ULTIMATE KCET

CRASH COURSE 2026

Physics | Lecture :- 01

Thermodynamics + KTG

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Recap of previous lecture

1. MECHANICAL PROPERTIES OF FLUIDS
2. QUESTIONS ON MPOF
3. THERMAL PROPERTIES OF MATTER
4. QUESTION TPOM

Topics

to be covered

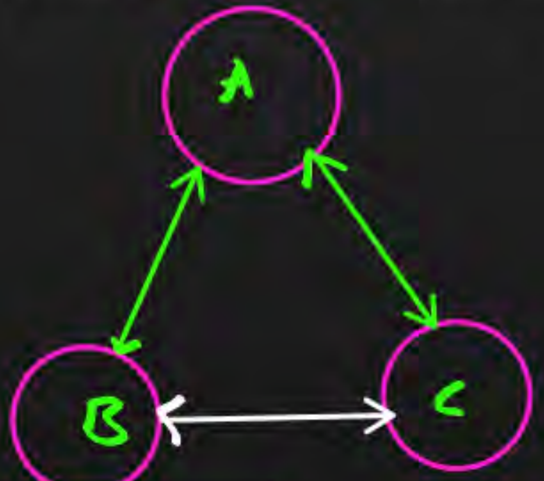
1. THERMODYNAMICS
2. QUESTIONS ON THERMODYNAMICS
3. KINETIC THEORY
4. QUESTIONS ON KINETIC THEORY

Thermo-Dynamics

Thermo-dynamics

Laws of thermodynamics

Zeroth law of thermodynamics: Two systems each in thermal equilibrium with a third system are in thermal equilibrium with each other



First law of thermodynamics: $\boxed{\begin{array}{c}\Delta Q = \Delta W + \Delta U \\ Q = W + U\end{array}}$ *

Equation for Isothermal process, $T = \text{constant}$, $PV = nRT \Rightarrow \boxed{PV = \text{const}}$

Equation for Adiabatic process $\Delta Q = 0$, $\boxed{PV^{\gamma} = \text{const}}$, $\gamma = \frac{C_P}{C_V}$

Equation for Isobaric process, $P = \text{constant}$, $V = \frac{nRT}{P} \Rightarrow \boxed{\frac{V}{T} = \frac{nR}{P} = \text{const}}$

Thermo-dynamics

Work done in processes

Isothermal process:

$$W = nRT \ln\left(\frac{V_f}{V_i}\right) = nRT \ln\left(\frac{P_i}{P_f}\right)$$

Adiabatic process:

$$W = \frac{P_iV_i - P_fV_f}{\gamma - 1} = \frac{nR(T_i - T_f)}{\gamma - 1}$$

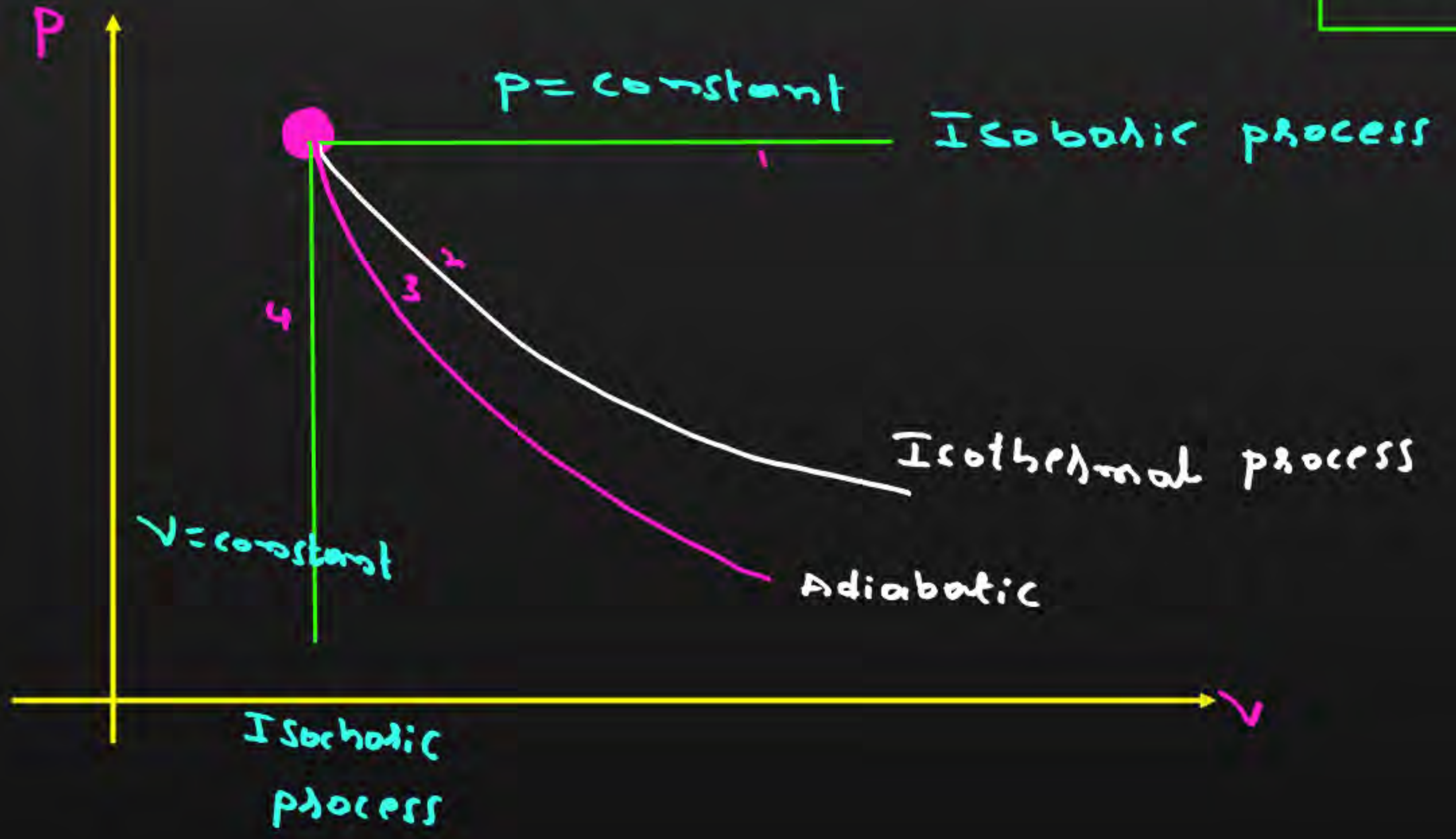
Isobaric process :

$$W = P(V_f - V_i) = nR(T_f - T_i)$$

P-V Diagrams of thermodynamics

Work done = Area under P-V Diagram

P-V Diagram



Thermo-dynamics

Second Law of Thermodynamics :

→ conservation of Energy.

Kelvin-Planck statement : No process is possible whose sole result is the absorption of heat from a reservoir and complete conversion of the heat into work.

Clausius statement : No process is possible whose sole result is the transfer of heat from a colder object to a hotter object.

Thermo-dynamics

The second law implies that no heat engine can have efficiency η equal to 1 or no refrigerator can have coefficient of performance β equal to infinity.

Efficiency of a heat engine,

$$* \quad \eta = \frac{work\ done}{heat\ absorbed} = \frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

Cycle Process

During this process the system undergoes a series of changes & finally returns to the original state is called cyclic process.

