5}$

$\Rightarrow \quad \lambda_2 = \dfrac{1}{5} \times \lambda_1$ or $\dfrac{1}{5}\times10$

$\Rightarrow \quad \lambda_2 = 2$ cm

37. $\lambda = \dfrac{KT}{\sqrt{2}\pi r^2\times P}$

on substituting the values, we get

$\lambda = 3.3\times10^3$ cm.

EXERCISE # O-II

1. $2A(g) \longrightarrow 3B(g) + 2C(g)$

$P_i \rightarrow$ 1   0   0

$P_f \rightarrow$ 0.8 $\left(\dfrac{3}{2}\times.2\right)$ 0.2

Total final pressure = (0.8 + 0.3 + 0.2) = 1.3 atm

$\Rightarrow$ Total pressure increases by 0.3 atm

As, $P_{gas} > P_{atm.}$

$\Rightarrow$ difference in mercury level is 22.8 cm or 228 mm.

2. Slope of P-T curve gives volume.

3. For untainer-1 before opening the value,

$P = \dfrac{nRT}{V} = \dfrac{2\times0.082\times300}{16.42} = 3$ atm.

Pressure in each compartment is same after opening the value, as total moles remains conserved.

4. $r \propto \dfrac{1}{\sqrt{M}}$

5. (A) Average kinetic energy per molecule of A is equal to that of B.

(B) Root mean square velocity of B is four times that of A

(C) Pressure exerted by B is eight time of that exerted by A

(D) Number of molecules of B, in the cylinder, is eight time that of A

6. (A) Average molecular speed of gases increases with decrease in fraction of molecules moving slowly

(B) Rate of effusion of gases increases with increase in collision frequency at constant volume.

7. $K.E \propto T$

8. Average angle of approach remains unaffected.

9. $U_{mps} \propto \sqrt{\dfrac{T}{M}}$

10. $P.e^{v/2} = nCT$

At $P = 1$ atm, $V = 0$

$\Rightarrow$ $i.e^{\circ} = 2 \times C \times 500$

$\Rightarrow$ $C = \dfrac{1}{1000}$

$\Rightarrow$ $C = 10^{-3}$ or 0.001

11. For P.T. curve, slope $= \dfrac{nc}{e^{v/2}}$

$$= \frac{2 \times 0.001}{e} = \frac{2}{1000\,e}$$

12.. $n = \dfrac{PV}{RT}$

$= \dfrac{1 \times 200}{0.0821 \times 200}$ $= 12.18$

As, $P = \dfrac{nCT}{e^{v/2}}$

$$= \frac{12.18 \times 0.001 \times 821}{e^{200/2}} = \frac{10}{e^{100}}$$

13. $\frac{r_1}{r_2} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}} = \frac{\ell_1 / t}{\ell_2 / t}$

$\frac{\ell_1}{\ell_2} = \frac{1}{x} = \frac{1}{2}\sqrt{\frac{64}{4}}$

$x = \frac{1}{2}$ m = 50 cm

14. $\frac{r_1}{r_2} = \frac{n_1}{n_2} = \sqrt{\frac{M_2}{M_1}}$

$\frac{4/2}{x/32} = \sqrt{\frac{32}{2}}$

$\frac{64}{x} = 4$

$x = 16$

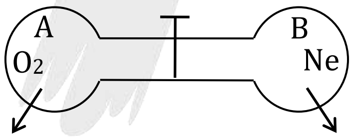
15. $P V = n R T$

$\frac{4.1\times 3}{300\times 0.0821} = n_x = 0.5 = n_{He} + n_x$

$n_x = 0.1$

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

$\frac{0.4}{0.1} = \sqrt{\frac{M}{4}}$ M = 64



$P_1 = 950$ mm $P_2 = 900$ mm

16.

$n_T = n_1 + n_2$

$$\frac{\frac{910}{760}\times(V_A + V_B)}{RT} = \frac{\frac{950}{760}V_A}{RT} = \frac{\frac{900}{760}V_B}{RT}$$

$V_B = 4V_A$

17. $n_T = \frac{\frac{910}{760}\times\left(\frac{5}{4}\times 304\right)}{0.08\times 300}$

