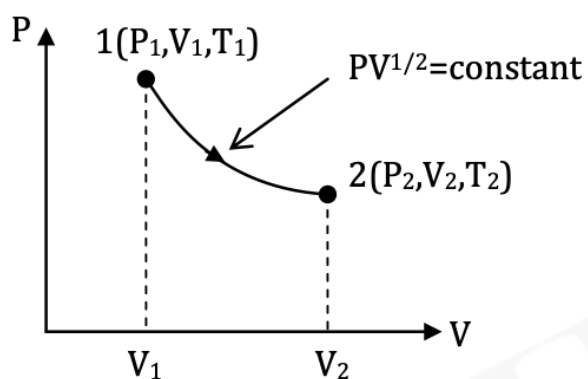
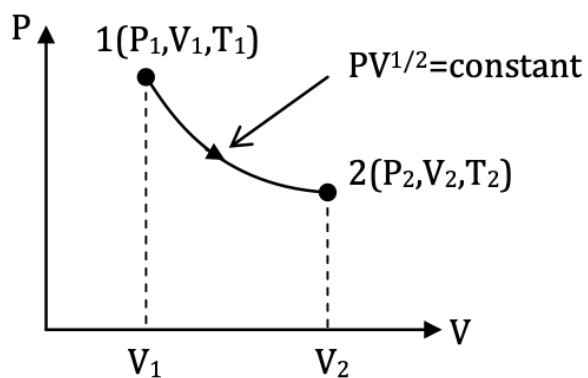


Topic : KTG, Thermometry and thermodynamics

1. Thermodynamic process is shown below on a $P - V$ diagram for one mole of an ideal gas . If $V_2 = 2V_1$, then the ratio of temperature $\frac{T_2}{T_1}$ is :



- A. $\frac{1}{\sqrt{2}}$
 B. $\frac{1}{2}$
 C. 2
 D. $\sqrt{2}$



Given , $PV^{\frac{1}{2}} = \text{constant} \dots\dots(1)$

We know that $PV = nRT$

$P \propto \frac{T}{V} \dots\dots(2)$ [For one mole of gas]

Using (1) and (2) we get :

$$\left(\frac{T}{V}\right) V^{\frac{1}{2}} = \text{constant}$$

$$\frac{T_2}{T_1} = \left(\frac{V_2}{V_1}\right)^{\frac{1}{2}} = \left(\frac{2V_1}{V_1}\right)^{\frac{1}{2}}$$

$$\frac{T_2}{T_1} = \sqrt{2}$$

2. Given below are two statements :

Statement 1 : In a diatomic molecule , the rotational energy at a given temperature obeys Maxwell's distribution .

Statement 2 : In a diatomic molecule , the rotational energy at a given temperature equals the translational kinetic energy for each molecule.

In the light of above statements, choose the correct answer from the options given below:

- A. Both statement 1 and statement 2 are false .
- B. Both statement 1 and statement 2 are true .
- C. Statement 1 is false but statement 2 is true
- D. Statement 1 is true but statement 2 is false .

The translational kinetic energy and rotational kinetic energy both obey Maxwell's distribution , independent of each other .

$$\text{T.K.E of diatomic molecule} = \frac{3}{2}KT \quad (\text{Translational degree of freedom} = 3)$$

$$\text{R.K.E of diatomic molecule} = \frac{2}{2}KT \quad (\text{Rotational degree of freedom} = 2)$$

So , Statement 1 is true but statement 2 is false .

Option (d) is the correct answer .

3. On the basis of kinetic theory of gases, the gas exerts pressure because its molecules:

- A. suffers change in momentum when impinge on the walls of container.
- B. continuously stick to the walls of the container.
- C. continuously lose their energy till it reaches wall.
- D. are attracted by the walls of the container.

Based on kinetic theory of gases, molecules suffer change in momentum when impinge on the walls of the container. Due to this, they exert a force resulting in exerting pressure on the walls of the container.

4. The root mean square speed of molecules of a given mass of a gas at 27°C and 1 atmosphere pressure is 200 ms^{-1} . The root mean square speed of molecules of the gas at 127°C and 2 atmosphere pressure is $\frac{x}{\sqrt{3}} \text{ ms}^{-1}$.

. The value of x will be .

