

Topics to be covered



- 1) KTG & Thermodynamics
- 2)
- 3)
- 4)
- 5)

Assumption

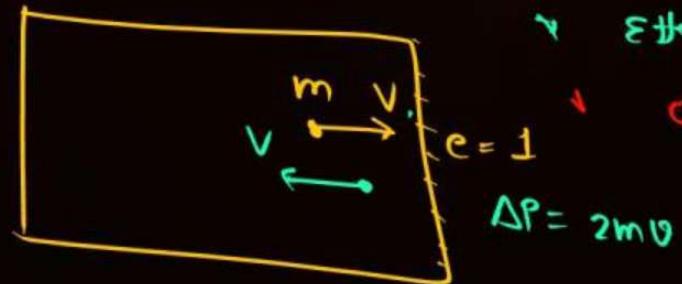
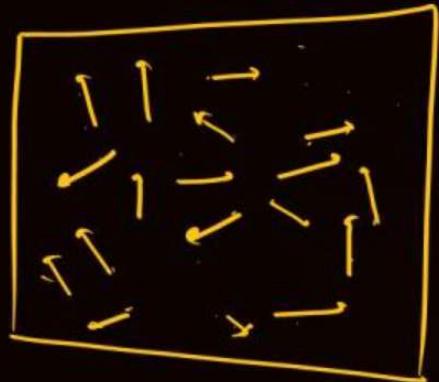
- * Random motion
- * All collision are elastic (particle-particle
particle-wall)
- * size of molecule \ll size of scat
- * There is no interaction b/w molecules.

$$P.E. = 0$$

whatever be the energy that will be in the form of K.E.

- * Effect of gravity is neglected .

Obey Newton's Law





ASSUMPTIONS OF IDEAL GAS



- The molecules of a gas are in a state of continuous random motion. They move with all possible velocities in all possible directions. They obey Newton's law of motion.
- Mean momentum = 0; Mean velocity = $0 < \vec{v} > = 0$;
- The time during which a collision takes place is negligible as compared to time taken by the molecule to cover the mean free path so NTP ratio of time of collision to free time of motion $10^{-8} : 1$.
- All those assumptions can be justified, if number of gas molecules are taken very large



DIFFERENT SPEEDS OF GAS MOLECULES



- **Average velocity**

Because molecules are in random motion in all possible direction in all possible velocity. Therefore, the average velocity of the gas in molecules in container is zero.

$$\langle \vec{v} \rangle = \frac{\vec{v}_1 + \vec{v}_2 + \dots + \vec{v}_N}{N} = 0$$

$$\text{rms speed of molecules } v_{\text{rms}} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3RT}{M_w}} = \sqrt{\frac{3kT}{m}} = 1.73 \sqrt{\frac{kT}{m}}$$

Mean speed of molecules : By maxwell's velocity distribution law v_M or

$$\langle |\vec{v}| \rangle = v_{\text{mean}}$$

Q Suppose there are 10 molecules having speed 2, 4, 4, 5, 3, 2, 4, 1, 0, 1, 5 m/s



$$\text{Avg speed} = \frac{2+4+4+5+3+2+4+0+1+5}{10} = 3$$

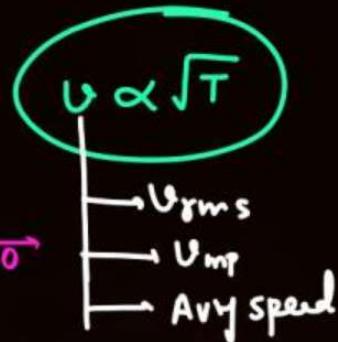
$$U_{rms} = \text{Root mean square speed} = \sqrt{\frac{2^2 + 4^2 + 4^2 + 5^2 + 3^2 + 2^2 + 4^2 + 0^2 + 1^2 + 5^2}{10}} = \sqrt{\langle v^2 \rangle}$$
$$= \sqrt{11.6} \text{ (check)}$$

$$\text{most probable speed} = 4 \text{ m/s}$$

Imp & results

Avg velocity = 0

$$\langle \vec{v} \rangle = \frac{\vec{v}_1 + \vec{v}_2 + \vec{v}_3 + \dots}{n} = \vec{0}$$



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

$$\text{Avg Speed} = \langle \text{Speed} \rangle = \sqrt{\frac{8}{\pi} \frac{RT}{M}}$$

$$v_{\text{most probable speed}} = \sqrt{\frac{2RT}{M}}$$

$$R = \frac{25}{3} \frac{\text{J}}{\text{mol K}^{-1}}$$

$$PV = nRT$$



$v_{rms} > v_{\text{Avg}} > v_{\text{Most prob. spe}}$

| PAM

$$\begin{aligned} * & PV = nRT \\ * & PM = PRT \end{aligned}$$



DIFFERENT SPEEDS OF GAS MOLECULES



$$\langle |\vec{v}| \rangle = v_{\text{mean}} = \frac{|\vec{v}_1| + |\vec{v}_2| + \dots + |\vec{v}_n|}{N} = \sqrt{\frac{8P}{\pi\rho}} = \sqrt{\frac{8RT}{\pi M_w}} = \sqrt{\frac{8kT}{\pi m}} = 1.59 \sqrt{\frac{kT}{m}}$$

Most probable speed of molecules (v_{mp})

At a given temperature, the speed to which maximum number of molecules belongs

$$\text{is called as most probable speed } (v_{\text{mp}}) \quad v_{\text{mp}} = \sqrt{\frac{2P}{\rho}} = \sqrt{\frac{2RT}{M_w}} = \sqrt{\frac{2kT}{m}} = 1.41 \sqrt{\frac{kT}{m}}$$

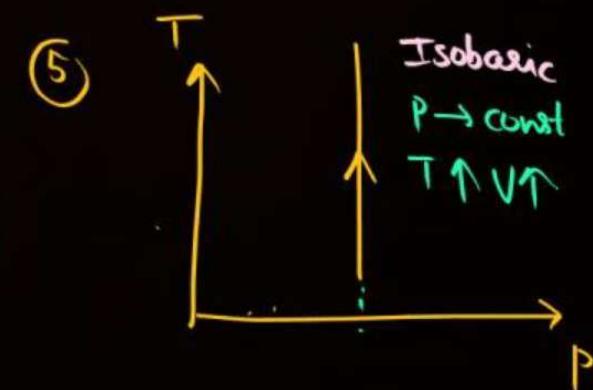
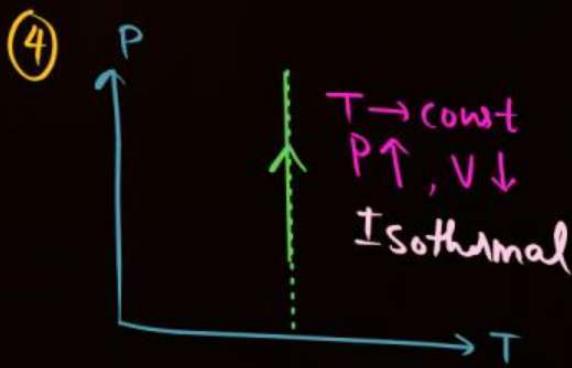
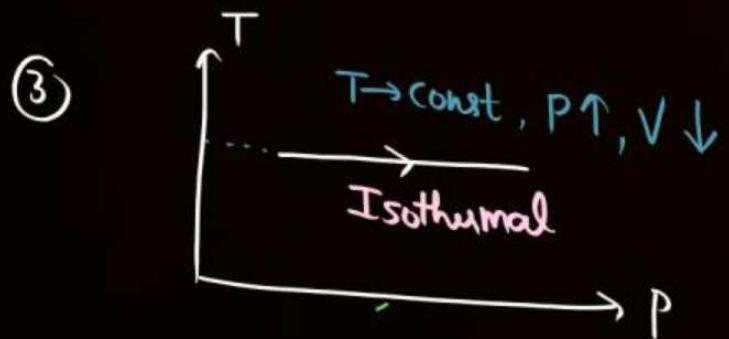
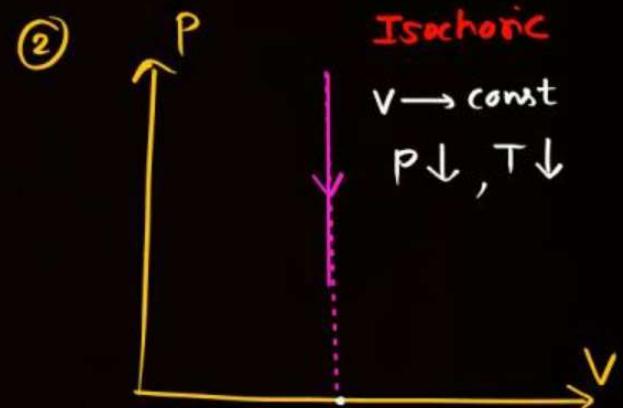
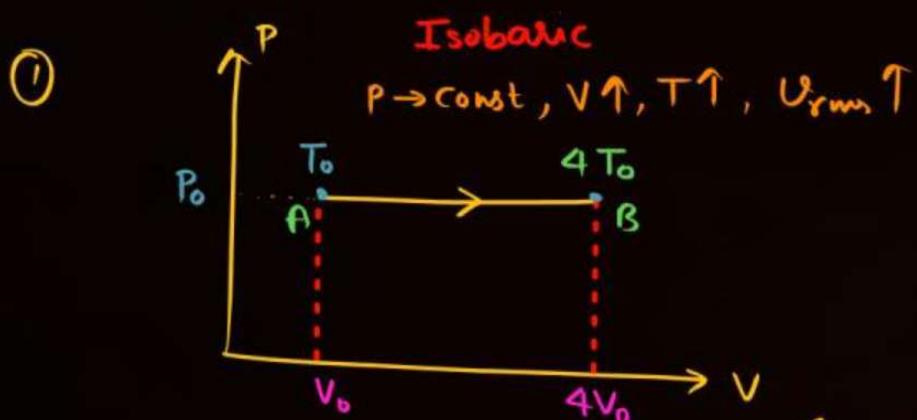
Graph

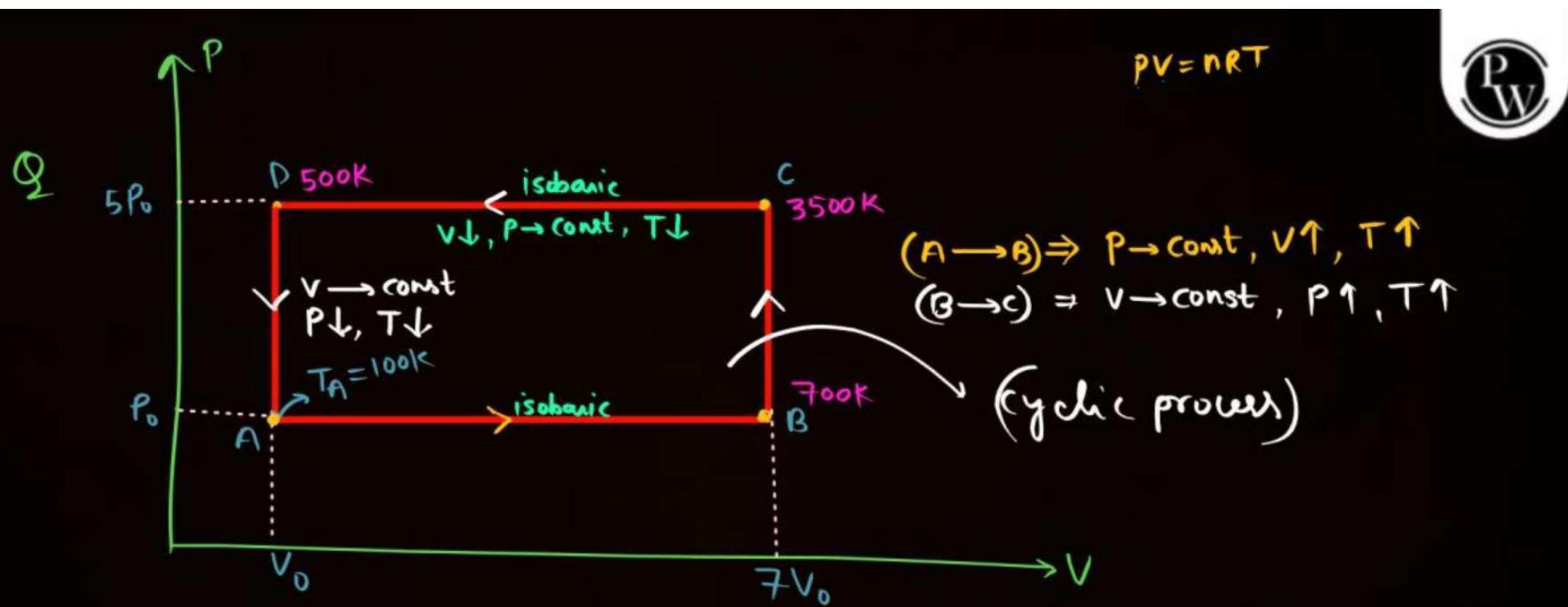
$$PV = nRT$$

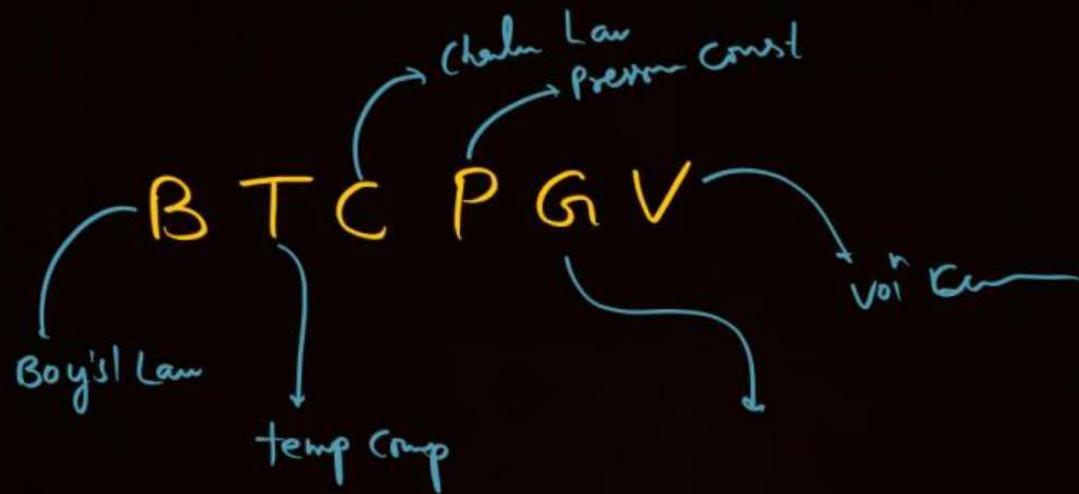
$$PV = nRT$$

unit dimensions

$$\textcircled{P} \textcircled{W}$$



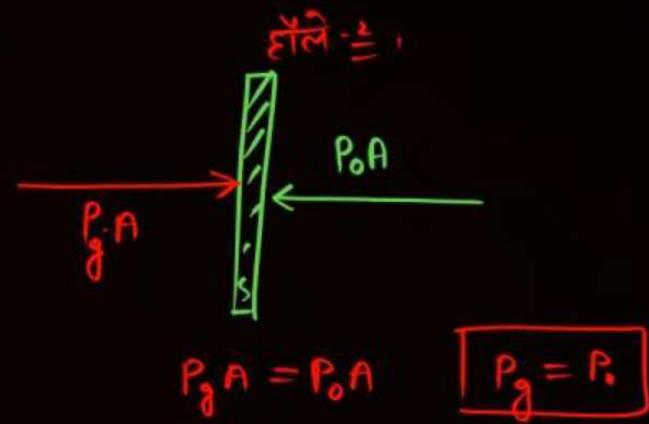
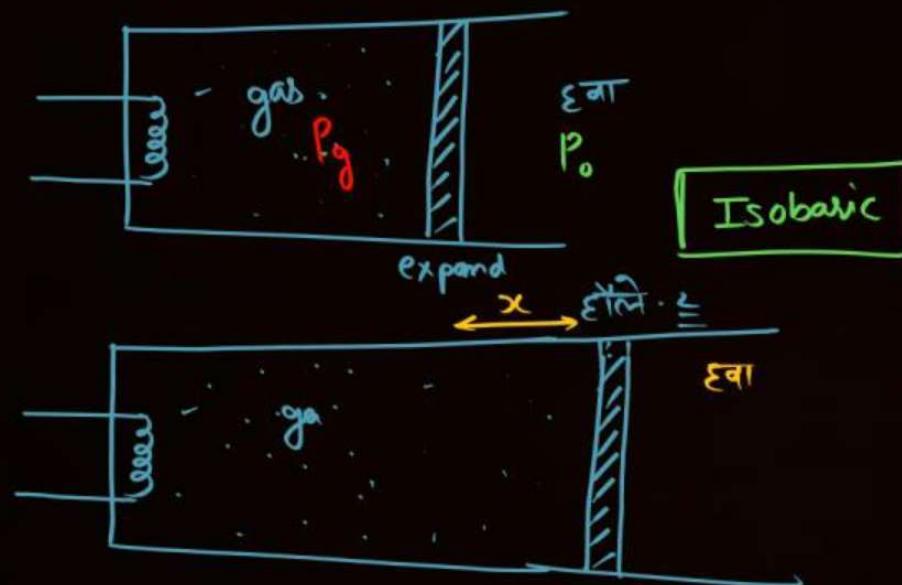




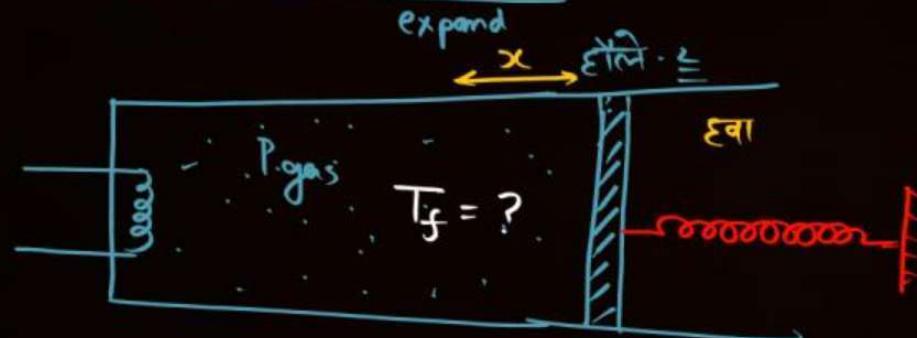
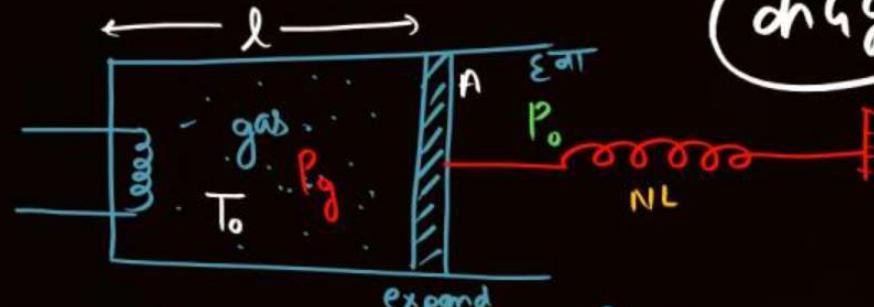


- * Isothermal process $\rightarrow (T \rightarrow \text{const})$
- * Isochoric " $\rightarrow (V \rightarrow \text{const})$
- * Isobaric " $\rightarrow (P \rightarrow \text{const})$
- * Adiabatic process $\Rightarrow \Delta Q = 0,$
- * $PV^{\gamma} = \text{const} \equiv \text{Polytropic Process}$