$= 18.95$

$\frac{n_A}{n_B} = \frac{V_A}{V_B} = \frac{1}{4}$

$n_B = \frac{4}{5} \times n_T$

$n_B = 15.16$

$n_A = \frac{1}{5} \times n_T$

$= 3.790$

18. $y = \frac{1}{V^2}$ or $\sqrt{y} = \frac{1}{V}$

$P = X$ & $P = \text{constant}/V$

$A \longrightarrow R\ (X = K\sqrt{y} \Rightarrow y = K^1x^2)$

$B \longrightarrow S\ (V = KT, y = V\ \&\ \frac{1}{T} = x \quad \therefore y = \frac{K}{x})$

$C \longrightarrow P\ (P = RT; PT = RT^2 \text{ or } y = kx)$

$D \longrightarrow Q\ (V = \frac{C}{P} \Rightarrow y = c\sqrt{x}; y^2 = cx)$

EXERCISE # S-II

1. T_{max} at P_{max}

$PV = nRT$

$\frac{1}{8.21}$ $P \times 8.21 \times P = 1 \times 0.0821 \times T$

At $P = 10$ atm

$100 \times 8.21 = 1 \times 0.0821 \times T$

$T = 10000$ K

2. $P_{(glycerine)} = \frac{2.75 \times 5}{13.6} + 76 = 176$ cm of Hg

$\Rightarrow \quad n_{gas} = \frac{\frac{176}{76} \times 10}{0.0821 \times 300} \quad \Rightarrow \quad n_{gas} = 0.94$

3. $10 \times 4 = P_1 \times 8$

$P_1 = 5$

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

$$\frac{8}{300} = \frac{V_1}{600}$$

$V_1 = 16L$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{5}{600} = \frac{3}{T_3}$$

$$T_3 = \frac{600 \times 3}{5} = 360\ K$$

$$\frac{5}{300} = \frac{P_2}{T_4}$$

4. $P \propto d$

So $P = kd$

it $P_1 = 1$ atm $d_1 = 1$ m $\Rightarrow$ $K = 1$ atm m^{-1}

(a) $$\frac{P_1V_1}{n_1} = \frac{P_2V_2}{n_2}$$

$$\frac{P_1 \times \frac{4}{3}\pi r_1^3}{n_1} = \frac{P_2 \times \frac{4}{3}\pi r_2^3}{n_2}$$

$$\frac{1 \times 1}{1} = \frac{3 \times (3)^3}{n_2}$$

$n_2 = 81$

So moles of gas added = 81 – 1 = 80

(b) at 7 atm pressure d = 7 m

$V_{balloon} = 57.1\pi\ m^3$

So balloon will burst is its volume becomes $36\pi m^3$

$\frac{4}{3}\pi r^3 = 36\pi \quad \Rightarrow r = 3\text{ m}$

D = 6 m

P = 6 atm

$$\frac{P_1V_1}{n_1} = \frac{P_2V_2}{n_2}$$

$$\frac{1\times\frac{4}{3}\pi\times\frac{1}{8}}{1} = \frac{6\times36\pi}{n_2}$$

$n_2 = 1296$

moles added = 1296 – 1 = 1295

5. $\frac{r_{mix}}{r_{kr}} = \sqrt{\frac{M_{kr}}{M_{mix}}}$

$1.16 = \sqrt{\frac{84}{M_{mix}}}$

$M_{mix} = 62.42$

$62.42 = \frac{71}{1+\propto}$

$1 + \propto = \frac{71}{62.42} = = 1.137$

$\propto = 0.137$

6. $NH_4Cl(s) \longrightarrow NH_3(g) + HCl(g)$

	$NH_4Cl(s)$	$NH_3(g)$	$HCl(g)$
n_i	1	0	0
n_f	0	1	1

$$P_{gas} = \frac{2\times0.0821\times600}{24.63} = 4\text{ atm}$$

7. $A_2 \longrightarrow 2A$

	A_2	$2A$
n_i	1	0
n_f	0.5	1

PV = nRT

$P \times 33.6 = 1.5 \times 0.0821 \times 546$

$P = 2$ atm

8. (i) $P = \dfrac{nRT}{V}$

$= \dfrac{10^{-3} \times 0.08 \times 300}{2} = 0.012$ atm

(ii) $\dfrac{P_1}{n_1T_1} = \dfrac{P_2}{n_2T_2}$

$\dfrac{0.012}{10^{-3} \times 300} = \dfrac{1}{n_2 \times 600}$

$n_2 = \dfrac{1}{24}$

$N = \dfrac{6 \times 10^{23}}{24} = 2.5 \times 10^{22}$

(iii) KE total $= \dfrac{3}{2}$ RT × n

$= \dfrac{3}{2} \times 8 \times 300 \times 10^{-3}$

(vi) KE total $= \dfrac{3}{2} \times 8 \times 6000 \times \dfrac{1}{24}$

$= 300$ J

(v) $\dfrac{\mu_{mps}, A}{m_{mps}, B} = \sqrt{\dfrac{T_A}{T_B}} = \dfrac{1}{\sqrt{2}}$