OR

If a system originates and ends at the same state after a series of changes then the process is called a cyclic process.

$$* \boxed{\Delta U = 0} \Longrightarrow \boxed{\Delta Q = \Delta W}$$

Cycle Process

Work done in cyclic process:

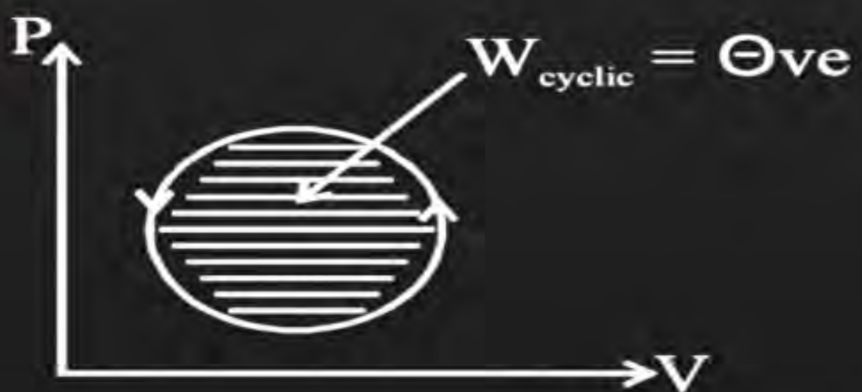
(a) ΔW = Area enclosed between closed loop

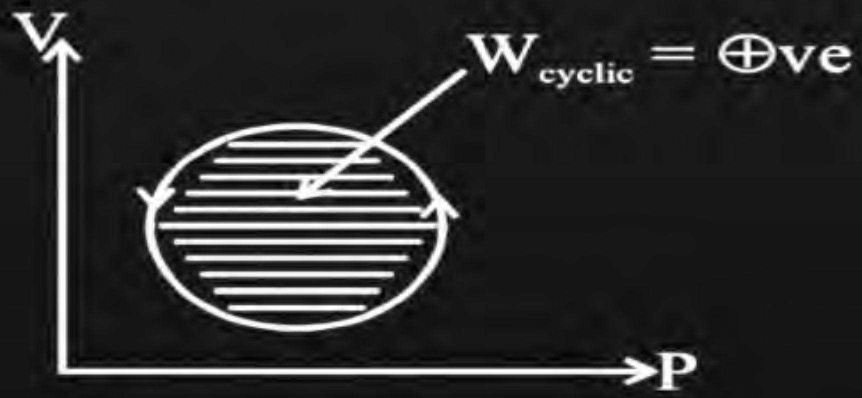
(b) In PV graph

Direction
- C.W. $\Rightarrow$ $\Delta W = +ve$
- ACW $\Rightarrow$ $\Delta W = -ve$

(c) In V-P graph

Direction
- C.W. : $\Delta W = -ve$
- ACW. : $\Delta W = +ve$





Kinetic Theory of Gases

Kinetic Theory of Gases

Equation of an ideal gas : $\boxed{PV = nRT}$

$R = 8.34$ J/mol-K

$R = 2$ cal/mol-°c

Boyle's law : $T = \text{const}$

$$\boxed{PV = \text{constant}}$$

$$\boxed{P_1V_1 = P_2V_2}$$

Charles' law : $P = \text{const}$

$$\boxed{\frac{V}{T} = \frac{nR}{P} = \text{const}}$$

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

Gay Lussac's law $V = \text{const}$

$$\boxed{\frac{P}{T} = \frac{nR}{V} = \text{const.}}$$

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

Kinetic Theory of Gases

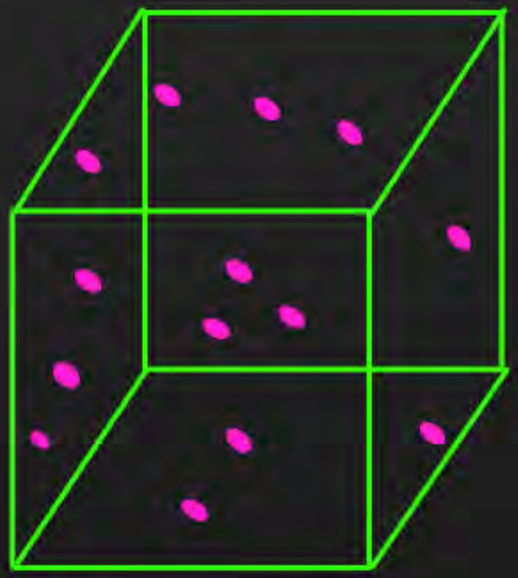
Pressure Exerted by a Gas :

$$\boxed{P = \frac{1}{3} \rho v^2}$$

$$\boxed{P = \frac{1}{3}\left(\frac{m}{V_{ol}}\right) v^2}$$

$$P = \frac{2}{2} \times \frac{1}{3} (\rho v^2)$$

$$\boxed{P = \frac{2}{3}\left(\frac{1}{2} \rho v^2\right)} \Rightarrow \boxed{P = \frac{2}{3} E}$$



Kinetic Theory of Gases

From Maxwell's speed distribution law: For one molecule of a gas

Mean speed or average speed,

$$v_{avg} = \sqrt{\frac{8}{\pi}\frac{KT}{m}}$$

$K \to R$

$m \to M$

$K = 1.38 \times 10^{-23}$

Root mean square speed,

$$v_{rms} = \sqrt{\frac{3KT}{m}}$$

Most probable speed,

$$v_{mps} = \sqrt{\frac{2KT}{m}}$$

Kinetic Theory of Gases

From Maxwell's speed distribution law: For one mole of a gas

Mean speed or average speed $v_{avg} = \sqrt{\frac{8}{\pi}\frac{RT}{M}}$

Root mean square speed, $v_{rms} = \sqrt{\frac{3RT}{M}}$

Most probable speed, $v_{mps} = \sqrt{\frac{2RT}{M}}$

Kinetic Theory of Gases

Degrees of freedom can be calculated as, $f = 3N - K$, where f = degree of freedom, N = number of independent particles, K = number of constraint.

(a)For monatomic gas : Ex : He, Ne and Ar

$$f = 3(1) - 0$$

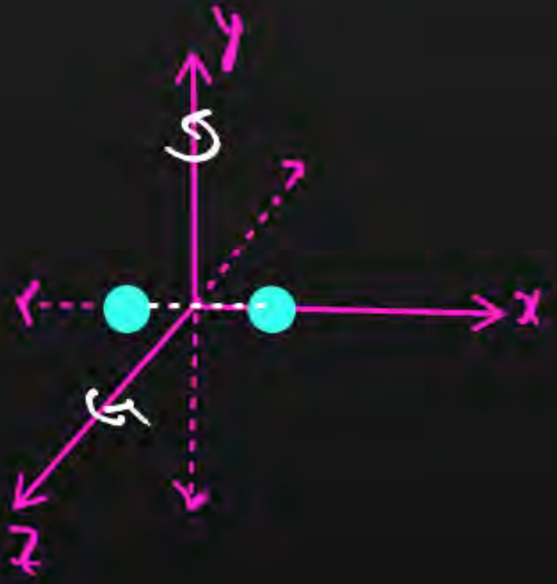
$\boxed{f = 3}$ → 3 ways-Translation Energy

(b) For diatomic gas : Ex : H_2, N_2 and O_2

$$f = 3(2) - 1$$

$f = 6 - 1$ → 3-Translation Energy

$\boxed{f = 5}$ → 2-Rotational Energy



Kinetic Theory of Gases

Mayer's Formula :

$$\boxed{R = C_p - C_v}$$

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

$$C_v = \frac{fR}{2}$$

Kinetic Theory of Gases

Law of Equipartition of Energy (Boltzmann law) : The average KE per molecule of a gas per degree of freedom $\frac{1}{2}k_BT$, where k_B is Boltzmann constant and T is the absolute temperature in kelvin.

$$\boxed{E = \frac{f}{2}k_BT = \frac{1}{2}nfRT}$$

For monoatomic gas $f = 3$

Average KE per molecule of a gas $= \frac{3}{2}k_BT$

Average KE per mole of a gas $= \frac{3}{2}(k_BT)N = \frac{3}{2}RT$

Molar specific heat of gas at constant volume, $C_V = \frac{3}{2}R$.