Q

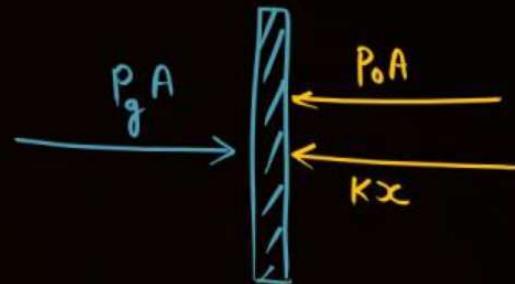


Q



$x \uparrow$, $V \uparrow$, $P_g \uparrow$, $T \uparrow$

oh gfg



$$P_g A = P_0 A + Kx$$

$$P_g = P_0 + \frac{Kx}{A}$$

Isobaric X

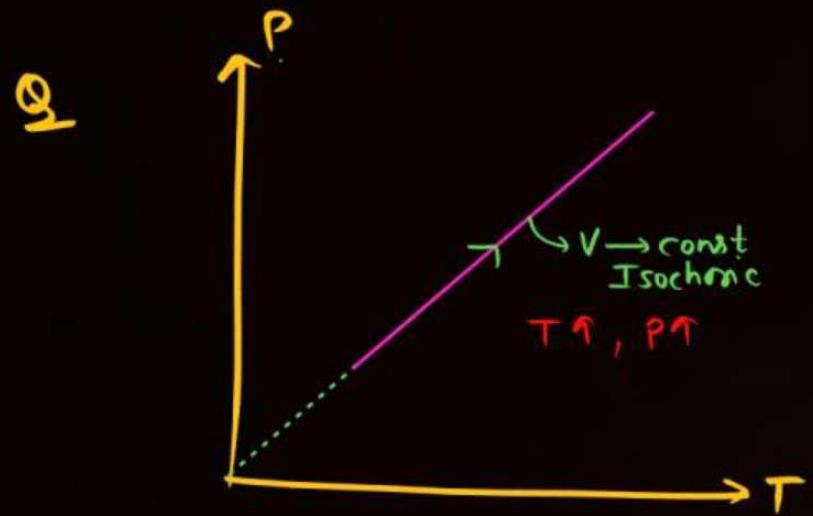
Qm

$$\frac{V_0}{A} = \checkmark, \frac{x}{K} = \checkmark$$

$$P_f = P_0 + \frac{Kx}{A}$$

$$n_i = n_f$$

$$\frac{P_i V_i}{R T_i} = \frac{P_f V_f}{R T_f}$$

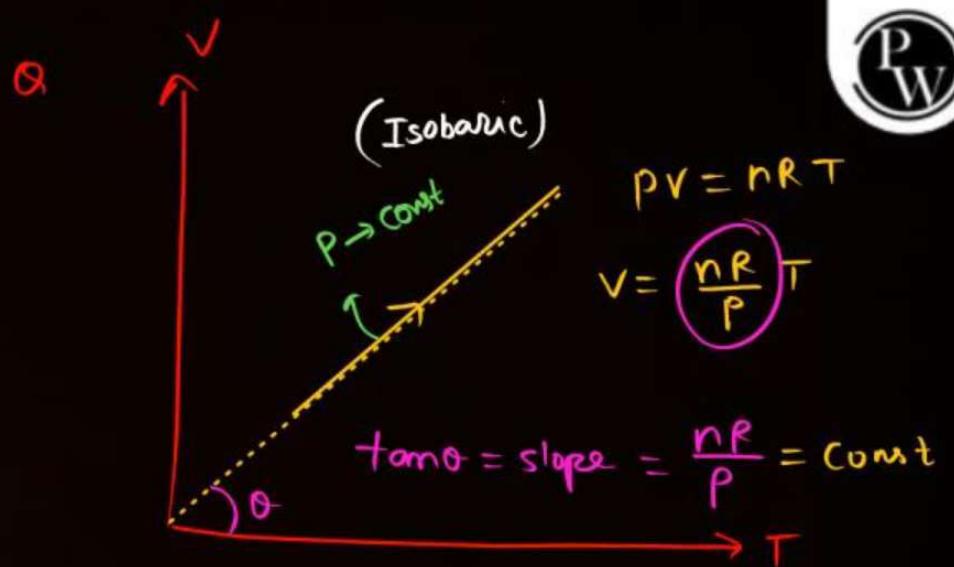


$$PV = nRT$$

$$P = \left(\frac{nR}{V}\right)T$$

$$y = mx$$

$V \rightarrow \text{const}$



$$\text{tang} = \text{slope} = \frac{nR}{P} = \text{const}$$

$$PV = nRT$$

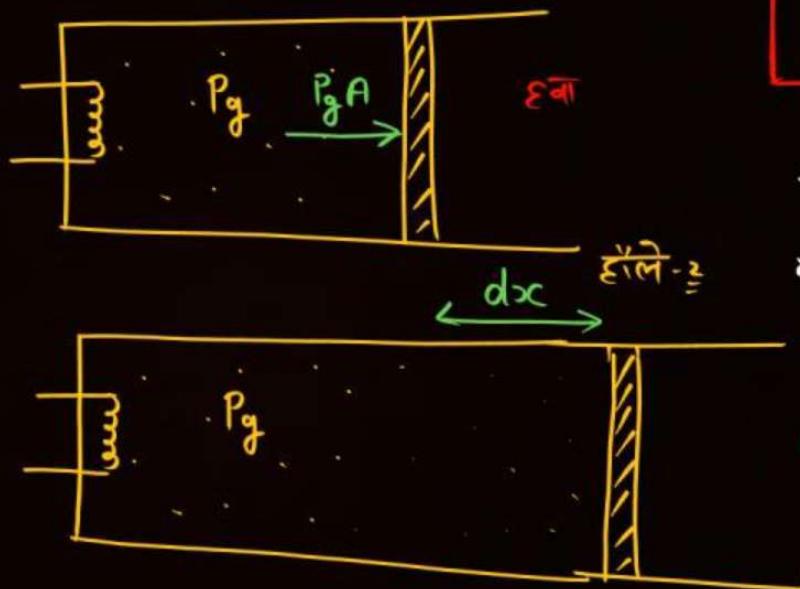
$$V = \left(\frac{nR}{P}\right)T$$

(WD) by gas

$$(\text{WD})_{\text{by gas}} = \int F \cdot dx$$

$$= \int P_g A \underline{dx}$$

$$\boxed{(\text{WD})_{\text{by gas}} = \int P_g dv}$$



$$w_{\text{gas}} = \int P dV$$

* $V \uparrow w_{\text{by gas}} > 0$

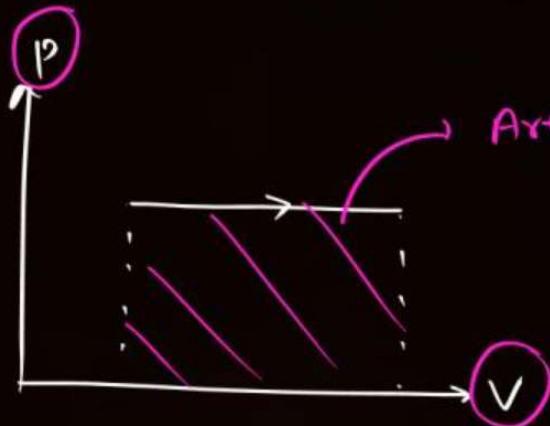
* $V \downarrow w_{\text{by gas}} < 0$

* $V \rightarrow \text{const} w_{\text{gas}} = 0$

* Isochoric process $\frac{\partial V}{\partial P} = 0$
 $w_{\text{gas}} = 0$

$$(WD)_{\text{gas}} = \int P dV$$

$$\begin{aligned}\text{Area} &= \int y dx \\ &= \int P dV\end{aligned}$$



$$\text{Area} = (WD)_{\text{by gas}}$$

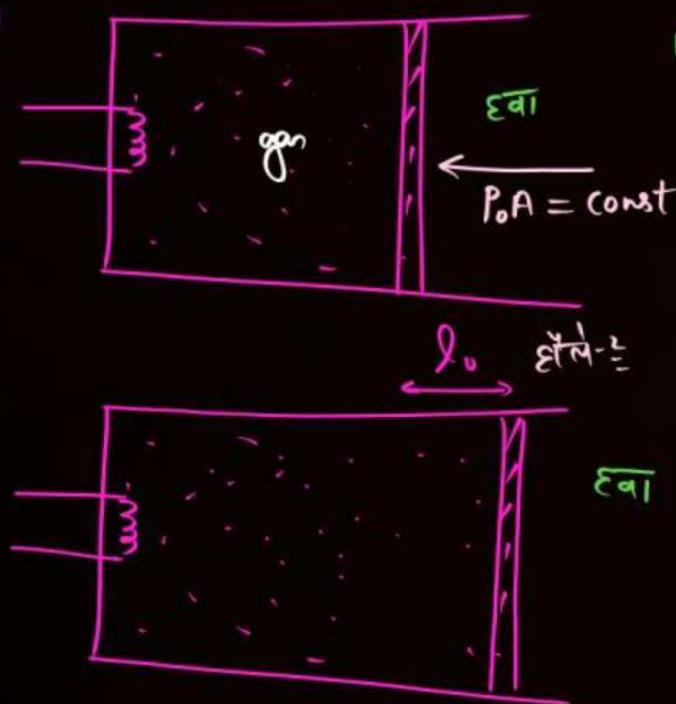
|| इसका sign पता करने के लिए

Arrow देख

$$V \uparrow \Rightarrow w_g > 0$$



①



$$\begin{aligned}
 W_{\text{gas}} &= \int p dV \\
 &= \int_0^{l_0} P_0 A dx \\
 &= P_0 A l_0 \\
 P_f &= P_0
 \end{aligned}$$

p of gas

W.E.T.

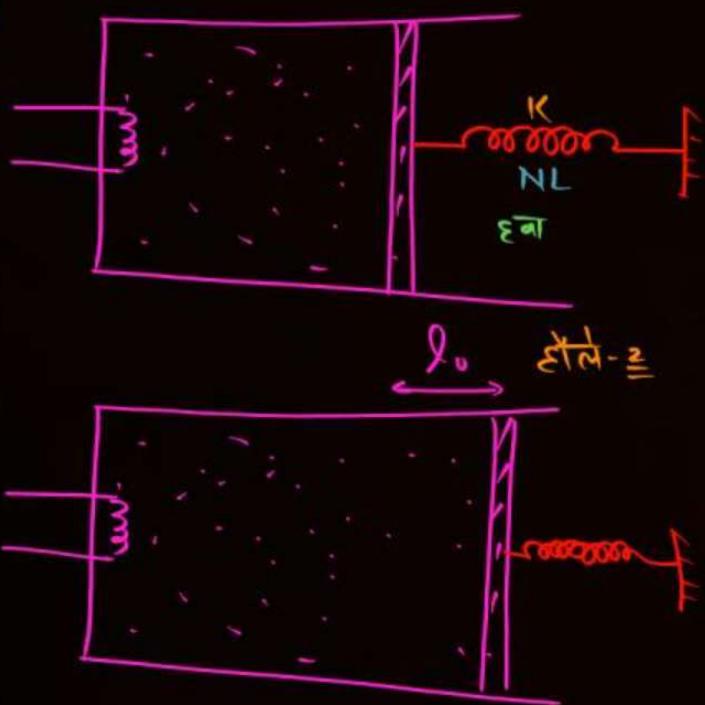
$$(WD)_{\text{all the force}} = \Delta K.E.$$

$$(WD)_g + (WD)_{\text{ext}} = \Delta K.E.$$

$$(WD)_g - P_0 A l_0 = 0$$

$$W_{\text{gas}} = P_0 A l_0$$

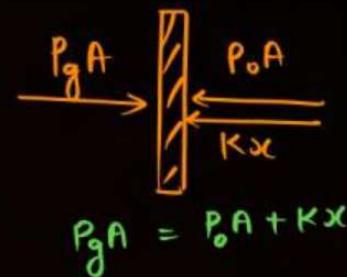
①



$$(WD)_{\text{by gas}} = \int P dV$$

$$\begin{aligned} W_{\text{gas}} &= \int P A dx \\ &= \int_0^{l_0} (P_0 A + Kx) dx \end{aligned}$$

$$W_{\text{gas}} = P_0 A l_0 + \frac{K l_0^2}{2}$$



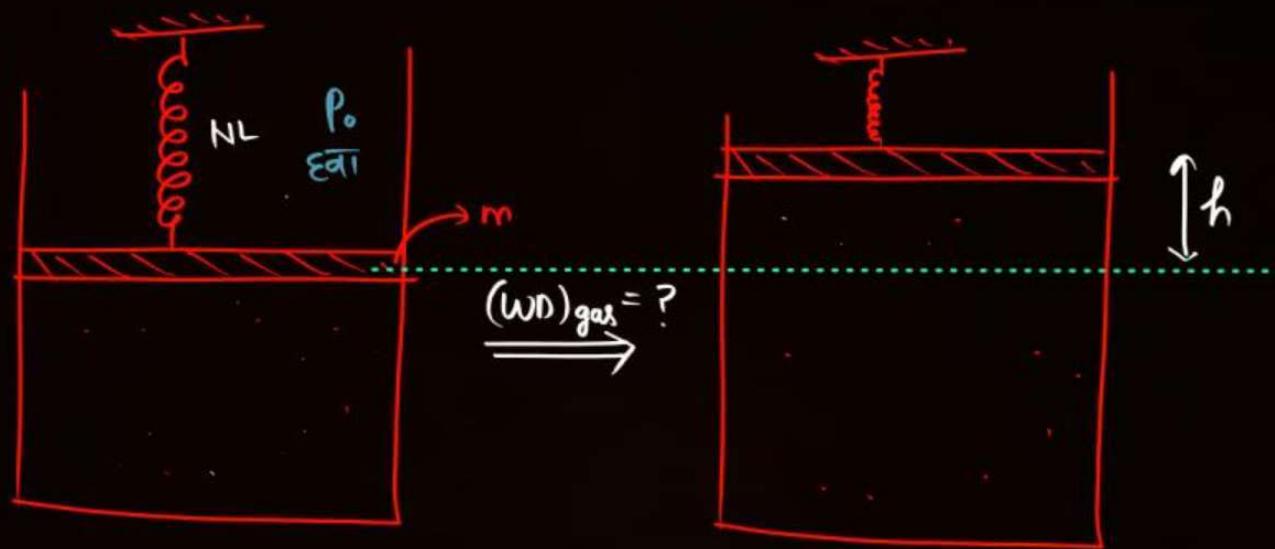
W.E.T.

$$W_{\text{gas}} + W_{\text{ext}} + W_{\text{sp}} = \Delta K E$$

$$\begin{aligned} W_{\text{gas}} - P_0 A l_0 - \frac{1}{2} K (l_0^2 - 0^2) \\ = 0 - 0 \end{aligned}$$

$$W_{\text{gas}} = P_0 A l_0 + \frac{1}{2} K l_0^2$$

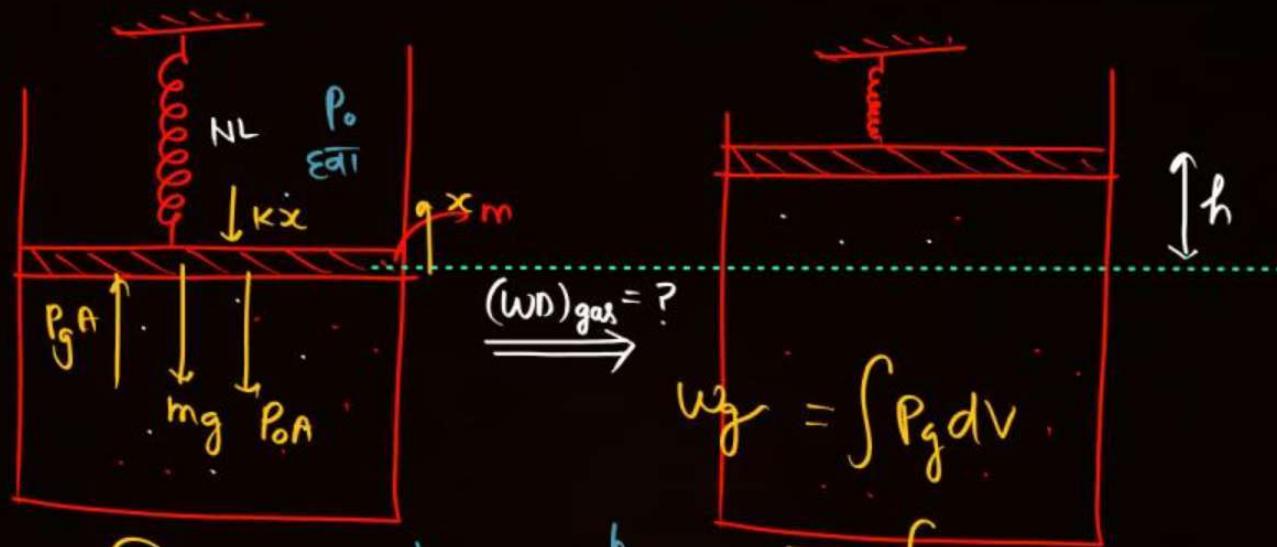
Q



$$w_{\text{gas}} + w_{\text{ext}} + w_{\text{sp}} + w_{\text{grav,h}} = \Delta K \cdot \varepsilon.$$

$$w_{\text{gas}} - P_0 A h - \frac{1}{2} k (x_0^2 - \delta^2) - mgh = 0 - 0$$

Q



$$(WD)_{gas} = ?$$

$$W_g = \int P_g dV$$

$$\int P_g A dx = \int mg dx + \int P_0 A dx + \int kx dx$$

$$W_g = mgh + P_0 Ah + \frac{k h^2}{2}$$

$$(\omega_0)_{SP} = -\frac{1}{2} \kappa (x_f^2 - x_i^2)$$

or

$$\frac{1}{2} \kappa (x_i^2 - x_f^2)$$

$$\textcircled{3} \quad P = 12V^5$$

(W_b) by gas if gas expand from $V_0 \longrightarrow 2V_0$

$$(W_b)_g = \int_{V_0}^{2V_0} P dV = \int_{V_0}^{2V_0} 12V^5 dV = 12 \times \frac{[(2V_0)^6 - V_0^6]}{6}$$

$$\textcircled{4} \quad P_{\text{gas}} = aV^2 + bV \quad \text{gas } V_0 \longrightarrow 2V_0$$

$$(W_b)_{\text{gas}} = \int_{V_0}^{2V_0} (aV^2 + bV) dV$$

$$P \propto V^2$$

$$P = 3V^2 \quad (P_0, V_0, T_0)$$

$V_0 \longrightarrow 2V_0$ expand

$$\text{so!} \quad P_f = \frac{4P_0}{V_f} = 8T_0$$

$$(W_b)_{\text{gas}} = \int P dV = \int_{V_0}^{2V_0} 3V^2 dV = \checkmark$$

$$\text{Q} \quad P = K V^2$$

↑
Const

If $V \longrightarrow 2$ times
 $w_g > 0$

$P \longrightarrow 4$ times
 $T \longrightarrow 8$ times

$$\text{Q} \quad P = K V^3$$

(P_0, V_0, T_0) initially

$V_0 \longrightarrow 2V_0$
 $P_0 \longrightarrow 8P_0$
 $T_0 \longrightarrow 16T_0$
 $V_{rms} \longrightarrow 4$ times

Expand \checkmark , $w_g > 0$

$$\text{Q} \quad V = K T^2$$

(P_0, V_0, T_0) given

$T_0 \longrightarrow 2T_0$
 $V_0 \longrightarrow 4V_0$
 $P_0 \longrightarrow \frac{P_0}{2}$

$$PV = n R T$$

\downarrow
 $\frac{1}{2} \text{dim } 4 \text{ times}$
 \downarrow
 2 times

\textcircled{P} \textcircled{W}

$$PV = n R T$$

double

Q

$$P = kT^2$$

Volume \longrightarrow 4 times

$T \longrightarrow ?$

इसे याद रखें $\Rightarrow (V, T)$ में Relation

$$PV = nRT$$

$$P = \frac{nRT}{V}$$

$$\frac{nRT}{V} = kT^2$$

$$nR = kTV$$

$$TV = \text{const}$$

$$\begin{array}{c} \downarrow \\ \downarrow \\ \text{4 times} \end{array}$$

$$\frac{1}{4} \text{ dim}$$

Degree of freedom

- No. of independent ways in which a molecule can have energy. is called Dof.

① monoatomic gas \Rightarrow He, Ne... Dof = 3 (v_x, v_y, v_z)

② Diatomic gas ($N_2, O_2 \dots$) Dof = 5 $(v_x, v_y, v_z, w_x, w_y \text{ let})$

At very high temp

$\xrightarrow{\text{3 translational + 2 rotational Dof}}$

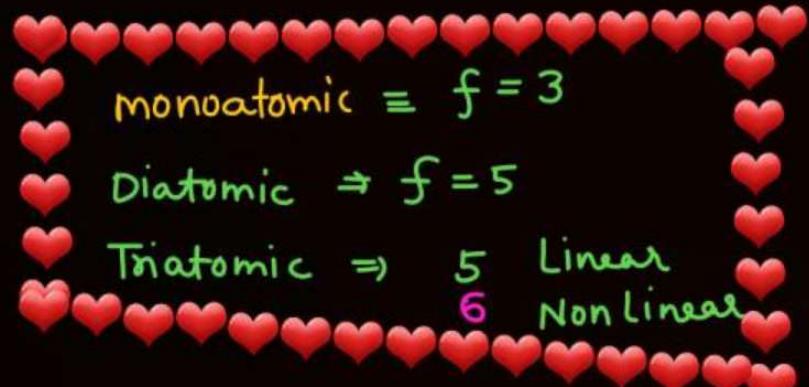
$$\text{Total Dof} = 5 + 2 = 7$$

③ Triatomic $\xrightarrow{\text{Linear}} \text{Dof} = 5$

$\xrightarrow{\text{Vibration Dof}}$

$\xrightarrow{\text{Nonlinear}} \text{Dof} = 3 + 3 = 6$

$(v_x, v_y, v_z, w_x, w_y, w_z)$



- * $T \uparrow \Delta U > 0$
- * $T \downarrow \Delta U < 0$

- * $V \uparrow \omega_g > 0$
- * $V \downarrow \omega_g < 0$

maxwell Equipartition Law

$$U = \frac{nfRT}{2}$$

internal Energy

$n \rightarrow$ no. of moles

$f \rightarrow$ dof

depends on
temp only

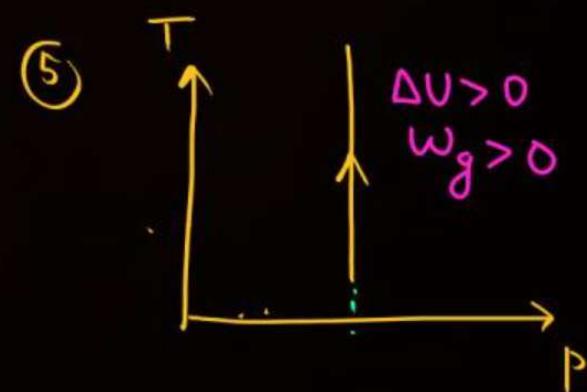
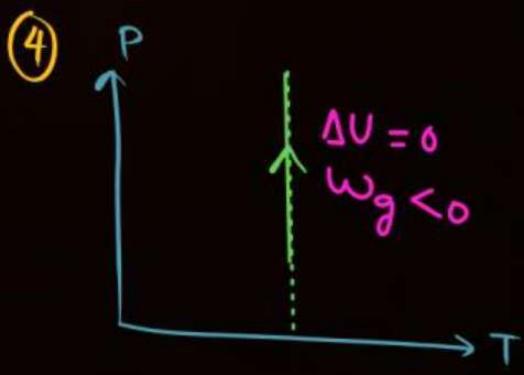
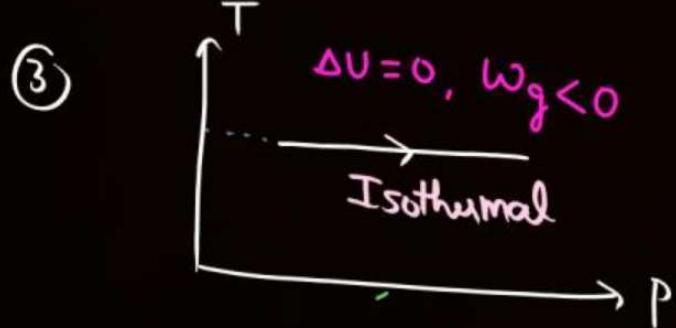
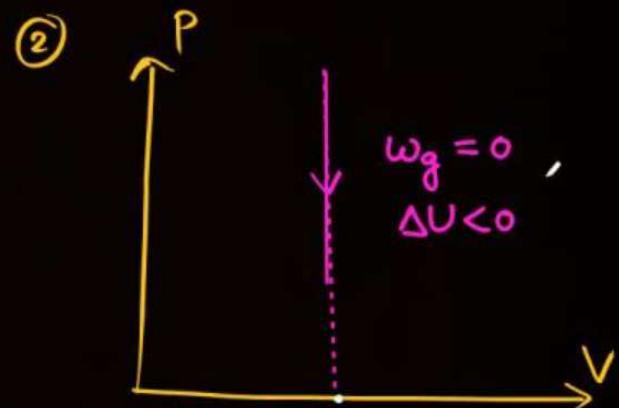
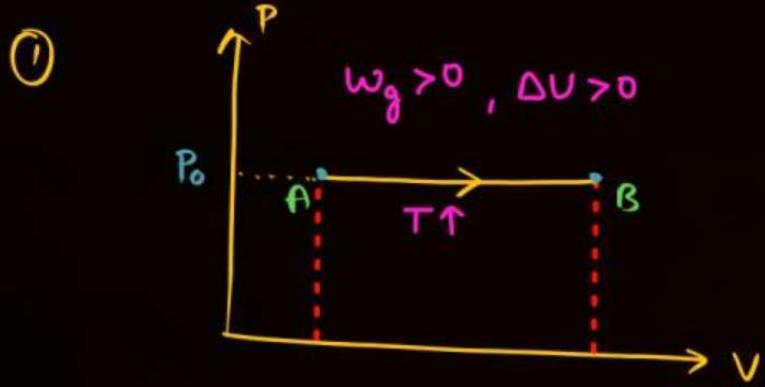
$$\Delta U = \frac{nfr \Delta T}{2}$$