(vi) $Z_{11} = \dfrac{1}{\sqrt{2}} \pi\sigma^2 \mu_{avg} (N)^2$

$z_{11} \propto \dfrac{P^2}{T^{\frac{3}{2}}}$

$\dfrac{z_{11}, A}{z_{11}, B} = \left(\dfrac{12 \times 10^{-3}}{1}\right) 2 \times \left(\dfrac{600}{300}\right)^{3/2} = 0.4 \times 10^{-3} : 1$

9. (a) $\lambda = \dfrac{1}{\sqrt{2}\pi\sigma^2 N^*}$

$N^* = \dfrac{1}{\sqrt{2}\times 3.14\times(0.26\times10^{-9})^2\times 2.6\times10^{-5}}$

$N^* = 1281\times10^{20}\ M^{-3}$

(b) $N^* = \dfrac{P}{KT}$

$1281\times10^{20} = \dfrac{P\times6\times10^{23}}{8.314\times300}$

$P = 530.6$ Pa

EXERCISE # JEE-MAIN

1. Factual

2. $2BCl_3 + 3H_2 \longrightarrow 2B + 6HCl$

mole : $\left(\frac{21.6}{10.8}\right) = 2$

$n_{H_2} = 3$

$\Rightarrow$ Volume of H_2 at 273K & 1 atm

= 3 × 22.4

= 67.2 L

3. K. E $\propto$ T

$\Rightarrow \frac{(K.E)_{40°C}}{(L.E)_{20°C}} = \frac{313}{293}$

4. P $\propto$ n

$\Rightarrow \frac{P_{CH_4}}{P_{O_2}} = \frac{w \times 32}{16 \times w} = \frac{2}{1}$

Fraction of total pressure excreted by O_2 is $\frac{1}{3}$

5. $u \propto \sqrt{T}$

6. u > v > a

7. As, V remains constant

$n \propto \frac{1}{T}$

i.e. $n_1T_1 = n_2T_2$

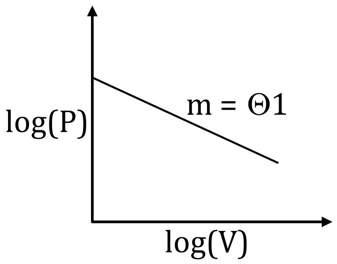
$\Rightarrow n_1 \times 300 = \frac{3}{5} n_1 \times T_2$

$\Rightarrow T_2 = \frac{300 \times 5}{3}$

$\Rightarrow T_2 = 500$ k

8. As $P = \frac{nRT}{V}$

$\Rightarrow$ $\log(P) = \log(nRT) + \log\left(\frac{1}{V}\right)$



or, $\log(P) = \log(nRT) - \log(V)$

For, 1 mole ideal gas,

$$\log(P) = \log(RT) - \log(V)$$

9. $\sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3}$

10. Factual

11. $U_{rms} = \sqrt{\frac{3RT}{m}}$

i.e. $U_{rms} \propto \sqrt{T}$

$$\frac{5\times10^4}{10\times10^4} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{1}{4} = \frac{T_1}{T_2}$$

$\Rightarrow (T_2 = 4T_1)$

12. $U_{mps} = C = \sqrt{\frac{2RT}{m}}$

$V_{Avg} = \overline{C} = \sqrt{\frac{8RT}{\pi m}}$ & $U_{rms} = C = \sqrt{\frac{3RT}{m}}$

$\Rightarrow C : \overline{C} : C = 1 : 1.128 : 1.225$

13.

