PHYSICS

Q.1 A vessel is filled with a gas at a pressure of 76 cm of mercury at a certain temperature. The mass of the gas is increased by 50 % by introducing more gas in the vessel at the same temperature. The resultant pressure, in cm of Hg, is -

(A) 76 (B) 152 (C) 114 (D) 1117 **[C]**

Sol. $P \propto m$

Since m is increased by a factor of $\frac{3}{2}$,

therefore, P will increase by a factor of $\frac{3}{2}$.

$\therefore$ New pressure = $\frac{3}{2} \times 76$ cm of Hg

= 114 cm of Hg.

Q.2 One mole of ideal monoatomic gas (γ = 5/3) is mixed with two mole of diatomic gas (γ = 7/5). What is γ for mixture ?

(A) 3/2 (B) $\frac{23}{15}$

(C) $\frac{19}{13}$ (D) 4/3 **[C]**

Sol. $\gamma_{mix} = \frac{\mu_1 C_{p_1} + \mu_2 C_{p_2}}{\mu_1 C_{v_1} + \mu_2 C_{v_2}}$

$$= \frac{\left(1\times\frac{5}{2}R\right)+\left(2\times\frac{7}{2}R\right)}{\left(1\times\frac{3}{2}R\right)+\left(2\times\frac{5}{2}R\right)} = \frac{19}{13}$$

Q. 3 RMS velocity of an ideal gas at 27°C is 500 m/s. Temperature is increased four times, rms velocity will become -

(A) 1000 m/s (B) 560 m/s

(C) 2000 m/s (D) None of these **[B]**

Sol. $v_{rms} \propto \sqrt{T}$ [T = temperature in Kelvin]

$T_1 = 27 + 273 = 300$ K

$T_2 = 4 \times 27 + 273 = 381$ K

$\therefore v_2 = \sqrt{\frac{381}{300}} \times 500 \simeq 560$ m/s

Q. 4 One kg of a diatomic gas is at a pressure of 8×10^4 N/m^2. The density of the gas is 4 kg/m^3. What is the energy of the gas due to its thermal motion ? **[AIEEE- 2009]**

(A) 3×10^4 J (B) 5×10^4 J

(C) 6×10^4 J (D) 7×10^4 J **[B]**

Sol. $E = \frac{f}{2} RTn.$

Since gas is diatomic hence f = 5

$E = \frac{5}{2}$ RTn ($\because$ PV = nRT)

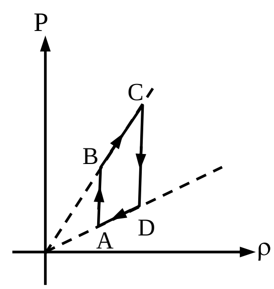
$E = \frac{5}{2}$ PV

$E = \frac{5}{2}\frac{PM}{D}\left(\begin{matrix} M = \text{Mass} \\ D = \text{Density}\end{matrix}\right)$

$E = \frac{5}{2} \times \frac{8\times10^4\times1}{4} = 5 \times 10^4$ J.

So option (2) is correct.

Q. 5 Pressure versus density graph of an ideal gas is shown in figure -



(A) during the process AB work done by the gas is positive

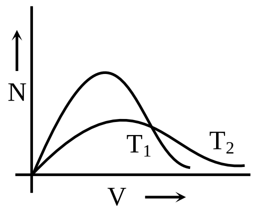
(B) during the process AB work done by the gas is negative

(C) during the process BC internal energy of the gas is increasing

(D) none of these **[D]**

Sol. As density increases, work done is – ve.

Q. 6 Maxwell's velocity distribution curve is given for two different temperatures. For the given curves -

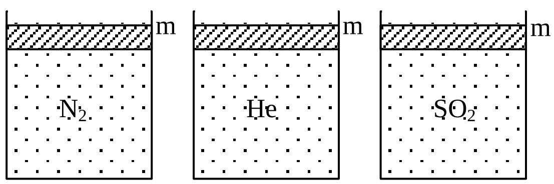


(A) $T_1 > T_2$ (B) $T_1 < T_2$

(C) $T_1 \leq T_2$ (D) $T_1 = T_2$ **[B]**

Sol. Higher is the temperature greater is the most probable velocity.

