Q-1 - 11796759

The ratio of the number of moles of a monoatomic to a polyatomic gas in a mixture of the two, behaving as an diatomic gas is : (vibrational modes of freedom is to be ignored)

(A) $2:1$

(B) $1:2$

(C) $2:3$

(D) $3:2$

CORRECT ANSWER: B

SOLUTION:

Let the required ratio be $n : 1$

$Q_1 = n\left(\frac{f_1 R}{2}\right)\Delta T$ and $Q_2 = 1\left(\frac{f_3 R}{2}\right)\Delta T$

and Q

$$= (n+1)\left(\frac{f_2 R \Delta T}{2}\right)$$

$Q = Q_1 + Q_2$, so $(n+1)f_2 = nf_1 + f_3$

or,

$(n+1)5 = n(3) + 6$

$\Rightarrow n = 1/2$

.

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Q-2 - 13074435

Three containes of the same volume contain three different gases. The masses of the molecules are m_1, m_2 and m_3 and the number of molecules in their respective containers are N_1, N_2 and N_3. The gas pressure in the containers are P_1, P_2 and P_3 respectively. All the gases are now mixed and put in one of the containers. The pressure P of mixture will be

(A) $P < (P_1 + P_2 + P_3)$

(B) $P = \frac{P_1 + P_2 + P_3}{3}$

(C) $P = P_1 + P_2 + P_3$

(D) $P > (P_1 + P_2 + P_3)$

CORRECT ANSWER: C

SOLUTION:

$P = P_1 + P_2 + P_3$ (Dalton's law of partial pressures)

Q-3 - 10059053

Three closed vessels A, B and C are at the same temperature T and contain gasses which obey the Maxwellian distribution of velocities. Vessel A contain only O_2 and N_2. If the average speed of the O_2 molecules in vessel A is v_1 that of the N_2 molecules in vessel B us v_2, the average speed of the O_2 molecules in vessel C is

(A) $\frac{v_1 + v_2}{2}$

(B) v_1

(C) $(v_1 v_2)^{\frac{1}{2}}$

(D) $\sqrt{\frac{3kT}{M}}$

CORRECT ANSWER: B

SOLUTION:

(b) All three vessels are at same temperature.

According to Maxwell's distrubution of speed, average speed of molecules of a gas $v \propto \sqrt{T}$.

$\therefore$ The velocity of oxygen molecules will be same in A as well as C.

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Q-4 - 15085730

A close container of volume $0.02m^3$ contains a mixture of neon and another gas A of unknown molecular mass. The container contains 4 g of Neon and 24 g of gas A. At a temperature of $27C$ the pressure of the mixture is $105N/m^2$. Is there any possibility of finding gas A in the atmosphere of a planet of radius 600 km and mean density $r = 5x103kg/m^3$?

Temperature of the planet is $2200C$.

Molar molecular mass of neon = 20 g,

Gas constant $R = 8.314\text{J mol}^1 K^1$

Gravitational constant $G = 6.67x10^{11} Nm^2 kg^2$

CORRECT ANSWER: NO

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Q-5 - 9098419

The mercury manometer consists if two unequal arms of equal cross section `1 cm^(2) and lenghths 100cm and 50cm. The two open ends are sealed with air in the tube at a pressure of 80cm of mercurey. Some amount of mercury is now introduced in the manometer through the stopcock connected to it. If mercury rises in the shorter tube to a lenght 10cm in steady state, find the length of the mercury column risen in the longer tube.

SOLUTION:

Let p_1 and p_2 be the pressures in centimetre of mercury in the two arms ater introducing mercury in the tube.

Suppose the mercury column rises in the second arm to

$l_0 cm$.

using

$pV = cons\tan tf$ or

$thesh$ or $terarm$,

(80cm) (50cm)= p_(1)(50cm-10cm)

or, p_(1)=100cm. ...(i) Using pV=constant fir the longer

arm,

$(80cm)(100cm)$

$= p_2(100 - l_0)cm$

....(ii)

From the figure,

$p_1 = p_2 + (l_0 - 10)cm$.

Thus by (i)

$100cm = p_2$

$+ (l_0 - 10)cm$

$p_2 = 100cm - l_0 cm$.

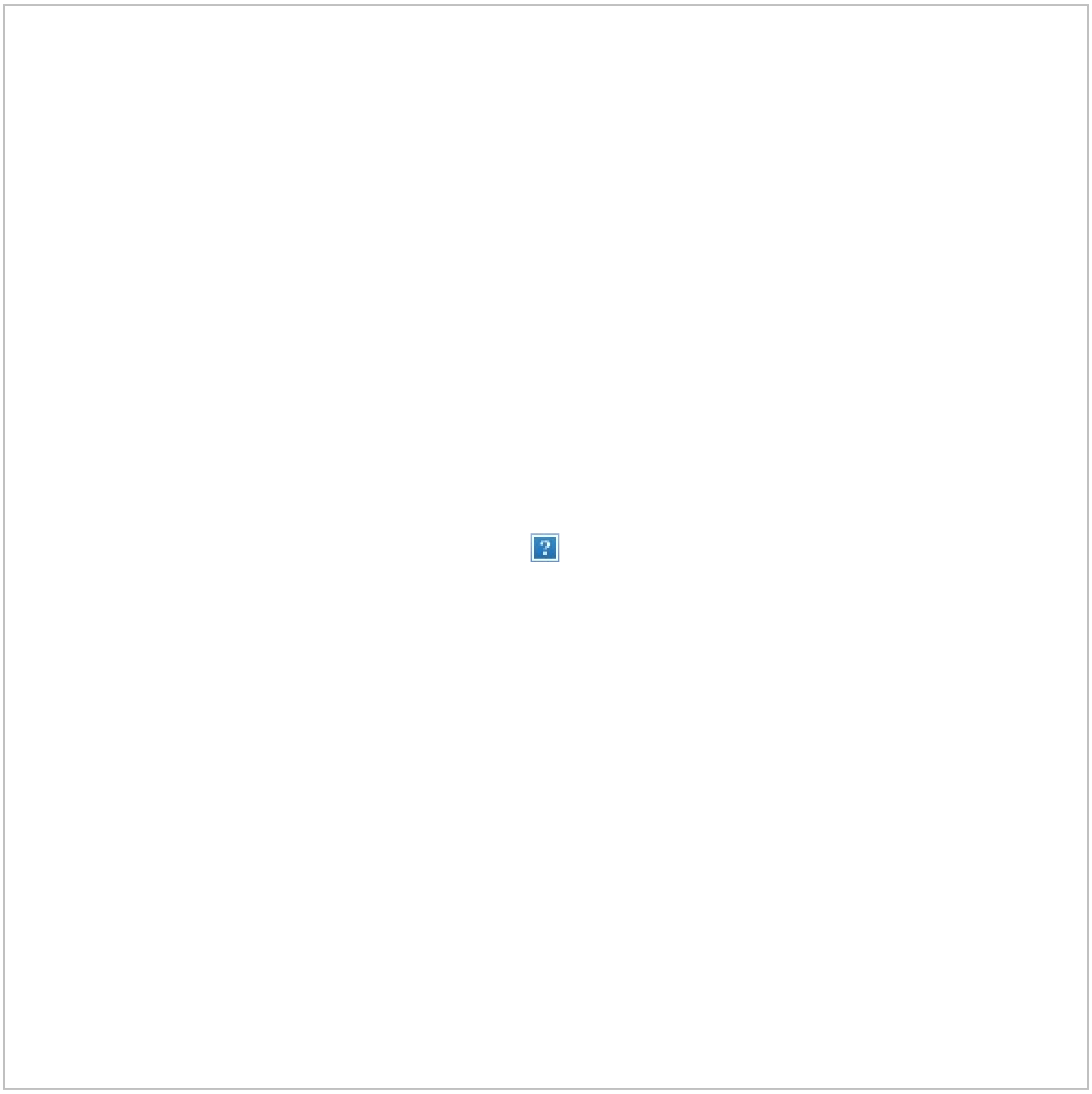
Putting in (ii),

$$(110 - l_0)(100 - l_0)$$
$$= 8000$$

or, $l_0^2 - 210 l_0 + 3000 = 0$

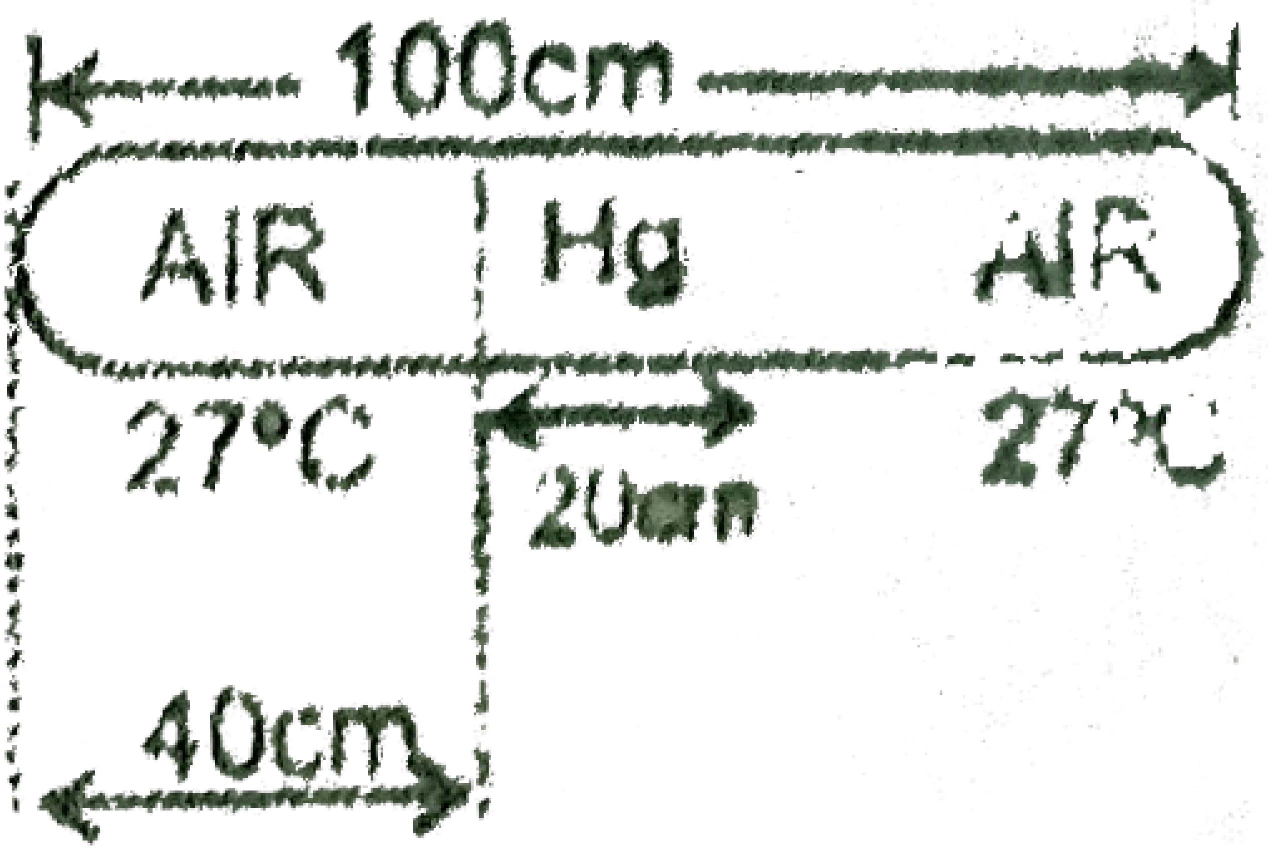
or, $l_0 = 15.5$.

The requrired length is $15.5 cm$.



Q-6 - 14162982

In the given figure a glass tube lies horizontally with the middle $20cm$ containing mercury. The two ends of the tube contains air at $27C$ and at a pressure $76cm$ of mercuy. Now the air column on one side in maintained at $0C$ and the other side is maintained at $127C$. Find the new length of the air column on the cooler side. Neglect the changes in the volume of mercury and of the glass.



CORRECT ANSWER: $L = \dfrac{21840}{673} CM$

SOLUTION:

At equilibrium pressure on both side is same, for initial

condition $PV = n_1 RT$ and $PV = n_2 RT$

here $n_1 = n_1$ and $n_2 = n_2$

for

$n_1 = n'_1 \Rightarrow \dfrac{pA \times 40}{R \times 300}$

$= \dfrac{p'A \times x}{R \times 273}. (1)$

for

$n_2 = n'_2 \Rightarrow \dfrac{pA \times 40}{R \times 300}$

$= \dfrac{p'A \times (80 - x)}{R \times 400}$

...(2)

form (1) & (2)

$$\frac{x}{273} = \frac{80 - x}{400} \Rightarrow x$$

$$= \frac{80 \times 273}{673}$$

$$= \frac{21840}{673} cm$$

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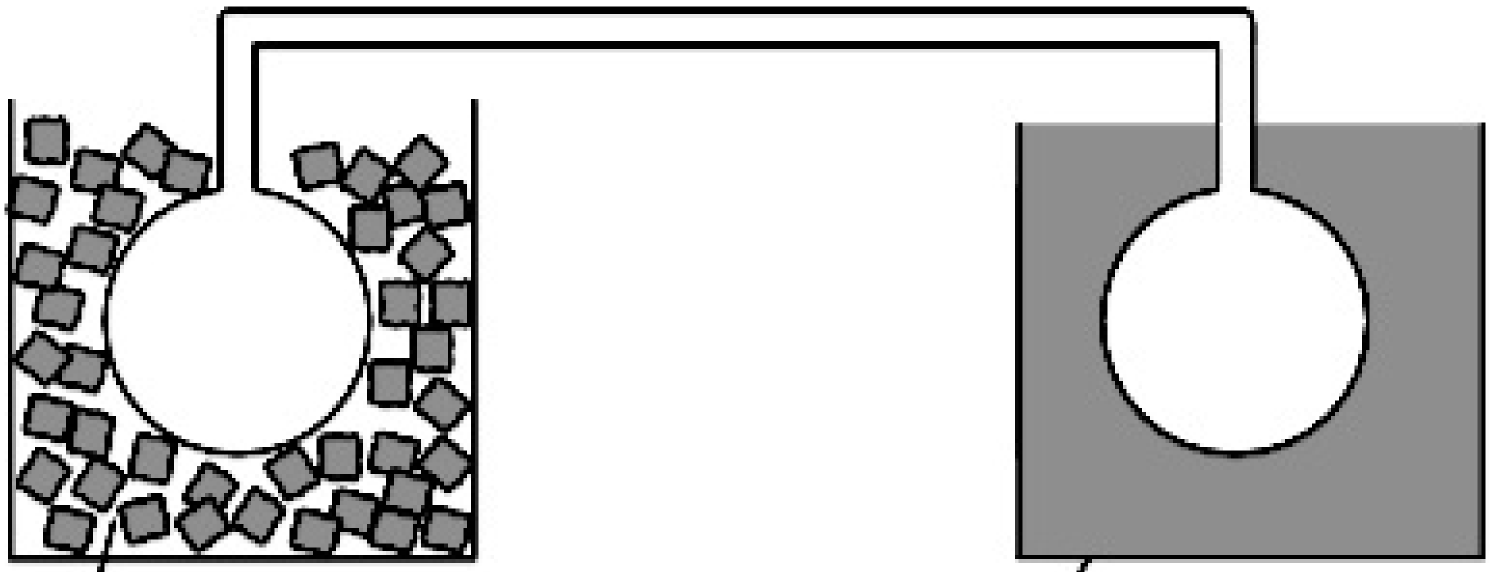
Q-7 - 15085723

Two identical glass bulbs are interconnected by a thin tube of negligible volume. An ideal gas is filled in the bulbs at STP. One bulb is placed in a tub of melting ice and the other bulb is placed in a hot bath. The gas pressure in the bulbs becomes 1.5 times. Find the tem perature of the hot bath. Which bulb has more gas?



CORRECT ANSWER: 819 K

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Q-8 - 11796768

A gas in a vessel is at the pressure P_0. If the masses of all the molecules be made hall and their speed be made double, them the resultant pressure will be

(A) $4P_0$

(B) $2P_0$

(C) P_0

(D) $P_0 / 2$

CORRECT ANSWER: B

SOLUTION:

$$P' = \frac{1}{3} \frac{\left(\frac{m}{2}\right) n}{V} (2C)^2$$
$$= 2P_0$$

.

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Q-9 - 14155728

Two vessels having equal volume contain molecular hydrogen at one atmosphere and helium at two atmospheres respectively. What is the ratio of rms speeds of hydrogen molecule to that of helium molecule if both the samples are at same temperature.

(A) $(V_{rms})_n = (V_{rms})_{He}$

(B) $(V_{rms})_{He} = \sqrt{2}(V_{rms})_H$

(C) $(V_{rms})_H = \sqrt{2}(V_{rms})_{He}$

(D) $(V_{rms})_H = 2(V_{rms})_{He}$

CORRECT ANSWER: C

SOLUTION:

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\Rightarrow v_{rms} \propto \frac{1}{\sqrt{M}}$$

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Q-10 - 12009401

Assertion : The ratio C_P / C_v for a diatomic gas is more than that for a monoatomic gas.