Element	% (by mass)	relation no. of moles	Simplest atomic ratio
N	87.5	$\frac{87.5}{14} = 6.25$	$\frac{6.25}{6.25} = 1$
H	12.5	$\frac{12.5}{1} = 12.5$	$\frac{12.5}{6.25} = 2$

Empirical formula = NH_2

Molar mass of compound = 32

As, molecular formula = n × empirical formula

$\Rightarrow n = \frac{32}{16} = 2$

$\Rightarrow$ (m.f = N_2H_4)

14. $P_1V_1 = P_2V_2$

$840 \times 750 = 360 \times V_2$

$\Rightarrow V_2 = \frac{840 \times 750}{360}$

$\Rightarrow V_2 = 1750$ ml or 1.750 L

15. $(U_{rms})_{O_2} = (U_{rms})_{He}$

$\sqrt{\frac{3R \times T}{32}} = \sqrt{\frac{3R \times 300}{4}}$

$\Rightarrow \frac{T}{32} = \frac{300}{4}$

$\Rightarrow T = \frac{32 \times 300}{4}$

$\Rightarrow T = 2400$ K

16. Factual

17. $V_{rms} \times \sqrt{\frac{T}{M}}$

T is doubled

M is lalfed

$V'_{rms} = \sqrt{4}\ V_{rms}$

$V'_{rms} = 2\ V_{rms}$

$= 2\ \mu$

18. $(n_i)_T = (n_f)_T$

$\frac{P_1V}{RT_1} + \frac{P_1V}{RT_1} = \frac{P_fV}{RT_1} + \frac{P_fV}{RT_2}$

$\frac{2P_1V}{RT_1} = \frac{P_fV}{R}\left(\frac{1}{T_1} + \frac{1}{T_2}\right)$

$\Rightarrow P_f = 2P_1\left(\frac{T_2}{T_1+T_2}\right)$

19. $V_1 = V_2$, $n_2 = \frac{3}{5} n_1$

$n_1T_1 = n_2T_2$

$n_1(300) = n_2 (T_2)$

$300 = \frac{3}{5} T_2$

$T_2 = 500$ K

20. $V_A = 2V_B$

$Z_A = 3Z_B$

$\frac{Z_A}{Z_B} = \frac{P_A}{P_B}\frac{V_A}{V_B}$

$3 = \frac{P_A}{P_B} \times 2 \quad \Rightarrow \quad 2P_A = 3P_B$

21. $n_A = 0.5$ $n_B = x$ mole

For the container

P = 200 Pa

V = 10 m^3

T = 1000 K

P V = n R T

$200 \times 10 = (0.5 + x)\, R \times 1000$

$0.5 + x = \frac{2}{R}$

$x = \frac{2}{R} - 0.5 \quad \Rightarrow \quad \frac{4-R}{2R}$

22. V_{MPS} is proportional to $\sqrt{\frac{T}{M}}$

23. if volume of 3 cm balloon is = V

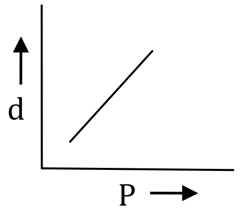
then volume of 12 cm radius balloon = 64V

So pressure will become 1/64 times = $1/64 \times 48 \times 10^{-3}$ bar = 750×10^{-6} bar

24. $d = \frac{PM}{RT}$

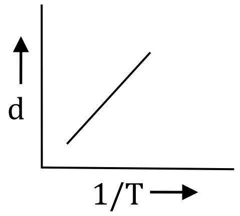
d Vs P

$d = \left(\frac{M}{RT}\right)P$



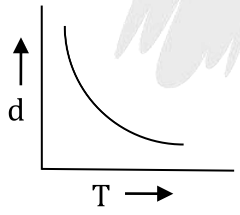
d Vs $\frac{1}{T}$

$d = \left(\frac{PM}{R}\right).\frac{1}{T}$



d Vs T

$d \times T = \frac{PM}{R}$



25. Assuming ideal behaviour $P = \frac{dRT}{M}$

$P = \frac{100}{760}$ atm T = 257 + 273 = 530 K

d = 0.46 gm/L

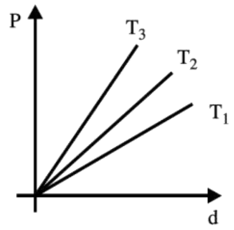
So, $M = \frac{0.46 \times 0.082 \times 530}{100} \times 760$