Molar specific heat of gas at constant pressure, $C_P = \frac{5}{2}R$.

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

$E = \frac{1}{2}(1)\,3RT = \frac{3RT}{2}$

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

$C_V = \frac{fR}{2} = \frac{3R}{2}$

$\boxed{\gamma = \frac{5}{3}}$

$C_P = \left(1 + \frac{f}{2}\right)R = \frac{5R}{2}$

Kinetic Theory of Gases

For diatomic gas

Average KE per molecule of gas $= \frac{5}{2}k_BT$

Average KE per mole of gas $= \frac{5}{2}RT$

Molar specific heat of gas at constant volume $C_V = \frac{5}{2}R$

Molar specific heat of gas at constant pressure, $C_P = \frac{7}{2}R$

Kinetic Theory of Gases

According to kinetic theory, mean free path is given by

$$\boxed{\lambda = \frac{1}{\sqrt{2}\pi n d^2}} \qquad \lambda \propto \frac{1}{d^2} \qquad \lambda \propto \frac{1}{r^2}$$

where d is the diameter of the molecule and n is number of molecules per unit volume of the gas.

QUESTION

The work by an ideal monoatomic gas along the cyclic path $LMNOL$ is

A $\boxed{PV}$

B $2\,PV$

C $3\,PV$

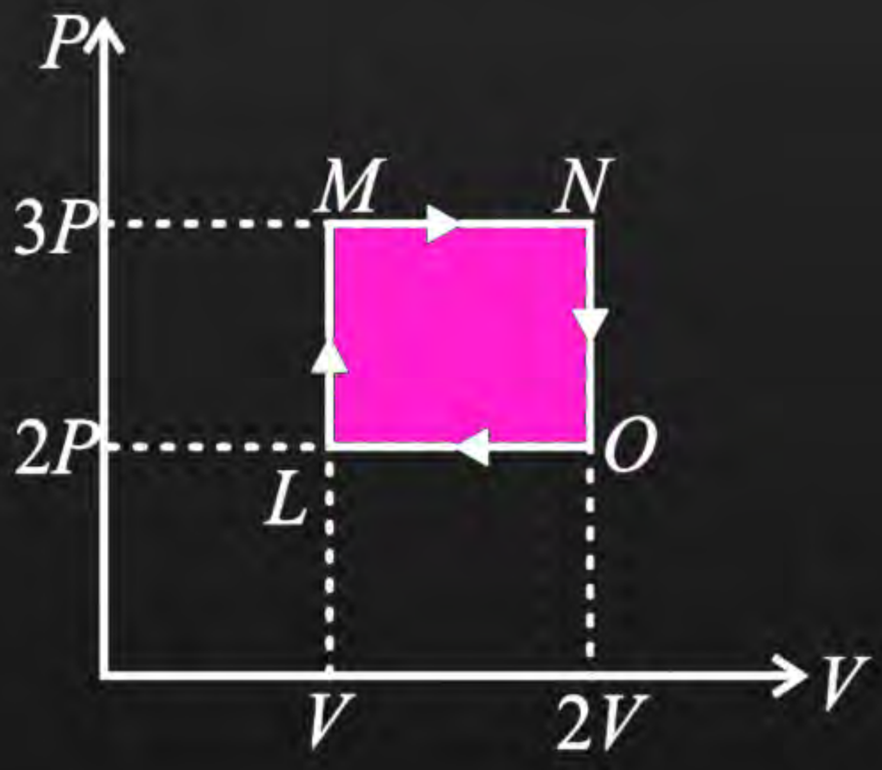
D $4\,PV$

$W = +(l \times b)$

$W = (2V - V) \times (3P - 2P)$

$W = V \times P$

$\boxed{W = PV}$



QUESTION

The work done by a gas taken through the closed process *ABCA* is

A $\boxed{6P_0V_0}$

B $4P_0V_0$

C P_0V_0

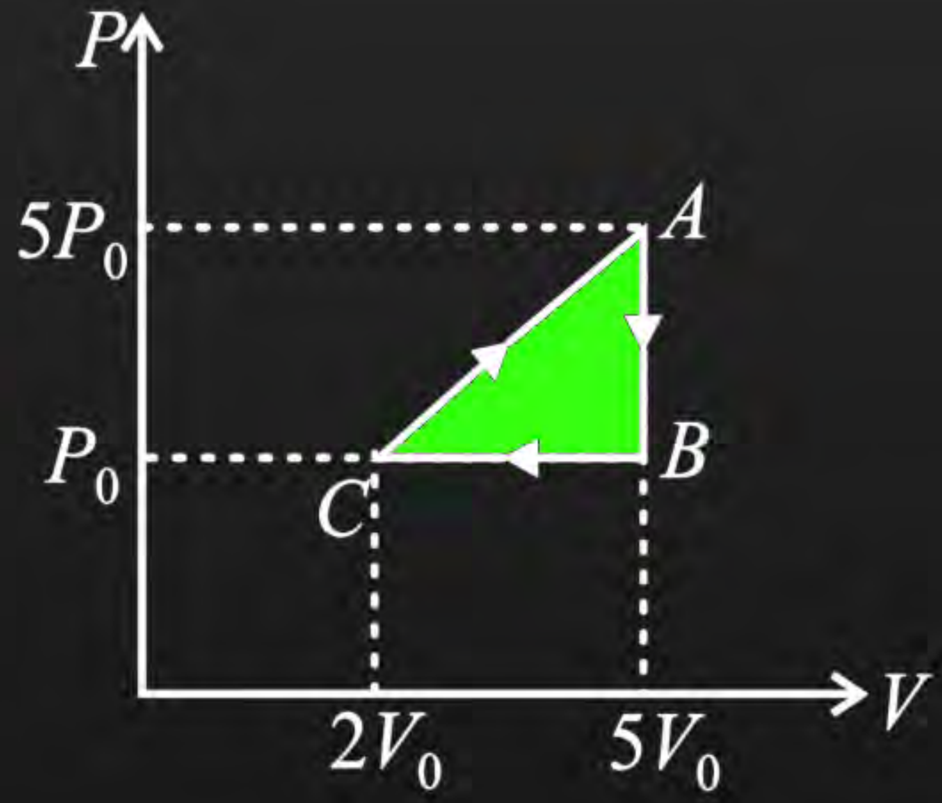
D zero

$W = +\left(\frac{1}{2} \times b \times h\right)$

$W = \frac{1}{2} \times (5V_0 - 2V_0) \times (5P_0 - P_0)$

$W = \frac{1}{\cancel{2}} \times 3V_0 \times \overset{2}{4}P_0$

$\boxed{W = 6P_0V_0}$



QUESTION

The first law of thermodynamics is based on:-

$\Delta \overset{\checkmark}{Q} = \Delta \overset{\checkmark}{W} + \Delta \overset{\checkmark}{U}$

- **A** Law of conservation of energy
- **B** Law of conservation of mechanical energy ✗
- **C** Law of conservation of gravitational P.E. ✗
- **D** None of the above

QUESTION

$\Delta Q = +500\ \text{cal} = 500 \times 4.186\ \text{J}$

In a process, 500 calories of heat is given to a system and at the same time 100 joules of work is done on the system. The increase in the internal energy of the system is :-