Accepted Answers

400 400.0 400.00

Solution:

$$V_{\text{rms}} = \sqrt{\frac{3RT_1}{M_0}}$$

$$200 = \sqrt{\frac{3R \times 300}{M_0}} \dots\dots\dots(1)$$

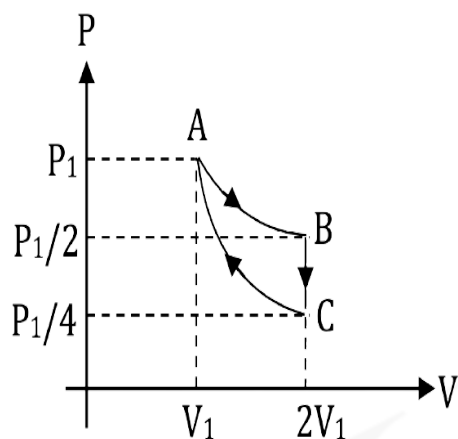
$$\text{Also, } \frac{x}{\sqrt{3}} = \sqrt{\frac{3R \times 400}{M_0}} \dots\dots\dots(2)$$

Dividing equation(1) by (2)

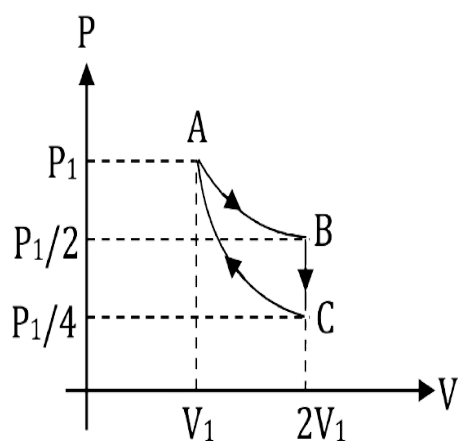
$$\frac{200}{\frac{x}{\sqrt{3}}} = \sqrt{\frac{300}{400}} = \sqrt{\frac{3}{4}}$$

$$\Rightarrow x = 400$$

5. If one mole of an ideal gas at (P_1, V_1, T) is allowed to expand reversibly and isothermally (A to B) its pressure is reduced to $\frac{1}{2}$ of original pressure (see figure). This is followed by a constant volume cooling till its pressure is reduced to one-fourth of initial value ($B \rightarrow C$). Then it is restored to its initial state by a reversible adiabatic compression (C to A). The net work done by the gas is equal to :



- A. 0
 B. $-\frac{RT}{2(\gamma - 1)}$
 C. $RT \left[\ln 2 - \frac{1}{2(\gamma - 1)} \right]$
 D. $RT \ln 2$



$AB \rightarrow$ Isothermal process,

$$\therefore W_{AB} = nRT \ln 2 = RT \ln 2$$

$BC \rightarrow$ Isochoric process,

$$\therefore W_{BC} = 0$$

$CA \rightarrow$ Adiabatic compression,

$$\therefore W_{CA} = \frac{P_1 V_1 - \frac{P_1}{4} \times 2V_1}{1 - \gamma}$$

$$= \frac{P_1 V_1}{2(1 - \gamma)} = \frac{RT}{2(1 - \gamma)}$$

So, total work done,

$$W_{ABCA} = RT \ln 2 + \frac{RT}{2(1 - \gamma)}$$

$$= RT \left[\ln 2 - \frac{1}{2(\gamma - 1)} \right]$$

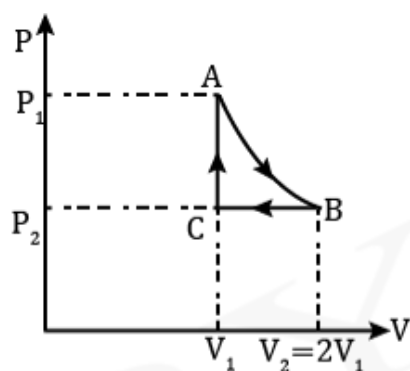
6. n moles of a perfect gas undergoes a cyclic process $ABCA$ (see figure) consisting of the following processes -

$A \rightarrow B$: Isothermal expansion at temperature T so that the volume is doubled from V_1 to V_2 and pressure changes from P_1 to P_2 .

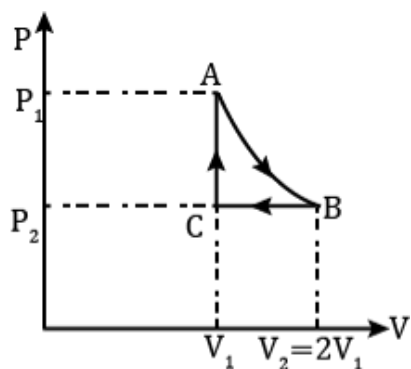
$B \rightarrow C$: Isobaric compression at pressure P_2 to initial volume V_1 .

