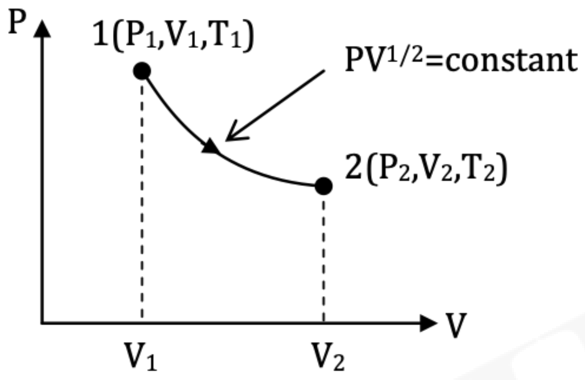
Topic : KTG, Thermometry and thermodynamics

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. $\sqrt{2}$

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 .

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.

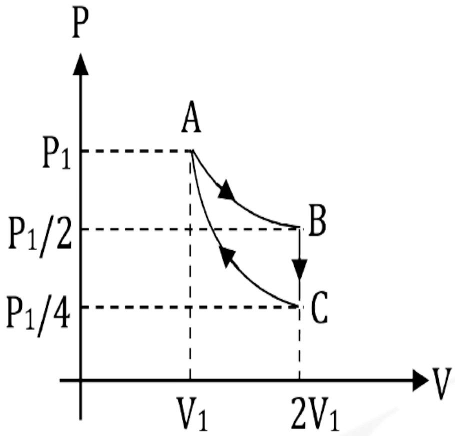
B. continuously stick to the walls of the container.

C. continuously lose their energy till it reaches wall.

D. are attracted by the walls of the container.

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

5. If one mole of an ideal gas at (P_1, V_1, T) is allowed to expand reversibly and isothermally $(A \text{ to} B)$ 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 $(C \text{ to } A)$. 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. $RT \ln 2$

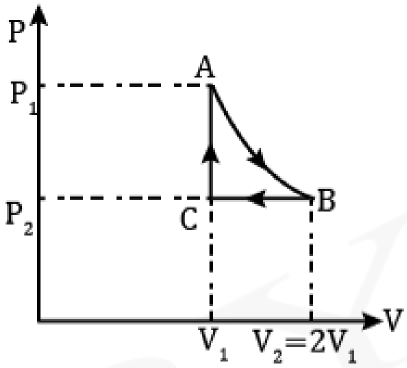
6. n moles of a perfect gas undergoes a cyclic process $ABCA$ (see figure) consisting of the following processes -

$A \to B$: 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.

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

$C \to A$: 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. $nRT\left(\ln 2 - \frac{1}{2}\right)$

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. $(a)-(iii),(b)-(ii),(c)-(i),(d)-(iv)$

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

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. $3:5:2$

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.