Reason : The moleculess of a monoatomic gas have more degrees of freedom than those of a diatomic gas.

(A) If, both Assertion and reason are ture and the Reason is the correct explanation of the Assertion.

(B) If both, Assertion and reason are true but Reason is not a correct expationation of the Assertion.

(C) If Assertion is true but the Reason is false.

(D) If Both, Assertion and reason are false.

CORRECT ANSWER: D

SOLUTION:

For a monoatomic gas, no of degree of freedom $n = 3$, and for a diatomic gas, $n = 5$.

As,

$$\frac{C_p}{C_v} = \gamma = 1 + \frac{2}{n}$$

$$\therefore \left(\frac{C_p}{(C_v)_{mono}}\right.$$

$$> \left(\frac{C_p}{(C_v)_{di}}\right.$$

Both the assertion and reason are false.

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Q-11 - 12009090

Find γ for a mixture of gases containing n_1 moles of a monoatomic gas and n_2 moles of a diatomic gas. Assuming diatomic molecules to be right.

SOLUTION:

$\gamma = ?$

Internal energy of n_1 of monoatomic gas

$$\Delta U_1 = n_1\left(\frac{3}{2}RT\right)\Delta T$$

Internal energy of n_2 moles of diatomic gas

$$\Delta U - \Delta U_1 + \Delta U_2$$

$$= \frac{R}{2}(3n_1 + 5n_2)\Delta T$$

If C_V is specific heat at constant volume for the mixture

containing $(n_1 + n_2)$ moles,

then $C_V = \dfrac{\Delta U}{(n_1 + n_2)\Delta T}$

C_V

$$= \frac{R}{2}\frac{(3n_1 + 5n_2)\Delta T}{(n_1 + n_2)\Delta T}$$

$$= \frac{(3n_1 + 5n_2)}{(n_1 + n_2)}\frac{R}{2}$$

Now, $C_p = C_v + R$

$$= \frac{R}{2} \frac{(3n_1 + 5n_2)}{n_1 + n_2} + R$$

$$= \frac{R}{2} \left[\frac{3n_1 + 5n_2}{(n_1 + n_2)} + 2 \right]$$

$$C_p = \frac{R}{2} \left(\frac{5n_1 + 7n_2}{n_1 + n_2} \right)$$

$$\gamma = \frac{C_p}{C_v} = \frac{5n_1 + 7n_2}{3n_1 + 5n_2}.$$

Q-12 - 11796776

The rms speed of oxygen molecules at a certain temperature T is v. If the temperature is doubled and oxygen gas dissociates into atomic oxygen, then the rms speed

(A) remains same

(B) becomes double

(C) increase by a factor of

(D) None of these

CORRECT ANSWER: B

SOLUTION:

$$C' = \sqrt{\frac{3R(2T)}{m/2}}$$

$$= 2C$$

.

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Q-13 - 12009198

Three vessel of equal capacity have gases at the same temperature and pressure. The first vessel contains neon (monoatomic), the second contains chlorine (diatomic), and the third contains uranium hexafluoride (polyatomic). Do the vessels contains equal number of respectice molecules ? Is the root mean square speed of molecules the same in the three cases ? If not, which case is v_{rms} the largest?

SOLUTION:

All the three vessels (at the same temperature and pressure) have same volume. So, in according with the Avogadro's law, the three vessels will contain equal number of respective molecules, being equal to avogadro's number $N = 6.023 \times 10^{23}$

As, $v_{rms} = \sqrt{\frac{3kT}{m}}$. i.e., at a given temp.

$v_{rms} \propto \frac{1}{\sqrt{m}}$

Therefore, rms speed of molecules will not be the same in the three cases.

As neon has the smallest mass, therefore, rms speed will be the largest in case of neon.

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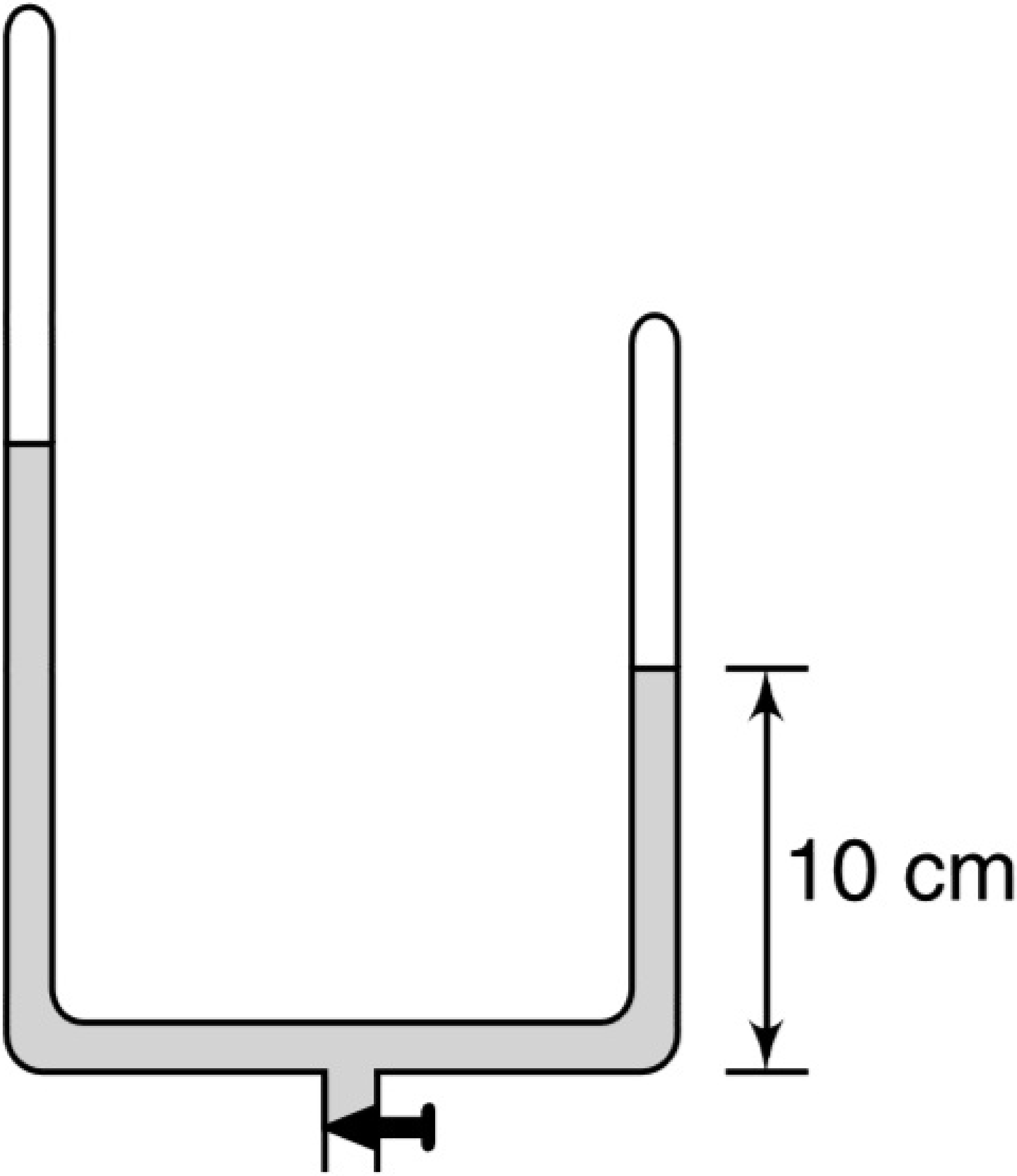
Q-14 - 15085720

A U shaped tube has two arms of equal cross section and lengths $l_1 = 80$ cm and $l_2 = 40$ cm. The open ends are sealed with air in the tube at a pressure of 80 cm of mercury. Some mercury is now introduced in the tube through a stopcock connected at the bottom (the air is not allowed to leak out). In steady condition the length of mercury column in the shorter arm was found to be 10 cm. Find the length of the mercury column in the longer arm. Neglect the volume of the part of the tube connecting two arms and assume that the temperature is constant.



CORRECT ANSWER: 16.27 CM

Q-15 - 13074488

If pressure of CO_2 (real gas) in a container is given by $P=\dfrac{RT}{2V-b}-\dfrac{a}{4b^2}$, then mass of the gas in container is

(A) $11g$

(B) $22g$

(C) $33g$

(D) $44g$

CORRECT ANSWER: C

SOLUTION:

van der Walls gas equation for n moles of real gas

$$\left(P+\frac{n^2a}{V^2}\right)(V-nb)$$
$$=nRT$$

$$P = \frac{nRT}{V - nb} - \frac{n^2 a}{V^2}$$
$$= \frac{RT}{\frac{V}{n} - b} - \frac{a}{V^2 / n^2}$$
(i)

Given equation

$$P = \frac{RT}{2V - b} - \frac{a}{4b^2} \text{ (ii)}$$

Comparing (i) and (ii)

$$n = \frac{1}{2} = \frac{M}{M_0} = \frac{M}{44}$$
$$M = 22g$$

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Q-16 - 15085733

The core of the sun is a plasma. It is at a temperature of the order of 10^7 K and contains equal number of protons and electrons. The density of the core of the Sun is $10^5 kgm^3$. Assume that molar mass of proton is 1g mol^1 and the mass of an electron to be negligible compared to the mass of a proton. Estimate the pressure at the core of the sun. Assume that plasma behaves like an ideal gas.

CORRECT ANSWER: $2XX10^{16}P_A$

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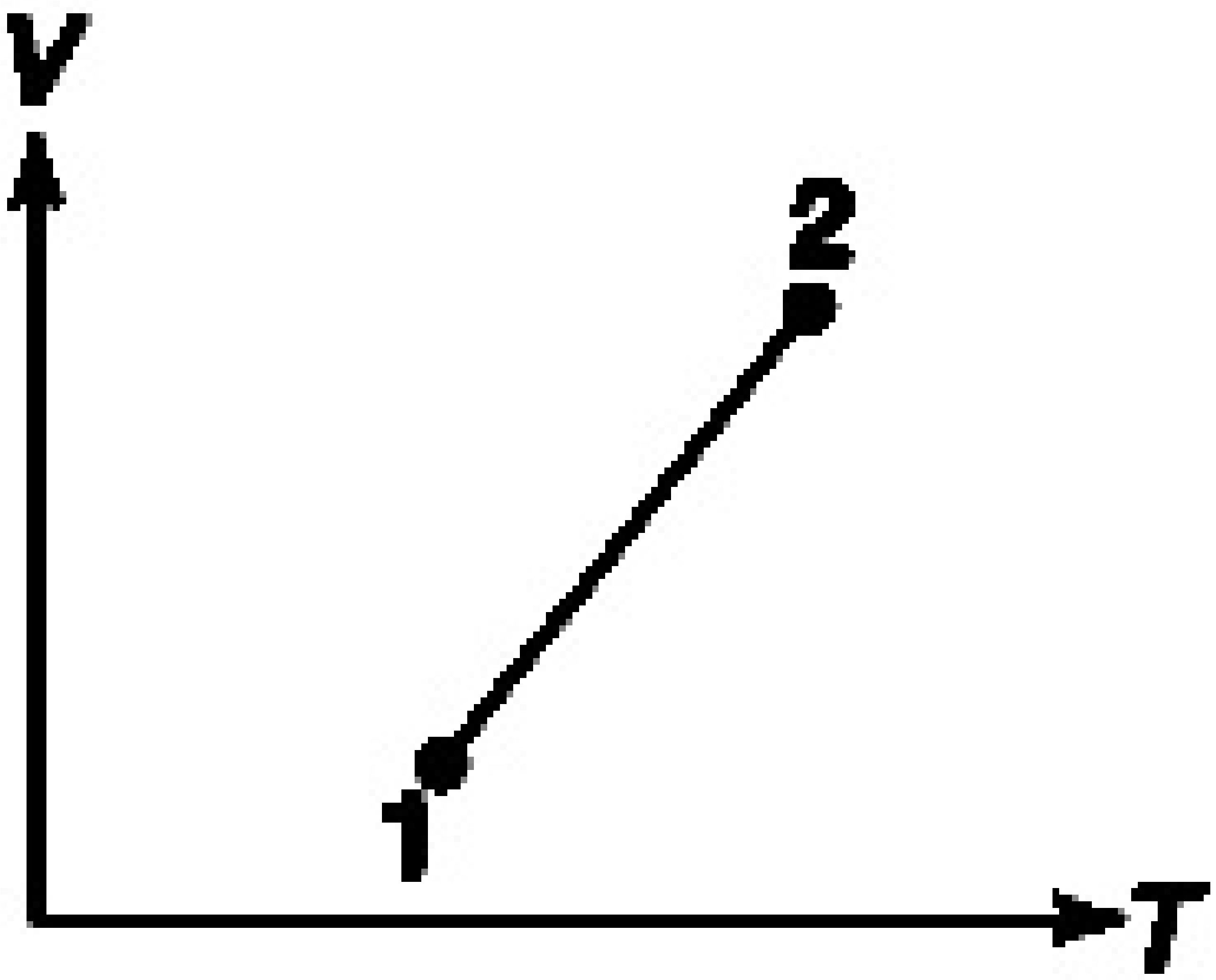
Q-17 - 15085725

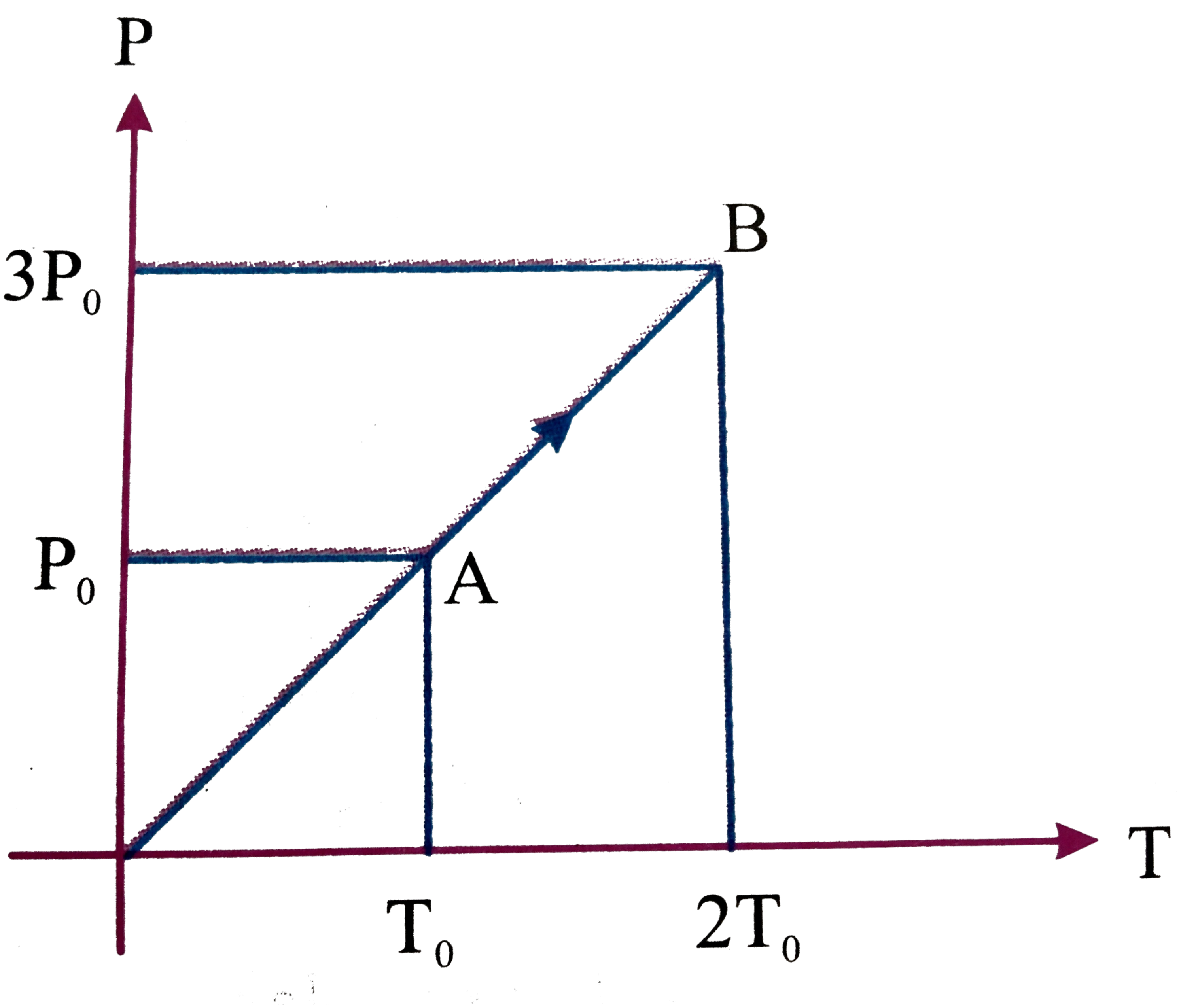
Two states 1 and 2 of an ideal gas has been shown in VT graph. In which state is the pressure of the gas higher?