= 151.93

≈ 152

26. P vs d:

$$P = \left(\frac{RT}{M}\right)d$$



$T_3 > T_2 > T_1$

27. O_2 + Ne

Xgm 200gm

P_{total} = 25 bar ; P_{Ne} = 20

$$P_{O_2} + P_{Ne} = 25$$

$$P_{O_2} = 25 - 20 = 5l$$

$$5 = \frac{\frac{x}{32}}{\frac{x}{32} + \frac{200}{20}} \times 25$$

$$\frac{1}{5} = \frac{\frac{x}{32}}{\frac{x}{32} + 10}$$

$$\frac{1}{5} = \frac{x \times 32}{32(x + 320)}$$

5x = x + 320

4x= 320

$$x = \frac{320}{4} = 80\,gm$$

EXERCISE # JEE-ADVANCED

1. $n_{He} = \frac{.4}{4} = 0.1$

$n_{O_2} = \frac{1.6}{32} = 0.05$

$n_{N_2} = \frac{1.4}{28} = 0.05$

$P_T = \frac{0.2 \times 0.0821 \times 300}{10}$

$P_T = 0.492$ atm

$P_{He} = \frac{0.1}{0.2} \times 0.492$

$\Rightarrow P_{He} = 0.246$ atm

2. According to Graham's Law,

$\frac{r_A}{r_B} \propto \frac{P_A}{P_B}\left(\frac{M_B}{M_A}\right)^{1/2}$

3. Mass of liquid = 148 – 50 = 98g

Volume of liquid = $\frac{98}{0.98}$ = 100 ml = volume of flask

Mass of gas = 50.5 – 50 = 0.50 g

Using, PV = nRT, we get

$M = \frac{wRT}{PV} = \frac{0.5 \times 0.082 \times 300}{1 \times 0.1}$

$\Rightarrow M = 123 \text{ g mol}^{-1}$

4. For a fixed amount of gas at constant volume,

$P \propto T$

$\frac{1}{1.1} = \frac{T}{T+10}$

$\Rightarrow T = 100$ K or Θ 173°C

Also, $V = \frac{nRT}{P} = \frac{12}{120} \times \frac{0.0821 \times 100}{1}$

$\Rightarrow V = 0.82$ L

5. For the same amount of gas being diffused,

$$\frac{r_1}{r_2} = \frac{t_2}{t_1} = \frac{P_1}{P_2}\sqrt{\frac{M_2}{M_1}}$$

$$\frac{57}{38} = \frac{0.8}{1.6}\sqrt{\frac{M_2}{28}}$$

$\Rightarrow M_2 = 252 \text{ g mol}^{-1}$

The formula of compound can be considered to be XeF_n

$\Rightarrow 131 + 19n = 252$

$\Rightarrow n = 6$

$\Rightarrow$ The unknown gas is XeF_6.

6. $(U_{rms})_{H_2} = \sqrt{7}(U_{rms})_{N_2}$

$$\frac{T_{(H_2)}}{2} = 7 \times \frac{T_{(N_2)}}{28}$$

$$\Rightarrow T_{(H_2)} = \frac{T_{(N_2)}}{2}$$

$$\Rightarrow T_{(H_2)} < T_{(N_2)}$$

7. **Statement-1:** False, Besides amount, pressure also depends on volume.

Statement-2: True as $u_{rms} \propto \sqrt{T}$

8. $U_{rms} = \sqrt{\frac{3RT}{m}} = \sqrt{\frac{3P}{d}}$

$$\Rightarrow U_{rms} \propto \left(\frac{1}{d}\right)^{1/2}$$

9. For an ideal gas , V_m = 22.4 lit at 273 K & 1 atm.

In option (C), at the initial point, the volume is 22.4 lit. as required by the ideal gas equation & $\left(\frac{V}{T}\right)$ have the same value at both initial & final points.

10. $\frac{V_{Avg}}{U_{rms}} = \sqrt{\frac{8RT}{\pi m}} \div \sqrt{\frac{3RT}{m}}$

$$= \sqrt{\frac{8}{3\pi}}$$

$\Rightarrow U_{rms} = \sqrt{\frac{3\pi}{8}} \times 400$

$= \sqrt{\frac{3 \times 3.14}{8}} \times 400$

$\Rightarrow U_{rms} = 434.17$ m/s.

11. $U_{rms} = \sqrt{\frac{3RT}{M}}$ ....(1)

The average kinetic energy (E) of the gas is given by the following expression.