- * $T \uparrow, U \uparrow, \Delta U > 0$
- * $T \downarrow, U \downarrow, \Delta U < 0$
- * $T \rightarrow \text{Const} \Rightarrow U \rightarrow \text{Const} \Rightarrow \Delta U = 0$
- * If $T_i = T_f \Rightarrow U_i = U_f \Rightarrow \Delta U = 0$
(In any problem)

$$\textcircled{P_W}$$

$$PV = nRT$$

Graph



Imp Results

$$* \quad w_g = \int P dV$$

$$V \uparrow \quad w_g > 0$$

$$V \downarrow \quad w_g < 0$$

$$* \quad \Delta U = \frac{nfR\Delta T}{2}$$

$$* \quad T \uparrow, \quad \Delta U > 0$$

$$* \quad T \downarrow \quad \Delta U < 0$$

ΔQ

heat given
or
heat taken

1st Law of thermodynamics

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

↓
heat given
or
heat taken

↓
 (W_D) by gas
 ↓
 change in internal Energy
 $\Delta U = \frac{h_f R \Delta T}{2}$

Sing conversion

- $V \uparrow w_g > 0$, $V \downarrow w_g < 0$
- $T \uparrow \Delta U > 0$, $T \downarrow \Delta U < 0$

ΔQ

- * If heat is given to gas/system $\equiv \Delta Q > 0$
- * " supplied $\equiv \Delta Q > 0$
- * " .. taken away from system $\Delta Q < 0$
- * heat is rejected by system $\equiv \Delta Q < 0$



$$Q \quad P = K V^2$$

\uparrow
Const

If $V \longrightarrow$ double
 $P \longrightarrow$ 4 times
 $T \longrightarrow$ 8 times

$V \uparrow \omega_g > 0, \Delta V > 0$
 $\Delta \theta > 0$

$$Q \quad P = K V^3$$

(P_0, V_0, T_0) initially

$V_0 \longrightarrow 2V_0$
 $P \longrightarrow 8 \text{ times}$
 $T \longrightarrow 16 \text{ times}$

$$\Delta V > 0 \\ \omega_g > 0$$

$$\Delta \theta = \Delta V + \Delta \omega$$

+ + +

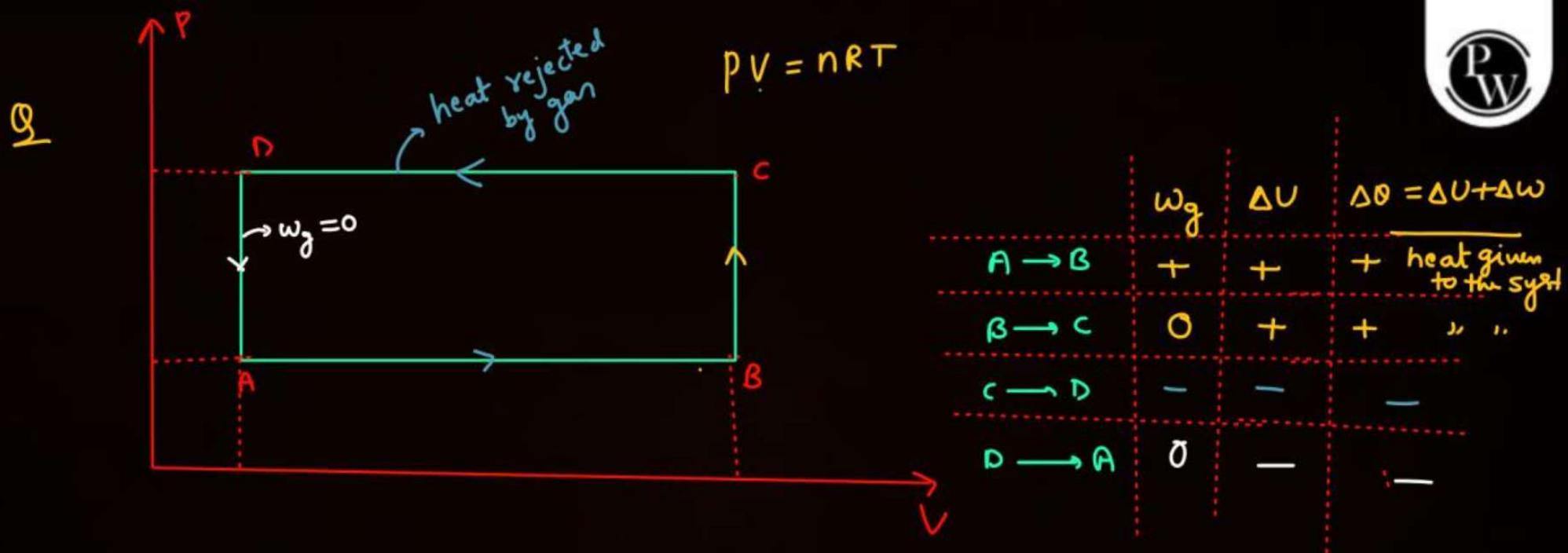
$\Delta \theta > 0$

$$Q \quad V = K T^2$$

(P_0, V_0, T_0) given

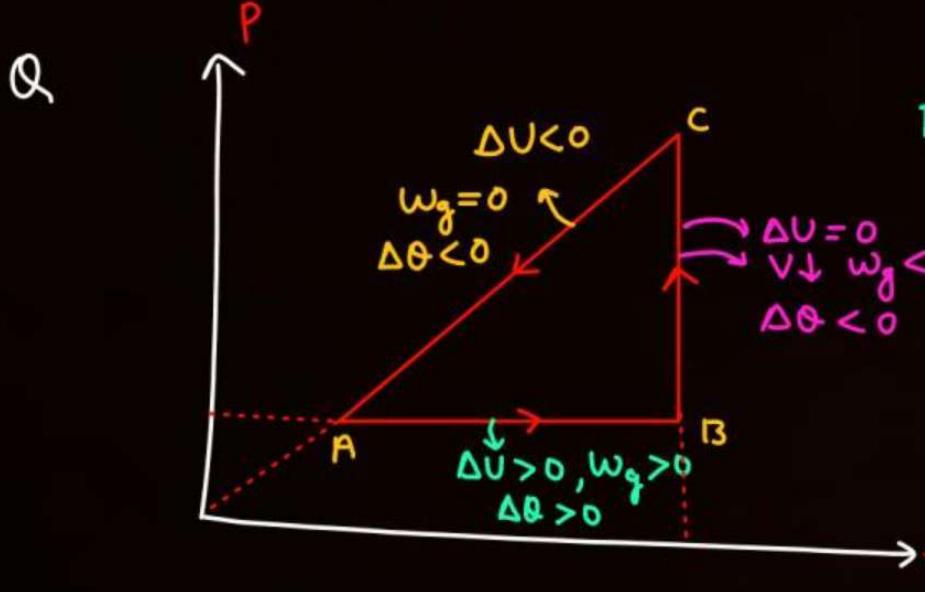
$T_0 \longrightarrow 2T_0, \Delta V > 0$
 $V \longrightarrow 4 \text{ times} \quad V \uparrow \omega_g > 0$

$\Delta \theta > 0$



	w_g	ΔU	$\Delta Q = \Delta U + \Delta W$
$A \rightarrow B$	+	+	+ heat given to the sys
$B \rightarrow C$	0	+	+
$C \rightarrow D$	-	-	-
$D \rightarrow A$	0	-	-

$$\eta = \frac{(w_D)_{net}}{Q_{\text{in}} \text{ [जीवनी]}} = \frac{w_{AB} + w_{BC} + w_{CD} + w_{DA}}{\Delta Q_{AB} + \Delta Q_{BC}}$$



$$PV = nRT$$

Cyclic process

$$\eta = \frac{(\text{WD})_{\text{net}}}{Q_+} = \frac{w_{A \rightarrow B} + w_{B \rightarrow C} + w_{C \rightarrow A}}{\Delta Q_{A \rightarrow B}}$$

$$\Delta\Theta = \Delta U + \Delta W$$

- Sign ✓

- Values = ?

$$\Delta U = \frac{n f R \Delta T}{2}$$

$$\Delta W = \int P dV$$

$$Q \quad P = kV^2$$

$$W_D = \int_{V_0}^{2V_0} kV^2 dV = \checkmark.$$

Calculation of (ω_D) by gas

① Isochoric Process

$$V \rightarrow \text{const}$$

$$\omega_g = 0$$

$$\Delta \Theta = \Delta U + \Delta \omega^0$$

$$\Delta \Theta = \Delta U = \frac{nFRT}{2}$$

② Isobaric Process

$$\omega_g = \int p dv$$

$$\omega_g = p \int_{V_i}^{V_f} dv = p \Delta V$$

$\omega_g = p \Delta V = nR\Delta T$

③ Isothermal

$$T \rightarrow \text{const} \quad \Delta U = 0$$

$$\Delta \Theta = \Delta U + \Delta \omega$$

$$\Delta \Theta = \Delta \omega$$

$$\omega_g = \int p dv = \int \frac{nRT}{v} dv = nRT \int \frac{dv}{v}$$

$$\omega_g = nRT \ln \frac{V_2}{V_1} = nRT \ln \frac{P_1}{P_2}$$

$$PV = nRT = \text{const}$$

$$P_1 V_1 = P_2 V_2$$

$$PV = \text{const}$$



Q If 1000J of heat is supplied to a 2 mole monoatomic gas at 100K at
Const Volume.
find final Temp

Sol

$$\Delta Q = +1000$$

$$W_g = 0$$

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

$$+1000 = \frac{n_f R \Delta T}{2} + 0$$

$$1000 = \frac{2 \times 3 \times \frac{25}{3} (T_f - 100)}{2}$$

* If ΔQ heat is supplied to 2 mole monoatomic gas at const pressure.
 Such that temp of gas is increase by 100K.

$$\Delta Q = ?$$

$$w_g = nR\Delta T = ?$$

Sol

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

$$w_g = 2 \times R \times 100 = +200R$$

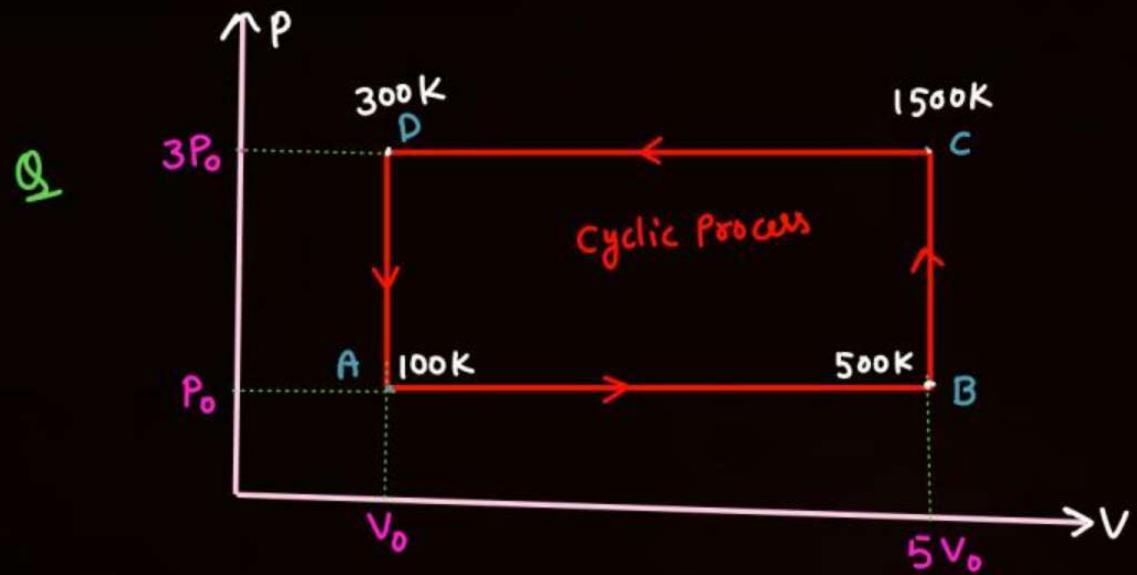
$$= \frac{n_f R \Delta T}{2} + nR\Delta T$$

$$w_g = \int P dV \quad P \rightarrow \text{const}$$

$$= \frac{2 \times 3 \times R \times 100}{2} + 2R \times 100$$

$$V \neq \text{const}$$

$$= 500R$$



Given { 2 mole monoatomic gas
 $T_A = 100\text{K}$

① Find
 $T_B = 500\text{K}$

$$\bar{T} =$$

$$T_D =$$

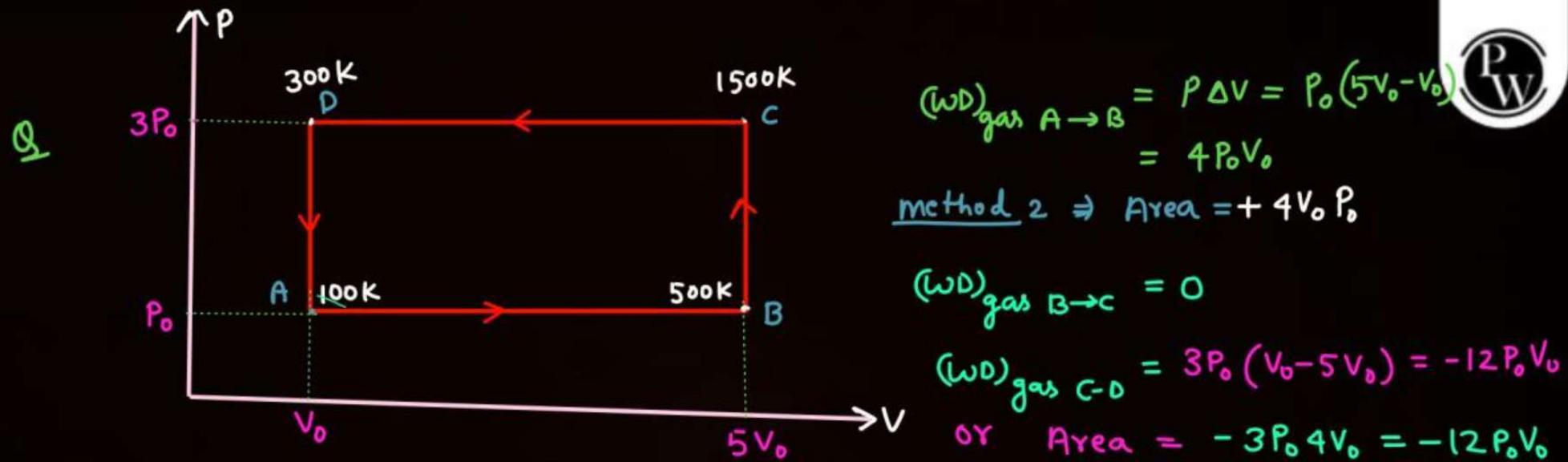
$$\Delta U_{A \rightarrow B} = \frac{n_f R \Delta T}{2} = \frac{2 \times 3 \times R \times 400}{2} = +1200R$$

$$\Delta U_{B \rightarrow C} = \frac{n_f R \Delta T}{2} = \frac{2 \times 3 \times R \times 1000}{2} = +3000R$$

$$\Delta U_{C \rightarrow D} = \frac{2 \times 3 \times R (300 - 1500)}{2} = -3600R$$

$$\Delta U_{D \rightarrow A} = \frac{2 \times 3 \times R (100 - 300)}{2} = -600R$$

$$\Delta U_{\text{net}} = 1200R + 3000R - 3600R - 600R = 0$$



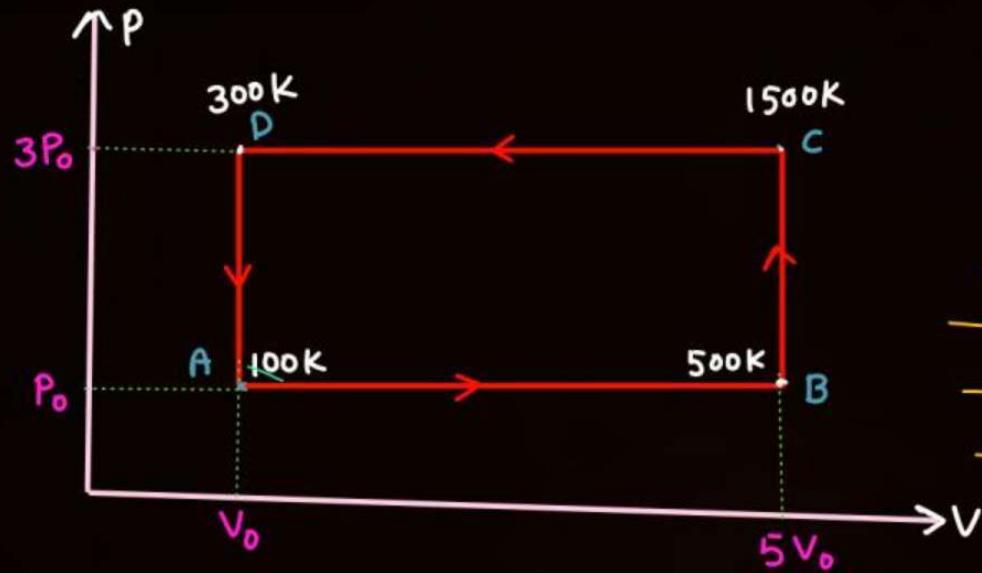
Given $\begin{cases} 2 \text{ mole monoatomic gas} \\ T_A = 100 \text{ K} \end{cases}$

$$(\text{WD})_{A \rightarrow B \rightarrow C \rightarrow D \rightarrow A} = (\text{WN})_{\text{cyclic}} = 4P_0V_0 + 0 - 12P_0V_0 + 0$$

$$= -8P_0V_0$$

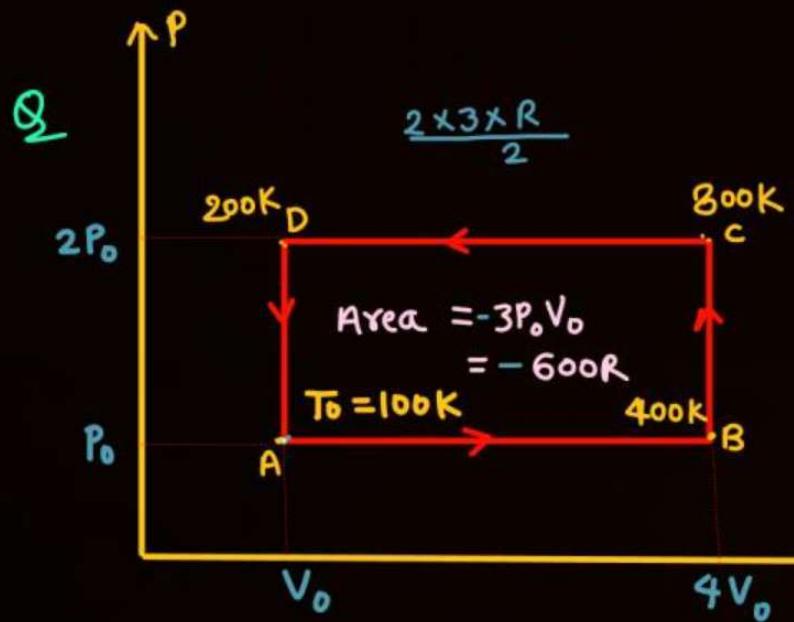
$= \text{Area of } ABCD$

Q



$$\begin{aligned}
 \textcircled{A} = P_0 V_0 &= n R T_A = n R T_0 \\
 &= 2 \times R \times 100 \\
 &= 200 R
 \end{aligned}$$

	ΔU	w_{gas}	ΔQ
AB	+1200 R	$4P_0 V_0 = +800 R$	+2000 R
BC	+3000 R	0	+3000 R
CD	-3600 R	$-12P_0 V_0 = -2400 R$	-6000 R
DA	-600 R	0	-600 R
Net	0	$-8P_0 V_0 = -1600 R$	-1600 R



$$T_A = 100K$$

2 mole monoatomic gas
 $f = 3$

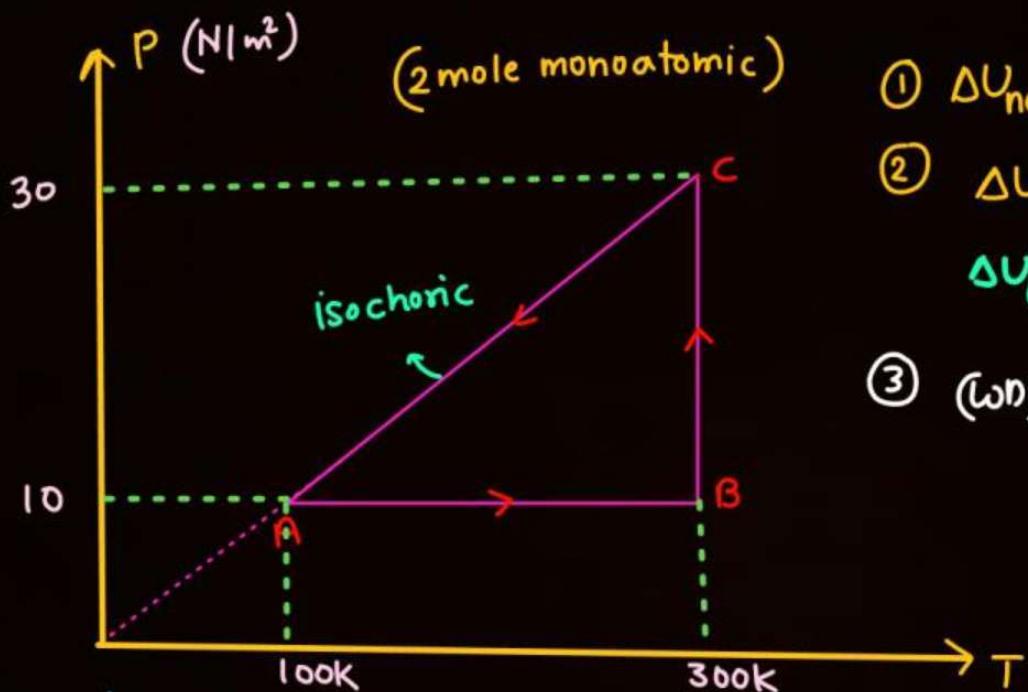
$$\text{At } A \quad P_0 V_0 = 2R \times 100 \\ = 200R$$