CORRECT ANSWER: STATE 1

Q-18 - 14155698

Pressure versus temperature graph of an ideal gas is shown in figure. Density of the gas at point A is P_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) $2\rho_0$

CORRECT ANSWER: B

SOLUTION:

$$\rho = \frac{PM}{RT} \text{ or } \rho \propto \frac{P}{T}$$
$$\left(\frac{P}{T}\right)_A = \frac{P_0}{T_0} \text{ and } \left(\frac{P}{T}\right)_B = \left(\frac{3}{2}\right)\frac{P_0}{T_0}$$
$$\left(\frac{P}{T}\right)_B = \frac{3}{2}\left(\frac{P}{T}\right)_A$$
$$\therefore \rho_B = \frac{3}{2}\rho_A = \frac{3}{2}\rho_0$$

.

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Q-19 - 11796788

The temperature at which rms velocity of helium molecules is equal to the rms velocity of hydrogen molecules at NTP is

(A) $100K$

(B) $300K$

(C) $502K$

(D) $546K$

CORRECT ANSWER: D

SOLUTION:

$$C = \sqrt{\frac{3RT}{M}} \text{ or } T$$
$$\propto M$$

$$\therefore \frac{T'}{T} = \frac{4}{2} = 2 \text{ or } T$$
$$' = 2T$$

or

$$T = 2 \times 273K$$
$$= 546K$$

.

Q-20 - 12009208

A gas mixture consists of 2.0 moles of oxygen and 4.0 moles of neon at temperature T. Neglecting all vibrational modes, calculate the total internal energy of the system. (Oxygen has two rotational modes.)

SOLUTION:

Oxygen has 5 degree of freedom $\therefore$ Energy per mole of oxygen = $\frac{5}{2}RT$

For 2 moles of oxygen , energy, $E_1 = 5RT$

Neon has 3 degrees of freedon $\therefore$ Energy per mole of neon = $\frac{3}{2}RT$

For 4 moles of neon energy ,

$$E_2 = 4 \times \frac{3}{2} RT$$
$$= 6RT$$

Total energy of mixture =
$$E_1 + E_2 = 5RT$$
$$+ 6RT = 11RT$$

.

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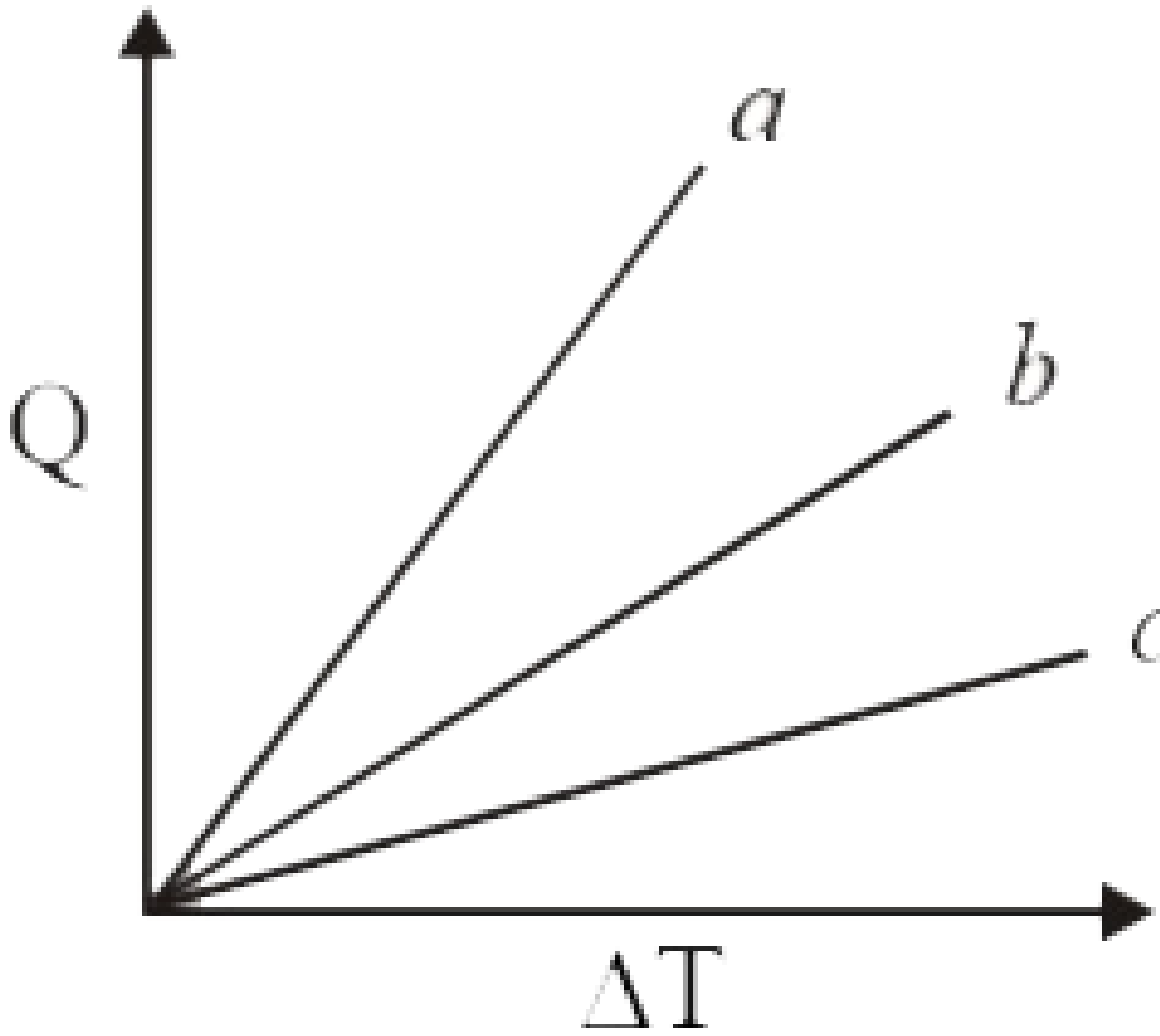
Q-21 - 14927864

Figure shows the variation in temperature (DT) with the amount of heat supplied (Q) in an isobaric process corresponding to a monoatomic (M), diatomic (D) and a polyatomic (P) gas. The initial state of all the gases are the same and the scales for the two axes coincide. Ignoring vibrational degrees of freedom, the lines a, b and c respectively correspond to



(A) P.MandD

(B) M,DandP

(C) P,D and M

(D) D,M and P

Q-22 - 12009290

Estimate the temperature at which the oxygen molecules will have the same rms velocity as hydrogen molecules at $150C$. Molecular weight of oxygen is 32 and that of hydrogen is 2.

CORRECT ANSWER: $6495^\circ C$

SOLUTION:

$$C_{OXY}=C_H$$

$$\sqrt{\frac{3RT}{M_OXY}}$$

$$=\sqrt{\frac{3RT_H}{M_H}}\therefore\frac{T}{32}$$

$$=\frac{(273+150)}{2}$$

$$T=423\times16=6768$$
$$-273=6495C$$

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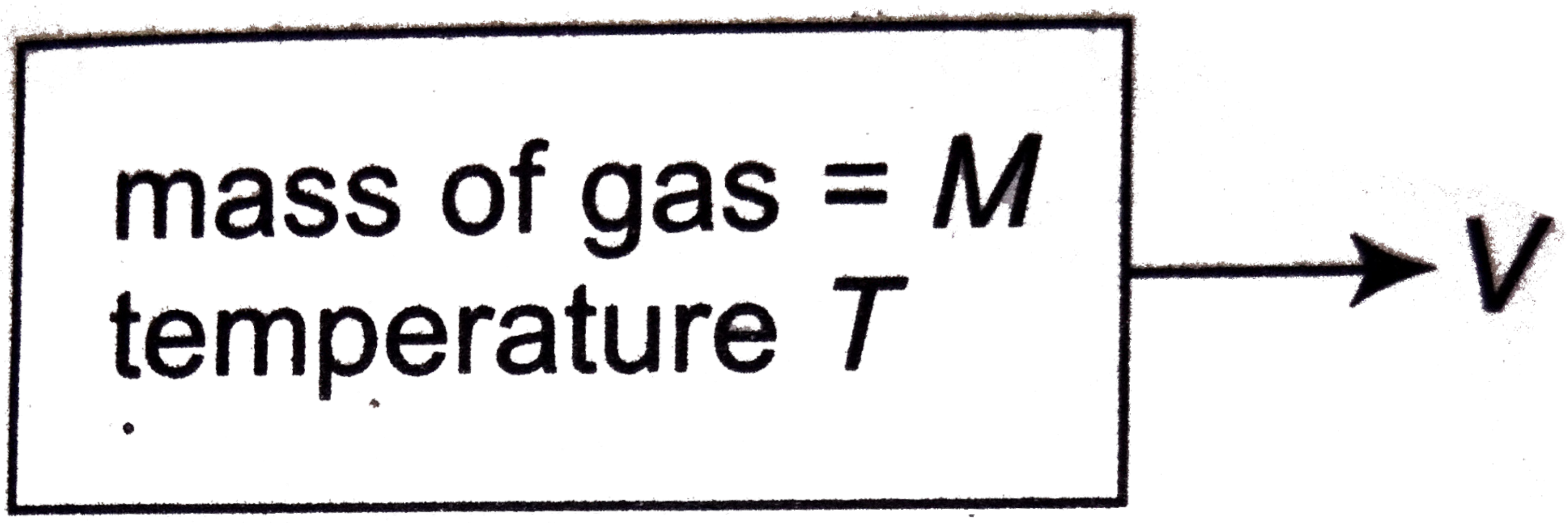
Q-23 - 11796810

A light container having a diatomic gas enclosed with in is moving with velocity v. Mass of the gas is M and number of moles is n. The kinetic energy of gas w.r.t ground is



(A) $\frac{1}{2}MV^2 + \frac{3}{2}nRT$

(B) $\frac{1}{2}MV^2$

(C) $\frac{1}{2}MV^2 + \frac{5}{2}nRT$

(D) $\frac{5}{2}nRT$

CORRECT ANSWER: C

SOLUTION:

The kinetic energy of gas w.r.t, ground=kinetic energy of centre of mass w.r.t ground+Kinetic energy of gas w.r.t. Centre of mass.

$$K.E. = \frac{1}{2}MV^2 + \frac{5}{2}nRT$$

.

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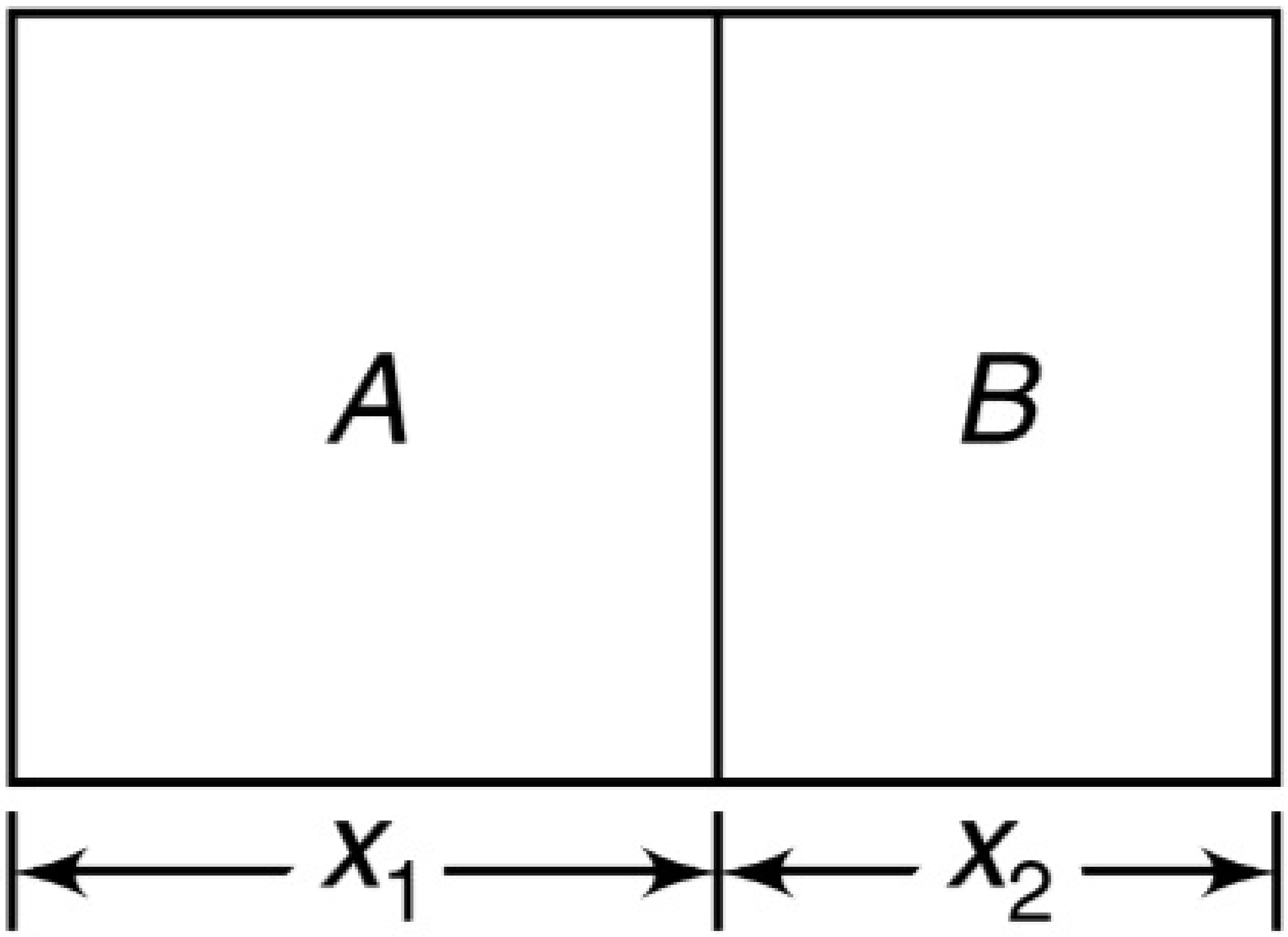
Q-24 - 15085718

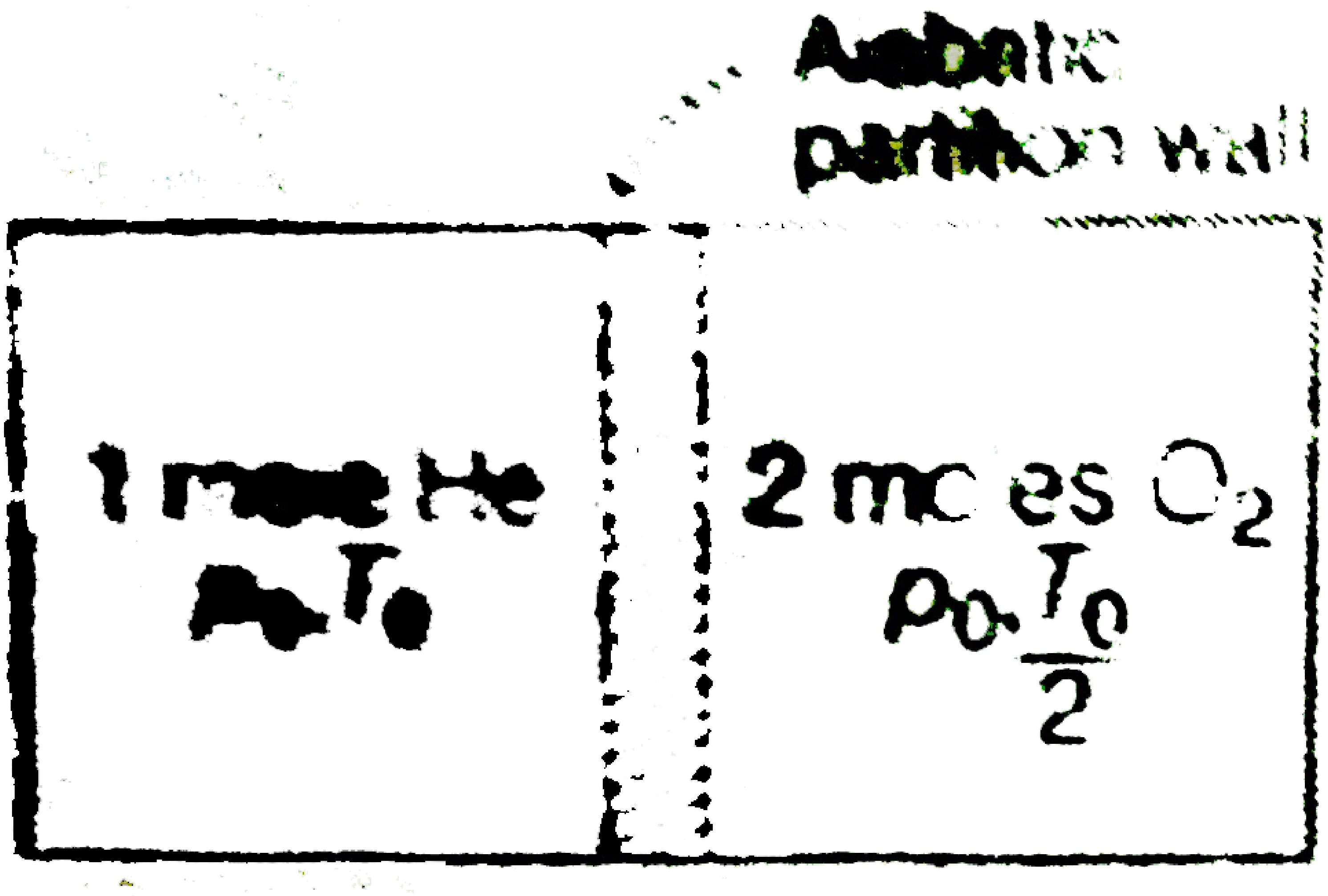
A conducting piston separates a cylindrical tube into two compartments A and B. The two compartments contain equal mass of two different gases. The molar mass of two gases are $M_A = 32g$ and $M_B 28g$. Find the ratio of lengths $(X_1 : X_2)$ of the two compartments in equilibrium.