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

$RT = \frac{2}{3}E$ ......(2)

Substitute (2) into (1)

$U_{rms} = \sqrt{\frac{3 \times \frac{2}{3}E}{M}}$

$U_{rms} = \sqrt{\frac{2E}{M}}$

12. Given that for absorbed N_2 on surface sites,

$P_{N_2} = 0.001$ atm, $V = 2.46$ cm^3

$= 2.46 \times 10^{-3}$ *l*, T = 298 K

$\therefore\ n_{N_2} = \frac{PV}{RT} = \frac{0.001 \times 2.46 \times 10^{-6}}{0.0821 \times 298} = 1.0 \times 10^{-7}$

Molecules of absorbed $N_2 = 1.0 \times 10^{-7} \times 6.023 \times 10^{23} = 6.023 \times 10^{16}$

Total surface sites available = Number of sites

per cm^2 × Area = $60.23 \times 10^{14} \times 1000 = 6.023 \times 10^{17}$

Surface sites on which N_2 is absorbed = 20% × Available sites

$= \frac{20}{100} \times 6.023 \times 10^{17} = 12.046 \times 10^{16}$

$\therefore$ Number of sites absorbed per molecule of

$N_2 = \dfrac{12.046\times10^{16}}{6.023\times10^{16}} = 2$

13. $\dfrac{r_{He}}{r_{CH_4}} = \sqrt{\dfrac{16}{4}} = 2$

14. $(U_{rms})_x$ at 400 K = $(U_{mps})_y$ at 60 K

$\Rightarrow \sqrt{\dfrac{3R\times400}{40}} = \sqrt{\dfrac{2R\times60}{m_y}}$

$\Rightarrow \dfrac{3\times400}{40} = \dfrac{2\times60}{m_y}$

$\Rightarrow m_y = \dfrac{2\times60\times40}{3\times400}$

$\Rightarrow m_y = 4$

15. Partial pressure of He = 1 – 0.68 = 0.32

$V = \dfrac{n_{He}.R_T}{P_{He}}$

$= \dfrac{0.1\times0.082\times273}{0.32}$

$\Rightarrow$ V = 7 lit.

$\Rightarrow$ Volume of container = volume of He.

16. Let distance covered by X is d, then distance covered by Y is (24 – d)

If r_x & r_y are the rate of diffusion of gases X & Y

$\dfrac{r_x}{r_y} = \dfrac{d}{24-d} = \sqrt{\dfrac{40}{10}} = 2$

$\Rightarrow$ d = 16 cm

17. The experimental value of d is found to smaller than the estimated value obtained using Graham's law. This is due to increased collision frequency of Y with the inert gas as compared to that of X with the inert gas. ($\because$ As, the collision frequency increases, the molecular speed decreases much more than expected.)

18. (DC) Diffusion coefficient $\propto \lambda$ (mean free path) $\propto U_{mean}$

Thus (DC) $\propto \lambda\, U_{mean}$

But $\lambda = \dfrac{RT}{\sqrt{2}\, N_0 \sigma p} \Rightarrow \lambda \propto \dfrac{T}{p}$

and $U_{mean} = \sqrt{\dfrac{8RT}{\pi M}}$

$U_{mean} \propto \sqrt{T}$

$\therefore$ $DC \propto \dfrac{(T)^{3/2}}{p}$

$$\frac{(DC)_2}{(DC)_1}(x) = \left(\frac{p_1}{p_2}\right)\left(\frac{T_2}{T_1}\right)^{3/2} = \left(\frac{p_1}{2p_1}\right)\left(\frac{4T_1}{T_1}\right)^{3/2}$$

$$= \left(\frac{1}{2}\right)(8) = 4$$

19. Finally, $P_A = P_B$ & $T_A = T_B$

So, $\dfrac{n_A}{n_B} = \dfrac{V_A}{V_B}$

$$\frac{\dfrac{5}{400R}}{\dfrac{3}{300R}} = \frac{V_A}{V_B}$$

$\Rightarrow \dfrac{V_A}{V_B} = \dfrac{5}{4}$ $\Rightarrow V_A = \dfrac{5}{9} \times 4 = \dfrac{20}{9} = 2.22$

20. The root mean square speed (U_{rms}) and average translational kinetic energy ($\in_{av}$) has following relation with temperature and molecular mass

$\in_{av} = \dfrac{3}{2} RT$, $U_{rms} = \sqrt{\dfrac{3RT}{M}}$ and $U_{rms} \propto \dfrac{1}{\sqrt{M}}$

$\therefore$ $\in_{av}$ doesn't depend on its molecular mass.

According to the relation given above $\in_{av}$ gets doubled when the temperature is increased 2 times. Thus option B is incorrect.

21. As a symmetrical graph is given, the average value of speed will be the middle symmetrical speed which is also the most probable speed.

When we are calculating the rms speed we have to take the average of square of speeds and its root. In square of speed, higher speeds will give more contribution so the value will be more than the average value.