$C \rightarrow A$: Isochoric change, leading to change of pressure from P_2 to P_1 .

Total work done in the complete cycle $ABCA$ is :



- A. 0
- B. $nRT \left(\ln 2 + \frac{1}{2} \right)$
- C. $nRT(\ln 2)$
- D. $nRT \left(\ln 2 - \frac{1}{2} \right)$



Given:

$A \rightarrow B$: Isothermal process
 $B \rightarrow C$: Isobaric process
 $C \rightarrow A$: Isochoric process

Also, $V_2 = 2V_1$

So, $P_2 = \frac{P_1}{2}$ as AB is an Isothermal process.

Work done by gas in the complete cycle $ABCA$ is

$$W = W_{AB} + W_{BC} + W_{CA} \dots\dots(1)$$

Now,

$W_{CA} = 0$ as Isochoric Process.

$$W_{AB} = P_1 V_1 \ln\left(\frac{V_2}{V_1}\right) = nRT \ln 2$$

$$W_{BC} = P_2(V_1 - V_2) = P_2(V_1 - 2V_1) = -P_2 V_1 = -\frac{nRT}{2}$$

Now, putting the values of W_{AB} , W_{BC} and W_{CA} in equation (1), we get :

$$W = nRT \ln 2 - \frac{nRT}{2} + 0$$

$$\Rightarrow W = nRT \left(\ln 2 - \frac{1}{2} \right)$$

7. Match List-I with List-II.

List-I	List-II
(a) Isothermal	(i) Pressure constant
(b) Isochoric	(ii) Temperature constant
(c) Adiabatic	(iii) Volume constant
(d) Isobaric	(iv) Heat content is constant

Choose the correct answer from the options given below -

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

By theory :

- (1). Isothermal process - Temperature is constant.
- (2). Isochoric process - Volume is constant.
- (3). Adiabatic process - Heat content is constant.
- (4). Isobaric process - Pressure is constant.

Hence, option (B) is correct.

8. Each side of a box made of metal sheet in cubic shape is a at room temperature T . The coefficient of linear expansion of the metal sheet is ' α '. The metal sheet is heated uniformly, by a small temperature ΔT , so that its new temperature is $T + \Delta T$. Calculate the increase in the volume of the metal box.

A. $\frac{4}{3}\pi a^3 \alpha \Delta T$

B. $4\pi a^3 \alpha \Delta T$

C. $3a^3 \alpha \Delta T$

D. $4a^3 \alpha \Delta T$

Coefficient of volumetric expansion,
 $\gamma = 3\alpha$

$$\frac{\Delta V}{V} = \gamma \Delta T$$

$$\Rightarrow \Delta V = V \gamma \Delta T$$

$$\Rightarrow \Delta V = 3a^3 \alpha \Delta T$$

9. A diatomic gas, having $C_p = \frac{7}{2}R$ and $C_v = \frac{5}{2}R$ is heated at constant pressure. The ratio $dU : dQ : dW$ is -

A. 3 : 7 : 2

B. 5 : 7 : 2

C. 5 : 7 : 3

D. 3 : 5 : 2

At constant pressure *i. e.* in Isobaric process,

$$dU : dQ : dW = C_v : C_p : R$$

$$\Rightarrow dU : dQ : dW = \frac{5}{2}R : \frac{7}{2}R : R$$

$$\Rightarrow dU : dQ : dW = 5 : 7 : 2$$

10. Given below are two statements : One is labelled as Assertion A and the other is labelled as Reason R .

Assertion A : When a rod lying freely is heated, no thermal stress is developed in it.

Reason R : On heating, the length of the rod increases.

In the light of the above statements, choose the correct answer from the options given below.

- A. A is true, but R is false.
- B. Both A and R are true, and R is the correct explanation of A .
- C. Both A and R are true, but R is **NOT** the correct explanation of A .
- D. A is false, but R is true.

If a rod is free, and it is heated, then there is no thermal stress produced in it as there is no external agent to produce stress.

The rod will expand due to an increase in temperature.

So, both A and R are true.

However, R is not the correct explanation of A .