CORRECT ANSWER: $\frac{7}{8}$

Q-25 - 17818246

Consider the adjacent figure. A piston divides a cylindrical container into two equal parts. The lets part contains 1 mole of helium gas and the right part contains two moles or oxygen gas. The initial temperatures and pressures of the gases in the left chamber are T_0 and p_0 and the right chamber are $\frac{T_0}{2}$ and p_0 respectively as shown in the figure. The piston as well as the walls of the container are adiabatic. After removal of the piston, gases mix homoganeously and the final pressure becomes $p = \frac{4n}{13}p_0$. Find the value of n.



CORRECT ANSWER: C

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Q-26 - 9098465

The pressure of a gas kept in an isothermal container is 200Kpa. If half the gas is removed from it, the pressure will be

(A) (a)$100kPa$

(B) (b)$200kPa$

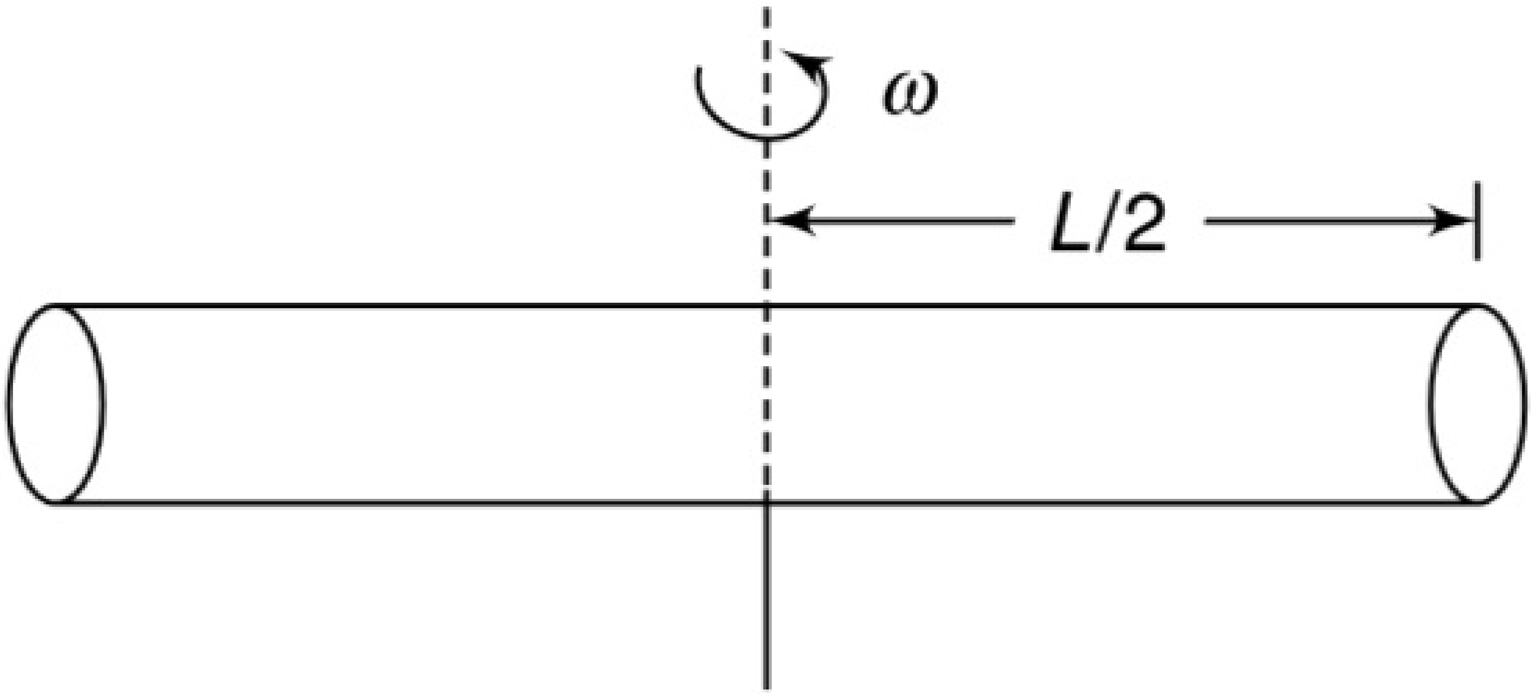
(C) (c)$400kPa$

(D) (d)$800kPa$

CORRECT ANSWER: A

Q-27 - 15085745

A cylindrical container of length 2 L is rotating with an angular speed w about an axis passing through its centre and perpendicular to its length. Its contains an ideal gas of molar mass M. Calculate the ratio of gas pressure at the end of the container to the pressure at its centre. Neglect gravity and assume that temperature of the gas throughout the container is T.



CORRECT ANSWER: $E^{\frac{MOMEGA^2L^2}{2RT}}$

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Q-28 - 14162987

An ideal gas $(C_p / C_v = \gamma)$ having initial pressure P_0 and volume V_0 (a) The gas is taken isothermally to a pressure $2P_0$ and then adiabatically to a pressure $4P_0$. Find the final volume. (b) The gas is brought back to its initial state. It is adiabatically taken to a pressure $2P_0$ and then isothermally to a pressure $4P_0$. Find the final volume.

CORRECT ANSWER: $\dfrac{V_0}{2^{\frac{GAMMA+1}{GAMMA}}}$ IN EACH CASES

SOLUTION:

Initial pressure of an ideal gas $= P$

Initial volume of an idela gas $= V_0$

(a) For isothermal process $P_2 V_2 = P_1 V_1$

$$\Rightarrow V_2 = \frac{P_1 V_1}{P_2} = \frac{V_0}{2}$$

For adiabatic process $P_3 V_3^{\gamma-1} = P_2 V_2^{\gamma}$

$$\Rightarrow V_3 = \left(\frac{P_2}{P_3}\right)^{1/\gamma} V_2$$

$$\Rightarrow V_3 = \frac{V_0}{2^{\frac{\gamma+1}{\gamma}}}$$

(b) For adiabatic process

$P_2 V_2^{\gamma} = P_1 V_1^{\gamma} = V_2$

$$= \left(\frac{P_1}{P_2}\right)^{1/\gamma} V_1$$

$$\Rightarrow V_2 = \frac{V_0}{2^{\frac{1}{\gamma}}}$$

For isothermal process $P_3 V_3 = P_2 V_2$

$$\Rightarrow V_3 = \frac{P_2V_2}{P_3}, V_3$$

$$= \frac{V_0}{2^{\frac{\gamma+1}{\gamma}}}$$

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Q-29 - 12009141

A mixture of helium and hydrogen gases is filled in a vessel at $30C$. Compare the rms velocities of molecules of the two gases. Atomic weights of hydrogen and helium are 1 and 4 respectively.

SOLUTION:

$\frac{C_1}{C_2} = 1$ as rms velocity depends only on temperature of the gas.

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Q-30 - 11796763

Molecular hydrogen at one atmosphere and helium at two atmosphere occupy volume V each at the same temperature. The rms velocity of hydrogen molecules is x times the rms velocity of helium molecules. What is the value of x?

(A) 1

(B) 2

(C) $\sqrt{2}$

(D) $\sqrt{3}$

CORRECT ANSWER: C

SOLUTION:

$C_{H_2} = xC_{He}$

As, $c \propto \dfrac{1}{\sqrt{M}}$

$\sqrt{M_{He}} = x\sqrt{M_{H_2}}$

$$\sqrt{4} = x\sqrt{2}$$

or $x = \dfrac{2}{\sqrt{2}}$ or $x = \sqrt{2}$.

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Q-31 - 14162972

Two moles of an ideal monoatomic gas are confined within a cylinder by a massless and frictionless spring loaded piston of cross-sectional area $4 \times 10^{-3} m^2$. The spring is, initially in its relaxed state. Now the gas is heated by an electric heater, placed inside the cylinder, for some time. During this time, the gas expands and does $50J$ of work in moving the piston through a distance $0.10m$. The temperature of the gas increases by $50K$. Calculate the spring constant and the heat supplied by the heater.

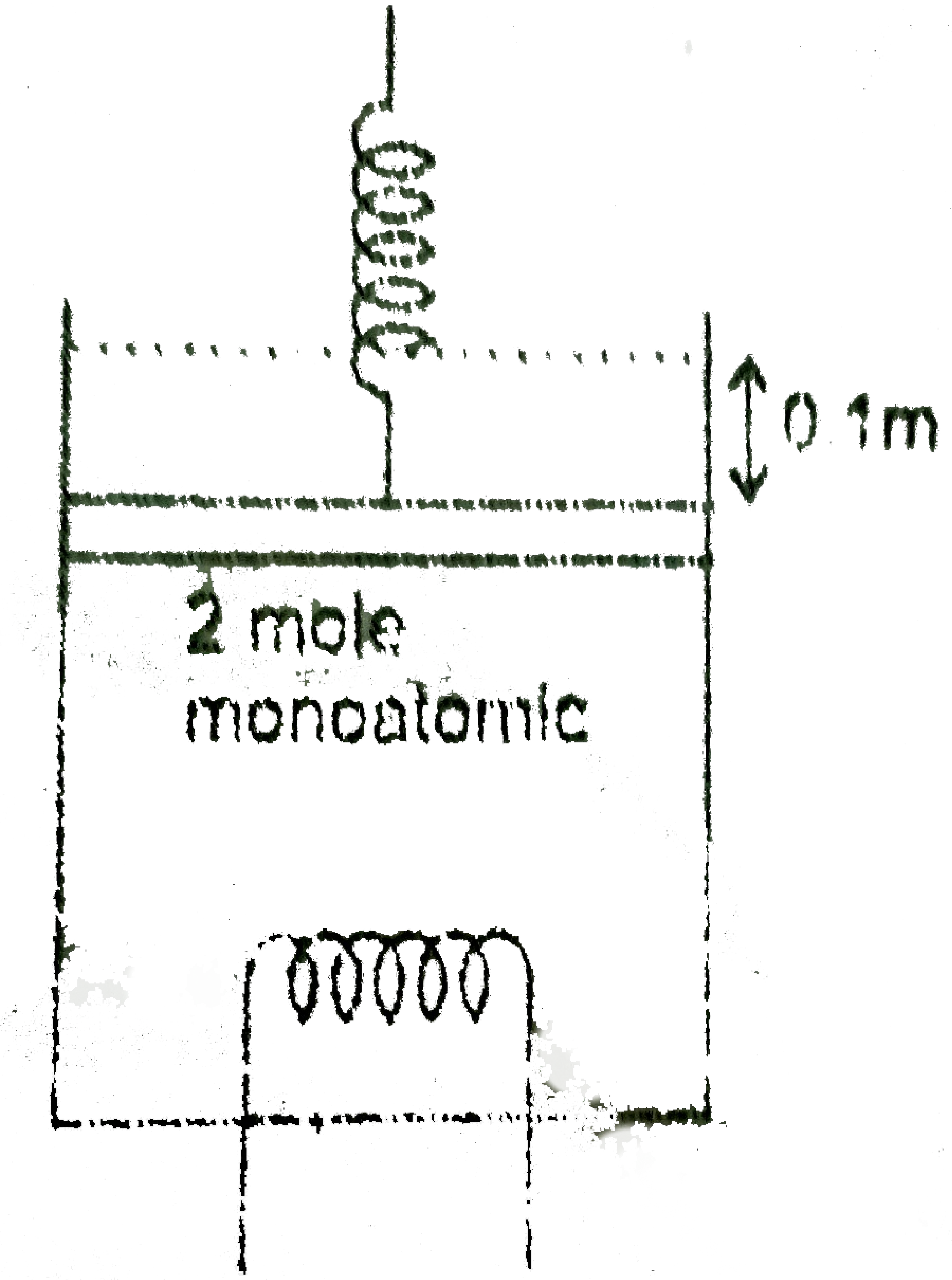
$P_{atm} = 1 \times 10^5 N / m^2 R$
$= 8.314 J / mol - K$

CORRECT ANSWER:

$K = 2000N/M, Q$
$= 923$
JOULES APPROX.

SOLUTION:

$W_{gas} = 50J$



$$\Delta T = 50K$$

$$P_{atm} = 1 \times 10^5 N/m^2$$

From work energy theorem

$$W_{\text{spring}} + W_{\text{atm}} + W_{gas} = \Delta KE$$

$$-\frac{1}{2}K(0.1)^2 - 10^5 \times 4 \times 10^{-3} \times 0.1 + 50 = 0$$

$$K = 2000N/m$$

$$\Delta Q = \Delta U + W = 2 \times \frac{3}{2}R \times 50 + 50$$

$$= 50 + 105R\text{Joules} \approx 923J$$

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Q-32 - 11446251

Two gases occupy two containers A and B then gas in A, of volume $0.10m^3$, exerts a pressure of $1.40Mpa$ and that in B, of volume $0.15m^3$, exerts a pressure $0.7MPa$. The two containers are joined by a tube of negligible volume and the gases are allowed to intermingle. Then if the temperature remains constant, the final pressure in the container will be (in MPa)

(A) 0.7

(B) 0.98

(C) 1.4

(D) 2.1

CORRECT ANSWER: B

SOLUTION:

b. As the quantity of gas remains constant,

$$\mu_A + \mu_B = \mu$$

$$\frac{P_A V_A}{RT} + \frac{P_B V_B}{RT}$$
$$= \frac{P(V_B + V_B)}{RT}$$

$$P = \frac{P_A V_A + P_B V_B}{V_A + V_B}$$
$$= \frac{1.4 \times 0.1 + 0.7 \times 0.15}{0.1 + 0.15}$$

$$\Rightarrow P = 0.98 MPa$$

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Q-33 - 26299939

A cubic vessel (with face horizontal + vetical) contains an ideal gas at NTP. The vessel is being carried by a rocket which is moving at a speed of $500 ms^{-1}$ in vertical direction. The pressure of the gas inside the vessel as observed by us on the ground.