	ΔU	W_g	ΔQ
$A \rightarrow B$	+900R	$+3P_0 V_0 = +600R$	$1500R$
$B \rightarrow C$	+1200R	0	+1200R
$C \rightarrow D$	-1800R	$-6P_0 V_0 = -1200R$	-3000R
$D \rightarrow A$	-300R	0	-300R
	0	-600R	-600R



JEE Adv
Q2

P
W



$$\textcircled{1} \quad \Delta U_{\text{net}} = 0$$

$$\textcircled{2} \quad \Delta U_{AB} = \frac{2 \times 3 \times R \times 200}{2} = 600R$$

$$\Delta U_{BC} = 0 \quad \Delta U_{CA} = -600R$$

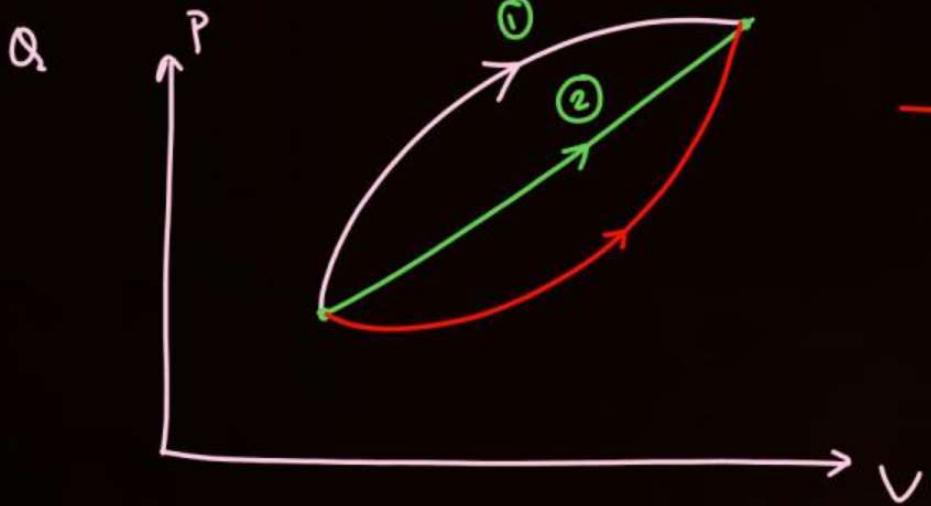
$$\textcircled{3} \quad (\Delta U)_{\text{gas}}_{A \rightarrow B} = nR\Delta T = 2R \times 200 = 400R$$

$$(\Delta U)_{B \rightarrow C} = nRT \ln \frac{P_1}{P_2}$$

$$= 2R300 \ln \frac{10}{30} = -600R \ln 3$$

$$(\Delta U)_{\text{gas}}_{C \rightarrow A} = 0$$

	ΔU	ΔW	ΔQ
$A \rightarrow B$	600R	400R	1000R
$B \rightarrow C$	0		
$C \rightarrow A$	-600R		



$$\Delta\omega_1 > \Delta\omega_2 > \Delta\omega_3$$

$$\Delta U_1 = \Delta U_2 = \Delta U_3$$

$$\Delta\theta_1 > \Delta\theta_2 > \Delta\theta_3$$



$$Q \quad P = V^2$$

Initially $n = 2 \text{ mole}$
 $V_i = 2 \text{ m}^3$ monoatomic gas
 $T = 100 \text{ K}$

$$\begin{array}{l} V_0 \longrightarrow 2V_0 (\text{double}) \\ V_i = 2 \longrightarrow V_f = 4 \end{array} \quad \begin{array}{l} V \longrightarrow 2 \text{ times} \\ P \longrightarrow 4 \text{ times} \\ T \longrightarrow 8 \text{ times} \end{array} \quad T_f = 800 \text{ K}$$

$$(\text{WD})_{\text{gas}} = \int P dV = \int_2^4 V^2 dV = \frac{64 - 8}{3} = \frac{56}{3}$$

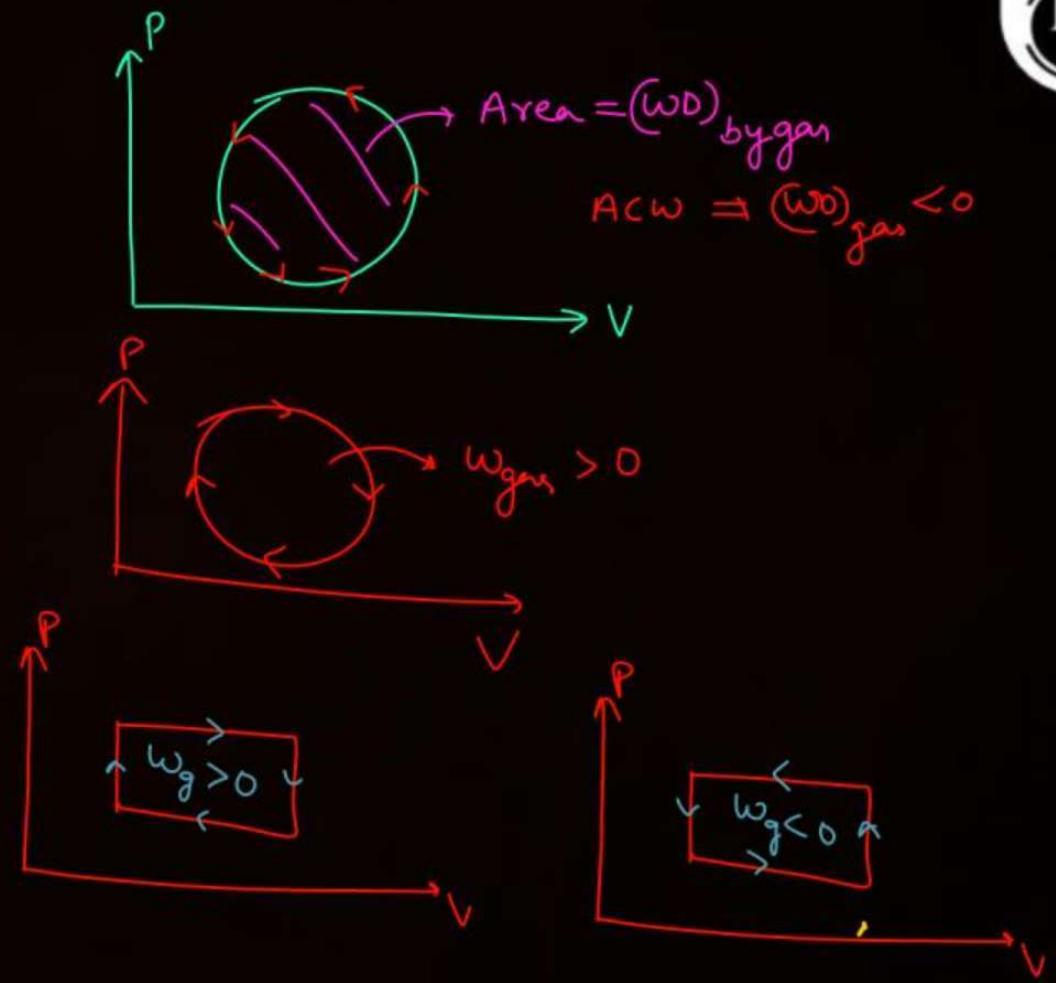
$$\Delta V = \frac{n_f R \Delta T}{2} = \frac{2 \times 3 \times R \times (800 - 100)}{2} = 2100 R$$

$$\Delta Q_{\text{int}} = \frac{56}{3} + 2100 R$$

Imp air

Cyclic process

- $\Delta U = 0$ (for cyclic process)
- $\Delta Q_{net} = \Delta U_{net} + \Delta W_{net}$
- $\boxed{\Delta Q_{net} = \Delta W_{net}}$



22:30 pm = तक की pdf → save की

→ C C_p C_v - - .

→ Adiabatic → 35 ग्रेड

$$\Upsilon = 1 + \frac{2}{f}$$

Molar specific heat

$$C = \frac{\Delta Q}{n \Delta T}$$

→ amount of heat required
to raise the temp by 1 Kelvin
of 1 mole of gas.

$$C = \frac{\Delta Q}{n \Delta T}$$

$$\Delta Q = n C \Delta T$$

↓
molar sp. heat

पुराना

$$\Delta Q = m S \Delta T$$

↓
molar sp. heat const



$$C = \frac{\Delta \theta}{n \Delta T} \rightarrow \text{molar sp. heat}$$

① Isothermal $C \rightarrow \infty$

② Adiabatic $C = 0$

③ Isochoric ($V \rightarrow \text{const}$)

$$C = \frac{\Delta \theta}{n \Delta T} = \frac{\Delta U + \cancel{\Delta W}^0}{n \Delta T} = \frac{n f R \Delta T}{2 n \Delta T} = \frac{f R}{2}$$

$$C = \frac{f R}{2} = C_V$$

$$\Delta U = \frac{n(fR)\Delta T}{2} = n C_V \Delta T$$

④

Isobaric (const Pressure)

$$C = \frac{\Delta \theta}{n \Delta T} = \frac{\Delta U}{n \Delta T} + \frac{\Delta W}{n \Delta T} = \frac{n f R \Delta T}{2 n \Delta T} + \frac{n R \Delta T}{n \Delta T}$$

$$C = \frac{f R}{2} + R = C_P$$

$$C_P = \frac{f R}{2} + R = C_V + R$$

$$C_P - C_V = R$$

\rightarrow molar sp. heat at const
Vol.

\rightarrow molar sp. heat at const
pressure.

	$C_V = \frac{fR}{2}$	$C_P = C_V + R$	$\gamma = \frac{C_P}{C_V}$
$f=3$ monatomic	$C_V = \frac{3R}{2}$	$\frac{3R}{2} + R = \frac{5R}{2}$	$\frac{5R/2}{3R/2} = \frac{5}{3} = 1.66$
$f=5$ Diatomic	$C_V = \frac{5R}{2}$	$7R/2$	$\frac{7}{5} = 1.4$
$f=6$ Triatomic (Nonlinear)	$C_V = \frac{6R}{2} = 3R$	$4R$	$\frac{4}{3} = 1.33$

$\gamma_{\text{mono}} > \gamma_{\text{dia}} > \gamma_{\text{triat.}}$

$\left[\gamma = 1 + \frac{2}{f} \right]$

JEE 24

$$(C_V)_{\text{mix}} = \frac{n_1 C_{V_1} + n_2 C_{V_2} + \dots}{n_1 + n_2 + \dots}$$

$$(C_P)_{\text{mix}} = \frac{n_1 C_{P_1} + n_2 C_{P_2} + \dots}{n_1 + n_2 + \dots}$$

$$\gamma_{\text{mix}} = \frac{(C_P)_{\text{mix}}}{(C_V)_{\text{mix}}}$$

$$(C_P)_{\text{mix}} = (C_V)_{\text{mix}} + R$$

Q 4 mole He + 2 mole O₂

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

$$C_{P_1} = 5R/2$$

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

$$C_{P_2} = 7R/2$$

$$(C_V)_{\text{mix}} = \frac{n_1 C_{V_1} + n_2 C_{V_2}}{n_1 + n_2} = \frac{4 \times \frac{3R}{2} + 2 \times \frac{5R}{2}}{4+2} = \frac{11R}{6}$$

$$(C_P)_{\text{mix}} = (C_V)_{\text{mix}} + R = \frac{17R}{6}$$

$$(C_P)_{\text{mix}} = \frac{4 \times \frac{5R}{2} + 2 \times \frac{7R}{2}}{6} = \frac{17}{6} R$$

$$\gamma = \frac{\frac{17R}{6}}{\frac{11R}{6}} = \frac{17}{11}$$



Isobaric Processes

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

$$= \frac{n f R \Delta T}{2} + n R \Delta T$$

$$\Delta Q = n C_V \Delta T + n R \Delta T$$

$$\Delta Q = n (C_V + R) \Delta T$$

Direct

Apply $\boxed{\Delta Q = n C_p \Delta T}$

Q find amount of heat required to raise temp by 100K at const pressure of 2 mole of monatomic gas

sol

$$\Delta Q = n C_p \Delta T$$

$$= 2 \times \frac{5R}{2} \times 100$$

$$C_p = C_v + R$$

$$= \frac{fR}{2} + R$$

$$= \frac{3R}{2} + R$$

$$= \frac{5R}{2}$$

(lamin Break)

Adiabatic Process

$$\Delta \Theta = \Delta U + \Delta W$$

- $\Delta \Theta = 0$, $\Delta W = -\Delta U$
- Sudden process

$PV^\gamma = \text{const}$
 $TV^{\gamma-1} = \text{const}$

$(\omega D)_{\text{by gas}} = \frac{nR\Delta T}{1-\gamma} = \frac{P_f V_f - P_i V_i}{1-\gamma}$

$$PV = nRT$$

$$PV^\gamma = \text{const} \quad \gamma = \frac{C_p}{C_v}$$

$$\frac{nRT}{V} V^\gamma = \text{const}$$

$$TV^{\gamma-1} = \text{const}$$

P-T relation for adiabatic process

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

$$P \left(\frac{nRT}{P} \right)^\gamma = \text{const}$$

$$P^{1-\gamma} T^\gamma = \text{const}$$

WD by gas in adiabatic process

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

$$P_1 V_1^\gamma = P_2 V_2^\gamma = K$$

$$(WD)_g = \int P dV = \int \frac{K}{V^\gamma} dV = K \int_{V_1}^{V_2} V^{-\gamma} dV = K \left(\frac{V^{-\gamma+1}}{-\gamma+1} \right) \Big|_{V_1}^{V_2}$$

$$W_g = \frac{K V_2^{1-\gamma} - K V_1^{1-\gamma}}{1-\gamma} = \frac{P_2 V_2^\gamma V_2^{1-\gamma} - P_1 V_1^\gamma V_1^{1-\gamma}}{1-\gamma}$$

$$W_g = \frac{P_2 V_2 - P_1 V_1}{1-\gamma} = \frac{n R T_2 - n R T_1}{1-\gamma} = \frac{n R \Delta T}{1-\gamma}$$

$$\gamma = 1 + \frac{2}{f}$$

$$f = \frac{2}{\gamma-1}$$

$$\Delta \vec{S}^0 = \Delta U + \Delta W$$

$$\Delta W = - \frac{n f R \Delta T}{2}$$

$$\Delta W = -n \frac{2}{\gamma-1} \frac{R \Delta T}{2}$$

$$\boxed{\Delta W = \frac{n R \Delta T}{1-\gamma}}$$

P
W

Q A diatomic gas (P_0, V_0, T_0) compress to final Volume $\frac{V_0}{32}$ adiabatically

$$\textcircled{1} \quad P_f = ?$$

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

$$P_0 V_0^{\gamma/5} = P_f \left(\frac{V_0}{32}\right)^{\gamma/5}$$

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

$$P_0 = P_f \left(\frac{1}{2}\right)^{5 \times \frac{7}{5}}$$

$$\boxed{P_f = P_0 2^7}$$

Q A diatomic gas (P_0, V_0, T_0) if final temp of gas becomes $\frac{T_0}{4}$ in adiabatic process

$$\textcircled{1} \quad V_f = ?$$

$$TV^{\gamma-1} = \text{const}$$

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

$$\textcircled{2} \quad (\text{WD})_{\text{gas}}$$

$$T_0 V_0^{2/5} = \frac{T_0}{4} \cdot V_f^{2/5}$$

$$\textcircled{3} \quad \Delta U = ?$$

$$V_f^{2/5} = 4 V_0^{2/5}$$

$$V_f^{2/5} = 2 V_0^{2/5}$$

$$V_f^{1/5} = 2 V_0^{1/5}$$

$$V_f = 2^5 \cdot V_0$$

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



Q

Adeabatic compression

$\Delta Q = 0, V \downarrow, W_g < 0, \Delta U > 0, T \uparrow$

Adeabatic expansion $\Rightarrow \Delta Q = 0, W_g > 0, \Delta U < 0, T \downarrow \rightarrow \text{cool}$

Polytropic Process

-

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

$$(W_D)_{\text{gas}} = \frac{nR\Delta T}{1-x}, \quad (x \neq 1)$$

Q

$$P = V^2$$

n=2 mole

if temp of gas is increase by 100K
find w_D by gas

Sol^b

$$PV^{-2} = \text{const}$$

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

$$\therefore \boxed{x = -2}$$

Adeabatic

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

$$(W_D)_{\text{gas}} = \frac{nR\Delta T}{1-\gamma} = \frac{P_f V_f - P_i V_i}{1-\gamma}$$

$$w_D = \frac{nR\Delta T}{1-x} = \frac{2 \times R \times 100}{1 - (-2)} = \frac{200R}{3}$$

For polytropic process:

$$C = \frac{\Delta Q}{n \Delta T} = \frac{\Delta U + \Delta W}{n \Delta T} = \frac{\Delta U}{n \Delta T} + \frac{\Delta W}{n \Delta T} = \frac{n C_V \Delta T}{n \Delta T} + \frac{n R \Delta T}{(1-\gamma) n \Delta T}$$

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

& $P = k V^\gamma$ find molar sp. heat monatomic gas

$$P V^{-3} = \text{const}$$

$$P V^\gamma = \text{const}$$

$\gamma = -3$

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

$$C = \frac{3R}{2} + \frac{R}{1-(-3)} = \checkmark$$

$$\Delta U = \frac{nfR\Delta T}{2} = nC_V\Delta T \quad \gamma = 1 + \frac{2}{f} = \frac{C_P}{C_V}$$

Isothermal

$$\Delta U = 0 \quad \Delta Q = \Delta W$$

$$W_D = nRT \ln \frac{V_2}{V_1} = nRT \ln \frac{P_1}{P_2}$$

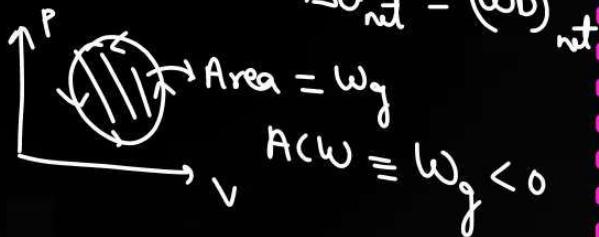
Isobaric

$$W_D = nR\Delta T = P \Delta V$$

$$\Delta Q = nC_P\Delta T$$

$$C_P = C_V + R$$

Cyclic Process



$$C_V + R = C_P$$

Isochoric

$$W_g = 0$$

$$\Delta U = \Delta Q = \frac{n f R \Delta T}{2}$$

$$\Delta U = nC_V\Delta T = \Delta Q$$

Polytropic

$$C_V = fR/2$$

isochoric

Adiabatic

isothermal

polytropic

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

Adiabatic

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

$$W_D = \frac{nR\Delta T}{1-\gamma}$$

$$\boxed{W_D = \frac{P_f V_f - P_i V_i}{1-\gamma}}$$

$$C = \frac{\Delta Q}{n \Delta T} \cdot \frac{P}{(W_D)_{gas}}$$

$$\text{isobaric} \rightarrow nR\Delta T$$

$$\text{Adiab.} \rightarrow \frac{nR\Delta T}{1-\gamma}$$

$$\text{Polytropic} \rightarrow \frac{nR\Delta T}{1-\gamma}$$

$$\gamma = 1 - \frac{T_{exit}}{T_{assi}}$$

* Q

$$P = KV^2 \quad PV^2 = \text{const}$$

2 moles, monoatomic gas
initial temp = 100 K.

$$\begin{aligned} V_0 &\rightarrow 2V_0 \\ P_0 &\rightarrow 4P_0 \\ T_0 &\rightarrow 8T_0 \end{aligned}$$

If volume become double find

$$\textcircled{1} \quad C = C_V + \frac{R}{1-\alpha} = \frac{3R}{2} + \frac{R}{1-(-2)} = \frac{3R}{2} + \frac{R}{3} = \frac{11R}{6}$$

$$\textcircled{2} \quad (\omega_0)_{\text{gas}} = \frac{nR\Delta T}{1-\alpha} = \frac{2 \times R \times 700}{1-(-2)} = \frac{1400R}{3}$$

$$\textcircled{3} \quad \Delta U = \frac{n_f R \Delta T}{2} = \frac{2 \times 3 \times R \times 700}{2} = 2100R$$

$$\textcircled{4} \quad \Delta Q = \Delta U + \Delta W = 2100R + \frac{1400R}{3} = \frac{7700R}{3}$$

P W

$$PV = nRT$$

2 mole monoatomic gas

Q $P = kT^2$

$$P = k \left(\frac{PV}{nR} \right)^2$$

$$1 = \frac{k}{n^2 R^2} P V^2 \quad PV^2 = \frac{n^2 R^2}{k} = \text{const}$$

$$\boxed{x=2}$$

$$\textcircled{1} \quad C_v = C_v + \frac{R}{1-x} = \frac{3R}{2} + \frac{R}{1-2} = \frac{R}{2}$$

② If temp is increase by 100K
find $\Delta U, \Delta \theta, (\text{WD})_{\text{gas}}$