$\Delta W = -100\ \text{J}$

$1\ \text{cal} = 4.186\ \text{J}$

A 40 calories

B 1993 joules

C $\boxed{\text{2193 joules}}$

D 82 calories

$\Delta Q = \Delta W + \Delta U$

$2093 = -100 + \Delta U$

$\Delta U = 2093 + 100$

$\boxed{\Delta U = 2193\ \text{J}}$

QUESTION

In a thermodynamic process pressure of a fixed mass of a gas is changed in such a manner that the gas releases 20 joules of heat and 8 joules of work was done on the gas. If the initial internal energy of the gas was 30 joules, then the final internal energy will be:-

A 2 J

B 42 J

C $\boxed{18\ J}$

D 58 J

$\Delta Q = -20J$

$\Delta W = -8J$

$U_i = 30J$

$U_f = ?$

$\Delta Q = \Delta W + \Delta U$

$-20 = -8 + \Delta U$

$\Delta U = -20 + 8$

$\Delta U = -12$

$U_f - U_i = -12$

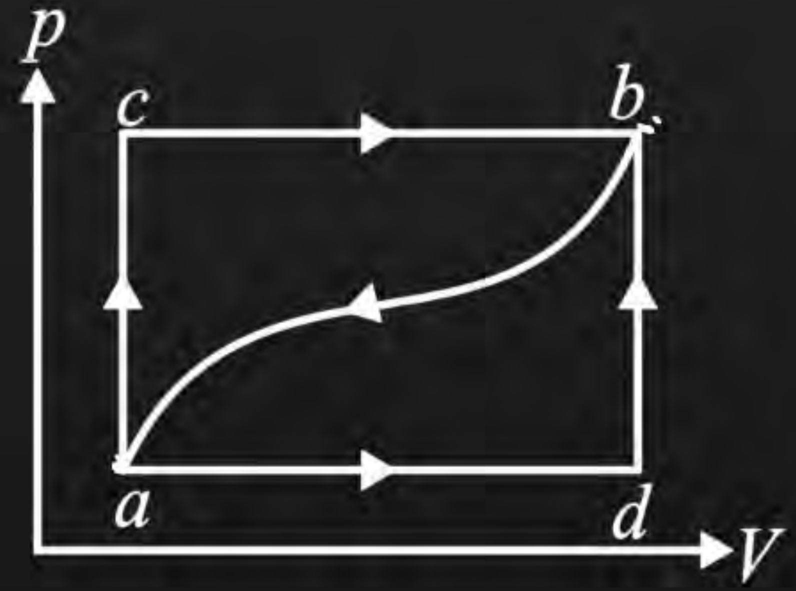
$U_f - 30 = -12$

$U_f = 30 - 12$

$\boxed{U_f = 18J}$

QUESTION

When a system is taken from state '*a*' to state '*b*' along the path '*acb*', it is found that a quantity of heat $Q = 200\ J$ is absorbed by the system and a work $W = 80\ J$ is done by it. Along the path '*adb*', $Q = 144\ J$. The work done along the path '*adb*' is



A 6 J

B 12 J

C 18 J

D $\boxed{24\ J}$

path acb: $\Delta Q = 200J$ $\Delta W = 80J$

$$\Delta Q = \Delta W + \Delta U$$

$$200 = 80 + \Delta U$$

$$\Delta U = 200 - 80 = 120J$$

$$\boxed{\Delta U = 120J}$$

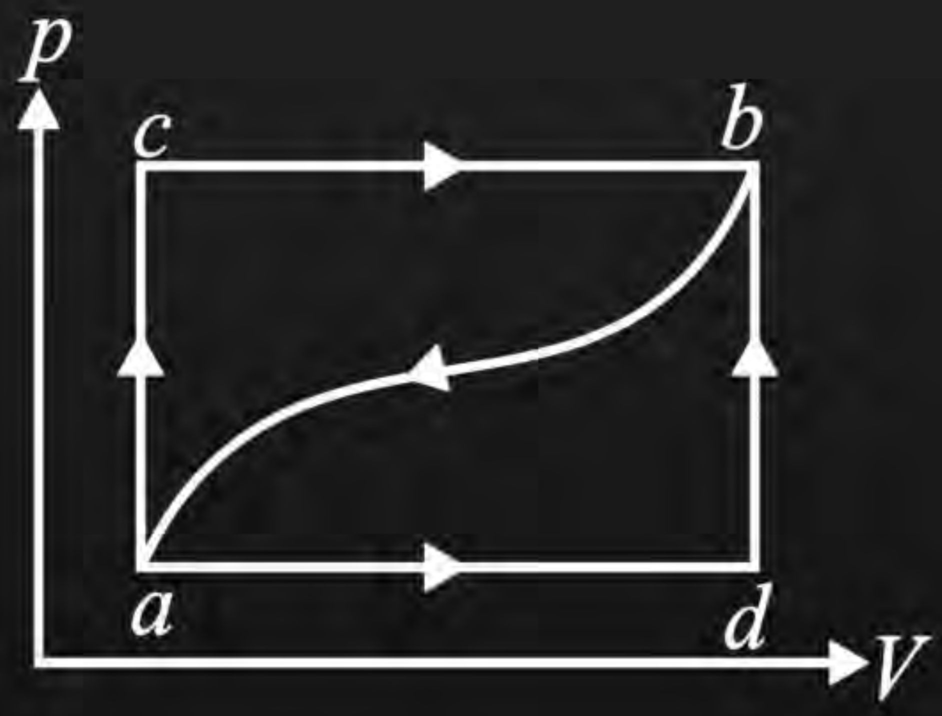
$\boxed{\text{Path adb:}}$ $\Delta Q = \Delta W + \Delta U$

$144 = \Delta W + 120 \Rightarrow \boxed{\Delta W = 144 - 120 = 24J}$

QUESTION

When a system is taken from state '*a*' to state '*b*' along the path '*acb*', it is found that a quantity of heat $Q = 200$ J is absorbed by the system and a work $W = 80$ J is done by it. Along the path '*adb*', $Q = 144$ J. If the work done on the system along the curved path '*ba*' is 52 J, heat absorbed is [H.W]

- **A** $-140\ J$
- **B** $-172\ J$
- **C** $140\ J$
- **D** $172\ J$



QUESTION

In the diagrams (i) to (iv) of variation of volume with changing pressure is shown. A gas is taken along the path *ABCDA*. The change in internal energy of the gas will be:-

$\boxed{\Delta U = 0}$

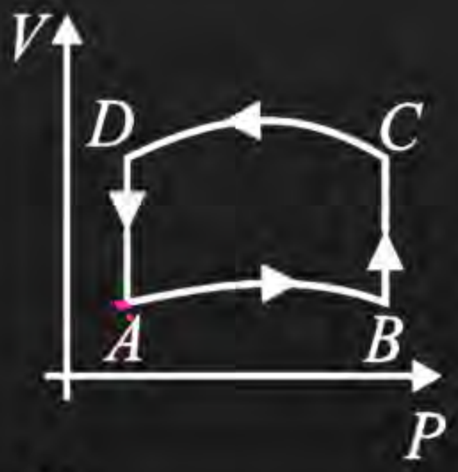
A Positive in all cases (i) to (iv)

B Positive in cases (i), (ii) and (iii) but zero in case (iv)