(A) remains the same because $500 ms^{-1}$ is very much smaller than v_{rms} of the gas

(B) remains the same because motion of the vessel as a whole does not not affect the relative motion of the gas molecules and the walls

(C) will increase by a factor equal to

$\left(V_{\mathrm{rms}}^{2}+(500)^{2}\right)$

$/V_{\mathrm{rms}}^{2}\quad\text{where}\quad V_{\mathrm{rms}}$

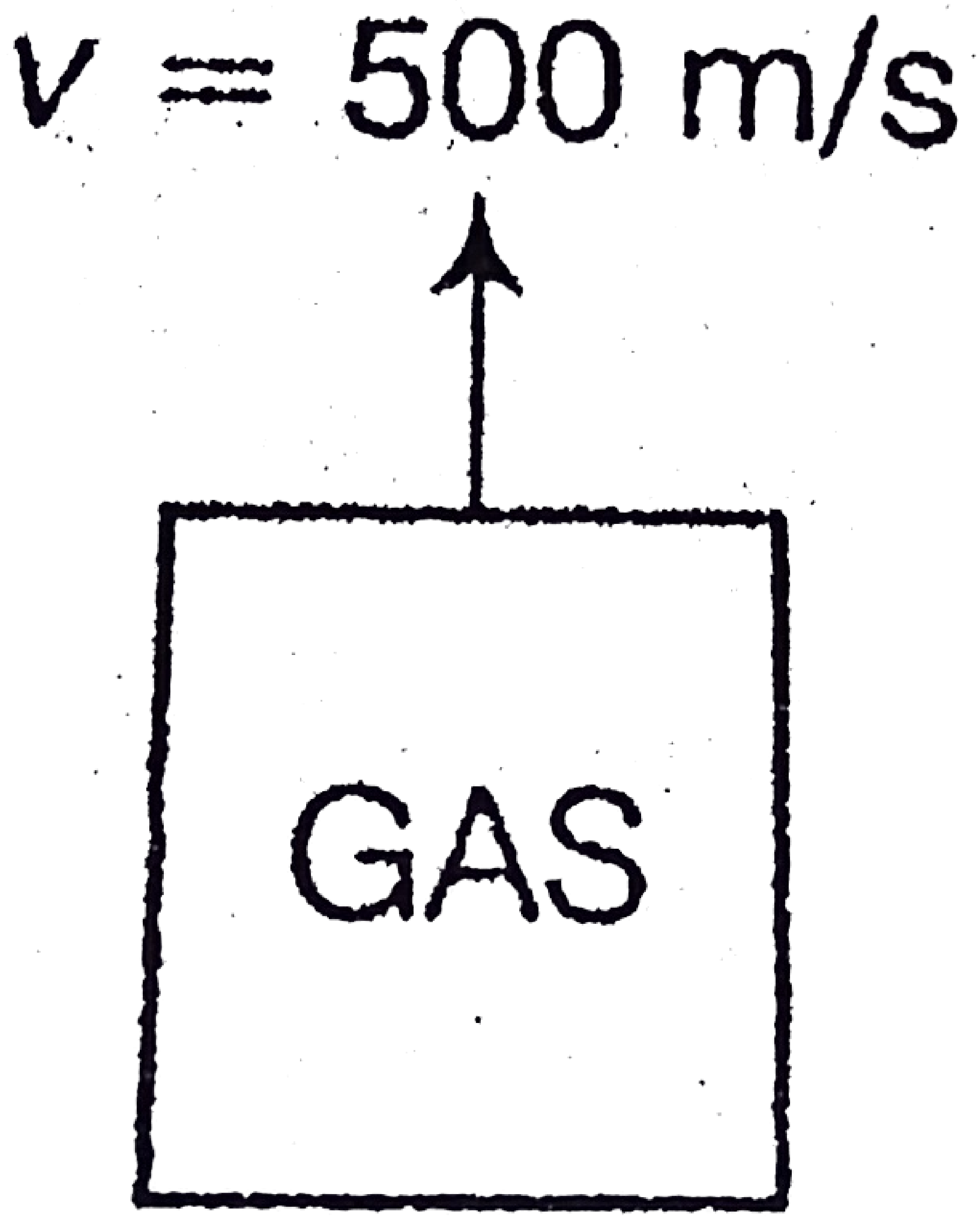
was the original mean square velocity of the gas

(D) will be different on the top wall and bottom wall of the vessel

---

SOLUTION:

As the motion of the vessel as a whole does not effect the ralative motion of the gas molecules with respect to the walls of the vessel , hence pressure of the gas inside the vessel as observed by us on the ground remians the same.



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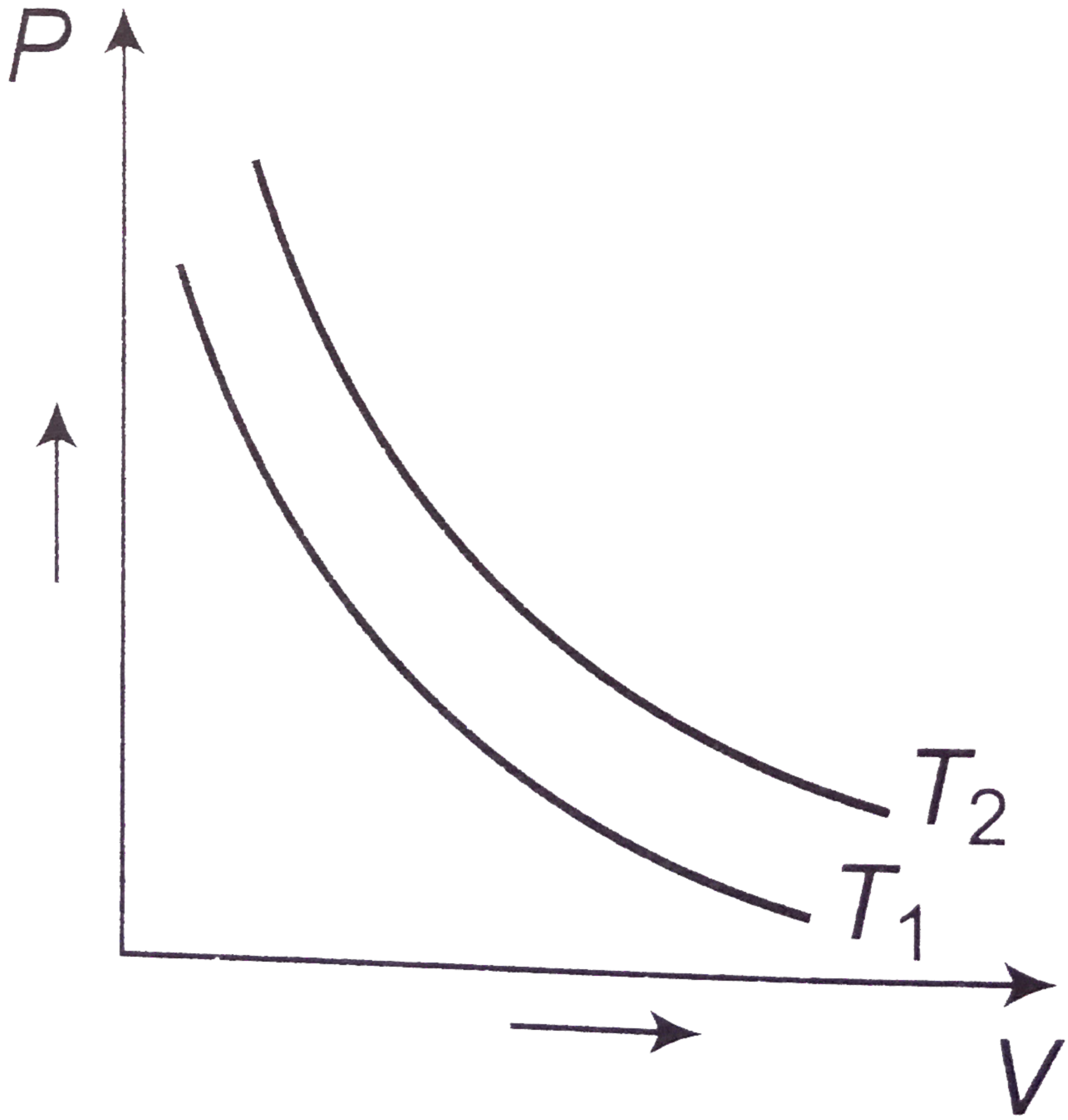
Q-34 - 13151938



The adjoining figure shows graphs of pressure and volume of a gas at two temperature T_1 and T_2 Which of the following inferences is correct?

(A) $T_1 > T_2$

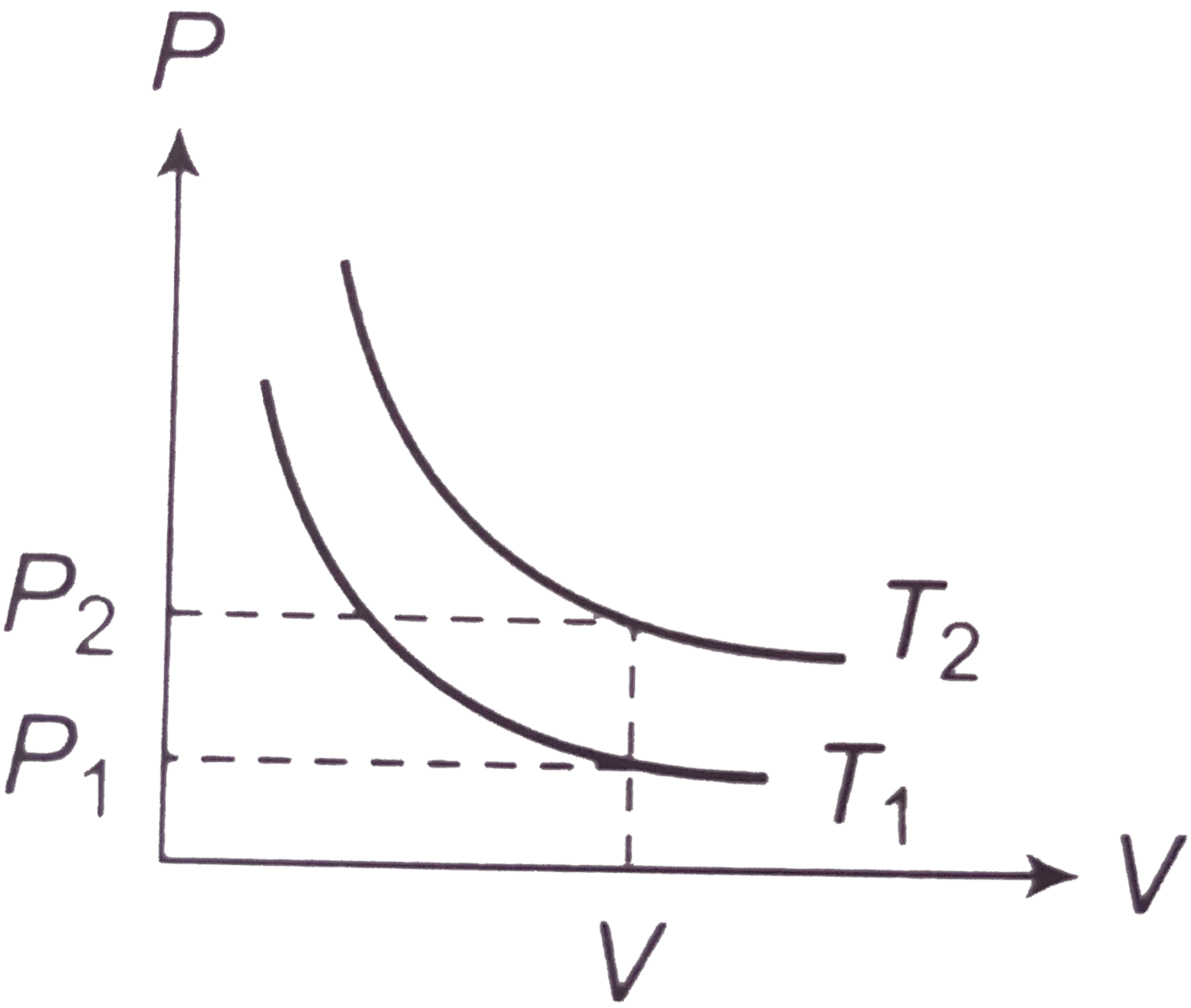
(B) $T_1 = T_2$

(C) $T_1 < T_2$

(D) none

CORRECT ANSWER: C

SOLUTION:



$$n = \frac{P_2V}{RT_2} = \frac{P_1V}{RT_1}$$

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

Since $P_2 > P_1$, hence, $T_2 > T_1$

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Q-35 - 11796932

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) $2.5R$

(C) $3R$

(D) $4\frac{R}{3}$

CORRECT ANSWER: C

SOLUTION:

$P - V$ diagram of the gas is a straight line passing through origin.

Hence $p \propto V$

Molar heat capacity in the process PV^{x}= constant is given by

$$C = \frac{R}{\gamma - 1} + \frac{R}{1 - x}$$

Here, $\gamma = 1.4$ (for diatomic gas)

$$C = \frac{R}{1.4 - 1} + \frac{R}{1 + 1}$$

$$= 3R$$

.

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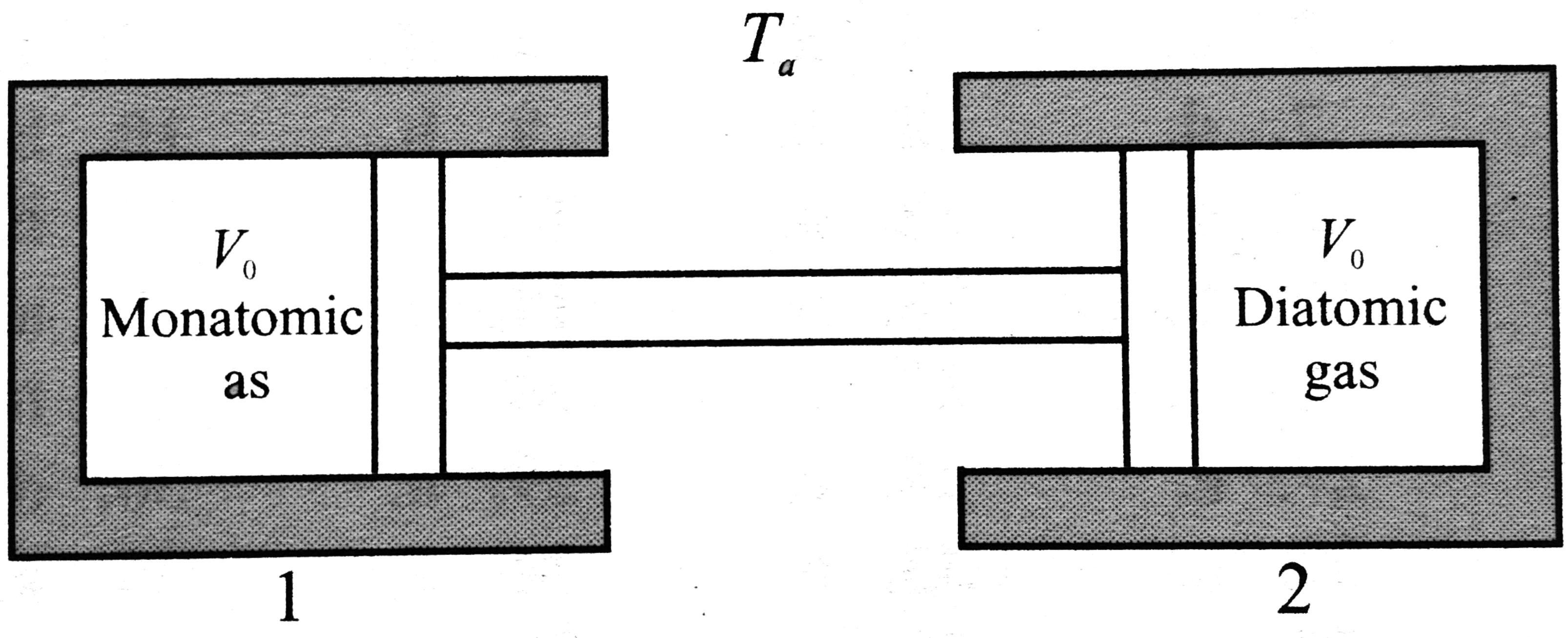
Q-36 - 11446504

The two conducting cyliner-piston systems shows below are linked. Cyliner 1 is filled with a certain molar quantity of a monatomic ideal gas, and cylinder 2 is filled with an equal molar quantity of a diatomic ideal gas. The entire apparatus is situated inside an oven whose temperature is $T_a = 27C$. The cylinder volumes have the same initial value $V_0 = 100$. When the oven temperature is slowly raised to $T_b = 127C$. What is the volume change ΔV (in cc) of cylinder 1 ?



CORRECT ANSWER: 0

SOLUTION:

$$P_0 V_0 = nRT$$

$$(P_0 + \Delta P)(V_0 + \Delta V_0)$$
$$= nRT_b$$

$$(P_0 + \Delta P)(V_0 - \Delta V)$$
$$= nRT_b$$

$$\Delta V = 0$$

Pressure depends on number of moles and is independent of nature of gas.