11. A container is divided into two chambers by a partition. The volume of the first chamber is 4.5 L and the second chamber is 5.5 L. The first chamber contains 3.0 mol of gas at pressure 2.0 atm and the second chamber contain 4.0 mol of identical gas at pressure 3.0 atm. After the partition is removed and the mixture attains equilibrium, then, the common equilibrium pressure existing in the mixture is $x \times 10^{-1}$ atm. Value of x is _____. (up to two significant figures)

Accepted Answers

26 26.0 26.00

Solution:

By energy Conservation :

$$\frac{n_1 fRT_1}{2} + \frac{n_2 fRT_2}{2} = \frac{(n_1 + n_2) fRT}{2}$$

Using, $PV = nRT$, we get,

$$P_1 V_1 + P_2 V_2 = P(V_1 + V_2)$$

$$\Rightarrow P = \frac{P_1 V_1 + P_2 V_2}{V_1 + V_2}$$

$$\Rightarrow P = \frac{2 \times 4.5 + 3 \times 5.5}{4.5 + 5.5}$$

$$\Rightarrow P = 2.55 \text{ atm} = 25.5 \times 10^{-1} \text{ atm} \approx 26 \times 10^{-1} \text{ atm}$$

12. Calculate the value of mean free path (λ) for oxygen molecules at temperature 27°C and pressure $1.01 \times 10^5\text{ Pa}$. Assume the molecular diameter 0.3 nm and the gas is ideal. ($k = 1.38 \times 10^{-23}\text{ JK}^{-1}$)

- A. 102 nm
- B. 32 nm
- C. 58 nm
- D. 86 nm

Given: $P = 1.01 \times 10^5\text{ Pa}$
 $d = 0.3\text{ nm} = 0.3 \times 10^{-9}\text{ m}$
 $k = 1.38 \times 10^{-23}\text{ JK}^{-1}$
 $T = 27^\circ\text{C} = 300\text{ K}$

We know that:

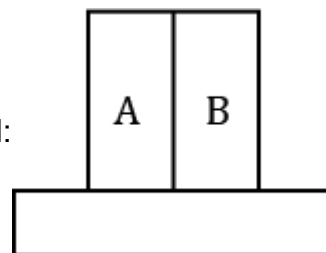
$$\lambda_{mean} = \frac{kT}{\sqrt{2}\pi d^2 P}$$

$$\Rightarrow \lambda_{mean} = \frac{1.38 \times 10^{-23} \times 300}{\sqrt{2} \times 3.14 \times 0.09 \times 10^{-18} \times 1.01 \times 10^5}$$

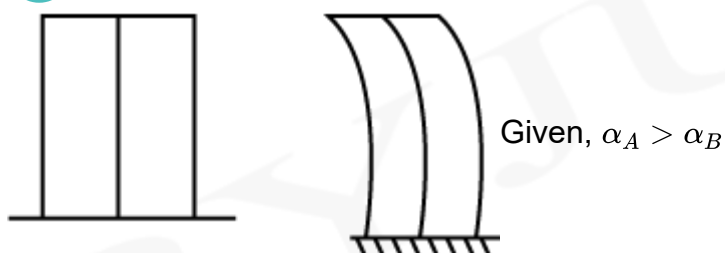
$$\therefore \lambda_{mean} = 102\text{ nm}$$

13. A bimetallic strip consists of metals A and B . It is mounted rigidly as shown. The metal A has higher coefficient of expansion compared to that of metal B .

When the bimetallic strip is placed in a cold bath, it will:



- A. Not bend but shrink
- B. Neither bend nor shrink
- C. Bend towards the right
- D. Bend towards the left



Length of both strips will decrease because their temperature will decrease when placed in cold bath.

We know, $\Delta L = L\alpha\Delta T$

So, change in length: $\Delta L_A > \Delta L_B$

$\Rightarrow A$ will be shorter and hence will bend towards left.

14. If one mole of a polyatomic gas has two vibrational modes and β is the ratio of molar specific heats for polyatomic gas. $\beta = \frac{C_p}{C_v}$, then the value of β is :

- A. 1.35
- B. 1.02
- C. 1.25
- D. 1.2

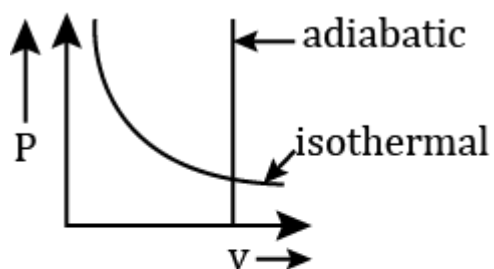
Here, number of translational degree of freedom = 3
 number of rotational degree of freedom = 3
 and number of vibrational degree of freedom = $2 \times 2 = 4$