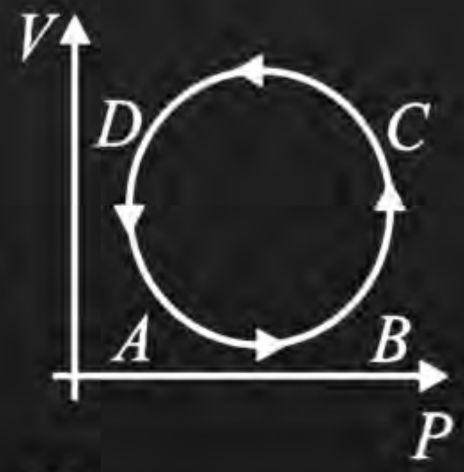
C Negative in cases (i), (ii) and (iii) but zero in case (iv)

D [✓ Zero in all the four cases]

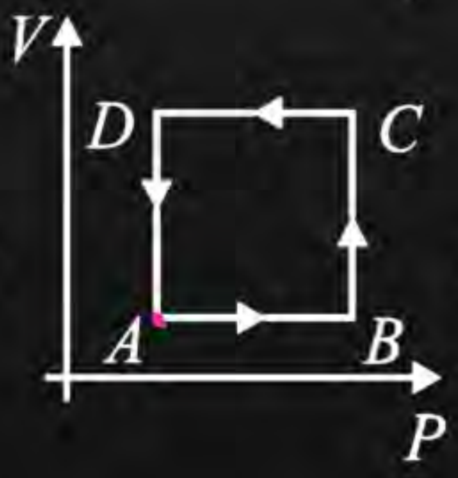
(i)



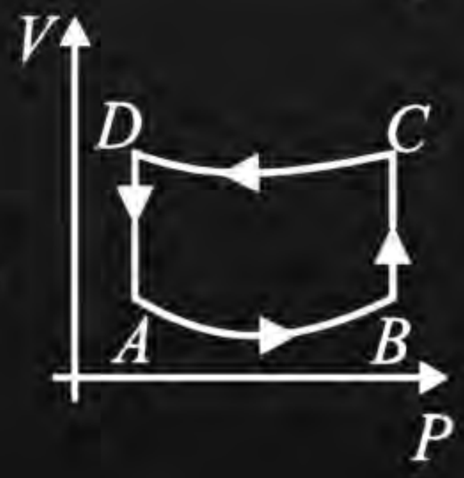
(ii)



(iii)



(iv)



QUESTION

A system is taken along the paths A and B as shown. If the amounts of heat given in these processes are Q_A and Q_B and change in internal energy are ΔU_A and ΔU_B respectively then :-

A $Q_A = Q_B;\ \Delta U_A < \Delta U_B$ ✗

B $Q_A \geq Q_B;\ \Delta U_A = \Delta U_B$ ✗

C $Q_A < Q_B;\ \Delta U_A > \Delta U_B$ ✗

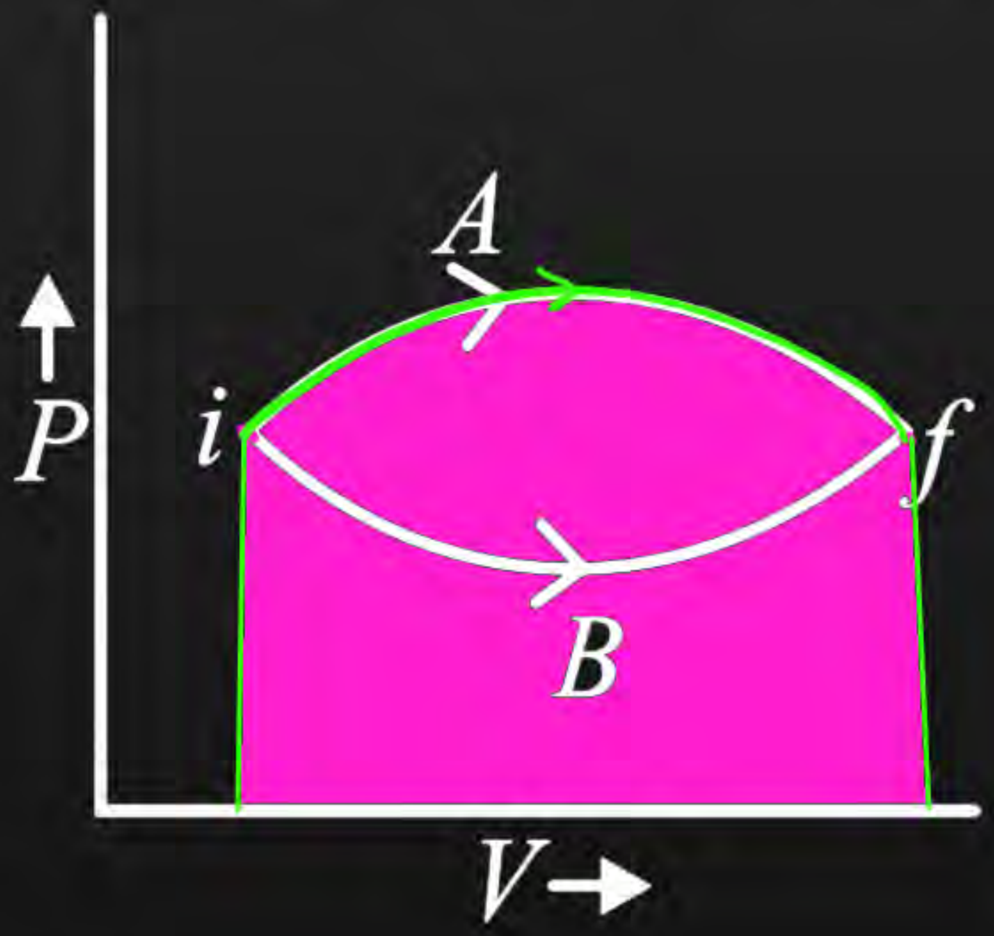
D $\boxed{Q_A > Q_B;\ \Delta U_A = \Delta U_B}$

$\Delta U_A = \Delta U_B$

$\Delta Q = \Delta W + \underline{\underline{\Delta U}}$

$\Delta Q = \underset{\hookrightarrow \text{Area}}{\Delta W}$

$\Delta Q_A > \Delta Q_B$



QUESTION

A system is taken along the paths A and B as shown. If the amounts of heat given in these processes are Q_A and Q_B and change in internal energy are ΔU_A and ΔU_B respectively then :-