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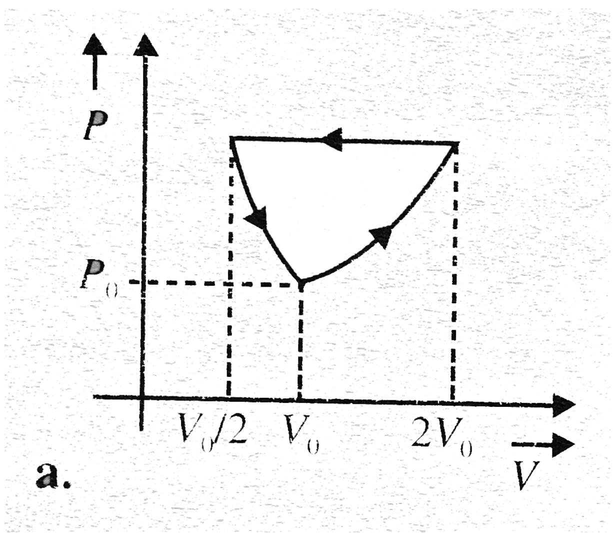
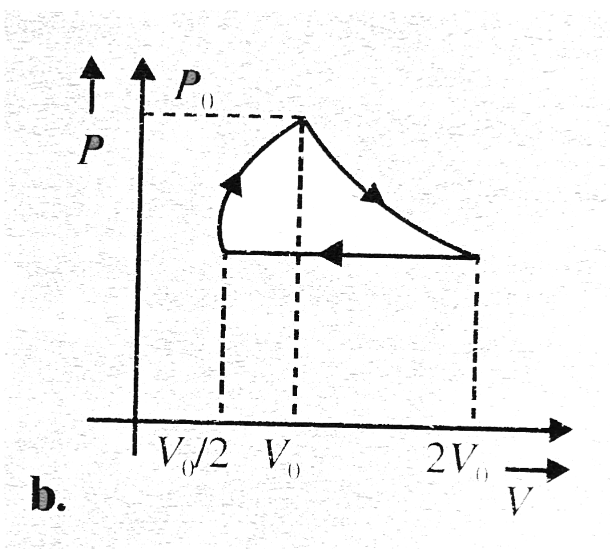
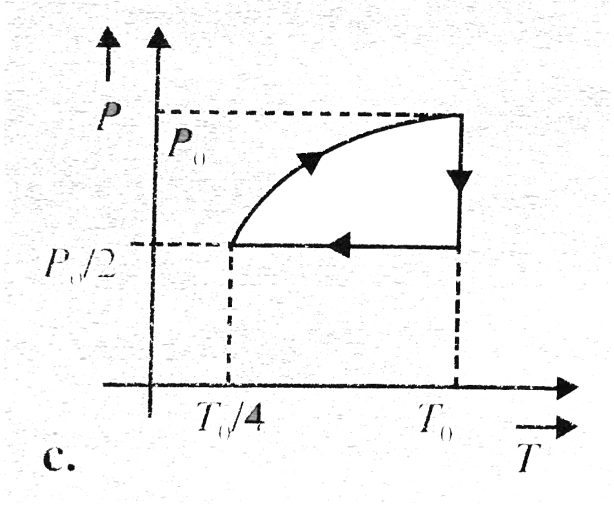
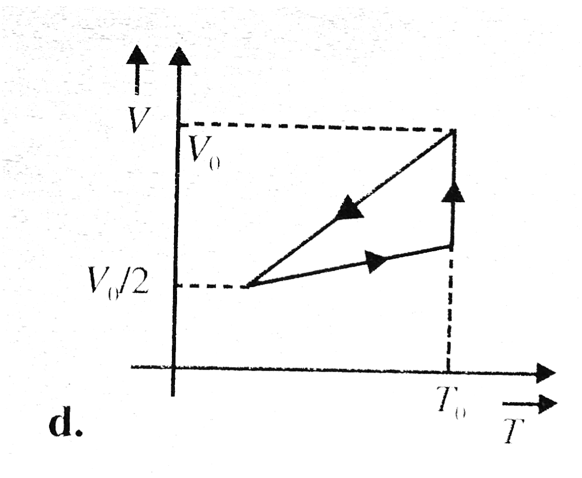
Q-37 - 11446356

One mole of an ideal gas at pressure P_0 and temperature T_0 is expanded isothermally to twice ist volume and then compressed at constant pressure to $(V_0 / 2)$ and the gas is brought bac to original state by a process in which $P \alpha V$ (pressure is direclty proportional to volume). The correct temperature of the process is

(A) 

(B) 

(C) 

(D) 

CORRECT ANSWER: C

SOLUTION:

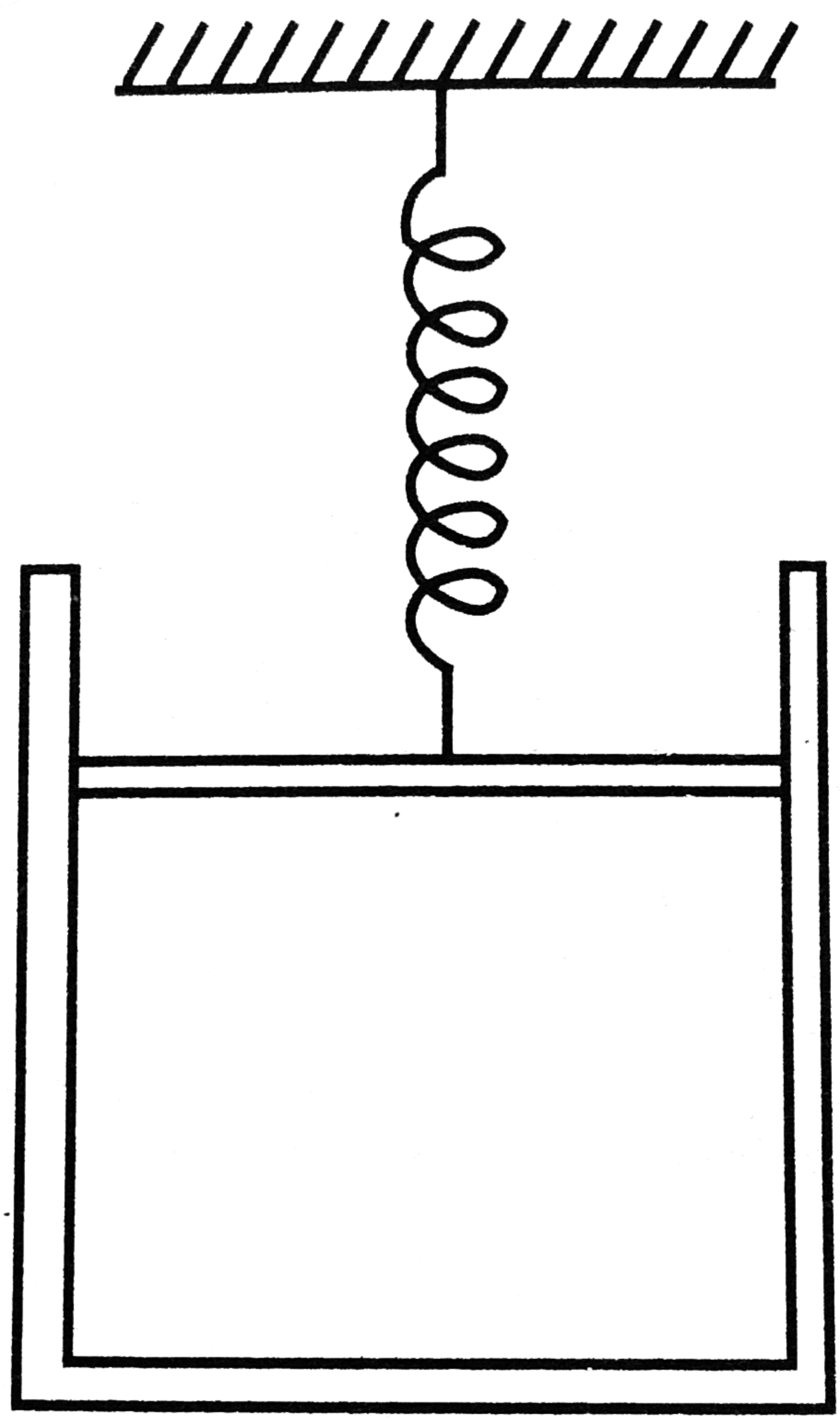
c. Process AB is isothermal expansion, BC is isobaric compression and in process CA

$$Pp \text{ or } p\frac{nRT}{P} \Rightarrow P^2$$

$$\propto T$$

Q-38 - 11446229

An ideal gas has a volume $0.3m^3$ at $150kPa$. It is confined by a spring-loaded piston in a vertical cylinder. Initially, the spring is in relaxed state. If the gas is heated to a final state of $0.5m^3$ and pressure $600kPa$ find the work done on the spring (atmospheric pressure, $P_0 = 1 \times 10^5 N/m^2$).



SOLUTION:

$P_{at} = 10^5$ Pa

Initial pressure of gas,

$P_1 P_{1at} + P_{1spring}$
$+ P_{1piston}$

P_{spring} : pressure due to spring

P_{piston} : pressure due to piston

Initially, the pressure is in relaxed position,

$P_{1spring} = 0$
$P_1 = 150 kPa = 1.5$
$\times 10^5 Pa$

$1.5 \times 10^5 = 10^5 + 0$
$+ P_{piston}$

Pressure due to piston
$= mg / A = 0.5$
$\times 10^5 N / m^2$

In the final condition,
$P' = P_0 + P'_{spring}$
$+ P'_{piston} (P_{piston} = P$
$'_{piston})$

$$P'_{spring} = 6 \times 10^5 - 1$$
$$\times 10^5 - 0.5 \times 10^5$$

$$4.5 \times 10^5 N/m^2$$

Initial load in the spring , $F_1 = 0$

Final load in the spring,

$$F_2 = P'_{spring} A$$
$$= (4.5 \times 10^5 A) N$$

Work done on the spring

= (Average force) (distance moved)

$$= \frac{(F_1 + F_2)}{2} \frac{(V_2 - V_1)}{A}$$

$$= \left[\left(\frac{0 + 4.5 \times 10^5}{2}\right) A\right.$$
$$\left.\times \left(\frac{0.5 - 0.3}{A}\right)\right]$$

$= 0.45 \times 10^5 J$
$= 45 kJ$

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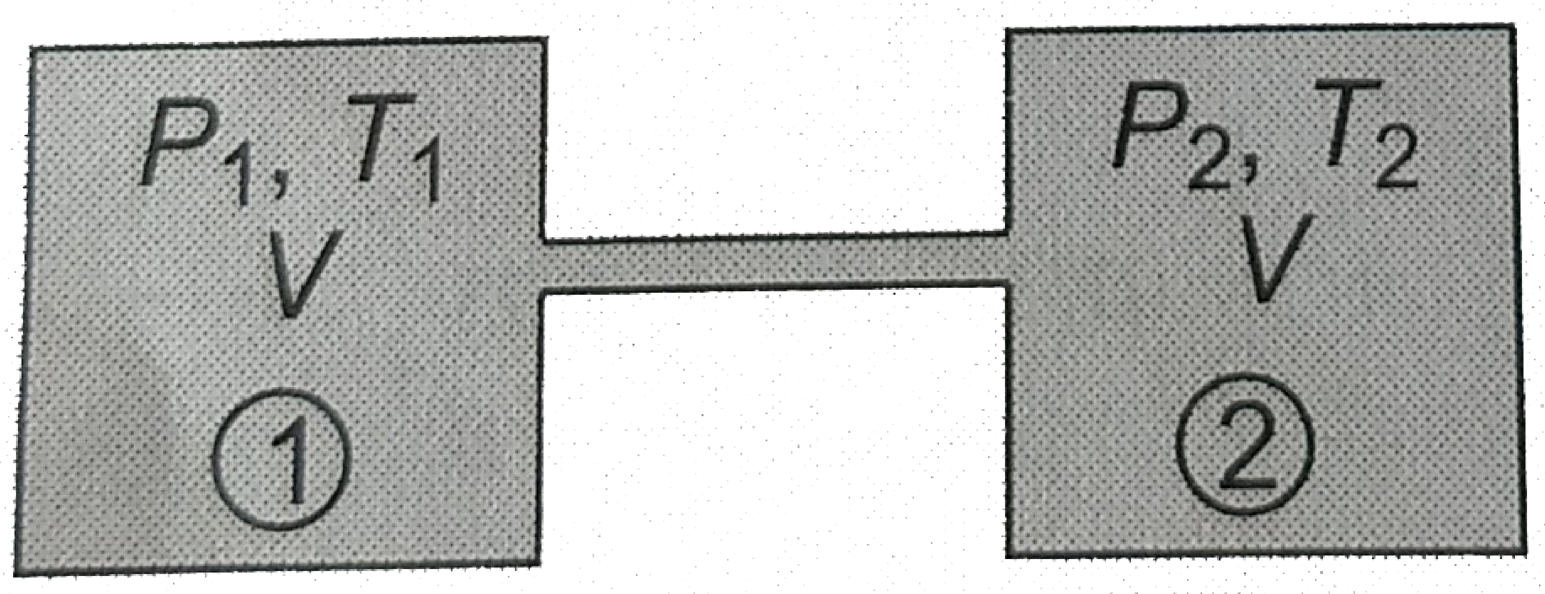
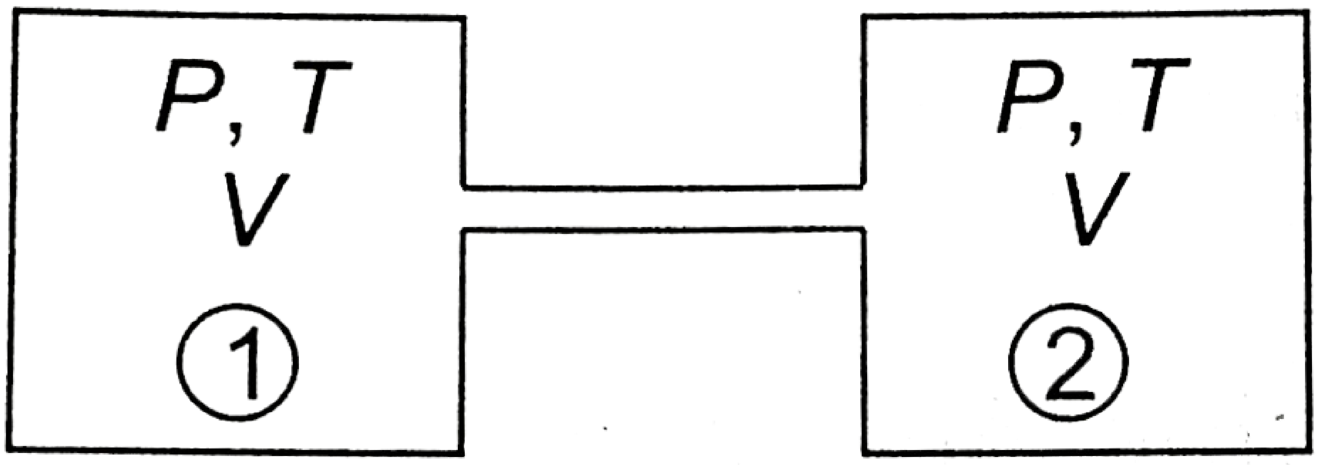
Q-39 - 13074380

Two vessels A and B with rigid walls containing ideal gases. The pressure, temperature and the volume are P_1, T_1, V in the vessel A and P_2, T_2, V in the vessel B. The vessels are now connected through a small tube. In equilibrium, pressure P and temerature T becomes same in two vessels. Find the value of P/T.



CORRECT ANSWER: N/A

SOLUTION:



Total number of moles in two vessels remains same before and after equilibrium

$$n_1 + n_2 = n + n$$

$$\frac{P_1V}{RT_1} + \frac{P_2V}{RT_2} = \frac{PV}{RT} + \frac{PV}{RT}$$

$$\frac{2P}{T} = \frac{P_1}{T_1} + \frac{P_2}{T_2}$$

$$\frac{P}{T} = \frac{1}{2}\left(\frac{P_1}{T_1} + \frac{P_2}{T_2}\right)$$

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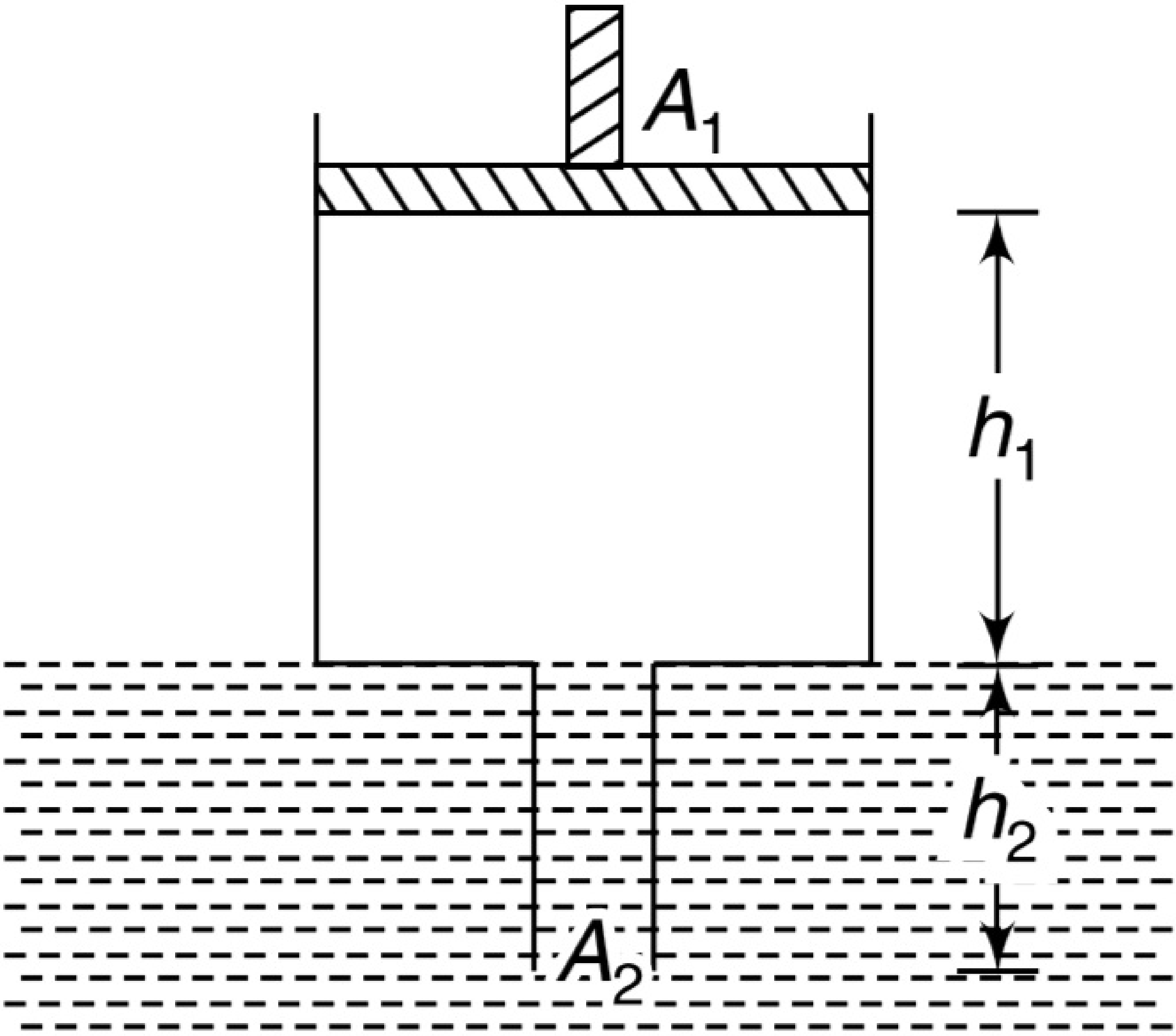
Q-40 - 15085757

A syringe has two cylindrical parts of cross sectional area $A_1 = 4cm^2$ and $A_2 = 1cm^2$. A mass less piston can slide on the inner wall of the part having cross section A_1. The end of the part having cross section A_2 is open. Syringe is dipped in a large water tank such that the narrower part remains completely submerged and the wider part is filled with air. The length shown in figure are $h_1 = 55cm$ and $h_2 = 100$ cm. The piston is pushed down by a distance x such that 25% of the air inside the syringe is expelled out through the open end of the narrower part. Assume that the temperature of air remains constant and calculate x.