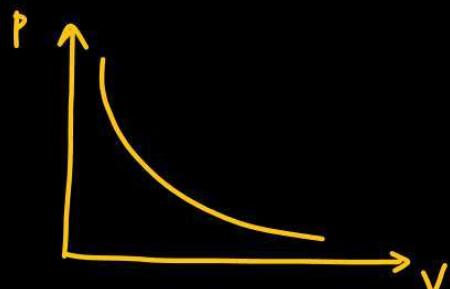
$$\Delta U = \frac{n f R \Delta T}{2} = \frac{2 \times 3 \times R \times 100}{2} \\ = +300R$$

$$(\text{WD})_{\text{gas}} = \frac{n R \Delta T}{1-x} = \frac{2 \times R \times 100}{1-2} = -200R$$

$$\boxed{\Delta \theta = 100R}$$

Isothermal Process

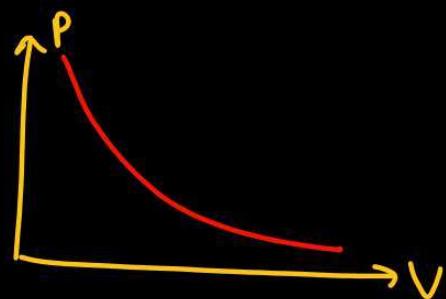
$$PV = \text{const}$$



$$\text{Slope} = \frac{dP}{dx}$$

Adiabatic Process

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



Comparison of PV-graph in isothermal & Adiabatic process

① Isothermal

$$PV = \text{const}$$

$$P \cdot x_1 + V \cdot \frac{dP}{dV} = 0$$

$$\boxed{\frac{dP}{dV} = -\frac{P}{V}}$$

 Slope

② Adiabatic

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

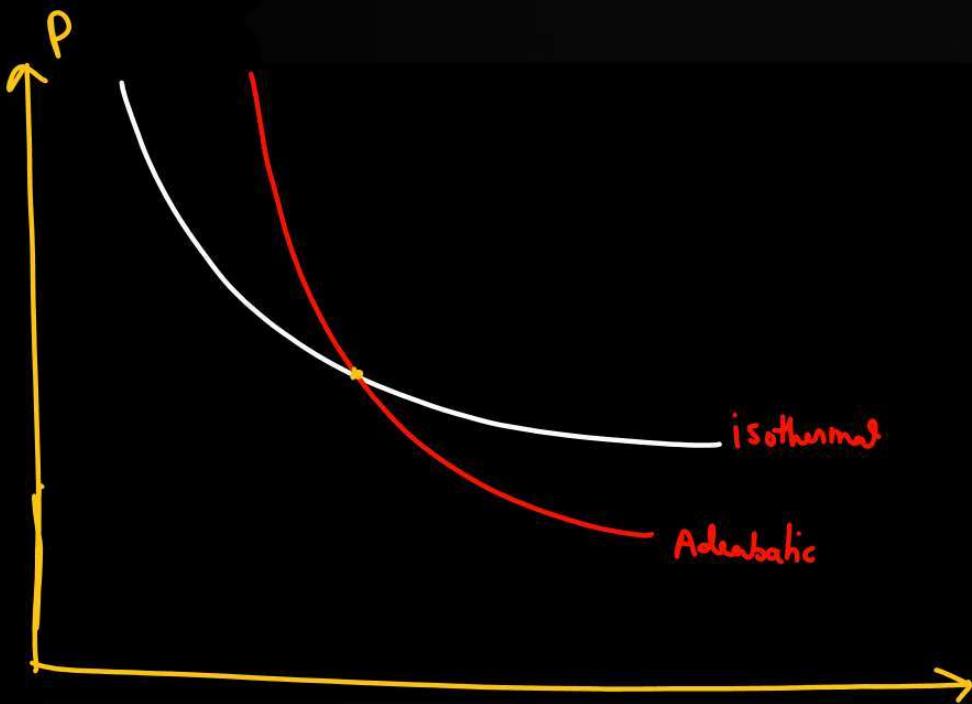
$$P \gamma V^{\gamma-1} + V^\gamma \cdot \frac{dP}{dV} = 0$$

$$\cancel{\gamma P V^{\gamma-1}} + \cancel{V^\gamma} \cdot V \frac{dP}{dV} = 0$$

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

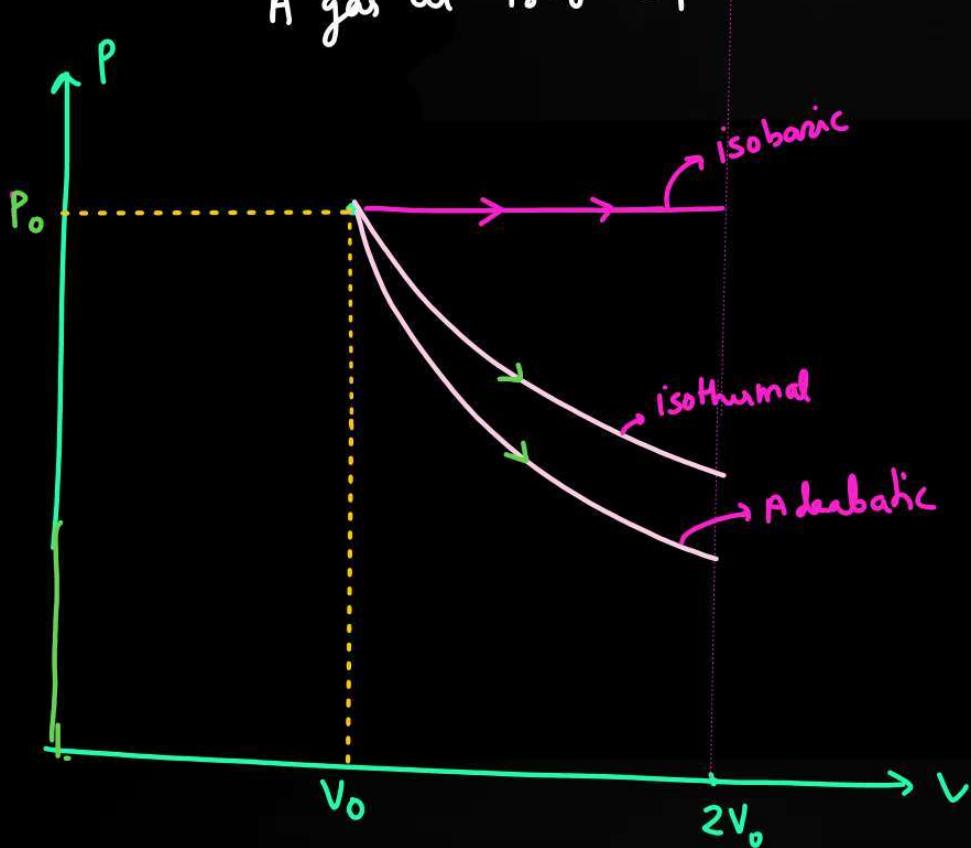
 Slope


 Adiab. proc. में
 p.v. graph में
 slope का magnitude
 isothermal के graph से
 γ times ज्यादा होता है



A gas at P_0, V_0 expand to $2V_0$ in diff process isobaric, Adiabatic & isothermal.

P
W



P_f order = ?

$(P_f)_{\text{Adiab.}} < (P_f)_{\text{isotherm.}} < (P_f)_{\text{isobaric}}$

$(wD)_{\text{isobaric}} > (wD)_{\text{isotherm.}} > (wD)_{\text{Adiab.}}$

Free Expansion

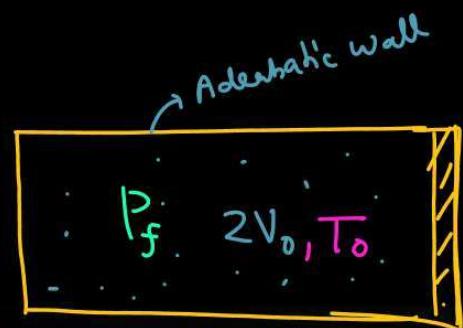
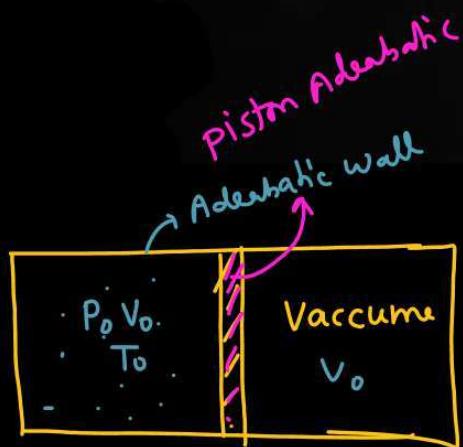
$$(\omega_D)_{\text{gas}} = 0$$

$$\Delta \theta = 0$$

$$\Delta \theta = \Delta v + \Delta \omega$$

$$\Delta v = 0$$

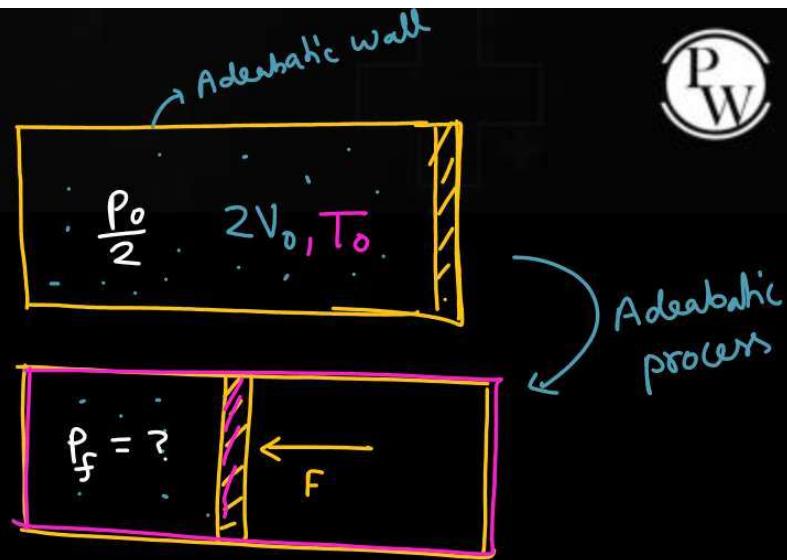
$$T \rightarrow \text{const}$$



$$n_i = n_f$$

$$\frac{P_0 V_0}{T_0} = \frac{P_f 2V_0}{T_0}$$

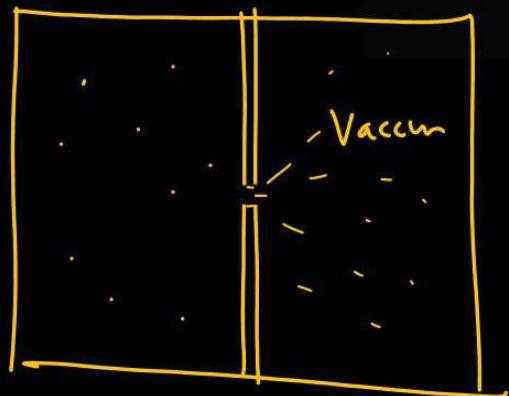
$$P_f = P_0 / 2$$



$$P_f V_f^\gamma = P_i V_i^\gamma$$

$$P_f (V_0)^\gamma = \left(\frac{P_0}{2}\right) (2V_0)^\gamma$$

$$P_f = P_0 2^{\gamma-1}$$



$$(WD)_{gap} = 0$$

KTH Based Question

$$PV = nRT$$

2. An ideal gas mixture filled inside a balloon expands according to the relation $PV^{2/3} = \text{constant}$. The temperature inside the balloon is
(A) increasing (B) decreasing (C) constant (D) can't be said

Ans : (A)

3. At a temperature T K, the pressure of 4.0g argon in a bulb is p . The bulb is put in a bath having temperature higher by 50K than the first one. 0.8g of argon gas had to be removed to maintained T original pressure. The temperature T is equal to

(A) 510 K

(B) 200 K

(C) 100 K

(D) 73 K

$$PV = \frac{4}{M} RT$$

$$4RT = 3.2 R(T+50)$$

$$PV = \frac{3.2}{M} R(T+50)$$

$$4T = 3.2T + 160$$

$$.8T = 160$$

$$\boxed{T = 200 \text{ K}}$$

Ratio

Ans : (B)

4. 28 gm of N₂ gas is contained in a flask at a pressure of 10 atm and at a temperature of 57°. It is found that due to leakage in the flask, the pressure is reduced to half and the temperature reduced to 27°C. The quantity of N₂ gas that leaked out is :-

- (A) 11/20 gm (B) 20/11 gm (C) 5/63 gm (D) 63/5 gm

$$PV = \frac{28}{M} R (273 + 57)$$

$$\frac{P}{2} V = \frac{28-x}{M} R (273 + 27)$$

$$\frac{PV M}{R} = \boxed{28 \times 330 = 2 \times (28-x)(300)}$$

Ans : (D)

5. A container X has volume double that of container Y and both are connected by a thin tube. Both contains same ideal gas. The temperature of X is 200K and that of Y is 400K. If mass of gas in X is m then in Y it will be:

- (A) $m/8$ (B) $m/6$ (C) $m/4$ (D) $m/2$

Ans : (C)

6. When 2 gms of a gas are introduced into an evacuated flask kept at 25°C the pressure is found to be one atmosphere. If 3 gms of another gas added to the same flask the pressure becomes 1.5 atmospheres. The ratio of the molecular weights of these gases will be :-

- (A) 1 : 3 (B) 3 : 1 (C) 2 : 3 (D) 3 : 2

Ans : (A)

7. A rigid tank contains 35 kg of nitrogen at 6 atm. Sufficient quantity of oxygen is supplied to increase the pressure to 9 atm, while the temperature remains constant. Amount of oxygen supplied to the tank is :

(A) 5 kg

(B) 10 kg

(C) 20 kg

(D) 40 kg

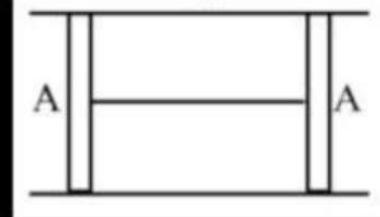
$$6V = \frac{35}{m_1} \times R \times T$$

$$9V = \left(\frac{35}{m_1} + \frac{x}{m_2} \right) R T$$

Ans : (C)

11. A cylindrical tube of cross-sectional area A has two air tight frictionless pistons at its two ends. The pistons are tied with a straight piece of metallic wire. The tube contains a gas at atmospheric pressure P_0 and temperature T_0 . If temperature of the gas is doubled then the tension in the wire is

- (A) $4 P_0 A$ (B) $P_0 A/2$
(C) $P_0 A$ (D) $2 P_0 A$



Ans : (C)

12. One mole of an ideal diatomic gas is taken through the cycle as shown in the figure.

1 → 2 : isochoric process

2 → 3 : straight line on P-V diagram

3 → 1 : isobaric process

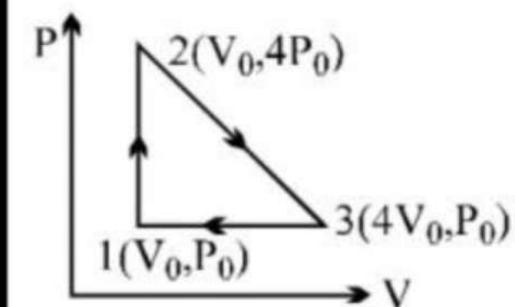
The average molecular speed of the gas in the states 1, 2 and 3 are in the ratio

(A) 1 : 2 : 2

(B) 1 : $\sqrt{2}$: $\sqrt{2}$

(C) 1 : 1 : 1

(D) 1 : 2 : 4



Ans : (A)



13. One mole of an ideal gas at STP is heated in an insulated closed container until the average speed of its molecules is doubled. Its pressure would therefore increase by factor.

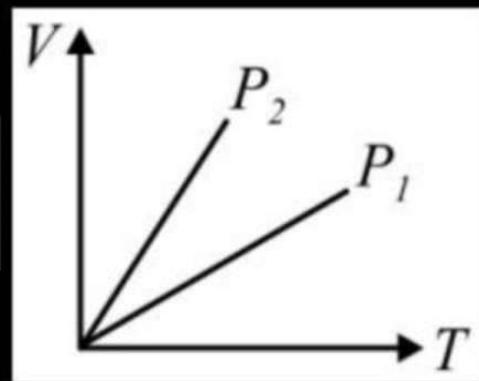
Ans : (D)

14. Three particles have speeds of $2u$, $10u$ and $11u$. Which of the following statements is correct?
- (A) The r.m.s. speed exceeds the mean speed by about u .
 - (B) The mean speed exceeds the r.m.s. speed by about u .
 - (C) The r.m.s. speed equals the mean speed.
 - (D) The r.m.s. speed exceeds the mean speed by more than $2u$.

Ans : (A)

7. In the adjacent $V-T$ diagram what is the relation between P_1 and P_2 ?

- (1) $P_2 = P_1$
- (2) $P_2 > P_1$
- (3) $P_2 < P_1$
- (4) cannot be predicated



Ans : (3)

QUESTION110

Nitrogen gas is at 300°C temperature. The temperature (in K) at which the rms speed of a H_2 molecule would be equal to the rms speed of nitrogen molecule, is
(Molar mass of N_2 gas 28 g)

(JEE Main - 2020)**Ans : (41.00)**

QUESTION

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

(JEE Main - 2021)

- 1** continuously lose their energy till it reaches wall.
- 2** are attracted by the walls of container.
- 3** continuously stick to the walls of container.
- 4** suffer change in momentum when impinge on the walls of container.

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

Ans : (4)

QUESTION

The volume V of an enclosure contains a mixture of three gases, 16 g of oxygen, 28 g of nitrogen and 44 g of carbon dioxide at absolute temperature T . Consider R as universal gas constant. The pressure of the mixture of gases is: (JEE Main - 2021)

- 1** $\frac{88RT}{V}$
- 2** $\frac{3RT}{V}$
- 3** $\frac{5}{2} \frac{RT}{V}$
- 4** $\frac{4RT}{V}$

Ans : (3)

QUESTION



H₂

O₂

CO₂

The rms speeds of the molecules of Hydrogen, Oxygen and Carbon dioxide at the same temperature are V_H, V_O and V_C respectively then:

(JEE Main - 2021)

1 $V_H > V_O > V_C$

$$v = \sqrt{\frac{3RT}{m}}$$

$$V_{CO_2}$$

2 $V_C > V_O > V_H$

$m \uparrow, v \downarrow$

$m \downarrow, v_{rel} \uparrow$

3 $V_H = V_O > V_C$

4 $V_H = V_O = V_C$

Ans : (1)

QUESTION

If the rms speed of oxygen molecules at 0°C is 160 m/s , find the rms speed of hydrogen molecules at 0°C .

(JEE Main - 2021)

$$\textcircled{1} \quad 640 \text{ m/s}$$

$$\textcircled{2} \quad 40 \text{ m/s}$$

$$\textcircled{3} \quad 80 \text{ m/s}$$

$$\textcircled{4} \quad 332 \text{ m/s}$$

$$\textcircled{273} \quad \textcircled{273} \\ \textcircled{O}_2 \equiv V_{\text{rms}} = \sqrt{\frac{3RT}{m}} \\ \downarrow \\ 160$$

$$\frac{V_1}{V_2} = \sqrt{\frac{m_2}{m_1}}$$

$$\frac{160}{V_2} = \sqrt{\frac{2}{32}}$$

$$V_2 = 160 \times 4 = 640$$

Ans : (1)

QUESTION

The root mean square velocity of molecules of gas is

(25 January 2023 - Shift 1)

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

- 1** Proportional to square of temperature (T^2).
- 2** Inversely proportional to square root of temperature $\sqrt{\frac{1}{T}}$.
- 3** Proportional to square root of temperature \sqrt{T} .
- 4** Proportional to temperature (T).

Ans : (3)

QUESTION

Three vessels of equal volume contain gases at the same temperature and pressure. The first vessel contains neon (monoatomic), the second contains chlorine (diatomic) and third contains uranium hexafluoride (polyatomic). Arrange these on the basis of their root mean square speed (v_{rms}) and choose the correct answer from the options given below:

(11 April 2023 - Shift 1)

- 1** $v_{rms}(\text{mono}) > v_{rms}(\text{dia}) > v_{rms}(\text{poly})$
- 2** $v_{rms}(\text{mono}) = v_{rms}(\text{dia}) = v_{rms}(\text{poly})$
- 3** $v_{rms}(\text{mono}) < v_{rms}(\text{dia}) < v_{rms}(\text{poly})$
- 4** $v_{rms}(\text{dia}) < v_{rms}(\text{poly}) < v_{rms}(\text{mono})$

Ans : (1)



1st Law

Graph

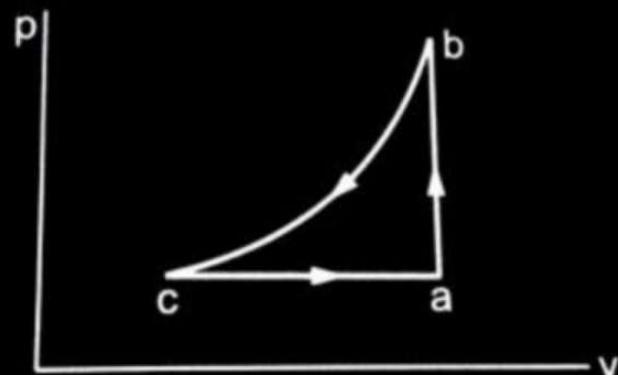
WD

Bareel Ques

Question



A sample of an ideal gas is taken through the cyclic process abca figure. It absorbs 50 J of heat during the part ab, no heat during bc and rejects 70 J of heat during ca. 40 J of work is done on the gas during the part bc. (a) Find the internal energy of the gas at b and c if it is 1500 J at a. (b) Calculate the work done by the gas during the part ca.



Ans. 20 J

Question

$$\Delta U = 0$$

Consider the cyclic process ABCA, shown in the given figure, performed, on a sample of 2.0 moles of an ideal gas. A total of 1200 J of heat is withdrawn from the sample in the process. Find the work done by the gas during the part BC.