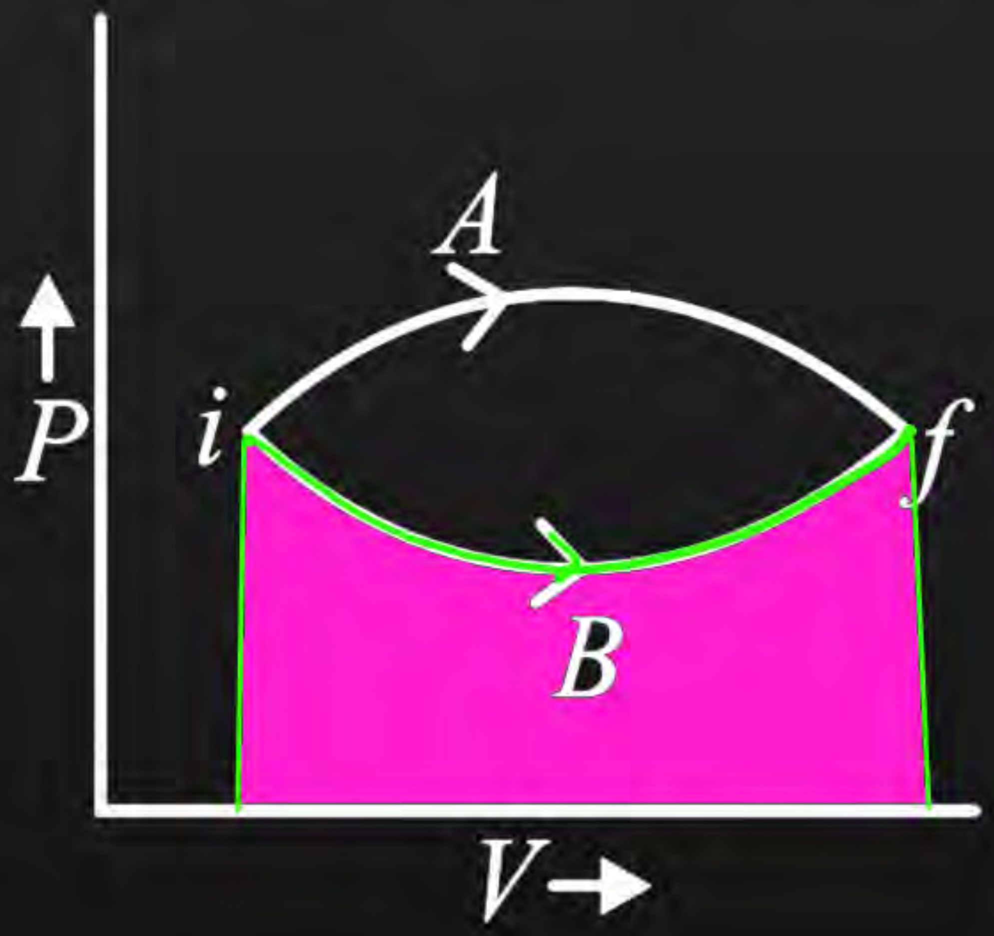
$\Delta U_A = \Delta U_B$

A $Q_A = Q_B; \Delta U_A < \Delta U_B$ X

B $Q_A \geq Q_B; \Delta U_A = \Delta U_B$

C $Q_A < Q_B; \Delta U_A > \Delta U_B$ X

D $Q_A > Q_B; \Delta U_A = \Delta U_B$



QUESTION

For an adiabatic expansion of a perfect gas, the value of $\Delta P/P$ is equal to:-

A $-\sqrt{\gamma}\,\Delta V/V$

B $-\Delta V/V$

C $\boxed{-\gamma\,\Delta V/V}$

D $-\gamma^2\,\Delta V/V$

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

$$\Delta P \cdot V^{\gamma} + P\gamma V^{\gamma-1}\Delta V = 0$$

$$\Delta P\, V^{\gamma} = -P\gamma V^{\gamma-1}\Delta V$$

$$\Delta P\,\cancel{V^{\gamma}} = -P\gamma\cdot\cancel{V^{\gamma}}\,V^{-1}\Delta V$$

$$\boxed{\frac{\Delta P}{P} = -\gamma\,\frac{\Delta V}{V}}$$

QUESTION

P-V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond respectively to

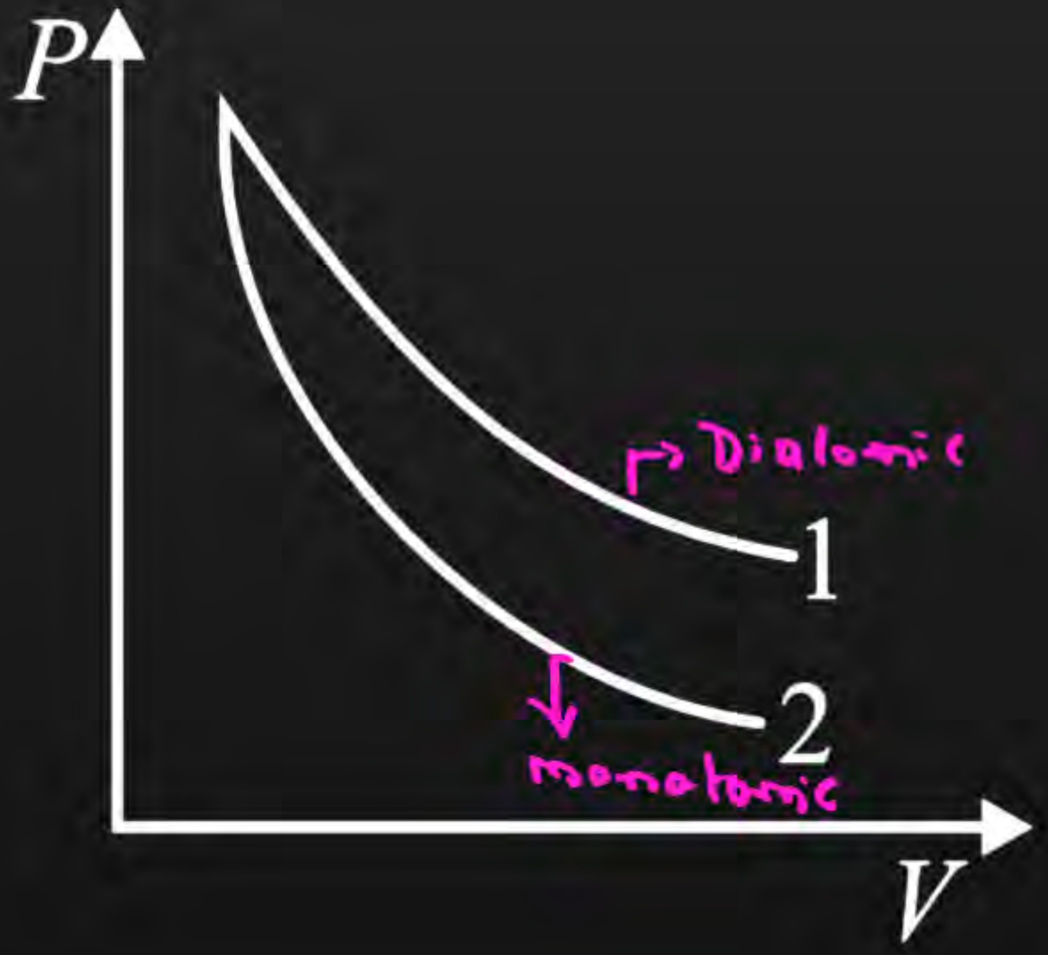
A He and O_2 ✗

B $\boxed{O_2 \text{ and } He}$ ✓

C He and Ar ✗

D O_2 and N_2 ✗

$\gamma_{mono} > \gamma_{Dia}$



QUESTION

In the following figures, four curves *A*, *B*, *C*, *D* are shown these curves are:

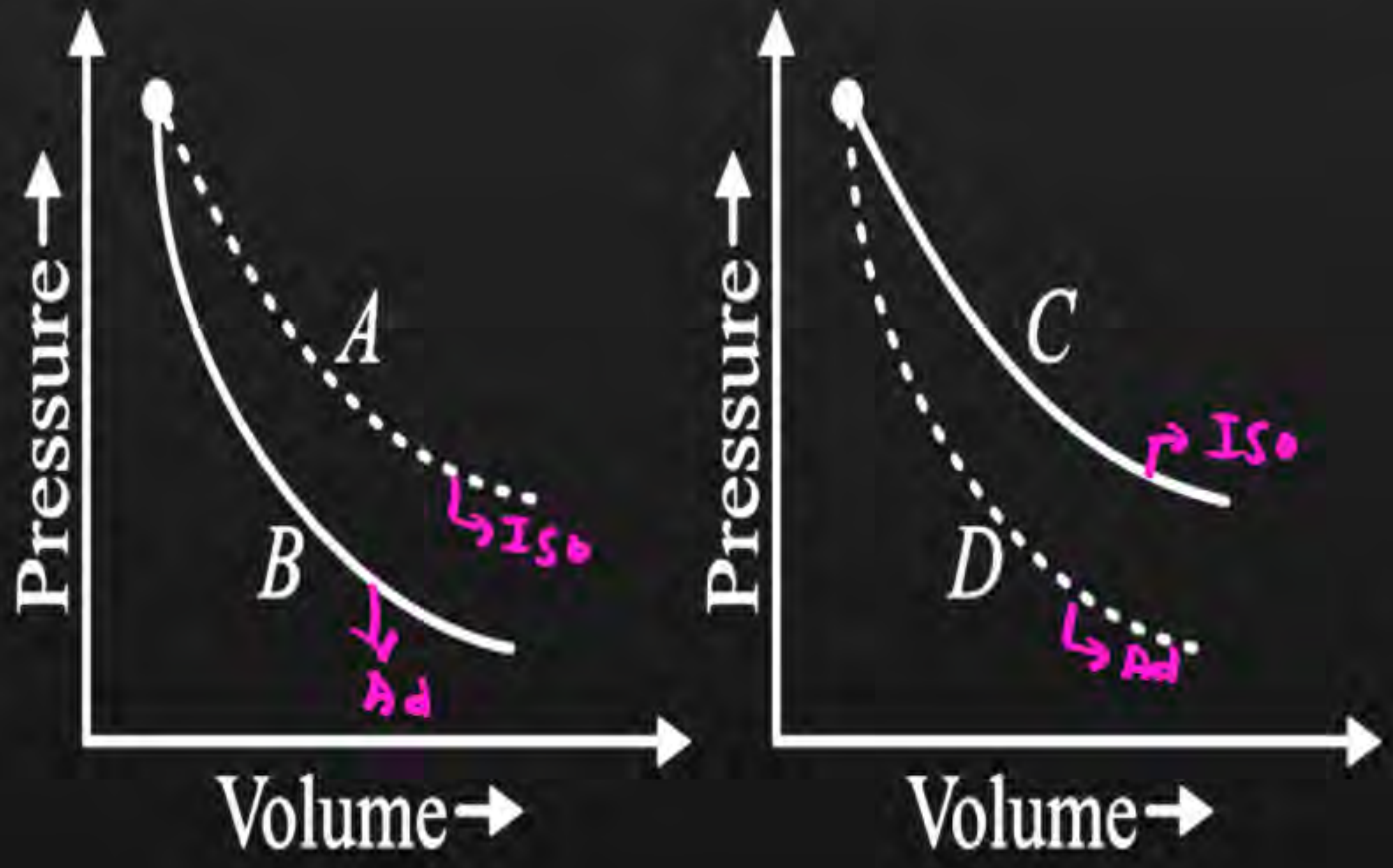
A Isothermal for *A* and *B* while adiabatic for *C* and *D* ✗

✓

B Isothermal for *A* and *C* while adiabatic for *B* and *D* ✓

C Isothermal for *A* and *D* ✗

D Adiabatic for *A* and *C* while isothermal for *B* and *D* ✗



QUESTION

"Heat cannot be flow itself from a body at lower temperature to a body at higher temperature". This statement corresponds to

A Conservation of momentum

B Conservation of mass

C First law of thermodynamics

D [✓ Second law of thermodynamics]

QUESTION

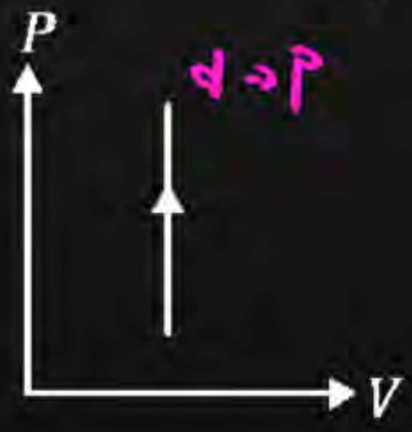
Match the correct:

A a →q; b →q, $\overset{\times}{\text{r}}$; c →q; d → p

B a →r, p; b $\overset{\times}{\rightarrow}$q, r; c → q,s ; d → p,r

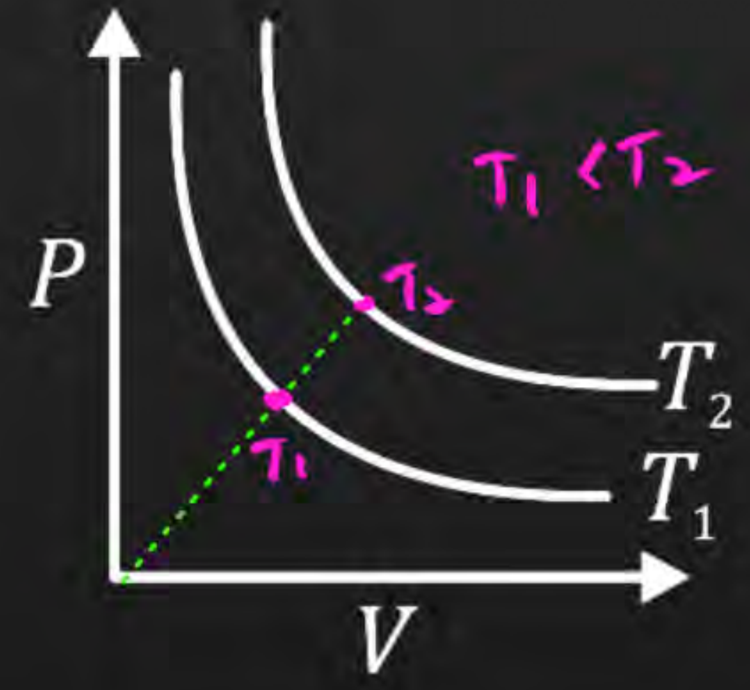
C a →q, r; b →q; c →q,s; d → p

D None

a	 a → r, q	p	Volume is constant
b	 b → q	q	Volume is increasing
c	 c → s, q	r	Temperature is constant
d	 d → p	s	Pressure is constant

QUESTION

Find the correct relation in given P-V diagram:



A $T_1 = T_2$

B $T_1 > T_2$

C $\boxed{T_1 < T_2}$

D $T_1 \leq T_2$

QUESTION

In the given $(V - T)$ diagram, what is the relation between pressure P_1 and P_2?