Q.7 Container below are filled with three different gases as shown. Piston is made to oscillate in below three cases. Time Period of oscillation is T_A, T_B, T_C. Then-



(A) $T_A > T_B > T_C$ (B) $T_C > T_A > T_B$
(C) $T_C > T_B > T_A$ (D) $T_B > T_A > T_C$

Sol. **[B]**

Time period of oscillation of piston is $T \propto \frac{1}{\sqrt{r}}$

where $\gamma = C_p/C_v$ adiabatic exponent
$\gamma_{mono} = 5/3$; $\gamma_{di} = 7/5$; $\gamma_{poly} = 4/3$

$\therefore \quad \gamma_{mono} > \gamma_{di} > \gamma_{poly}$

Q. 8 An ideal gas is held in a container of volume V at pressure P. The average speed of a gas molecule under these conditions is v. If now the volume and pressure are changed to 2V and 2P, the average speed of a molecule will be

(A) 1/2 v (B) v
(C) 2v (D) 4v

Sol. **[C]**

$PV = \frac{1}{3} m_o N v_{rms}^2$

$(2P)\,(2V) = \frac{1}{3} m_o N v'^2_{rms}$

$\varpi'_{rms} = 2v_{rms} = 2v$

Q.9 At NTP the density of a gas is 1.3 kg/m^3 and the velocity of sound propagation in the gas is 330 m/s. The degree of freedom of gas molecule is-

(A) 3 (B) 5
(C) 6 (D) 7 **[B]**

Sol.

$V = \sqrt{\gamma P / \rho}$

$330 = \sqrt{\gamma \times \frac{1 \times 10^5}{1.3}}$

$\frac{(33)^2 \times 100 \times 1.3}{1 \times 10^5} = \gamma$

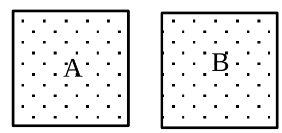
$\frac{1.089 \times 10^3 \times 10^2 \times 1.3}{1 \times 10^5} = \gamma$

$\frac{2}{f} + 1 = \gamma = 1.4 = 7/5$

$\frac{2}{f} = 2/5$

$f = 5$

Q.10



Two containers A & B contain ideal gases helium and oxygen respectively. Volume of both containers are equal and pressure is also equal. Container A has twice the number of molecules than container B then if v_A & v_B represent the rms speed of gases in containers A & B respectively, then -

(A) $\frac{v_A}{v_B} = \sqrt{2}$

(B) $\frac{v_A}{v_B} = 4$

(C) $\frac{v_A}{v_B} = 2$

(D) $\frac{v_A}{v_B} = \sqrt{8}$

Sol. **[C]**

$T_A = \frac{P_A V_A}{n_A R}$ and $T_B = \frac{P_B V_B}{n_B R}$

Given, $P_A = P_B$, $V_A = V_B$ and $n_A = 2n_B$

$\therefore \qquad T_A = \frac{T_B}{2}$

Now, $\frac{V_A}{V_B} = \sqrt{\frac{T_A}{T_B} \times \frac{M_B}{M_A}} = 2$

Q.11 P-V diagram of a diatomic gas is a straight line passing through origin. The molar heat capacity of the gas in the process will be -

(A) 4R (B) 2.5 R

(C) 3 R (D) $\frac{4R}{3}$ **[A]**

Sol. P = KV

PV = nRT

KV^2 = nRT

2KVdV = nRdT

$W = \int KVdV = \frac{nR}{2}\int dT = \frac{nR}{2}\Delta T$

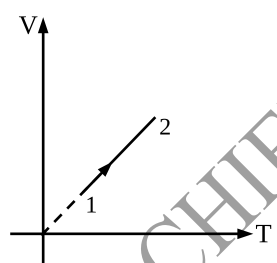
from first law of thermodynamics

$Q = W + \Delta U$

$nC\Delta T = \frac{nR}{2}\Delta T + nC_V\Delta T$

$C = \frac{R}{2} + C_V = \frac{R}{2} + \frac{7R}{2} = 4R$

Q.12 Volume versus temperature graph of two moles of helium gas is as shown in figure. The ratio of heat absorbed and the work done by the gas in process 1-2 is -



(A) 3 (B) 5/2

(C) 5/3 (D) 7/2 **[B]**

Sol. $\frac{Q}{W} = \frac{nC_p\Delta T}{nR\Delta T}$

Q.13 2 mole of an ideal monoatomic gas mix with 1 mole of a ideal diatomic gas. The $\frac{C_P}{C_V}$ for the mixture is -