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

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

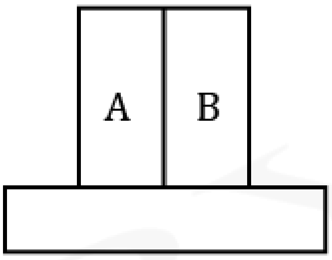
A. 102 nm

B. 32 nm

C. 58 nm

D. 86 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

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

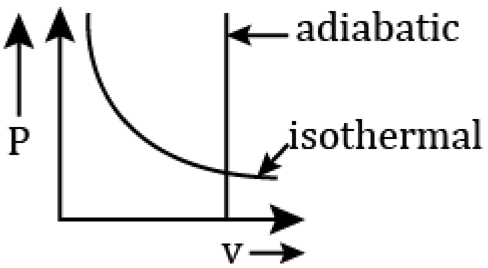
A. 1.35

B. 1.02

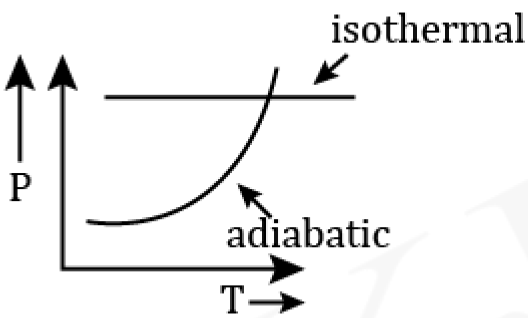
C. 1.25

D. 1.2

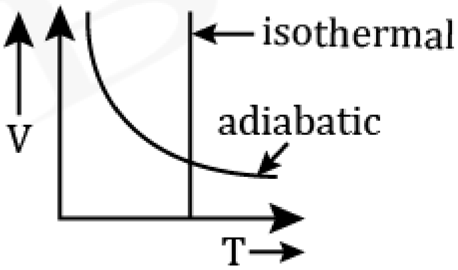
15. Which one is the correct option depicting the two different thermodynamic processes?



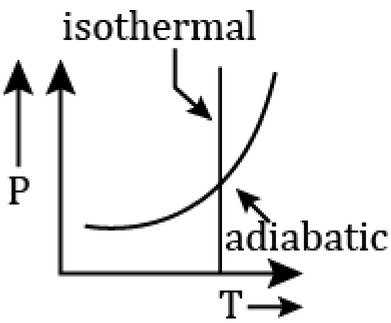
(a)



(b)



(c)



(d)

A. (c) and (d)

B. (b) and (c)

C. (a) only

D. (c) and (a)

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

A. $1900\ \mathrm{J}$

B. $3200\ \mathrm{J}$

C. $2400\ \mathrm{J}$

D. $1600\ \mathrm{J}$

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)

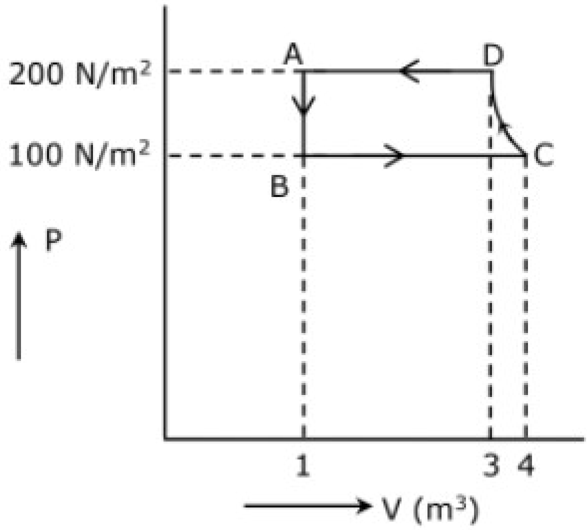
A. k_BT

B. $\frac{2}{3}k_BT$

C. $\frac{3}{2}k_BT$

D. $\frac{1}{2}k_BT$

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

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$= 32 \text{ g/mol}$; $R = 8.3 \text{ JK}^{-1}\text{mol}^{-1}$)

A. $\sqrt{\frac{5}{3}}$

B. $\sqrt{\frac{8}{3}}$

C. $\sqrt{\frac{3\pi}{8}}$

D. $\sqrt{\frac{8\pi}{3}}$

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

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. $\frac{S_1}{S_2}$

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. $5:7$

23. When the temperature of a metal wire is increased from $0^{\circ}\mathrm{C}$ to $10^{\circ}\mathrm{C}$, 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

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

A. $\dfrac{\alpha L_1 + \alpha_2 L_2}{L_1 + L_2}$

B. $2\sqrt{\alpha_1 \alpha_2}$

C. $\dfrac{\alpha_1 + \alpha_2}{2}$

D. $\dfrac{\alpha_1 \alpha_2 \qquad L_2 L_1}{\alpha_1 + \alpha_2 \, (L_2 + L_1)^2}$

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. $\dfrac{1}{v_A} > \dfrac{1}{v_B} > \dfrac{1}{v_C}$

C. $v_A = v_B \neq v_C$

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

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

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. $T_P > T_Q$

28. A system consists of two types of gas molecules A and B having the same number density $2 \times 10^{25}\ \mathrm{m}^{-3}$. The diameter of A and B are $10\ \dot{A}$ and $5\ \dot{A}$ 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 $\times 10^{-2}$

29. The number of molecules in one litre of an ideal gas at $300\ \mathrm{K}$ 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}

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

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

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

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

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