Density of water = $10^3 kgm^3$, $g = 10ms^2$, Atmospheric pressure = $10^5 Nm^2$.



CORRECT ANSWER: 42.5 CM

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Q-41 - 11446367

A spherial balloon contains air at temperature T_0 and pressure P_0. The balloon material is such that the instantaneous pressure inside is proportional to the square of the diameter. When the volume of the balloon doubles as a result of heat transfer, the expansion follows the law

(A) $PV =$ constant

(B) $PV^{2/5} =$ constant

(C) $PV^{-1} =$ constant

(D) $PV^{-2/3} =$ constant

CORRECT ANSWER: D

SOLUTION:

d. Pressure is directly proportional to square of the diameter of the balloon,

$$\frac{P_2}{P_1} = \frac{D_2^2}{D_1^2}$$

When

$$V_2 = 2V_1 \Rightarrow D_2^3 = 2D_1^3$$

$$\Rightarrow \frac{D_2}{D_1} = \left(\frac{V_2}{V_1}\right)^{1/3}$$

Form Eqs. (i) and (ii),

$$\frac{P_2}{P_1} = \left(\frac{V_2}{V_1}\right)^{2/3}$$

$$PV^{-2/3} = \text{ constant}$$

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Q-42 - 14155759

An ideal gas mixture filled inside a balloon expands according to the relation expands according to the relation $PV^{2/3} =$ constant. What will be the temperature inside the balloon

SOLUTION:

$$PV^{2/3} = \text{constant}$$

$$\Rightarrow \left(\frac{nRT}{V}\right)\left(V^{2/3}\right)$$

=constant

$T.V^{-1/3} =$ constant $\Rightarrow V \propto T^3$.

Temperature increases with increase in volume.

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Q-43 - 14927877

The kinetic theory of gases states that the average squared velocity of molecules varies linearly with the mean molecular weight of the gas. If the root mean square (rms) velocity of oxygen molecules at a certain temperature is 0.5 km/sec. The rms velocity for hydrogen molecules at the same temperature will be :

(A) 2km/sec

(B) 4km/sec

(C) 8km/sec

(D) 16km/sec

Q-44 - 10059064

Two identical containers A and B with frictionless pistons contain the same ideal gas at the same temperature and the same velocity V. The mass of the gas in A is m_A, and that in B is m_B. The gas in each cylinder is now allowed to expand isothermally to the same final volume 2V. The changes in the pressure in A and B are found to be ΔP and $1.5 \Delta P$ respectively. Then

(A) $4m_A = 9m_B$

(B) $2m_A = 3m_B$

(C) $3m_A = 2m_B$

(D) $9m_A = 4m_B$

CORRECT ANSWER: C

SOLUTION:

(c) Container A

$$P_A V = \frac{m_A}{M} RT$$

$$P_A(2V) = \frac{m_A}{M} RT$$

Container B

$$P_B V = \frac{m_B}{M} RT$$

P_B(2V)=(m_B)/M RTrArrP_A-P'_A=(m_ART)/(MV)-(m_ART)/(M(2V))rArrDeltaP=(m_ART)/(2MV)..(i)P_B-P'_B=(m_BRT)/(MV)-(m_BRT)/(M(2V))1.5 DeltaP=(m_BRT)/(2MV).....(ii)$Divid \in g(i)\ \text{and}\ (ii)$

(1.5DeltaP)/(DeltaP)=(m_B)/(M_A) rArr 3/2=(m_B)/(m_A) rArr 3m_A=2m_B`

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Q-45 - 15635249

An ideal gas is expanding such that $PT^2 =$ constant. The coefficient of volume expansion of lthe gas is:

(A) $\frac{1}{T}$

(B) $\frac{2}{T}$

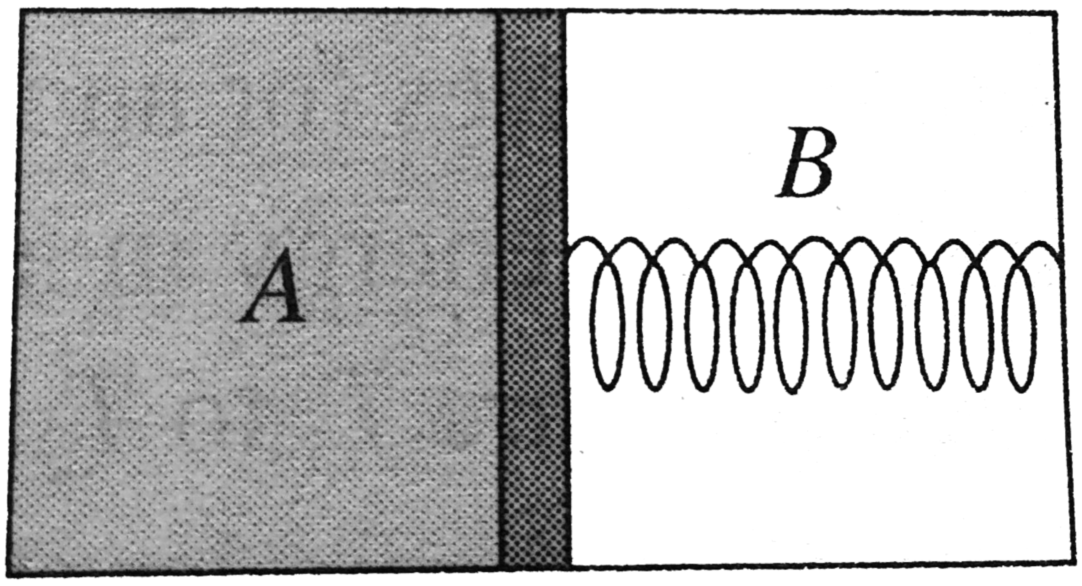
(C) $\frac{3}{T}$

(D) $\frac{4}{T}$

CORRECT ANSWER: C

Q-46 - 11446393

A thermally insulated chamber of volume $2V_0$ is divided by a frictionless piston of area S into two equal part A and B. Part A has an ideal gas at pressrue P_0 and temperature T_0 and part B is vacuum. A massless spring of force constant K is connected with the piston and the wall of the container as shown. Initially the spring is unstretched. The gas inside chamber A is allowed to expand. Let in equilibrium the spring be compressed by x_0. Then



(A) final pressure of the gas is $\frac{Kx_0}{S}$

(B) work done by the gas is $\frac{1}{2}Kx_0^2$

(C) change in internal energy of the gas is $\frac{1}{2}Kx_0^2$

(D) temperature of the gas is decreased

CORRECT ANSWER: A::B::C::D

SOLUTION:

Equilibrium of piston gives $PS = Kx_0$

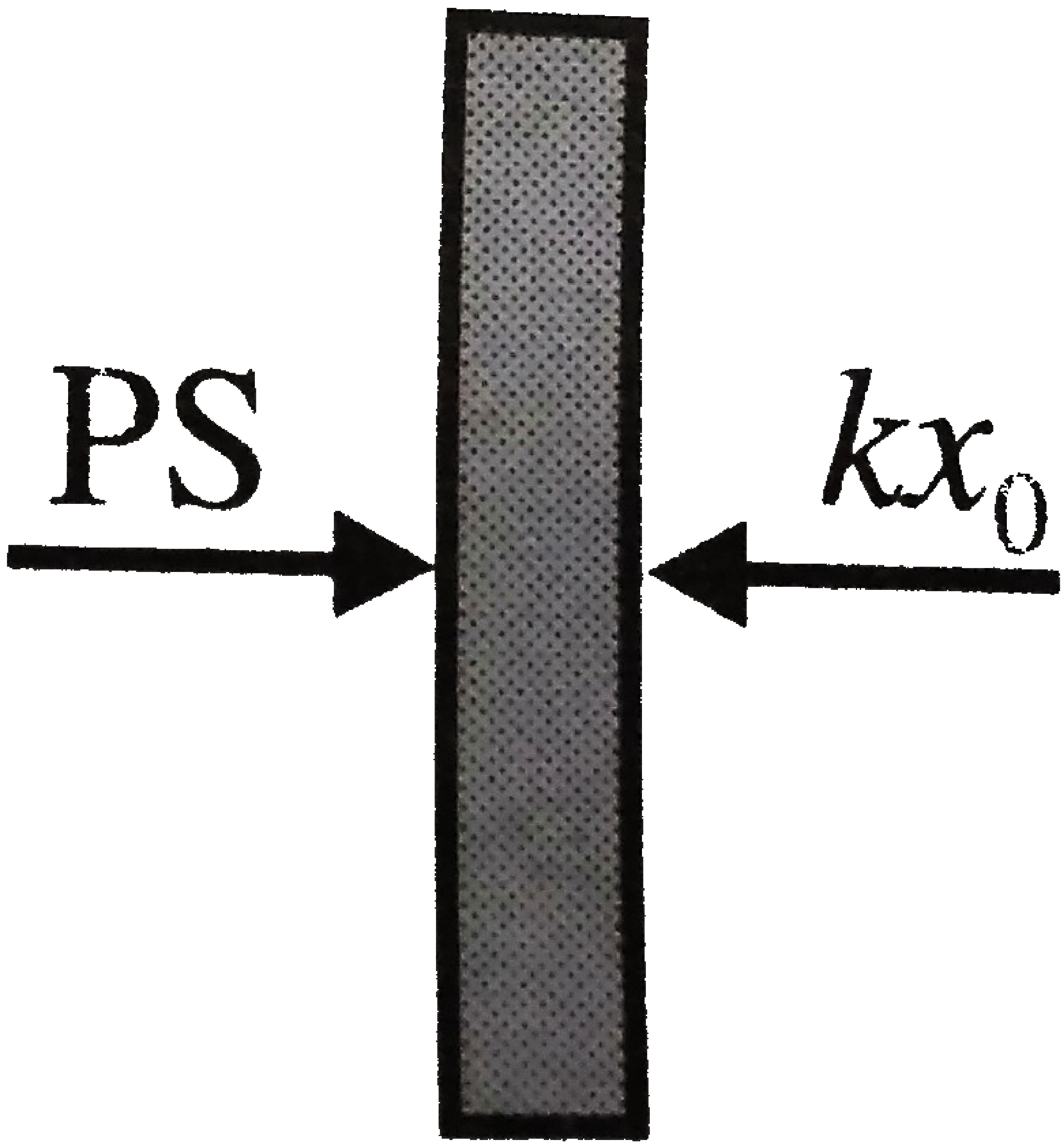
$$P = \frac{Kx_0}{S}$$

Since the chamber is thermally insulated, $\Delta Q = 0$

$\therefore$ Elastic PE of spring $=$ Work done by gas

or, Work done by gas $= \dfrac{1}{2} K x_0^2$

This work is done at the expense of internal energy of the gas. Therefore, internal energy of the gas is decreased by $(1/2) K x_0^2$.



Q-47 - 11796811

A cylinder contains a mixture of helium and argon gas in equilibrium at $150C$. What is the average kinetic energy for each type of gas molecules?

(A) $3.26 \times 10^{-21} J$

(B) $8.76 \times 10^{-21} J$

(C) $6.28 \times 10^{-21} J$

(D) $4.14 \times 10^{-21} J$

CORRECT ANSWER: B

SOLUTION:

Both kinds of molecules have the same average kinetic

as the temperature is same for both the gas molecules

The average kinetic energy of a molecules ,

$$\overline{K} = \frac{3}{2} k_B T$$

$$\overline{K} = \frac{3}{2} \left(1.38 \times 10^{-23} J / K\right)(423K)$$

$$= 8.76 \times 10^{-21} J$$

Q-48 - 11446386

Two identical containers A and B having volume of ideal gas at the same temperature have mass of the gas as m_A and m_B respectively. $2m_A = 3m_B$. The gas in each cylinder expand isothermally to double its volume. If the change in pressure in A is Δp, find the change in pressure in B:

(A) $2\Delta p$

(B) $3\Delta p$

(C) $\frac{2}{3}\Delta P$

(D) $\frac{4}{3}\Delta P$

CORRECT ANSWER: C

SOLUTION:

d. $2m_A = 3m_g$

$$p_A V = \frac{m_A}{M} RT$$

$$p_B V = \frac{m_B}{m} RT$$

$$= \frac{2}{3} \frac{m_A}{M} RT$$

So, $\frac{p_A}{p_B} = \frac{3}{2}$

The expanion is isothermal, so pressure will reduce to half when volume is doubled.

$p_A - \frac{p_A}{2} = \Delta P$ or $p_A = 2\Delta p$

$$p_B - \frac{p_B}{2} = \frac{p_B}{2} = \frac{1}{2}$$

$$\cdot \frac{1}{3} p_A = \frac{2}{3} \Delta p$$

So, $p_B = \frac{4}{3} \Delta p$

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Q-49 - 10059073

A container of fixed volume has a mixture of a one mole of hydrogen and one mole of helium in equilibrium at temperature T.