(A) $\frac{15}{11}$ (B) $\frac{17}{11}$

(C) $\frac{13}{11}$ (D) None **[B]**

Sol. $\frac{2+3}{\gamma_{min-1}} = \frac{2}{\frac{5}{3}-1} + \frac{1}{\frac{7}{5}-1}$

$\frac{3}{\gamma_{min-1}} = 3 + \frac{5}{2}$

$\frac{3}{\gamma_{min-1}} = \frac{11}{2}$

$\gamma_{min-1} = \frac{6}{11}$

$\gamma_{min} = \frac{6}{11} + 1 = \frac{17}{11}$

Q.14 Molecule of a gas can be modelled as three sphere connected through three rigid rods as to make triangle like structure. A gas containing such molecules performs 25 J of work when it expands at constant pressure. Heat given to gas is –

(A) 75 J (B) 100 J

(C) 150 J (D) 125 J **[B]**

Sol. For isobaric process

$\frac{Q}{W} = \frac{K+2}{K}$ [K = degree of freedom]

$Q = \frac{6+2}{2} \times 25 = 100$ J

Q.15 Choose the incorrect statement regarding the energy of gas molecules -

(A) Average KE of a diatomic gas molecule at normal temp is $\frac{5}{2}$ kT.

(B) Average translational KE of a molecule is $\frac{1}{2} m' v_{av}^2$ where m′ is the mass of molecules and v_{av} is the average speed of the molecules

(C) Average translational KE of all the gas molecules is the same as $\frac{3}{2}$ kT

(D) Rotational KE of all the diatomic gas molecules is the same as kT **[B]**

Sol. It is $\frac{1}{2} m' v_{rms}^2$.

Q.16 The absolute temperature of a gas increases 3 times. The root mean square velocity of the molecules will become:

(A) 3 times (B) 9 times

(C) (1/3) times (D) $\sqrt{3}$ times **[D]**

Sol. $v_{rms} \propto \sqrt{T}$

So, $\sqrt{3}$ times

Q.17 A triatomic molecule can be modelled as three rigid sphere joined by three rigid rods forming an triangle. Consider a triatomic gas consisting such molecule. If gas performs 30 J work when it expands under constant pressure the heat given to gas is -

(A) 60 J (B) 30 J

(C) 45 J (D) 120 J **[D]**

Sol. $\frac{\Delta Q}{W} = \frac{C_P}{R}$

$C_P = \left(\frac{f}{2}+1\right) R$

(f = degree of produce)

$= 4R$

$\therefore \Delta Q = 4W = 120$ J

Q.18 An ideal diatomic gas occupies a volume V_1 at a pressure P_1. The gas undergoes a process in which the pressure is proportional to the volume. At the end of process the rms speed of the gas molecules has doubled from its initial value then the heat supplied to the gas in the given process is -

(A) 7 P_1V_1 (B) 8 P_1V_1

(C) 9 P_1V_1 (D) 10 P_1V_1 **[C]**

Sol. As $P \propto V$

$\therefore$ PV^{-1} = constant

Also, $C = C_V - \frac{R}{x-1} = \frac{5}{2}R - \frac{R}{-1-1} = 3R$

But as rms speed is doubled therefore temperature becomes four times.

Hence, $Q = nC\Delta T = n \times 3R \times 3T_i = 9\,nRT_i$

$= 9\,P_1V_1$

Q.19 The molar heat capacity in a process of a diatomic gas if it does a work of $\frac{Q}{4}$ when a heat of Q is supplied to it is -

(A) $\frac{2}{5}$ R (B) $\frac{5}{2}$ R

(C) $\frac{10}{3}$ R (D) $\frac{6}{7}$ R **[C]**

Sol. From first law of thermodynamics

$Q = W + \Delta U$

$Q = \frac{Q}{4} + nC_V\Delta T$

$\frac{3Q}{4} = nC_V\Delta T$

$\frac{3}{4}\, nC\Delta T = nC_V\Delta T$

Q.20 The root mean square velocity of the molecules in a sample of helium is 5/7[th] that of the molecules in a sample of hydrogen. If the temperature of the hydrogen sample is 0ºC, that of helium samples is about:

(A) 0ºC (B) 0 K

(C) 273ºC (D) 100ºC **[A]**

Sol. $v_{H_e} = \frac{5}{7} v_{H_2}$

$\sqrt{\frac{3RT}{4}} = \frac{5}{7}\sqrt{\frac{3R \times 273}{2}}$

Q.21 If the rms velocity of oxygen molecule at certain temperature is 0.5 km/s, the rms velocity for hydrogen molecule at the same temperature will be:

(A) 2 km/s (B) 4 km/s

(C) 9 km/s (D) 16 km/s **[A]**

Sol. $\frac{v_{O_2}}{v_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{O_2}}} = \sqrt{\frac{2}{32}}$

$\frac{0.5}{v_{H_2}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$

Q.22 The speeds of three molecules of a gas are 3v, 4v and 5v respectively. Their rms speed will be-

(A) $\sqrt{\frac{50}{3}}$ v

(B) $\sqrt{\frac{3}{50}}$ v

(C) $\frac{\sqrt{50}}{3}$ v

(D) 4 v **[A]**

Sol. $v_{rms}^2 = \frac{(3v)^2 + (4v)^2 + (5v)^2}{3}$

Q.23 For a gas, $\gamma = 1.4$, then atomicity of gas, C_P and C_V are respectively -

(A) monoatomic] $\frac{5}{2}R$, $\frac{3}{2}R$

(B) monoatomic] $\frac{7}{2}R$, $\frac{5}{2}R$

(C) diatomic] $\frac{7}{2}R$, $\frac{5}{2}R$

(D) triatomic] $\frac{7}{2}R$, $\frac{5}{2}R$ **[C]**

Sol. $\gamma = 1.4$

$\therefore C_P = \frac{7}{2}R$ and $C_V = \frac{5}{2}R$

Q.24 1 mole of a monoatomic and 2 mole of diatomic gas are mixed, Now the resulting gas is taken through a process in which molar heat capacity was found 3R. Polytropic constant in the process is -

(A) $-\frac{1}{5}$ (B) $\frac{1}{5}$

(C) $\frac{2}{5}$ (D) None of these **[A]**

Sol. $C = Cv_{mix} + \frac{R}{1-n}$; $Cv_{mix} = \frac{n_1Cv_1 + n_2Cv_2}{n_1 + n_2}$

Q.25 One mole of an ideal monoatomic gas is mixed with one mole of an ideal diatomic gas. The molar specific heat of this mixture at constant volume is-

(A) R (B) $\frac{3}{2}R$

(C) 2 R (D) 2.5 R **[C]**

Sol. $\because (C_V)_{mix} = \frac{n_1C_{V_1} + n_2C_{V_2}}{n_1 + n_2}$

For monoatomic $C_{V_1} = \frac{3}{2}R$

For diatomic $C_{V_2} = \frac{5}{2}R$

$(C_V)_{mix} = \frac{1\times\frac{3}{2}R + 1\times\frac{5}{2}R}{1+1} = 2R$

Q.26 In a diatomic gas translatory, rotatory and vibratory degrees of freedom are present. Then C_P/C_V value is-

(A) 1.66 (B) 1.4

(C) 1.29 (D) 1.33 **[B]**

Sol. For diatomic

$\gamma = 1.4$

Q.27 The ratio of diameters of two spheres made of same materials is 1 : 2. Then ratio of their heat capacities is -

(A) 1 : 2 (B) 1 : 8

(C) 1 : 4 (D) 2 : 1 **[B]**

Sol. $\frac{(H.C)_1}{(H.C.)_2} = \frac{m_1C_{gm_1}}{m_2C_{gm_2}} = \frac{r_1^3}{r_2^3} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$

$\because m = \rho V = \rho \times \frac{4}{3}\pi r^3$ and

$\rho_1 = \rho_2$, $C_{gm_1} = C_{gm_2}$

Q.28 The ratio of specific heats of an ideal gas is -

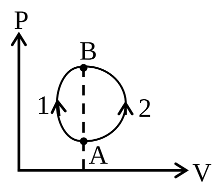
(A) $\frac{1}{1-\frac{R}{C_P}}$ (B) $1+\frac{R}{C_V}$

(C) $\frac{1}{1-\frac{C_V}{R}}$ (D) $\frac{C_V}{C_P}+R$ **[B]**

Sol. $\because C_P - C_V = R$, $\frac{C_P}{C_V} - 1 = \frac{R}{C_V}$

$\therefore \frac{C_P}{C_V} = \gamma = 1 + \frac{R}{C_V}$

Q.29 A certain amount of an ideal gas is taken from state A to state B first along process 1 and then along process 2. If the amount of heat absorbed by the gas is Q_1 and Q_2 respectively then -