A Cannot be predicated ✗

B $P_2 = P_1$ ✗

C $P_2 > P_1$ ✗

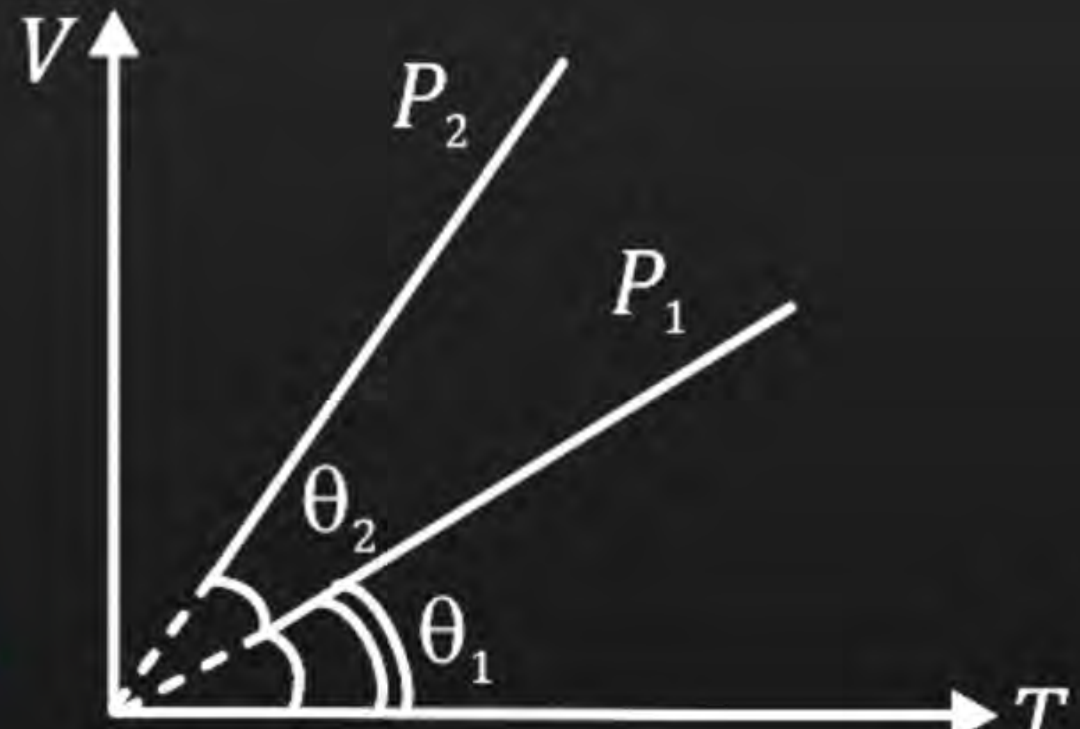
D $\boxed{P_2 < P_1}$

$\frac{V}{T} = \frac{nR}{P}$ $\quad \frac{V}{T} \propto \frac{1}{P}$

$\text{slope} = \frac{1}{P}$

$\text{slope} \rightarrow \tan\theta_1 < \tan\theta_2$

$$\boxed{\begin{array}{c} P_1 > P_2 \\ P_2 < P_1 \end{array}}$$



QUESTION

H.W

In the given $(P - T)$ diagram, what is the relation between pressure V_1 and V_2?

(A) Cannot be predicated ✗

(B) $V_2 = V_1$ ✗

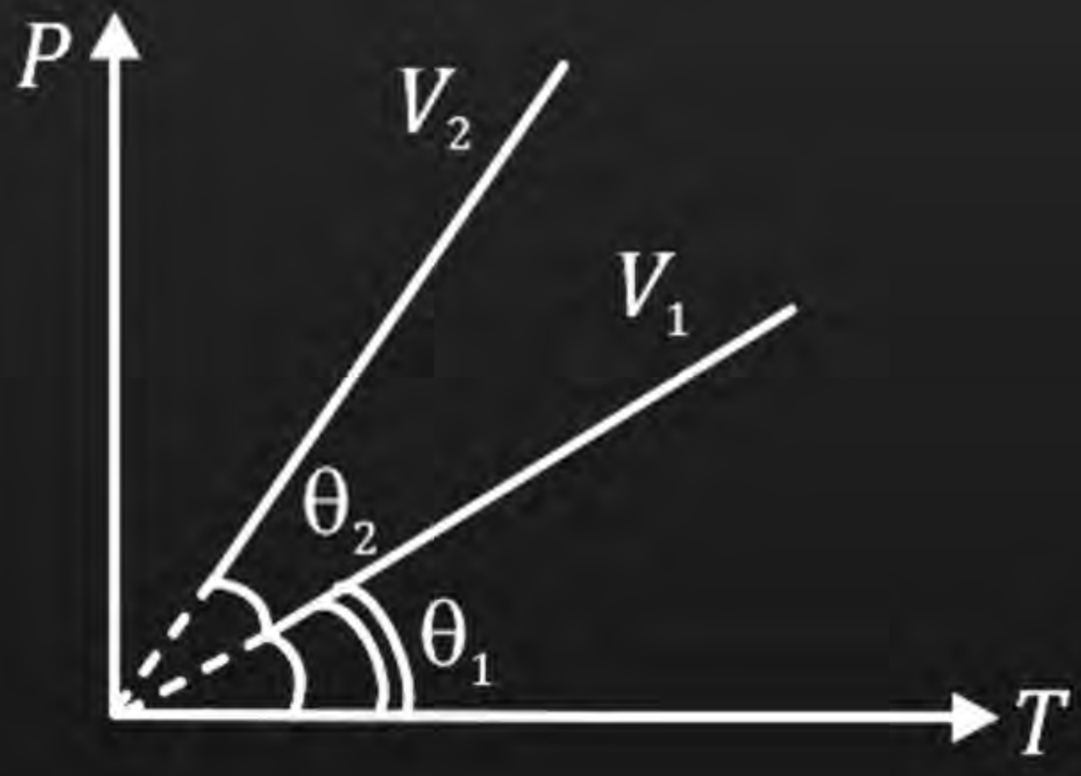
(C) $V_2 > V_1$

(D) $\boxed{V_2 < V_1}$

$\frac{P}{T} = \frac{nR}{V}$ $\boxed{\frac{P}{T} \propto \frac{1}{V}}$

$V_1 > V_2$

$V_2 < V_1$



QUESTION

The rms velocity of gas molecules of a given amount of a gas at 27°C and 1.0×10^5 Nm^{-2} pressure is 200 m s^{-1}. If temperature and pressure are respectively 127°C and 0.5×10^5 N m^{-2}, the rms velocity will be:

- **A** $\boxed{400/\sqrt{3}\ \text{ms}^{-1}}$
- **B** $100/\sqrt{2}\ \text{ms}^{-1}$
- **C** $100/\sqrt{2}/3\ \text{ms}^{-1}$
- **D** $50\sqrt{\frac{2}{3}}\ \text{ms}^{-1}$

$$V \propto \sqrt{T}$$

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

$T_1 = 27^\circ c$

$T_1 = 300K$

$T_2 = 127^\circ c$

$T_2 = 400K$

$$\frac{V_2}{200} = \sqrt{\frac{400}{300}} = \frac{2}{\sqrt{3}}$$

$$\boxed{V_2 = \frac{200\times 2}{\sqrt{3}} = \frac{400}{\sqrt{3}}}$$

QUESTION

$\uparrow f = 5$

The total kinetic energy of 1 mole of N_2 at 27°C will be approximately:-

A 1500 J

B $\boxed{\text{1500 calorie}}$

C 1500 kilo calorie

D 1500 erg.

$$E = \frac{1}{2} n f R T$$

$$E = \frac{1}{\cancel{2}} \times 1 \times 5 \times \cancel{2} \times 300$$

$$\boxed{E = 1500\,\text{cal}}$$

QUESTION

At which of the following temperature any gas have average moleculer kinetic energy double that of at 20°C

- **A** $\boxed{40\ ^\circ C}$
- **B** $80\ ^\circ C$
- **C** $313\ ^\circ C$
- **D** $586\ ^\circ C$

$$E \propto T$$

$$\frac{E_2}{E_1} = \frac{T_2}{T_1}$$

$$\frac{2\cancel{E}}{\cancel{E}} = \frac{T_2}{20}$$

$$\boxed{T_2 = 40^\circ C}$$

QUESTION

The following sets of values for C_V and C_P of a gas have been reported by different students. The units are cal/-mole-K. Which of these sets is most reliable?

A $\boxed{C_V = 3, C_P = 5}$

B $C_V = 4, C_P = 6$

C $C_V = 3, C_P = 2$

D $C_V = 3, C_P = 4.2$

$C_V = \frac{fR}{2} = \frac{3 \times \cancel{2}}{\cancel{2}} = 3$ ✓

$f = 3$

$R = 2$ cal/mol-K.

$C_P = \left(1 + \frac{f}{2}\right)R = 5$ ✓

Thank

You