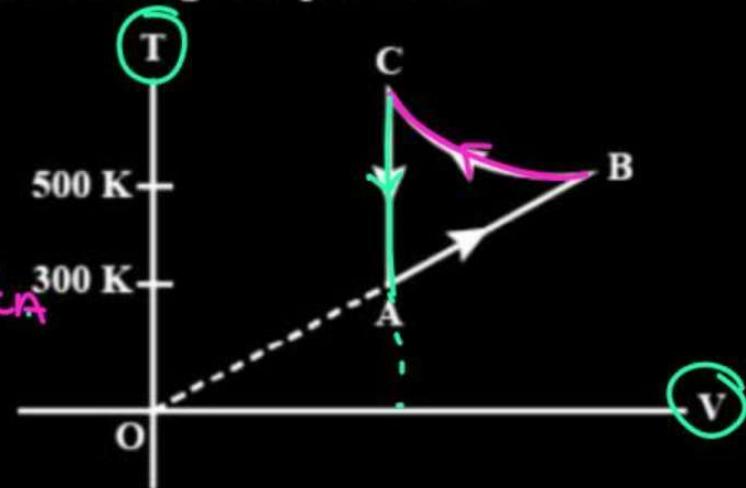
$$\Delta Q_{net} = -1200$$

$$\Delta \Theta_{net} = \Delta Q_{net} + \Delta W_{net}$$

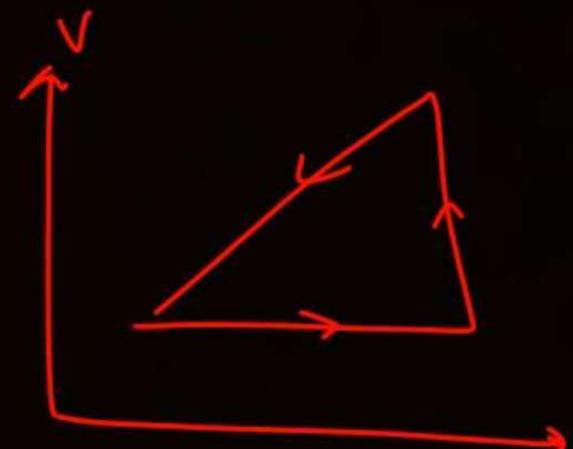
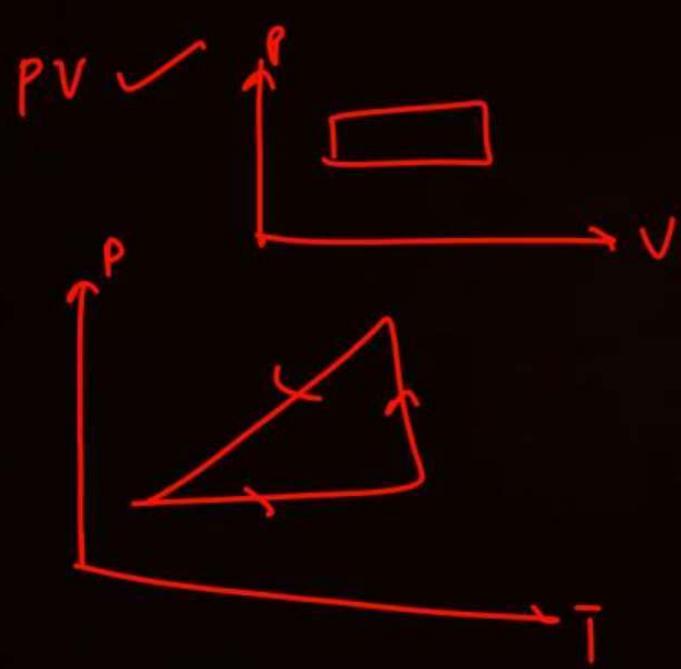
$$\Delta \Theta_{AB} + \Delta \Theta_{BC} + \Delta \Theta_{CA} = \omega_{AB} + \omega_{BC} + \omega_{CA}$$

$$-1200 = nR\Delta T + \omega_{BC} + 0$$

$$-1200 = 2 \times \frac{25}{3} \times 200 + \omega_{BC}$$



Ans. -4524 J



Question

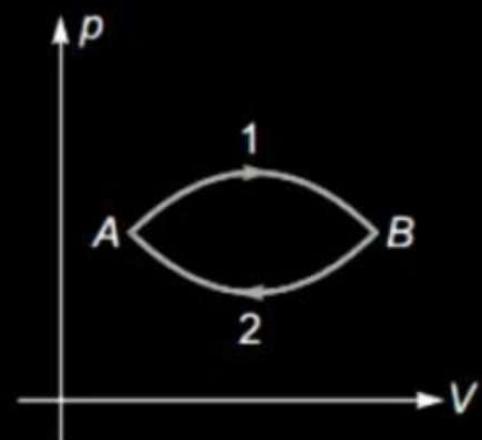
Three moles of a gas at 127°C expands isothermally, until volume is doubled. Find the amount of work done and heat absorbed.

Ans. 6912 J

Question

P
W

A certain amount of an ideal gas passes from state A to B first by means of process 1, then by means of process 2. In which process, is the amount of heat absorbed by the gas greater?

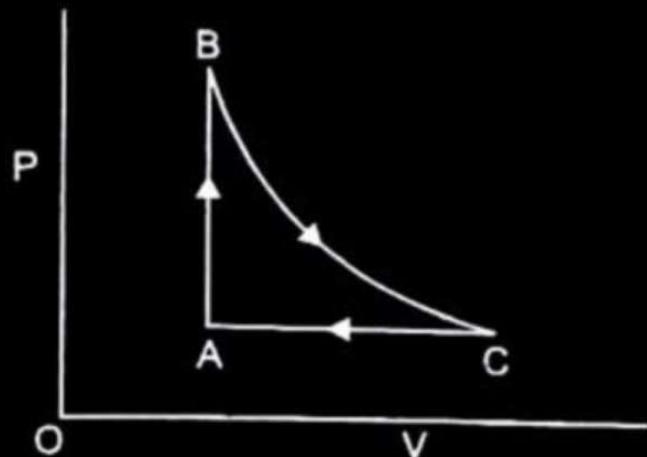


Ans. $\Delta Q_1 > \Delta Q_2$

Question



Gas within a chamber passes through the cycle shown in figure. Determine the net heat added to the system during process CA if the heat Q_{AB} added during process AB is 20 J, no heat is transferred during process BC and the net work done during the cycle is 15 J.



Ans. - 5 J

Question

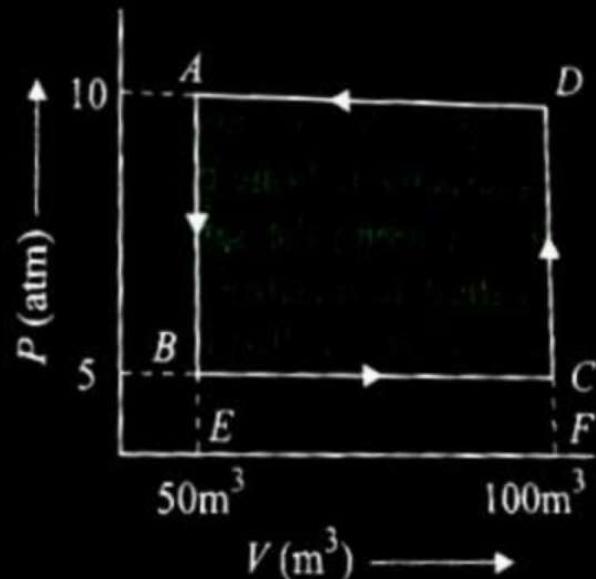
11/10

P
W

One mole of an ideal gas is taken through the cyclic process ABCDA as shown in the figure.

From the graph, find

- (a) Work done in the process $A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$ and $D \rightarrow A$.
- (b) Work done in the complete cycle $A \rightarrow B \rightarrow C \rightarrow D \rightarrow A$.
- (c) Heat rejected by the gas during the complete cycle.



Ans.

Question

Consider that 200 J of work is done on a system and 70 cal of heat is extracted from the system. What are the values of

- (a) ΔW
- (b) ΔQ
- (c) ΔU ?

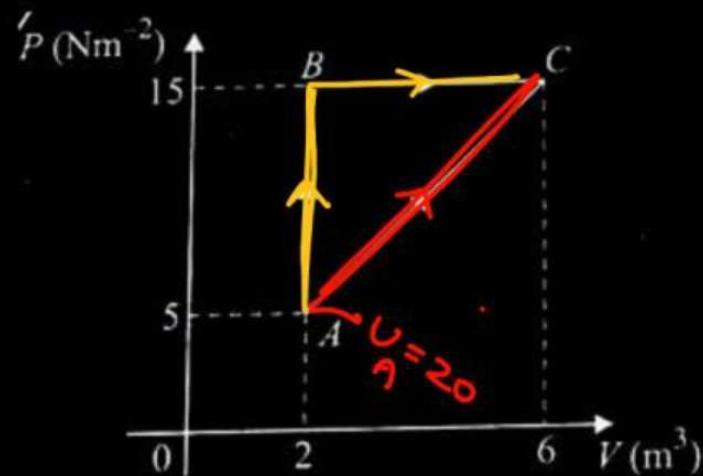
Ans. -94 J

Question

In fig, an ideal gas changes its state from A to state C by two paths ABC and AC.

- Find the work done along both the paths
- The internal energy of gas at A is 20 J and amount of heat supplied to change its state to C through the path AC is 200 J. Calculate the internal energy at C.
- The internal energy of gas at state B is 60 J. Find the amount of heat supplied to the gas to go from A to B.

$$\begin{aligned} \Delta U_{AC} &= 200 \text{ J} \\ 200 &= \Delta U_{AC} + 40 \\ \Delta U_{AC} &= 160 \\ U_C - 20 &= 160 \\ U_C &= 180 \end{aligned}$$



Ans. (a) = 60J = 40J, (b) = 180J, (C) = 40J

Question

$$\Delta U_{AB} = 0, \quad \Delta W_{AB} = +700 \quad \Delta \theta_{AB} = +700$$

An ideal gas expands isothermally along AB and does 700 J of work

(a) How much heat does the gas exchange along AB ? $+700$

(b) The gas then expands adiabatically along BC and does 400 J of work. When the gas returns to A along CA , it exhausts 100 J of heat to its surroundings. How much work is done on the gas along this path?

$$\Delta \theta_{BC} = 0$$

$$\Delta W_{BC} = +400$$

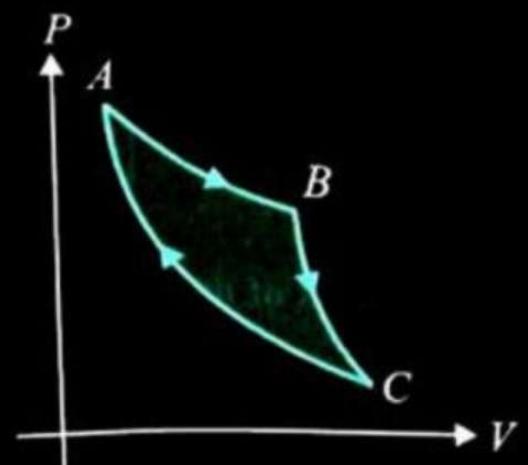
$$\Delta \theta_{CA} = -100$$

$$\Delta W_{CA} = ?$$

$$\Delta \theta_{\text{net}} = \Delta \theta_{\text{net}} + \Delta W_{\text{net}}$$

$$\Delta \theta_{AB} + \Delta \theta_{BC} + \Delta \theta_{CA} = 0 = \Delta W_{AB} + \Delta W_{BC} + \Delta W_{CA}$$

$$700 + 0 - 100 = 700 + 400 + \Delta W_{CA}$$



Ans. (a) = 700 J , (b) $\Delta W_{CA} = -500 \text{ J}$

QUESTION

Two moles of an ideal gas with $\frac{C_P}{C_V} = \frac{5}{3}$ are mixed with 3 moles of another ideal gas with $\frac{C_P}{C_V} = \frac{4}{3}$. The value of $\frac{C_P}{C_V}$ for the mixture is:

(JEE Main - 2020)

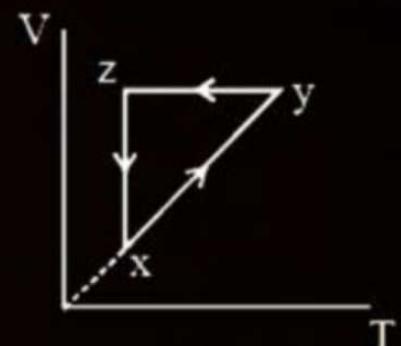
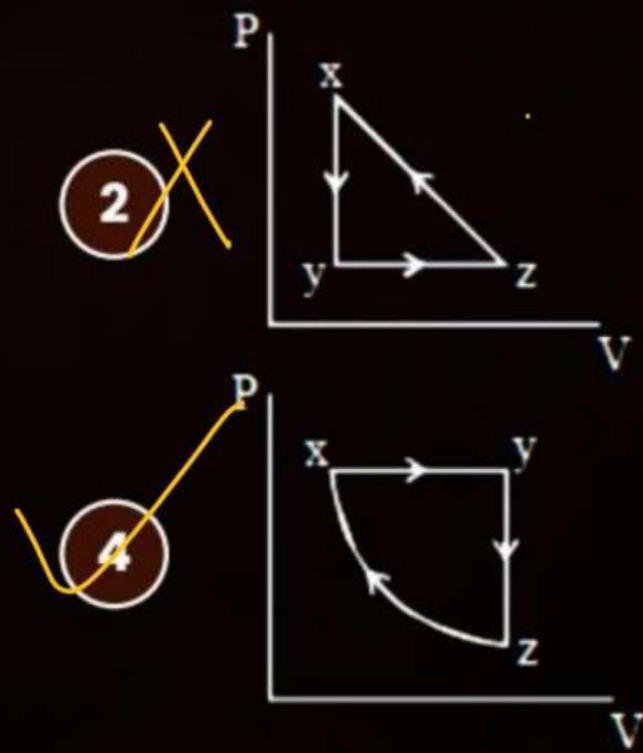
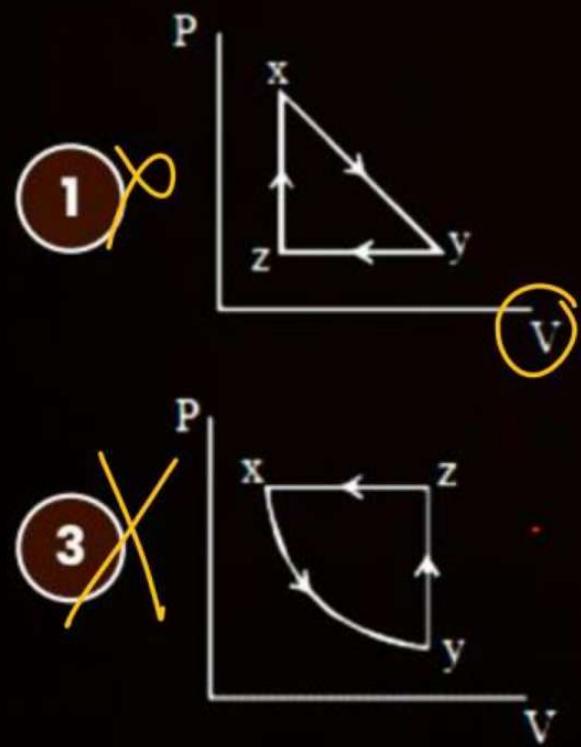
- 1** 1.50
- 2** 1.42
- 3** 1.45
- 4** 1.47

Ans : (2)

QUESTION

A thermodynamic cycle $xyzx$ is shown on a V-T diagram. The P-V diagram that best describes this cycle is: (Diagrams are schematic and not to scale)

(JEE Main - 2020)

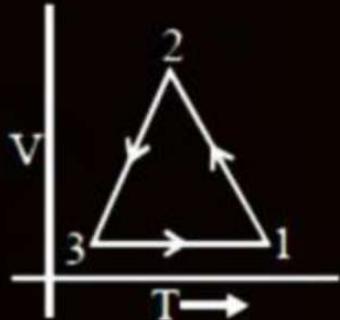
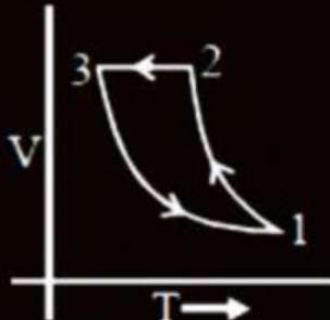
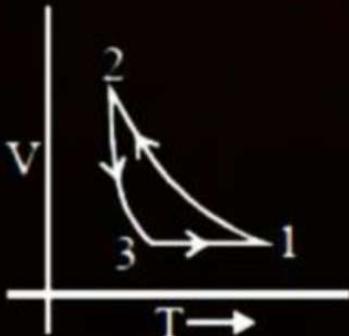
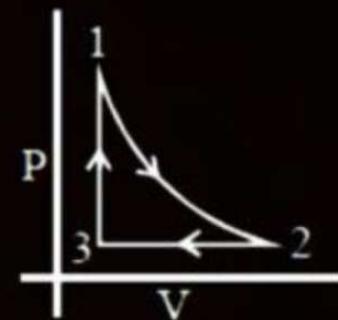
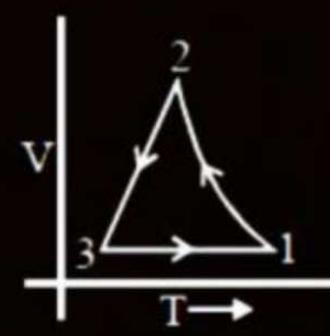


Ans : (4)

QUESTION

Which of the following is an equivalent cyclic process corresponding to the thermodynamic cyclic given in the figure? where, $1 \rightarrow 2$ is adiabatic. (Graphs are schematic and are not to scale)

(JEE Main - 2020)

1**2****3****4**

Ans : (4)

QUESTION

28 A gas mixture consists of 3 moles of oxygen and 5 moles of argon at temperature T. Assuming the gases to be ideal and the oxygen bond to be rigid, the total internal energy (in units of RT) of the mixture is:

(JEE Main - 2020)

- 1** 11
- 2** 15
- 3** 20
- 4** 13

Ans : (2)

QUESTION

Match the C_p/C_v ratio for ideal gases with different type of molecules:

Molecular type	C_p/C_v	
(A) Monoatomic	(I)	7/5
(B) Diatomic rigid molecules	(II)	9/7
(C) Diatomic non-rigid molecules	(III)	4/3
(D) Triatomic rigid molecules	(IV)	5/3

(JEE Main - 2020)

- 1** A – IV, B – I, C – II, D – III
- 2** A – IV, B – II, C – I, D – III
- 3** A – III, B – IV, C – II, D – I
- 4** A – II, B – III, C – I, D – IV

Ans : (1)

QUESTION

Match the thermodynamic processes taking place in a system with the correct conditions. In the table: ΔQ is the heat supplied, ΔW is the work done and ΔU is change in internal energy of the system:

(JEE Main - 2020)

Process	Condition
(I) Adiabatic	(A) $\Delta W = 0$
(II) Isothermal	(B) $\Delta Q = 0$
(III) Isochoric	(C) $\Delta U \neq 0, \Delta W \neq 0, \Delta Q \neq 0$
(IV) Isobaric	(D) $\Delta U = 0$

- 1** I – B, II – D, III – A, IV – C
- 2** I – B, II – A, III – D, IV – C
- 3** I – A, II – A, III – B, IV – C
- 4** I – A, II – B, III – D, IV – D

Ans : (1)

QUESTION

In an adiabatic process, the density of a diatomic gas becomes 32 times its initial value. The final pressure of the gas is found to be n times the initial pressure. The value of n is:

(JEE Main - 2020)

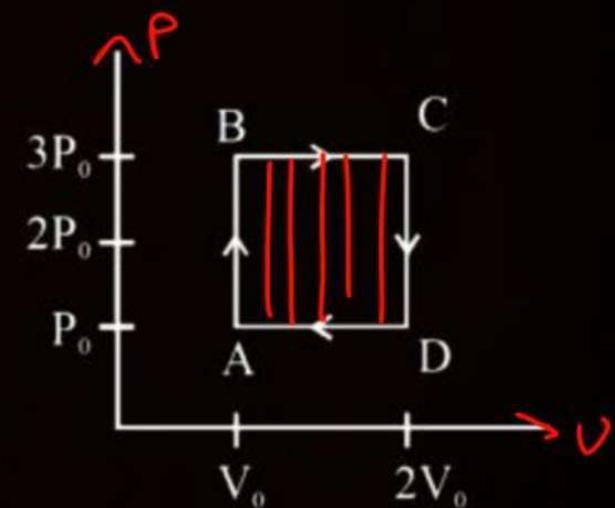
- 1** 326
- 2** $1/32$
- 3** 32
- 4** 128

Ans : (4)

QUESTION

An engine operates by taking a monatomic ideal gas through the cycle shown in the figure. The percentage efficiency of the engine is close to _____. **(JEE Main - 2020)**

$$\gamma = \frac{(\omega_0)_{\text{net}}}{Q_{\text{heat}}} = \frac{2P_0V_0}{\alpha_{\text{int}}}$$



Ans : (19.00)

QUESTION

n mole a perfect gas undergoes a cyclic process ABCA (see figure) consisting of the following processes.

A → B : Isothermal expansion at temperature T so that the volume is doubled from V_1 to $V_2 = 2V_1$ and pressure changes from P_1 to P_2 .

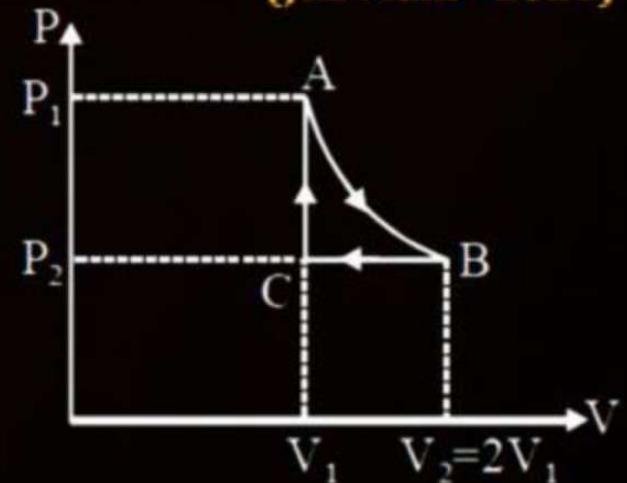
B → C: Isobaric compression at pressure P_2 to initial volume V_1 .

C → A : Isochoric change leading to change of pressure from P_2 to P_1 .