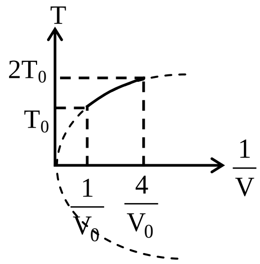
(A) $Q_1 > Q_2$ (B) $Q_1 < Q_2$

(C) $Q_1 = Q_2$ (D) data insufficient **[A]**

Sol. $W_1 > W_2$

$\Delta U_1 = \Delta U_{2ff}$

Q.30 Figure shows a parabolic graph between T and $\frac{1}{V}$ for a mixture of a gas undergoing an adiabatic process. What is the ratio of V_{rms} of molecules and speed of sound in mixture -



(A) $\sqrt{\frac{3}{2}}$ (B) $\sqrt{2}$

(C) $\sqrt{\frac{2}{3}}$ (D) $\sqrt{3}$ **[B]**

Sol. $T_0^2 V_0$ = constant

$\Rightarrow \gamma = 3/2$

$$\frac{V_{rms}}{V_{sound}} = \sqrt{\frac{3}{\gamma}} = \sqrt{2}$$

Q.31 N moles of monoatomic gas having translational KE 2U per molecule are mixed adiabatically inside a rigid boundry container with N moles of diatomic gas having translational KE U per molecule. What is final temperature of mixture ?

(A) $\frac{3N_AU}{8R}$ (B) $\frac{11N_AU}{12R}$

(C) $\frac{3N_AU}{12R}$ (D) None **[B]**

Sol. $(n_1 Cv_1 + n_2 Cv_2) T_f = n_1 Cv_1 T_1 + n_2 Cv_2 T_2$

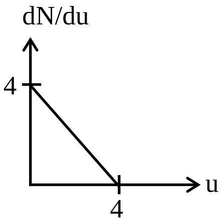
Q.32 Total K.E. per molecules of O_2 gas at 0ºC is -

(A) 0 (B) 273 K

(C) $\frac{3}{2} \times 273$ K (D) $\frac{5}{2} \times 273$ K **[D]**

Sol. $K_{total} = \frac{5}{2}$ K T

Q.33 Consider a hypothetical dN/du Vs u graph for an ideal gas particles. The root mean square speed of given distribution is -



(A) $\sqrt{\frac{8}{3}}$ (B) $\frac{2}{\sqrt{3}}$

(C) $\frac{4}{\sqrt{3}}$ (D) None **[A]**

Sol. $$V_{rms} = \frac{\int_0^4 u^2 dN}{\int_0^4 dN}$$

Q.34 The rotational K.E. of 2 gm H_2 gas at 27ºC is -

(A) RT (B) 2RT

(C) 1.5 RT (D) 2.5 RT

(R $\rightarrow$ Universal gas constant) **[A]**

Sol. $K_{rotational} = \frac{2}{2} \times 1 \times R\,T$

$= RT$

Q.35 The ratio of total K.E. per molecule of O_2 and He at same temperature is -

(A) 1 : 1 (B) 5 : 3

(C) 8 : 1 (D) 2 : 3 **[B]**

Sol. $$\frac{KE_{O_2}}{KE_{He}} = \frac{\frac{5}{2}kT}{\frac{3}{2}kT} = \frac{5}{3}$$

Q.36 The root mean square velocity of the molecules in a sample of helium is 5/7th that of the molecules in a sample of hydrogen. If the temperature of the hydrogen sample is 0°C, that of helium samples is about -

(A) 0°C (B) 0 K

(C) 273°C (D) 100°C **[A]**

Q.37 The rms velocity of a gas at a given temperature is 300 m/s. What will be the rms velocity of a gas having twice the molecular weight and half the temperature in K ?