Therefore, total number of degree of freedom, $f = 3 + 3 + 4 = 10$

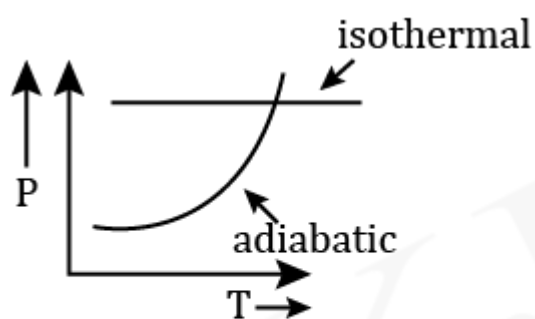
$$\beta = \frac{C_p}{C_v} = 1 + \frac{2}{f} = 1 + \frac{2}{10}$$

$$\beta = \frac{12}{10} = 1.2$$

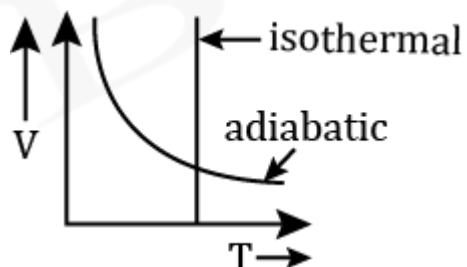
15. Which one is the correct option depicting the two different thermodynamic processes?



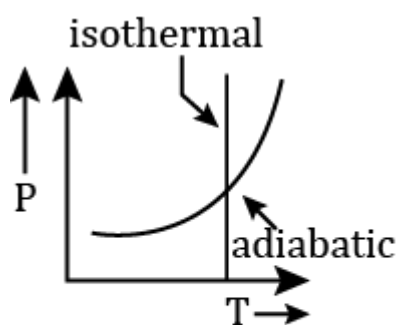
(a)



(b)



(c)



(d)

- A. (c) and (d)
- B. (b) and (c)
- C. (a) only
- D. (c) and (a)

Isothermal process means constant temperature which is only possible in graph (c) & (d)

for adiabatic process

$$PV^\gamma = \text{Constant} \dots(1)$$

$$\because PV = nRT$$

$$\Rightarrow P \propto \frac{T}{V}$$

$$\text{So, } \frac{T}{V} V^\gamma = \text{Constant}$$

$$\text{or, } TV^{\gamma-1} = \text{Constant} \dots(2)$$

Differentiating equation (2) w.r.t temperature T , we get

$$\frac{dV}{dT} = -\frac{V}{T(\gamma-1)}$$

Slope is negative

Similarly,

$$V \propto \frac{T}{P}$$

$$\Rightarrow P \left(\frac{T}{P} \right)^\gamma = \text{Constant}$$

$$\text{or, } P^{1-\gamma} T^\gamma = \text{Constant} \dots(3)$$

\because differentiating equation (3) w.r.t temperature

$$\Rightarrow (P)^{1-\gamma} \gamma (T)^{\gamma-1} dT + (T)^\gamma (1-\gamma) (P)^{1-\gamma-1} dP = 0$$

$$\text{or, } \frac{dP}{dT} = -\left(\frac{\gamma}{1-\gamma} \right) \left(\frac{P}{T} \right)$$

$$\text{or, } \frac{dP}{dT} = \left(\frac{\gamma}{\gamma-1} \right) \left(\frac{P}{T} \right),$$

It gives (+ve) slope.

16. A Carnot's engine working between 400 K and 800 K has a work output of 1200 J per cycle. The amount of heat energy supplied to the engine from the source in each cycle is :