Total work-done in the complete cycle ABCA is :

(JEE Main - 2021)

- 1** 0
- 2** $nRT\left(\ln 2 + \frac{1}{2}\right)$
- 3** $nRT \ln 2$
- 4** $nRT\left(\ln 2 - \frac{1}{2}\right)$



Ans : (4)

QUESTION

Match List-I with List-II:

Easy

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 :

(JEE Main - 2021)

1 (a) → (i), (b) → (iii), (c) → (ii), (d) → (iv)

2 (a) → (ii), (b) → (iii), (c) → (iv), (d) → (i)

3 (a) → (ii), (b) → (iv), (c) → (iii), (d) → (i)

4 (a) → (iii), (b) → (ii), (c) → (i), (d) → (iv)

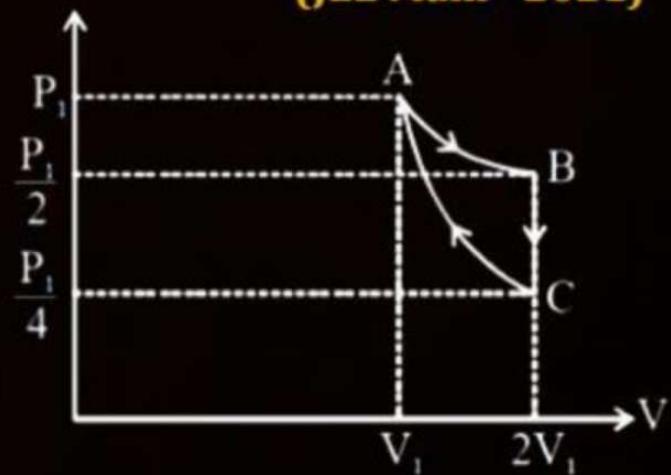
Ans : (2)

QUESTION

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

(JEE Main - 2021)

- 1** $\frac{4}{3}RT \left(\ln 2 - \frac{1}{2(\gamma-1)} \right)$
- 2** $-\frac{RT}{2(\gamma-1)}$
- 3** 0
- 4** $RT \ln 2$



Ans : (1)

QUESTION

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

(JEE Main - 2021)

- 1** 5 : 7 : 3
- 2** 5 : 7 : 2
- 3** 3 : 7 : 2
- 4** 3 : 5 : 2

Ans : (B)

QUESTION



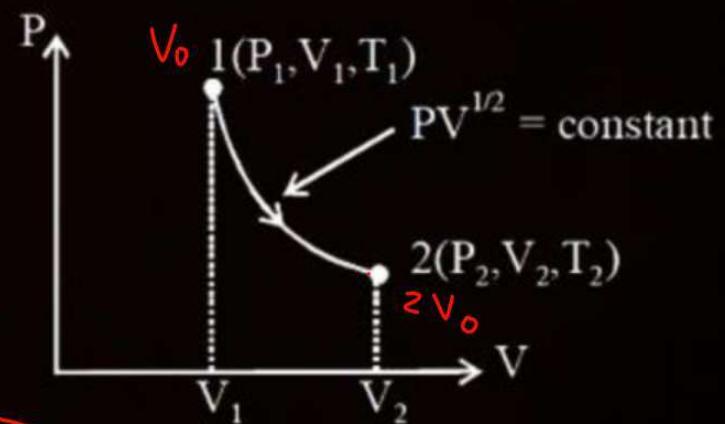
Thermodynamic process is shown below on a P-V diagram for one mole of an ideal gas. If $V_2 = 2V_1$ then the ratio of temperature T_2/T_1 is:

(JEE Main - 2021)

- 1** $\frac{1}{2}$
- 2** 0
- 3** $\sqrt{2}$
- 4** $\frac{1}{\sqrt{2}}$

$$PV^{\frac{1}{2}} = \text{const}$$

$V_o \longrightarrow 2V_o$
 $P_o \longrightarrow \frac{P_o}{\sqrt{2}}$
 $T \longrightarrow T\sqrt{2}$



Ans : (3)

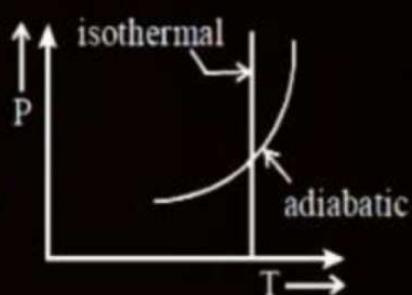
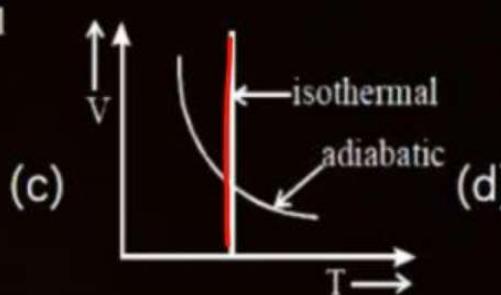
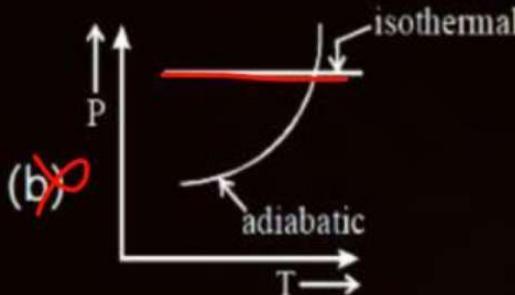
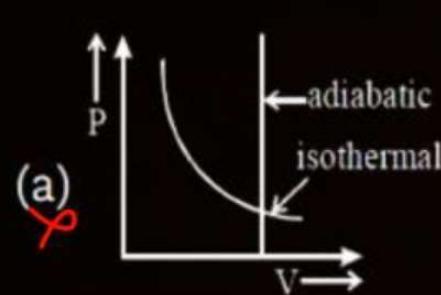
QUESTION

The volume V of a given mass of monoatomic gas changes with temperature T according to the relation $V = KT^{2/3}$. The workdone when temperature changes by 90 K will be xR . The value of x is [R = universal gas constant] **(JEE Main - 2021)**

Ans : (60)

QUESTION

Which one is the correct option for the two different thermodynamic processes?



(JEE Main - 2021)

- 1 (c) and (a)
- 2 (c) and (d)
- 3 (a) only
- 4 (b) and (c)

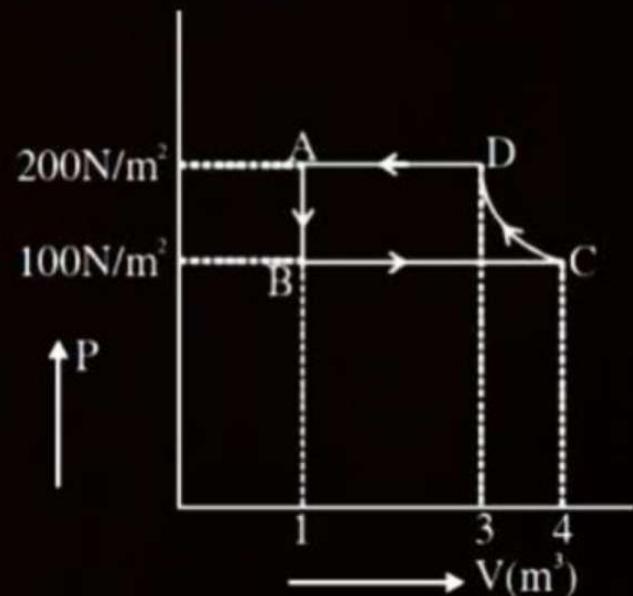
Ans : (2)

QUESTION

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 $\gamma = 1.4$):

(JEE Main - 2021)

- 1** -500 J
- 2** -400 J
- 3** 400 J
- 4** 200 J



Ans : (1)

QUESTION

For an adiabatic expansion of an ideal gas, the fractional change in its pressure is equal to (where γ is the ratio of specific heats):

(JEE Main - 2021)

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

2 $-\gamma \frac{V}{dV}$

3 $-\frac{1}{\gamma} \frac{dV}{V}$

4 $\frac{dV}{V}$

Ans : (1)

QUESTION

The amount of heat needed to raise the temperature of 4 moles of a rigid diatomic gas from 0°C to 50°C when no work is done is _____. (R is the universal gas constant) (JEE Main - 2021)

$V \xrightarrow{\text{11}} \text{cont}$

$$\begin{aligned}\Delta\theta &= \Delta U + \cancel{\Delta U}^{\circ} \\ &= \frac{n_f R \Delta T}{2} = \frac{4 \times 5 \times R \times 50}{2}\end{aligned}$$

- 1** 250 R
- 2** 750 R
- 3** 175 R
- 4** 500 R

Ans : (4)

QUESTION

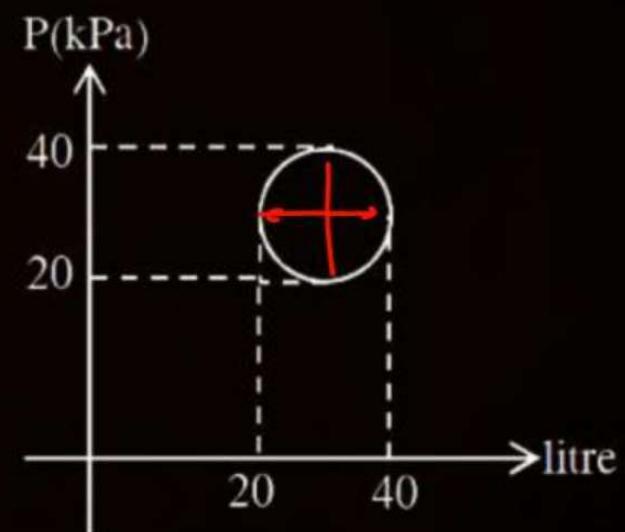
In the reported figure, heat energy absorbed by a system in going through a cyclic process is πJ .

(JEE Main - 2021)

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

$\gamma = 1.5$

$$\pi$$



Ans : (100)

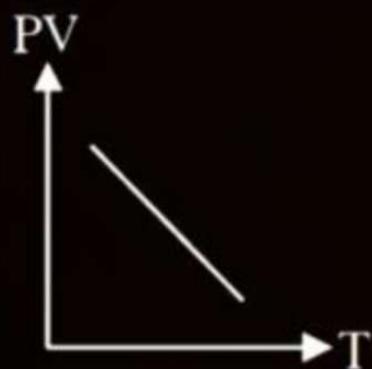
QUESTION



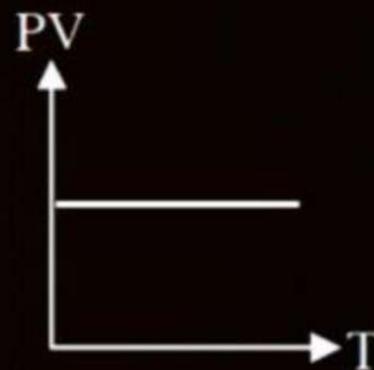
Which of the following graphs represent the behaviour of an ideal gas? Symbols have their usual meaning.

(JEE Main - 2021)

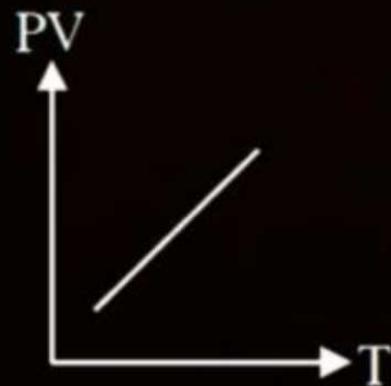
1



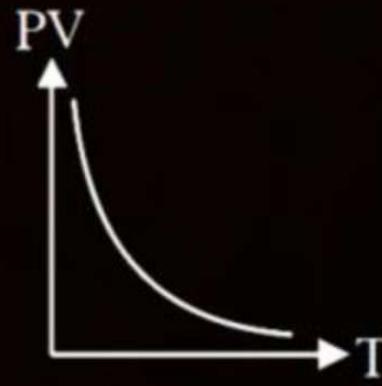
2



3



4



Ans : (3)

QUESTION

The correct relation between the degrees of freedom f and the ratio of specific heat γ is:

(JEE Main - 2021)

1 $f = \frac{2}{\gamma - 1}$

2 $f = \frac{2}{\gamma + 1}$

3 $f = \frac{\gamma + 1}{2}$

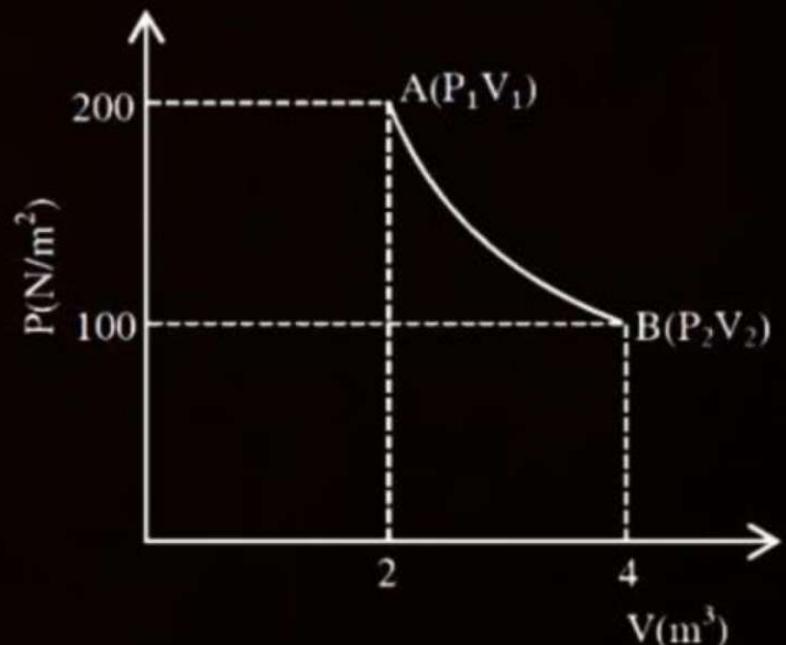
4 $f = \frac{1}{\gamma + 1}$

Ans : (A)

QUESTION

One mole of an ideal gas at 27°C is taken from A to B as shown in the given PV indicator diagram. The work done by the system will be _____ $\times 10^{-1}$ J.
[Given : $R = 8.3 \text{ J / mole K}$, $\ln 2 = 0.6931$] (Round off to the nearest integer)

(JEE Main - 2021)



Ans : (17258)

QUESTION

A sample of gas with $\gamma = 1.5$ is taken through an adiabatic process in which the volume is compressed from 1200 cm^3 to 300 cm^3 . If the initial pressure is 200 kPa . The absolute value of the workdone by the gas in the process = _____ J.

(JEE Main - 2021)

Ans : (480)

QUESTION

At a certain temperature, the degrees of freedom per molecule for a gas is 8. The gas performs 150 J of work when it expands under constant pressure. The amount of heat absorbs by the gas will be _____. **(JEE Main - 2022)**

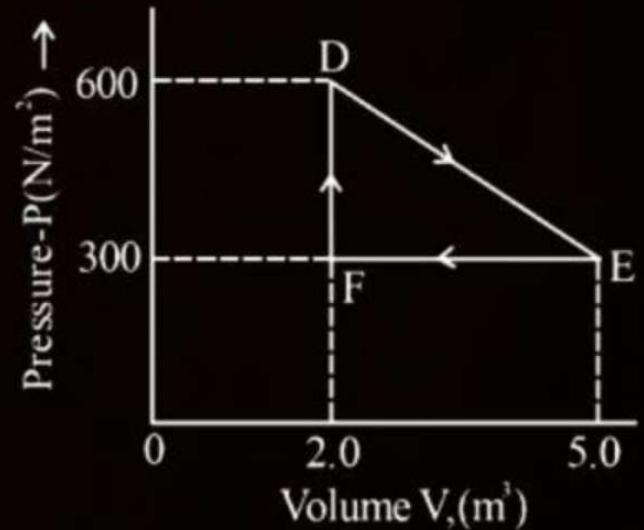
Ans : (750)

QUESTION

A thermodynamic system is taken from an original state D to an intermediate state E by the linear process shown in the figure. Its volume is then reduced to the original volume from E to F by an isobaric process. The total work done by the gas from D to E to F will be

(JEE Main - 2022)

- 1** -450 J
- 2** 450 J
- 3** 900 J
- 4** 1350 J



Ans : (2)

QUESTION



Match List I with List II:

Choose the correct answer from the options given below :

(25 January 2023 - Shift 2)

- 1** A-II, B-I, C-III, D-IV
- 2** A-II, B-I, C-IV, D-III
- 3** A-I, B-II, C-IV, D-III
- 4** A-I, B-II, C-III, D-IV

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

$$\Delta W = -\Delta U$$

	List I		List II
A.	Isothermal Process ii	I.	Work done by the gas decreases internal energy
B.	Adiabatic Process $\Delta Q = 0$ i	II.	No change in internal energy
C.	Isochoric Process IV	III.	The heat absorbed goes partly to increase internal energy and partly to do work
D.	Isobaric Process	IV.	No work is done in or by the gas

Ans : (2)

QUESTION*Chow*

Three vessels of equal volume contain gases at the same temperature and pressure. The first vessel contains **neon** (monoatomic), the second contains **chlorine** (diatomic) and third contains **uranium hexafluoride** (polyatomic). Arrange these on the basis of their root mean square speed (v_{rms}) and choose the correct answer from the options given below:

(11 April 2023 - Shift 1)

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

- 1** $v_{rms}(\text{mono}) > v_{rms}(\text{dia}) > v_{rms}(\text{poly})$
- 2** $v_{rms}(\text{mono}) = v_{rms}(\text{dia}) = v_{rms}(\text{poly})$
- 3** $v_{rms}(\text{mono}) < v_{rms}(\text{dia}) < v_{rms}(\text{poly})$
- 4** $v_{rms}(\text{dia}) < v_{rms}(\text{poly}) < v_{rms}(\text{mono})$

Ans : (1)

QUESTION



The thermodynamic process, in which internal energy of the system remains constant is.

(11 April 2023 - Shift 2)

$$T \rightarrow \text{const}$$

- 1 Isochoric
- 2 Adiabatic
- 3 Isothermal
- 4 Isobaric

Ans : (3)

QUESTION

The initial pressure and volume of an ideal gas are P_0 and V_0 . The final pressure of the gas when the gas is suddenly compressed to volume $\frac{V_0}{4}$ will be: (Given γ = ratio of specific heats at constant pressure and at constant volume.)

(13 April 2023 - Shift 2)

- 1** $P_0(4)^\gamma$
- 2** $4P_0$
- 3** P_0
- 4** $P_0(4)^{\frac{1}{\gamma}}$

Ans : (1)

QUESTION

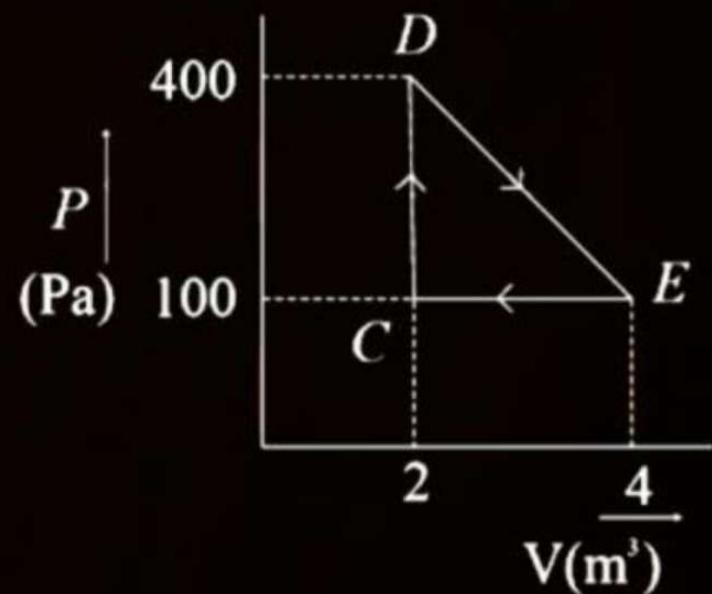


A thermodynamic system is taken through cyclic process. The total work done in the process is :

(15 April 2023 - Shift 1)

Area

- 1 200 J
- 2 300 J
- 3 100 J
- 4 Zero



Ans : (2)



Carnot & 2nd Law





SECOND LAW OF THERMODYNAMICS



The first law of thermodynamics is a generalization of the law of conservation of energy to include heat energy. It tells us that heat and mechanical work are mutually interconvertible.

Second law of thermodynamics tells us in what conditions heat can be converted into useful work.

➤ Kelvin-Planck Statement

It is impossible for an engine working between a cyclic process to extract heat from a reservoir and convert completely into work. In other words, 100% conversion of heat into work is impossible.



SECOND LAW OF THERMODYNAMICS



➤ Clausius Statement

It is impossible for a self-acting machine, unaided by any external agency to transfer heat from a cold to hot reservoir. In other words heat can not in itself flow from a colder to a hotter body.

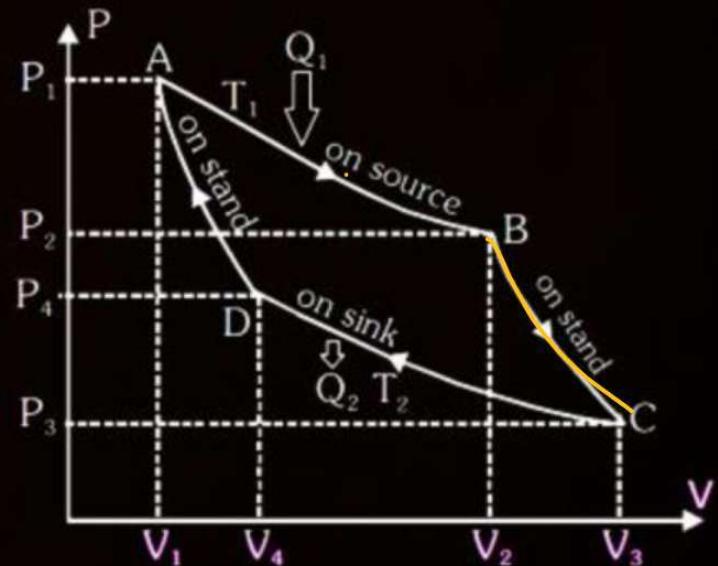


CARNOT CYCLE



Carnot devised an ideal engine which is based on a reversible cycle of four operations in succession :

- (i) isothermal expansion, $A \rightarrow B$
- (ii) adiabatic expansion, $B \rightarrow C$
- (iii) isothermal compression $C \rightarrow D$
- (iv) adiabatic compression. $D \rightarrow A$



Heat Engine

- It converts heat into mech. work.

$$\eta = \frac{(\text{WD})_{\text{net}}}{Q_{\text{in}}} \quad Q_{\text{in}} > 0$$

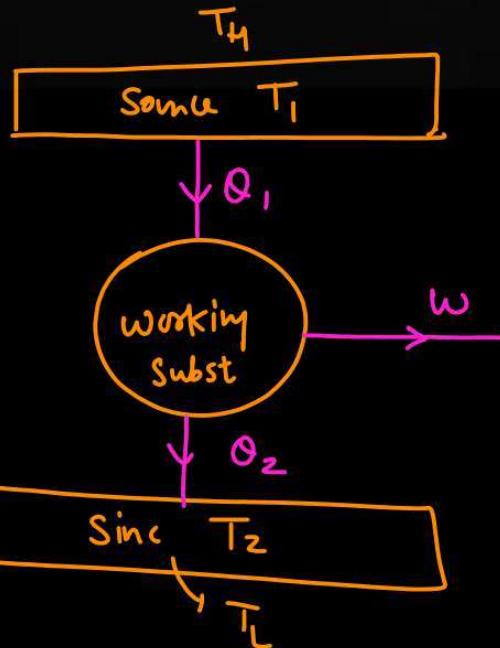
$$\eta = \frac{Q_1 - Q_2}{Q_1}$$

$$\eta = 1 - \frac{Q_2}{Q_1}$$

*
$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$$

$$Q_1 = W + Q_2$$

$$W = Q_1 - Q_2$$



T_2 → temp of sink,
 T_1 → Temp of source
 $T_2 < T_1$

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{\theta_2}{\theta_1}$$

$$\eta = 1 - \frac{T_{\text{sink}}}{T_{\text{source}}}$$

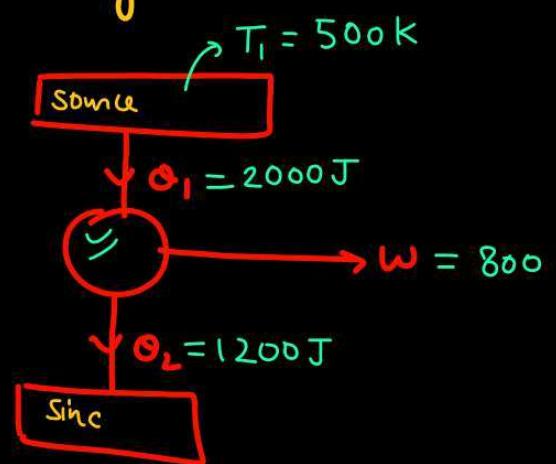
Q A Carnot cycle engine absorbs 2000 J of heat from source of heat engine at 227°C . and rejects 1200 J of heat during each cycle to Sinc.

$$\textcircled{1} \quad \eta = ? \quad \eta = \frac{(\text{WD})_{\text{net}}}{Q_{\text{in}}} = \frac{800}{2000} \times 100 = 40\%$$

$$\textcircled{2} \quad \text{temp of sinc} \quad \eta = 1 - \frac{T_2}{T_1} = .4 = 1 - \frac{T_2}{500}$$

$$T_2 = \checkmark$$

$$\textcircled{3} \quad \text{Amount of (WD) in each cycle} = 800$$



QUESTION



A Carnot engine operates between two reservoirs of temperatures 900 K and 300 K. The engine performs 1200 J of work per cycle. The heat energy (in J) delivered by the engine to the low temperature reservoir, in a cycle, is _____.