(A) 300 m/s (B) 600 m/s

(C) 75 m/s (D) 150 m/s **[D]**

Q.38 It takes for an electric kettle to heat a certain quantity of water from 0°C to boiling point

(100°C) in 15 minutes. It requires 80 minutes to turn all the water at 100°C into steam. The latent heat of steam is -

(A) 513.3 cal/g (B) 493.6 cal/g
(C) 533.3 cal/g (D) 425.4 cal/g **[C]**

Q.39 A calorimeter contains 70.2 g of water at 15.3°C. If 143.7 g of water at 36.5°C in mixed with it the common temperature is 28.7°C. The water equivalent of the calorimeter is -

(A) 15.6 g (B) 9.4 g
(C) 6.3 g (D) 13.4 g **[D]**

Q.40 Calculate the time required to heat 20 kg of water from 10°C to 35°C using an immersion heater rated 1000 W. Assume that 80% of the power input is used to heat the water. Specific heat capacity of water = 4200 J/kg-K.

(A) 24 min (B) 34 min
(C) 44 min (D) 54 min **[C]**

Q.41 The root mean square (rms) speed of oxygen molecules (O_2) at a certain absolute temperature is v. If the temperature is doubled and the oxygen gas dissociates into atomic oxygen, the rms speed would be -

(A) v (B) $\sqrt{2}$v
(C) 2v (D) $2\sqrt{2}$v **[C]**

Q.42 A gas has volume V and pressure P. The total translational kinetic energy of all the molecules of the gas is -

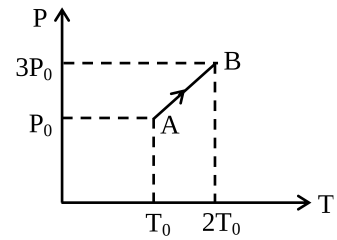
(A) $\frac{3}{2}$PV only if the gas is monoatomic

(B) $\frac{3}{2}$ PV only if the gas is diatomic

(C) > $\frac{3}{2}$ PV if the gas is diatomic

(D) $\frac{3}{2}$ PV in all cases **[D]**

Q.43 Pressure versus temperature graph of an ideal gas is as shown in figure. Density of the gas at point A is ρ_0. Density at B will be –



(A) $\frac{3}{4}\rho_0$ (B) $\frac{3}{2}\rho_0$
(C) $\frac{4}{3}\rho_0$ (D) $2\rho_0$ **[B]**

Q.44 A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300 K. The ratio of the average rotational kinetic energy per O_2 molecule to per N_2 molecule is -

(A) 1 : 1
(B) 1 : 2
(C) 2 : 1
(D) Depends on the moment of inertia of the two molecules **[A]**

Q.45 A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is -

(A) 4 RT (B) 15 RT
(C) 9 RT (D) 11 RT **[D]**

Q.46 The ratio of average translational kinetic energy to rotational kinetic energy of a diatomic molecule at temperature T is -

(A) 3 (B) 7/5
(C) 5/3 (D) 3/2 **[D]**

Q.47 One mole of an ideal gas at STP is heated in an insulated closed container until the average velocity of its molecules is doubled. Its pressure would therefore increases by factor -

(A) 1·5 (B) $\sqrt{2}$
(C) 2 (D) 4 **[D]**

Q.48 Two vessels of the same volume contain the same gas at same temperature. If the pressure in the vessels be in the ratio of 1 : 2, then –

(A) The ratio of the average kinetic energy is 1 : 2
(B) The ratio of the root mean square velocity is

1 : 1

(C) The ratio of the average velocity is 1 : 2

(D) The ratio of number of molecules is 1: 2

[D]

Q.49 At 0°C, the value of the density of a fixed mass of an ideal gas divided by its pressure is x. At 100°C, this quotient is -

(A) $\frac{100}{273}x$ (B) $\frac{273}{100}x$

(C) $\frac{273}{373}x$ (D) $\frac{373}{273}x$ **[C]**

Sol. $P = \rho \frac{RT}{M_w}$

$$\frac{\rho}{P} = \frac{M_w}{RT}$$

$$\left(\frac{\rho}{P}\right)_{0°C} = \frac{M_w}{R \times 273} = x$$

$$\left(\frac{\rho}{P}\right)_{100°C} = \frac{M_w}{R \times 373} = \frac{273}{373}x$$

Q.50 Jar A filled with gas characterized by parameter P,V and T and another jar B filled with a gas with parameter 2P, V/4 and 2T. The ratio of the number of molecules in jar A to those in jar B is-

(A) 1 : 1 (B) 1 : 2

(C) 2 : 1 (D) 4 : 1 **[D]**

Sol. $N = \frac{PV}{KT}$

$$\frac{N_A}{N_B} = \frac{PV}{KT} \times \frac{K2T}{2P(V/4)} = \frac{4}{1}$$