- A. 1900 J
- B. 3200 J
- C. 2400 J
- D. 1600 J

Efficiency,

$$\eta = 1 - \frac{T_2}{T_1} = \frac{W}{Q_1}$$

$T_1 = \text{Source's temperature} = 800 \text{ K}$

$T_2 = \text{Sink's temperature} = 400 \text{ K}$

$\eta = \text{Efficiency of engine}$

$W = \text{Work output} = 1200 \text{ J}$

$Q_1 = \text{Heat supplied to engine}$

So,

$$\eta = 1 - \frac{400}{800} = 0.5$$

$$\Rightarrow 0.5 = \frac{W}{Q_1} = \frac{1200}{Q_1}$$

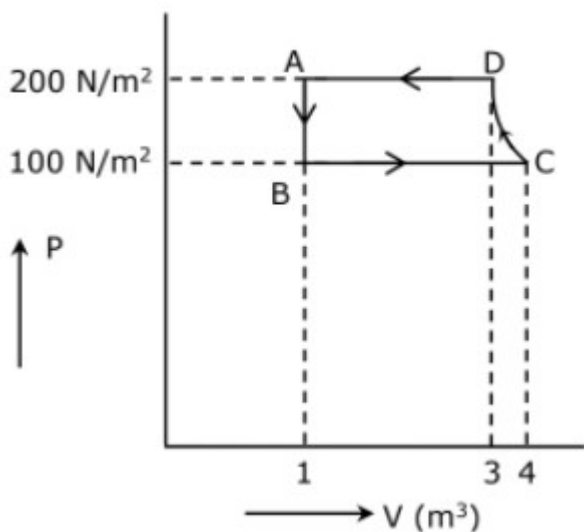
$$\Rightarrow Q_1 = 2400 \text{ J}$$

17. What will be the average value of energy along one degree of freedom for an ideal gas in thermal equilibrium at a temperature T ? (k_B is Boltzmann constant)

- A. $k_B T$
- B. $\frac{2}{3} k_B T$
- C. $\frac{3}{2} k_B T$
- D. $\frac{1}{2} k_B T$

Energy associated with each translational degree of freedom is $\frac{1}{2} k_B T$.

18. The $P - V$ diagram of a diatomic ideal gas system going under cyclic process as shown in figure. The work done during an adiabatic process CD is (use $\gamma = 1.4$):



- A. 200 J
- B. -500 J
- C. -400 J
- D. 400 J

workdone for adiabatic process is

$$W_{CD} = \frac{nR\Delta T}{1-\gamma} = \frac{P_f v_f - P_i v_i}{1-\gamma} = \frac{200 \times 3 - 100 \times 4}{1-1.4}$$

$$W_{CD} = \frac{600 - 400}{-0.4} = -\frac{200}{0.4} = -500 \text{ J}$$

$$W_{CD} = -500 \text{ J}$$

19. Consider a sample of oxygen gas behaving like an ideal gas. At 300 K, the ratio of root-mean-square (RMS) velocity to the average velocity of the gas molecules will be :

(Molecular weight of oxygen = 32 g/mol ; $R = 8.3 \text{ JK}^{-1}\text{mol}^{-1}$)

- A. $\sqrt{\frac{5}{3}}$
- B. $\sqrt{\frac{8}{3}}$
- C. $\sqrt{\frac{3\pi}{8}}$
- D. $\sqrt{\frac{8\pi}{3}}$

We know that,

$$v_{RMS} = \sqrt{\frac{3RT}{M}}, \text{ and,}$$

$$v_{avg} = \sqrt{\frac{8RT}{\pi M}}$$

$$\therefore \frac{v_{RMS}}{v_{avg}} = \sqrt{\frac{3\pi}{8}}$$

Hence, option (C) is the correct answer.

20. For adiabatic expansion of an ideal gas, the fractional change in its pressure is equal to :

(γ is the ratio of specific heats and V is the volume of the gas)

A. $-\gamma \frac{dV}{V}$

B. $\frac{dV}{V}$

C. $-\frac{1}{\gamma} \frac{dV}{V}$

D. $-\gamma \frac{V}{dV}$

For adiabatic process,

$$PV^\gamma = \text{constant}$$

$$\Rightarrow \ln P + \gamma \ln V = \text{constant}$$

Differentiating both sides,

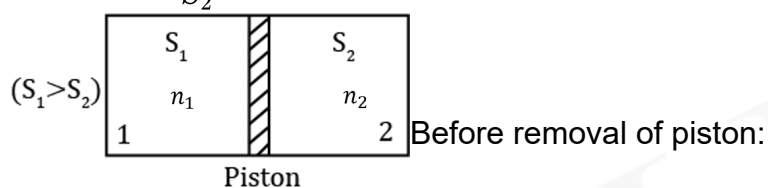
$$\frac{dP}{P} + \gamma \frac{dV}{V} = 0$$

$$\Rightarrow \frac{dP}{P} = -\gamma \frac{dV}{V}$$

Hence, option (A) is the correct answer.