Assuming the gasses are ideal, the correct statement (s) is (are)

(A) The average energy per mole of the gas mixture is

2RT

(B) The ratio of speed of sound in the gas mixture to tah

tin helium gas is $\sqrt{6/5}$

(C) The ratio of the rms speed of helium atoms to that of

hydrogen molecules is $1/2$

(D) The ratio of the rms speed of helium atoms to that of

hydrogen molecules is $\frac{1}{\sqrt{2}}$

CORRECT ANSWER: A::B::C

SOLUTION:

(a,b,c)

$$Totale \neq rgy = \frac{3}{2}RT$$

$$+ \frac{5}{2}RT = 4RT$$

$$\therefore Avera \geq e$$

$$\neq rgypermo \leq$$

$$= \frac{4RT}{2} = 2RT$$

We know that $V_{sound} = \sqrt{\frac{\gamma RT}{M}}$

$$\frac{n_1 + n_2}{\gamma_{mix} - 1}$$

$$= \frac{n_1}{(\gamma_1 - 1) + \frac{n_2}{(\gamma_2 - 1)}}$$

$$\Rightarrow \frac{2}{\gamma_{mix} = \frac{1}{\frac{5}{3} - 1} + \frac{1}{\frac{7}{5} - 1}}$$

$$\frac{2}{\gamma_{mix} = \frac{3}{2} + \frac{5}{2} = 4}$$

$$\therefore \gamma_{mix} - 1 = \frac{1}{2}$$

$$\therefore \gamma_{mix} = \frac{3}{2}$$

$$\frac{(V_s)_{mix}}{(V_s)_{He}}$$

$$= \sqrt{\frac{\gamma_m ix}{M_{mix}} \times \frac{M_{He}}{\gamma_{He}}}$$

$$= \sqrt{\frac{\frac{3}{2} \times 4}{3 \times \frac{5}{3}}} \left[\because M_{mix} \right.$$

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

$$\left. = 3 \right]$$

$$= \sqrt{\frac{6}{5}}$$

We know that $V_{rms} = \sqrt{\frac{3RT}{M}}$

$$\frac{(V_{rms})_{He}}{(V_{rms})_{H_2}} = \sqrt{\frac{M_{H_2}}{M_{He}}}$$

$$= \sqrt{\frac{2}{4}} = \frac{1}{\sqrt{2}}$$

$\therefore Option[A],$

$[B]$ and $[C]arec$ or

$rect.$

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Q-50 - 11446144

N molecules each of mass m of gas A and 2 N molecules each of mass 2m of gas B are contained in the same vessel which is maintined at a temperature T. The mean square of the velocity of the molecules of B type is denoted by v^2 and the mean square of the x-component of the velocity of a tye is denoted by ω^2. What is the ratio of $\omega^2 / v^2 = ?$

SOLUTION:

The mean square velocity of gas molecule is given by

$$V^2 = \frac{3kT}{m}$$

For gas A,

$$v_A^2 = \frac{3kT}{m}$$

For a gas molecule, $v^2 = v_x^2 + v_y^2 + v_z^2$

$$= 3v_x^2 \left(v_x^2 = v_y^2 = v_z^2\right)$$

or $v_x^2 = \dfrac{v^2}{3}$

From Eq. (i) we get

$$v_x^2 = \frac{v_A^2}{3}$$

$$= \left[\frac{(3kT/m)}{3}\right]$$

$$= \frac{kT}{m}$$

For gas b,

$$v_B^2 = v^2 = \frac{3kT}{m_B}$$

$$= \frac{3kT}{m}$$

Dividing Eq. (ii) by Eq. (iii) we get

$$\frac{\omega^2}{v^2} = \frac{kT/m}{3kT/2m} = \frac{2}{3}$$

Q-51 - 11446300

A vessel of volume $20L$ contains a mixture o hydrogen and helium at temperature of $27C$ and pressure $2.0atm$ The mass of the mixture is $5g$. Assuming the gases to be ideal, the ratio of the mass of hydrogen to heat of helium in the given mixture will be

(A) $1:2$

(B) $2:3$

(C) $2:1$

(D) $2:5$

CORRECT ANSWER: D

SOLUTION:

Suppose there are n_1 moles of hydrogen and n_2 moles of helium in the given mixture. Then the pressure of the mixture will be

$$P = \frac{n_1 RT}{V} + \frac{n_2 RT}{V}$$

$$= (n_1 + n_2)\frac{RT}{V}$$

(i)

$$2 \times 101.3 \times 10^3 = (n_1 + n_2)\frac{(8.3)(300)}{20 \times 10^{-3}}$$

$$(n_1 + n_2) = \frac{2 \times 101.3 \times 3 \times 10^3 \times 20 \times 10^{-3}}{(8.3)(300)} = 1.62$$

(ii)

The mass of the mixture is (in grams):

$$n_1 \times 2 + n_2 \times 4 = 5$$

$$(n_1 + 2n_2) = 2.5$$

Solving Eqs. (i) and (ii), $n_1 = 0.74, n_2 = 0.88$

Hence

$$\frac{m_H}{m_{He}} = \frac{0.74 \times 2}{0.88 \times 4}$$
$$= \frac{1.48}{3.52} \to 2:5$$

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Q-52 - 11446237

Air is filled at $60C$ in a vessel of open mouth. The vessle is heated to a temperature T so that $1/4th$ of air escapes. Assuming the volume of vessel remaining constant, the value of T is

(A) $80^\circ C$

(B) $440^\circ C$

(C) $333^\circ C$

(D) $171^\circ C$

CORRECT ANSWER: D

SOLUTION:

d.

$M_1 = M, T_1 = 60$
$+ 273 = 333K$

$$M_2 = M - \frac{M}{4}$$
$$= \frac{3M}{4}$$

(as $1/4th$ part of air escapes)

If pressure and volume of the gas remain constant, then

$MT =$ constant

$$\therefore \frac{T_2}{T_1} = \frac{M_1}{M_2}$$
$$= \left(\frac{M}{3M/4}\right) = \frac{4}{3}$$

$\Rightarrow T_2 = \frac{4}{3} \times T_1 = \frac{4}{3}$
$\times 333 = 444K$
$= 171C$

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Q-53 - 14162010

The average rotational kinetic energy of hydrogen molecule at a temperature T is E. The average translational kinetic energy of helium at same temperature will be:

(A) $\frac{2E}{3}$

(B) $\frac{5E}{3}$

(C) E

(D) $\frac{3E}{2}$

CORRECT ANSWER: D

SOLUTION:

Law of equipartition of energy

$$< KE_R > \ = 2.\frac{1}{2}kT$$

$$= E$$

$$\therefore \ < KE_T > \ = 3$$

$$.\frac{1}{2}kT$$

$$< KE_T > \ = \frac{3E}{2}$$

Q-54 - 12009412

Statement-1 : Mean free path of molecules of a gas decreases with increases in number density of the molecules.

Statement-2 : More the molecules per unit volume, more are the chances of molecular collision. Therefore, mean free path decreases.

(A) Statement-1 is ture, statement-2 is true and statement-2 is correct explanation of statement-1

(B) Statement-1 is ture, statement-2 is true but statement-2 is not correct explanation of statement-1

(C) Statement-1 is true, but statement-2 is false.

(D) Statement-1 is false, but statement-2 is true.

CORRECT ANSWER: A

SOLUTION:

Both the statement are ture adn statement-2 is correct expatination of statement-1.

Q-55 - 9098412

Calculate the rms speed of nitrogen at STP (pressure $= 1$ atm and temperature $= 0^0 C$. The density of nitrgoen in these conditions is $1.25 kgm^{-3}$

SOLUTION:

At STP, the pressure is $1.0 \times 10^5 Nm^{-2}$. The rms speed is

$$v_{rms} = \sqrt{3\frac{p}{\rho}}$$

$$= \sqrt{\frac{3 \times 10^5 Nm^{-2}}{(1.25 kgm^{-3})}}$$

$$= 490 ms^{-1}.$$

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Q-56 - 11446179

A mass M = 15 g of nitrogen is enclosed in a vessel at temperature T = 300 K. What amount of heat has to be transferred to the gas to increase the root-mean-square velocity of molecules 2 times ?

SOLUTION:

$$C=\sqrt{\frac{3RT}{M}}$$

Let the rms speed be doubled at T' then

$$2C=\sqrt{\frac{3RT}{M}}$$

$$\therefore 4=\frac{T'}{T}\Rightarrow T'$$

$$=4T=4\times 300$$

$$=1200K$$

$$\therefore \Delta T=1200-300$$

$$=900K$$

Heat

$$\Delta Q=\Delta U(\because \Delta W$$

$$=0)$$

Therefore,

$$\Delta Q = \frac{m}{M} C_v \Delta T$$

$$= \frac{m}{M} \times \frac{R}{\gamma - 1} \times$$

$$\Delta T$$

$$= \frac{15}{28} \times \frac{8.3}{\frac{7}{5} - 1}$$

$$\times 900$$

$$= 10004 J \approx 10 kJ$$

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Q-57 - 10059039

A mixture of 2 moles of helium gas $(a \rightarrow micmass = 4a\mu)$ and 1 mole of argon gas $(a \rightarrow micmass = 40a\mu)$ is kept at 300K in a container. The ratio of the rms speeds $\left(\frac{v_{rms}(helium)}{(v_{rms}(argon))}\right)$ is

(A) 0.32

(B) 0.45

(C) 2.24

(D) 3.16

CORRECT ANSWER: D

SOLUTION:

(d)

`v_(rms(helium))/(v_(argon))=sqrt(M_(argon)/M_(helium))=sc

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Q-58 - 12009398

A vessel contains two non-reactive gases oxygen (diatomic) and hydrogen (diatomic). The ratio of their partial pressure is $4:1$. estimate the ratio of their number of molecules.

CORRECT ANSWER: 4

SOLUTION:

Let us denote oxygen gas by 1 and hydrogen gas by 2.

Here, $\frac{P_1}{P_2} = \frac{4}{1}$

As particle pressure of a gas in a mixture is the pressure it would exerts for the same volume and temperature, if it alone occupied the vessel therefore for common V and T

$P_1V = \mu_1 RT$ and $P_2V = \mu_2 RT$

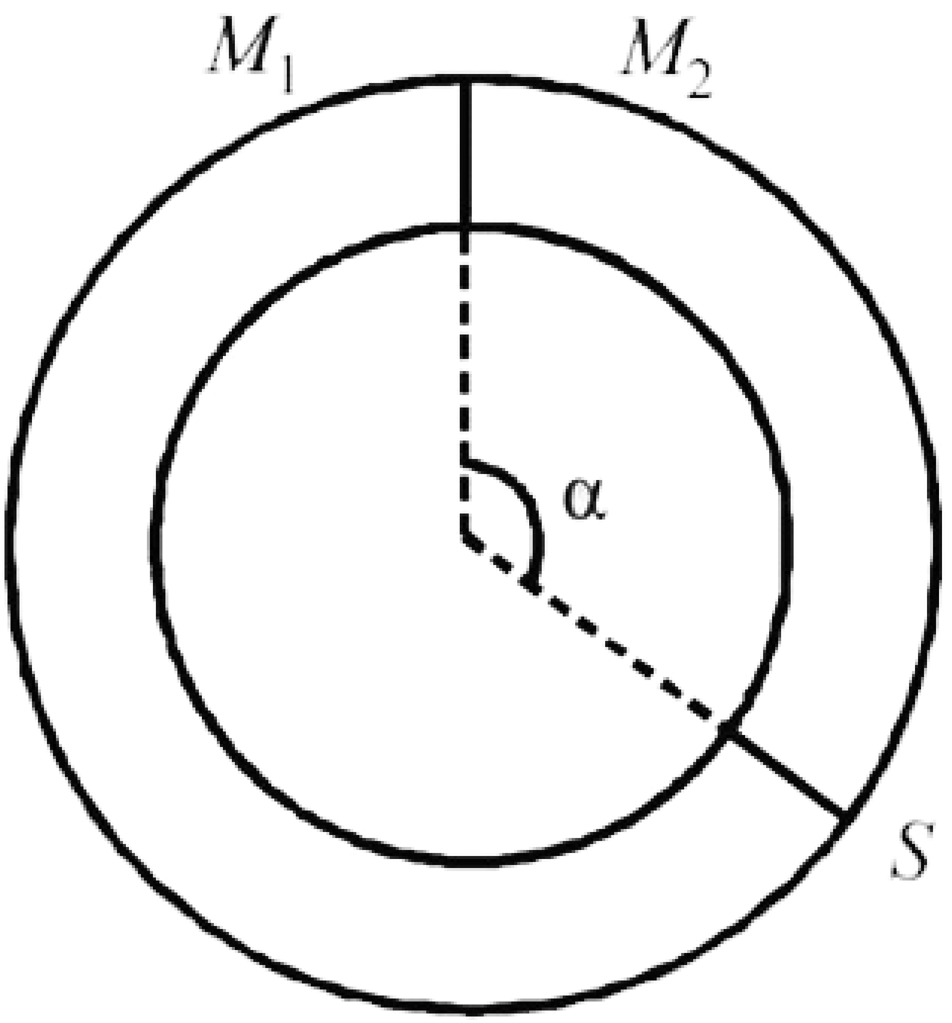
$$\therefore \frac{\mu_1}{\mu_2} = \frac{P_1}{P_2} = \frac{4}{1}.$$

Q-59 - 10058982

A ring shaped tube contain two ideal gases with equal masses and relative molar masses $M_1 = 32$ and $M_2 = 28$.

The gases are separated by one fixed partion and another movable stopper S which can move freely without friction inside the ring.

The angle α as shown in the figure is ...... degrees.



CORRECT ANSWER: A::B

SOLUTION:

The movable stopper will adjust to a position with equal

Pressure on either sides. Applying ideal gas equation to

the

two gases, we get

$$PV_1 = n_1 RT$$
$$= \frac{m}{M_1} RT, PV_2$$
$$= n_2 RT = \frac{m}{M_2} RT$$

Hence,

$$\frac{V_2}{V_1} = \frac{M_1}{M_2} = \frac{32}{28}$$
$$= \frac{8}{7}$$

$$\alpha = \frac{360^{\square}}{8+7} \times 8 = 192$$

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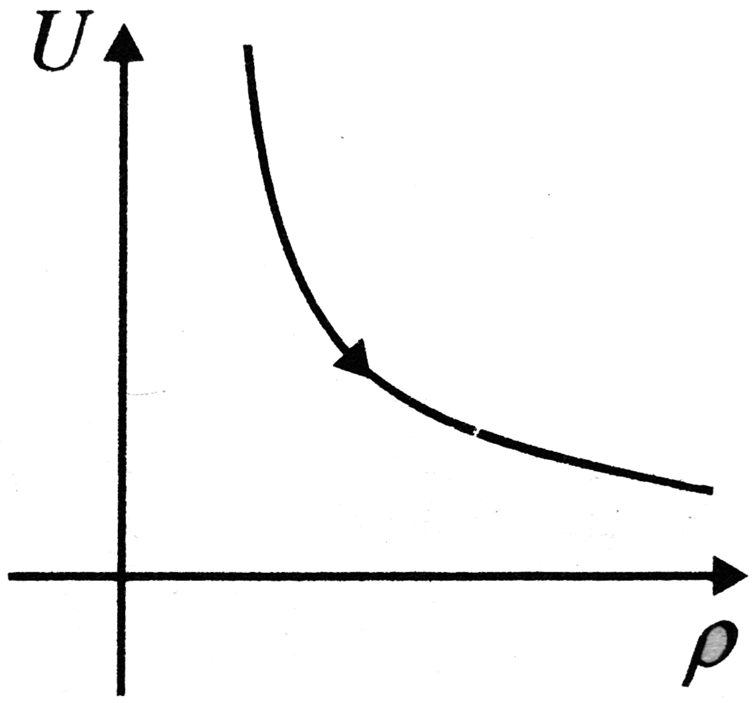
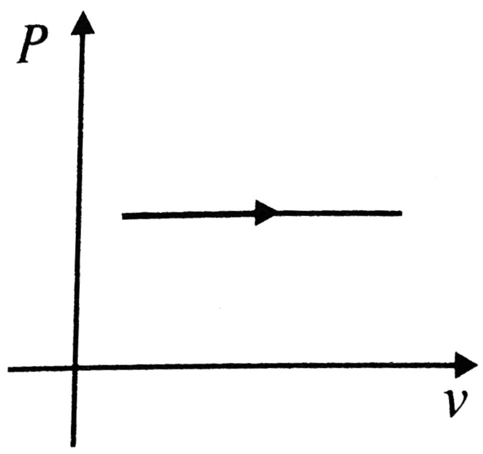
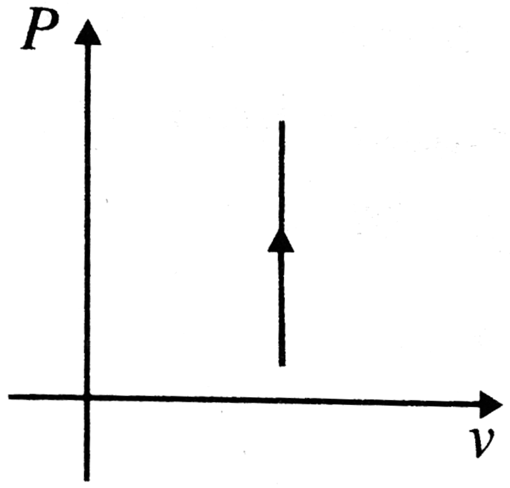
Q-60 - 11446298

Variation of internal energy with density of 1mole of monatomic gas is depicted in Fig. Corresponding variation of pressure with voluem can be depicted as (assume the curve is rectangular hyperbola)

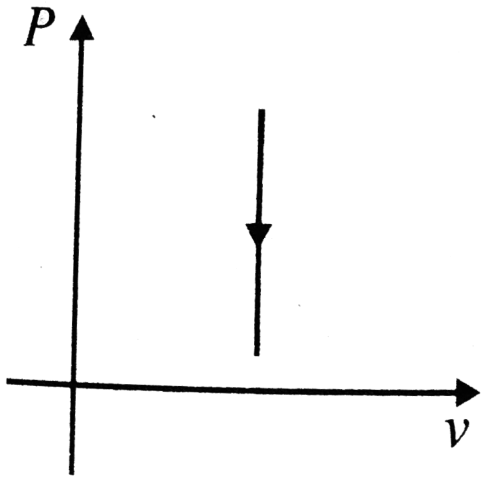


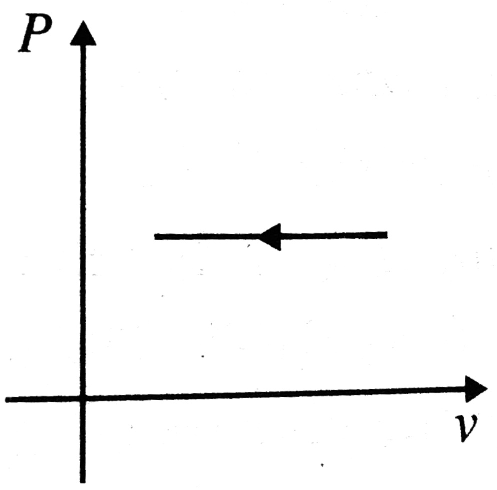


(A) **a.**



(B) **b.**

(C) c. 

(D) d. 

CORRECT ANSWER: D

SOLUTION:

d. Sincee $U\rho$ = constant,

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

$P =$ constant since ρ is increasing, therefore V is decreasing.

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