21. An ideal gas in a cylinder is separated by a piston in such a way that the entropy of one part is S_1 and that of the other part is S_2 . Given that $S_1 > S_2$. If the piston is removed, then the total entropy of the system will be :

- A. $S_1 + S_2$
- B. $S_1 - S_2$
- C. $S_1 \times S_2$
- D. $\frac{S_1}{S_2}$



For part 1, $S_1 = \frac{n_1 f R}{2}$

For part 2, $S_2 = \frac{n_2 f R}{2}$

After removal of piston:

Gas is identical, so f will be the same.

$$S = \frac{(n_1 + n_2) f R}{2}$$

$$\Rightarrow S = S_1 + S_2$$

Hence, option (A) is the correct answer.

22. Consider two ideal diatomic gases A and B at some temperature T . Molecules of the gas A are rigid, and have a mass m . Molecules of the gas B have an additional vibrational mode, and have a mass $\frac{m}{4}$. The ratio of the specific heats $(C_V)_A$ and $(C_V)_B$ of the gases A and B respectively, is:

- A. 7 : 9
- B. 5 : 9
- C. 3 : 5
- D. 5 : 7

Specific heat of gas at constant volume

$$C_V = \frac{1}{2}fR \quad f \rightarrow \text{degree of freedom}$$

For gas A (diatomic)

$f = 5$ (3 translational + 2 rotational)

$$\therefore (C_V)_A = \frac{5}{2}R$$

For gas B (diatomic) $f = 7$ (3 translational + 2 rotational), 2 vibrational degree of freedom.

$$\therefore (C_V)_B = \frac{7}{2}R$$

$$\text{Now, } \frac{(C_V)_A}{(C_V)_B} = \frac{\frac{5}{2}R}{\frac{7}{2}R} = \frac{5}{7}$$

Hence, (D) is the correct answer.

23. When the temperature of a metal wire is increased from 0°C to 10°C , its length increased by 0.02%. The percentage change in its mass density will be closest to

- A. 0.06
- B. 2.3
- C. 0.008
- D. 0.8

Change in length of the metal wire (Δl) when its temperature is changed by ΔT is given by

$$\Delta l = l\alpha\Delta T$$

Here, α Coefficient of linear expansion

Here, $\Delta l = 0.02\%$, $\Delta T = 10^{\circ}\text{C}$

$$\therefore \alpha = \frac{\Delta l}{l\Delta T} = \frac{0.02}{100 \times 10}$$

$$\Rightarrow \alpha = 2 \times 10^{-5}$$

Volume coefficient of expansion, $\gamma = 3\alpha = 6 \times 10^{-5}$

$$\frac{\Delta V}{V} \times 100 = \gamma\Delta T = (6 \times 10^{-5} \times 10 \times 100) = 6 \times 10^{-2}$$

Volume increase by 0.06%

$$\therefore \rho = \frac{M}{V}$$

Therefore, density decrease by 0.06%.

24. Two different wires having lengths L_1 and L_2 and respective temperature coefficient of linear expansion α_1 and α_2 are joined end to end. Then the effective temperature coefficient of linear expansion is:

- A. $\frac{\alpha L_1 + \alpha_2 L_2}{L_1 + L_2}$
- B. $2\sqrt{\alpha_1 \alpha_2}$
- C. $\frac{\alpha_1 + \alpha_2}{2}$
- D. $\frac{\alpha_1 \alpha_2 L_2 L_1}{\alpha_1 + \alpha_2 (L_2 + L_1)^2}$

Let L'_1 and L'_2 be the lengths of the wire when temperature is changed by $\Delta T^\circ C$

At $T^\circ C$

$$L_{eq} = L_1 + L_2$$

At $T + \Delta^\circ C$

$$L'_{eq} = L'_1 + L'_2$$

$$\therefore L_{eq}(1 + \alpha_{eq}\Delta T) = L_1(1 + \alpha_1\Delta T) + L_2(1 + \alpha_2\Delta T) [\because L' = L(1 + \alpha\Delta T)]$$

$$\Rightarrow (L_1 + L_2)(1 + \alpha_{eq}\Delta T) = L_1 + L_2 + L_1\alpha_1\Delta T + L_2\alpha_2\Delta T$$

$$\Rightarrow \alpha_{eq} = \frac{\alpha_1 L_1 + \alpha_2 L_2}{L_1 + L_2}$$

25. Consider a mixture of gas molecules of type A , B and C having masses, $m_A < m_B < m_C$. The ratio of their root-mean-square speeds at normal temperature and pressure is :

A. $v_A = v_B = v_C = 0$

B. $\frac{1}{v_A} > \frac{1}{v_B} > \frac{1}{v_C}$

C. $v_A = v_B \neq v_C$

D. $\frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_C}$

$$v_{\text{rms}} = \sqrt{\frac{3k_B T}{m}}$$

At the same, normal temperature and pressure,

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

$$\therefore m_A < m_B < m_C$$

$$\Rightarrow v_A > v_B > v_C$$

$$\Rightarrow \frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_C}$$

Hence, option (D) is the correct answer.

26. What will be the average value of energy for a monoatomic gas in thermal equilibrium at temperature T ?

A. $\frac{2}{3}k_B T$

B. $k_B T$

C. $\frac{3}{2}k_B T$

D. $\frac{1}{2}k_B T$

As per Equi-partition law :

Each degree of freedom contributes $\frac{1}{2}k_B T$ average energy.

In monoatomic gas, $D. O. F. = 3$

$$\Rightarrow \text{Average energy} = 3 \times \frac{1}{2}k_B T = \frac{3}{2}k_B T$$

Hence, (C) is the correct answer.

27. For a gas $C_P - C_V = R$ in a state P and $C_P - C_V = (1.10) R$ in a state Q . T_P and T_Q are the temperatures in two different states P and Q respectively. Then,

A. $T_P = T_Q$

B. $T_P < T_Q$

C. $T_P = 0.9 T_Q$

D. $T_P > T_Q$

Given equations,

$$C_P - C_V = R \quad [\text{Valid for an ideal gas}]$$

$$C_P - C_V = 1.10R \quad [\text{Valid for real gas}]$$

Any gas behaves as ideal gas, at high temperature and low pressure.

$$\text{So, } T_P > T_Q$$

Hence, (D) is the correct answer.

28. A system consists of two types of gas molecules A and B having the same number density $2 \times 10^{25} \text{ m}^{-3}$. The diameter of A and B are 10 \AA and 5 \AA respectively. They suffer collision at room temperature. The ratio of average distance covered by the molecule A to that of B between two successive collision is $\times 10^{-2}$

Accepted Answers

25

Solution:

The average distance covered by a molecule between two successive collision is called as mean free path.

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n}$$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{d_2^2 n_2}{d_1^2 n_1}$$

Here, $n_1 = n_2$, $d_2 = 5 \text{ \AA}$, $d_1 = 10 \text{ \AA}$

$$\Rightarrow \lambda = \left(\frac{5}{10}\right)^2 = 0.25 = 25 \times 10^{-2} \text{ m}$$

Hence, 25 is the correct answer.

29. The number of molecules in one litre of an ideal gas at 300 K and 2 atmospheric pressure with mean kinetic energy 2×10^{-9} J per molecule is :

A. 0.75×10^{11}

B. 3×10^{11}

C. 1.5×10^{11}

D. 6×10^{11}

Given:

$$T = 300 \text{ K}; P = 2 \text{ atm}$$

$$KE = 2 \times 10^{-9} \text{ J}; V = 10^{-3} \text{ m}^3$$

Average kinetic energy per molecules is given by,

$$KE = \frac{3}{2}kT = \frac{3 R}{2 N_A}T$$

$$\Rightarrow \frac{RT}{N_A} = \frac{2 \times KE}{3} = \frac{4 \times 10^{-9}}{3}$$

Ideal gas equation is given by,

$$PV = \frac{N}{N_A}RT$$

Putting the value in the above equation, we get

$$2 \times 1.01325 \times 10^5 \times 10^{-3} = N \times \frac{4 \times 10^{-9}}{3}$$

$$\therefore N = 1.5 \times 10^{11} \text{ molecules}$$

Hence, option (C) is correct.

30. An ideal gas is expanding such that $PT^3 = \text{constant}$. The coefficient of volume expansion of the gas is:

A. $\frac{1}{T}$

B. $\frac{2}{T}$

C. $\frac{3}{T}$

D. $\frac{4}{T}$

Given :-

$$PT^3 = k \text{ (let)}$$

$$\Rightarrow \left(\frac{nRT}{V} \right) \times T^3 = k$$

$$\text{Or, } \frac{T^4}{V} = k'$$

Differentiating the equation :-

$$\frac{4T^3}{V} dT - \frac{T^4}{V^2} dV = 0$$

$$\Rightarrow \frac{dV}{VdT} = \frac{4}{T}$$

$$\Rightarrow \beta = \frac{4}{T}$$

Where, $\beta = \frac{dV}{VdT}$ is the coefficient of volume expansion.