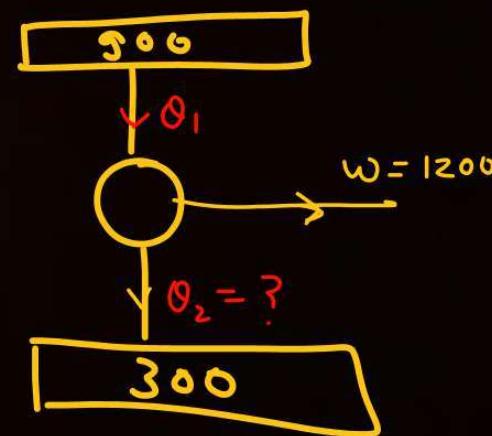
$$Q_1 = 1200 + Q_2$$

$$\eta = 1 - \frac{300}{900} = \frac{2}{3} = \frac{\omega}{Q_1}$$

$$\frac{2}{3} = \frac{1200}{Q_1}$$

$$Q_1 = 1800$$

(JEE Main - 2020)



$$Q_1 = \omega + Q_2$$

$$1800 = 1200 + Q_2$$

$$Q_L = 600$$

Ans : (600)

QUESTION

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:

$$Q_1 = ?$$

(JEE Main - 2021)

H10

- 1** 3200 J
- 2** 1800 J
- 3** 1600 J
- 4** 2400 J

Ans : (4)

QUESTION



A heat engine has an efficiency of $\frac{1}{6}$. When the temperature of sink is reduced by 62°C , its efficiency get doubled. The temperature of the source is: (JEE Main - 2021)

- 1 124°C
- 2 37°C
- 3 62°C
- 4 99°C

$$\eta = \frac{1}{6} = 1 - \frac{T_2}{T_1}$$

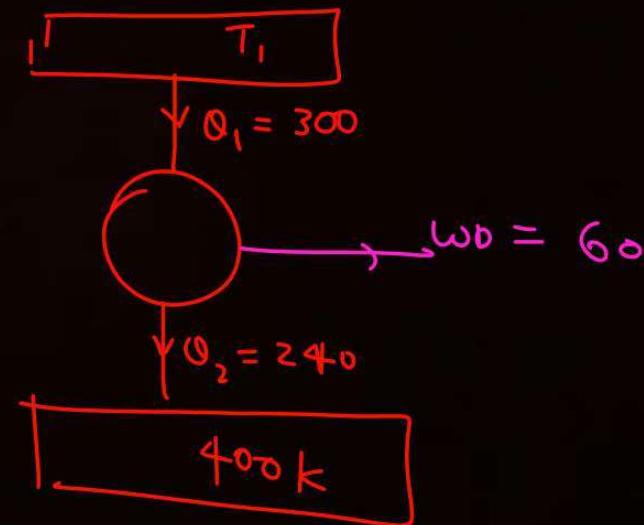
$$\frac{1}{3} = 1 - \frac{T_2 - 62}{T_1}$$

Ans : (4)

QUESTION

A heat engine operates between a cold reservoir at temperature $T_2 = 400\text{ K}$ and a hot reservoir at temperature T_1 . It takes 300 J of heat from the hot reservoir and delivers 240 J of heat to the cold reservoir in a cycle. The minimum temperature of the hot reservoir has to be _____ K

(JEE Main - 2021)



Ans : (500)

QUESTION

A reversible engine has an efficiency of $\frac{1}{4}$. If the temperature of the sink is reduced by 58°C , its efficiency becomes double. Calculate the temperature of the sink:

(JEE Main - 2021)

- 1** 174°C
- 2** 280°C
- 3** 80.4°C
- 4** 382°C

$$\eta = \frac{1}{4} = 1 - \frac{T_2}{T_1}$$

$$\frac{1}{2} = 1 - \frac{T_2 - 58}{T_1}$$

Ans : (1)

QUESTION

Let η_1 is the efficiency of an engine at $T_1 = 447^\circ\text{C}$ and $T_2 = 147^\circ\text{C}$ while η_2 is the efficiency at $T_1 = 947^\circ\text{C}$ and $T_2 = 47^\circ\text{C}$. The ratio $\frac{\eta_1}{\eta_2}$ will be:

(JEE Main - 2022)

1 0.41

$$\eta_1 = 1 - \frac{147 + 273}{447 + 273}$$

2 0.56

$$\eta_2 = 1 - \frac{47 + 273}{947 + 273}$$

3 0.73

4 0.70

Ans : (2)

QUESTION

A carnot engine has efficiency of 50%. If the temperature of sink is reduced by 40°C , its efficiency increases by 30%. The temperature of the source will be:

(JEE Main - 2022)

- 1** 166.7 K
- 2** 255.1 K
- 3** 266.7 K
- 4** 367.7 K

$$\frac{1}{2} = 1 - \frac{T_2}{T_1}$$

Ans : (3)

QUESTION

373 K

273 K



The efficiency of a Carnot's engine, working between steam point and ice point, will be :

(JEE Main - 2022)

- 1** 26.81%
- 2** 37.81%
- 3** 47.81%
- 4** 57.81%

$$\eta = \left(1 - \frac{273}{373} \right) \times 100$$

Ans : (1)

QUESTION

300 cal. Heat ~~X~~ is given to a heat engine and it rejects 225 cal. Of heat. If source temperature ~~X~~ is 227° , then the temperature of sink will be $\underline{\hspace{2cm}}$ $^\circ\text{C}$. **(JEE Main - 2022)**

Ans : (102)

QUESTION

A Carnot engine with efficiency 50% takes heat from a source at 600 K. In order to increase the efficiency to 70%, keeping the temperature of sink same, the new temperature of the source will be :

(25 January 2023 - Shift 1)

- 1 360 K
- 2 1000 K
- 3 900 K
- 4 300 K

$$50 = 1 - \frac{T_2}{600} \quad T_2 = 50 \times 600 = 300$$

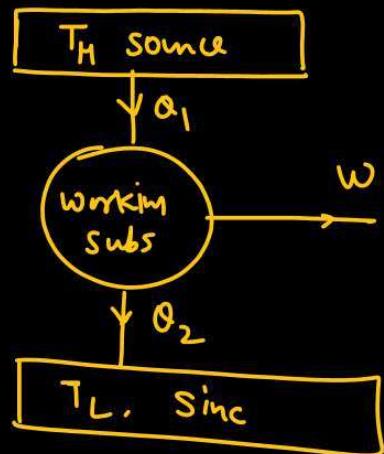
$$70 = 1 - \frac{T_2}{T_f}$$

$$70 = 1 - \frac{300}{T_f}$$

$$\frac{300}{T_f} = \frac{3}{10}$$

Ans : (2)

Heat engine

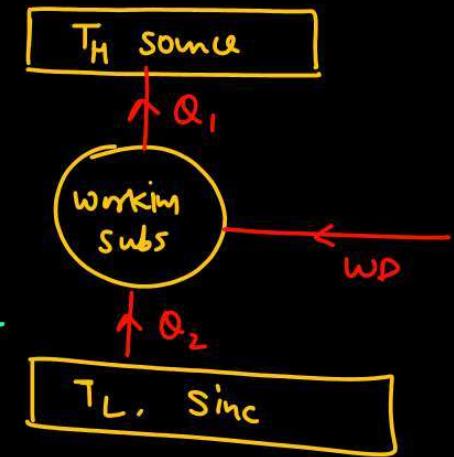


Refrigerator

- Reverse of heat engine

- $COP = \text{Coff. of perform}$

$$COP = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2}$$



$$W + Q_2 = Q_1$$

$$W = Q_1 - Q_2$$

QUESTION

Work done by a Carnot engine operating between temperatures 127°C and 27°C is 2 kJ. The amount of heat transferred to the engine by the reservoir is:

(08 April 2023 - Shift 2)

- 1** 8 kJ
- 2** 2.67 kJ
- 3** 2 kJ
- 4** 4 kJ

Ans : (1)

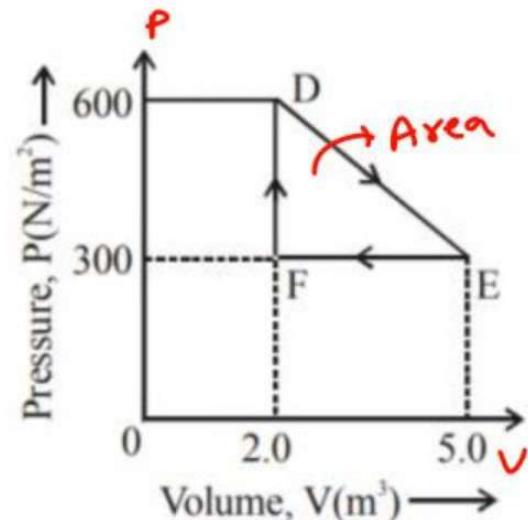


Imp Quen + JA(PY0)

Ex. Two samples of a gas initially at same temperature and pressure are compressed from a volume V to $\frac{V}{2}$. One sample is compressed isothermally and the other adiabatically. In which sample is the pressure greater?

Ans: $\Rightarrow P_2' = 2^\gamma P$ $\gamma > 1 \therefore 2^\gamma > 2$ and $P_2' > P_2$

12. A thermodynamic system is taken from an original state to an intermediate state by the linear process shown in figure. Its volume is then reduced to the original value from E to F by an isobaric process. Calculate the total work done by the gas from D to E to F



Ans : 450 J

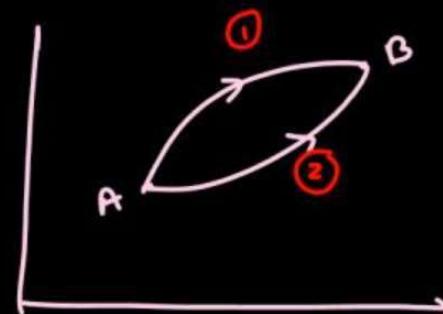
13. In changing the state of a gas adiabatically from an equilibrium state A to another equilibrium state B, an amount of work equal to 22.3 J is done on the system. If the gas is taken from state A to B via a process in which the net heat absorbed by the system is 9.35 cal, how much is the net work done by the system in the latter case ? (Take 1 cal = 4.19 J)

$$\textcircled{1} \quad \begin{aligned}\Delta W &= -22.3 \text{ J} \\ \Delta Q &= 0 \\ \hline \Delta U_{AB} &= 22.3 \text{ J}\end{aligned}$$

$$\text{2nd} \quad \begin{aligned}\Delta Q &= +9.35 \times 4.2 \text{ J} \\ \Delta U_{AB} &= 22.3 \text{ J} \\ \hline \Delta Q &= \Delta U + \Delta W\end{aligned}$$

↓ ↓ ↓

✓



Ans (16.9 J)

Round off

Ans : 16.9 J

12. One mole of an ideal diatomic gas is taken through the cycle as shown in the figure.

1 → 2 : isochoric process

2 → 3 : straight line on P-V diagram

3 → 1 : isobaric process \checkmark

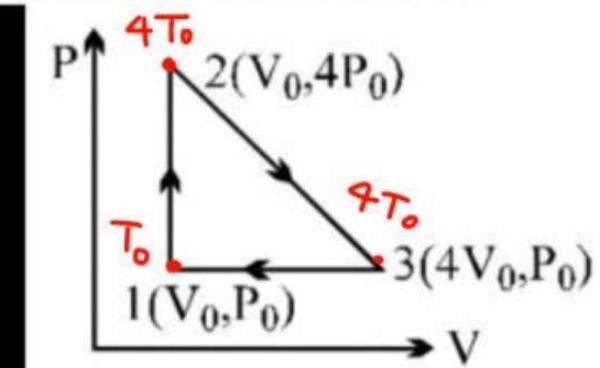
The average molecular speed of the gas in the states 1, 2 and 3 are in the ratio

(A) 1 : 2 : 2

(B) 1 : $\sqrt{2}$: $\sqrt{2}$

(C) 1 : 1 : 1

(D) 1 : 2 : 4



Ans : (A)

17. In thermodynamic process pressure of a fixed mass of gas is changed in such a manner that the gas releases 30 joule of heat and 18 joule of work was done on the gas. If the initial internal energy of the gas was 60 joule, then, the final internal energy will be :
(A) 32 joule (B) 48 joule (C) 72 joule (D) 96 joule

$$\Delta Q = -30$$

$$(WD)_g = -18$$

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

$$-30 = \Delta U - 18$$

$$\Delta U = -12$$

$$U_f - U_i = -12$$

$$U_f - 60 = -12$$

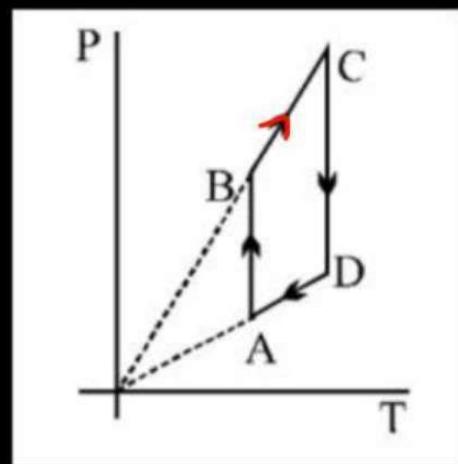
$$U_f = 48$$

,

Ans : (B)

20. Pressure versus temperature graph of an ideal gas is shown in figure
- (A) During the process AB work done by the gas is positive <0
 - (B) During the process CD work done by the gas is negative >0
 - (C) During the process BC internal energy of the gas is increasing
 - (D) None

P
W



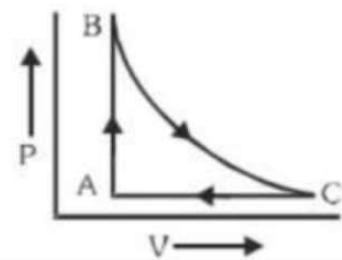
Ans : (C)

27. 2 moles of a monoatomic gas are expanded to double its initial volume, through a process $P/V = \text{constant}$. If its initial temperature is 300 K, then which of the following is not true.
- (A) $\Delta T = 900 \text{ K}$ (B) $\Delta Q = 3200 \text{ R}$ (C) $\Delta Q = 3600 \text{ R}$ (D) $W = 900 \text{ R}$

Ans : (B)

14. One mole of monoatomic ideal gas undergoes a cyclic process ABCA as shown in figure. Process BC is adiabatic. The temperatures at A, B and C are 300, 600 and 450K respectively. Choose the correct statement(s).

- (A) In process CA change in internal energy is $225R$.
- (B) In process AB change in internal energy is $-150R$.
- (C) In process BC change in internal energy is $-225R$.
- (D) Change in internal energy during the whole cyclic process is $+150R$.



Ans : (C)

3. Match the following for the given process :

Column I

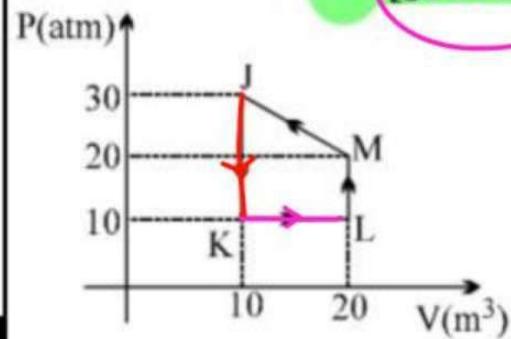
- S (A) Process J → K $w=0, \Delta U < 0, \Delta \theta < 0$
PR (B) Process K → L $w>0, \Delta U > 0, \Delta \theta > 0$
(C) Process L → M
(D) Process M → J

Column II

- (P) $W > 0$
(Q) $W < 0$
(R) $Q > 0$
(S) $Q < 0$

[JEE 2006]

P
W



Easy

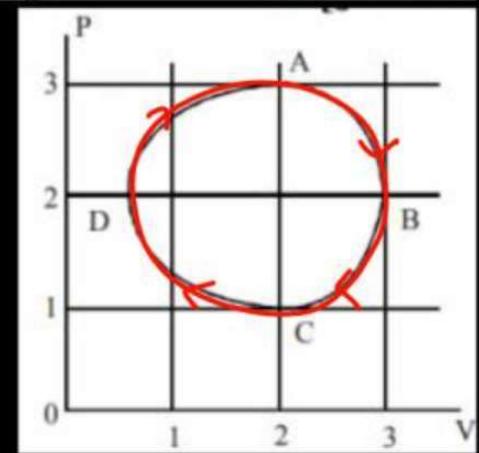
$$PV = nRT$$

Ans : (A) → S; (B) → P and R; (C) → R; (D) → Q and S

11. The figure shows the P-V plot of an ideal gas taken through a cycle ABCDA. The part ABC is a semicircle and CDA is half of an ellipse. Then,

[JEE-2009]

- (A) the process during the path $A \rightarrow B$ is isothermal \times
- (B) heat flows out of the gas during the path $B \rightarrow C \rightarrow D$
 $T \downarrow \Delta U < 0, w_g < 0, \Delta Q < 0$
- (C) work done during the path $A \rightarrow B \rightarrow C$ is zero \times
- (D) positive work is done by the gas in the cycle ABCDA \oplus



$$T_B > T_D$$

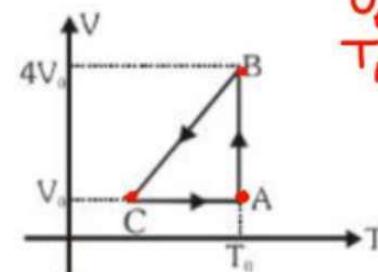


Ans : (B, D)

13. One mole of an ideal gas in initial state A undergoes a cyclic process ABCA, as shown in the figure. its pressure at A is P_0 . Choose the correct option(s) from the following. [JEE-2010]

- (A) Internal energies at A and B are the same
- (B) Work done by the gas in process AB is $P_0 V_0 \ln 4$
- (C) Pressure at C is $\frac{P_0}{4}$
- (D) Temperature at C is $\frac{T_0}{4}$

$$nRT_0 \ln \frac{4V_0}{V_0}$$



$$\begin{aligned} U_A &= U_B \\ T_A &= T_B \\ \Delta U &= 0 \end{aligned}$$

Easy

Ans : (A, B, C, D)

14. A diatomic ideal gas is compressed adiabatically to $1/32$ of its initial volume. In the initial temperature of the gas is T_i (in Kelvin) and the final temperature is aT_i , the value of a is [JEE-2010]

Ans : (4)

5/3

15. 5.6 liter of helium gas at STP is adiabatically compressed to 0.7 liter. Taking the initial temperature to be T_1 , the work done in the process is [JEE-2011]

- (A) $\frac{9}{8}RT_1$ (B) $\frac{3}{2}RT_1$ (C) $\frac{15}{8}RT_1$ (D) $\frac{9}{2}RT_1$

$$V \longrightarrow \frac{V}{8}$$

$$T_1 V_0^{\gamma-1} = T_f \left(\frac{V_0}{8}\right)^{\gamma-1}$$

$$W_D = \frac{nR\Delta T}{1-\gamma}$$

$$T_1 V_0^{2/3} = T_f \left(\frac{V_0}{8}\right)^{2/3}$$

=

$$T_1 = T_f \times \frac{1}{8}$$

$$T_f = 8T_1$$

Ans : (A)

- 16.** One mole of a monatomic ideal gas is taken through a cycle ABCDA as shown in P-V diagram. **Column II** gives the characteristics involved in the cycle. Match them with each of the processes given in **Column I**.

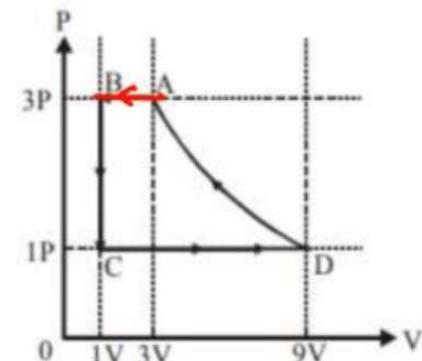
[JEE-2011]

Column I

- (A) Process A→B
 (B) Process B→C
 (C) Process C→D
 (D) Process D→A

Column II

- (P) Internal energy decreases.
 (Q) Internal energy increases.
 (R) Heat is lost.
 (S) Heat is gained.
 (T) Work is done **on** the gas.



कर्म $(W)_\text{by} < 0$ जारी
 V ↓

EASY

Ans : (A) → (P,R,T); (B) → (P,R); (C) → (Q,S); (D) → (R,T)

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

(A) 0.32

(B) 0.45

(C) 2.24

(D) 3.16

[JEE-2012]

Easy

$$\frac{(v_{rms})_{\text{He}}}{(v_{rms})_{\text{Ar}}} = \sqrt{\frac{m_{\text{Ar}}}{m_{\text{He}}}} = \sqrt{\frac{40}{4}} = \sqrt{10} = 3.16$$

Ans : (D)

19. Two non-reactive monoatomic ideal gases have their atomic masses in the ratio 2 : 3. The ratio of their partial pressures, when enclosed in a vessel kept at a constant temperature, is 4 : 3. The ratio of their densities is :-

[JEE-2013]

(A) 1 : 4

(B) 1 : 2

(C) 6 : 9

(D) 8 : 9

Easy

P, P, M

$$PM = PRT$$

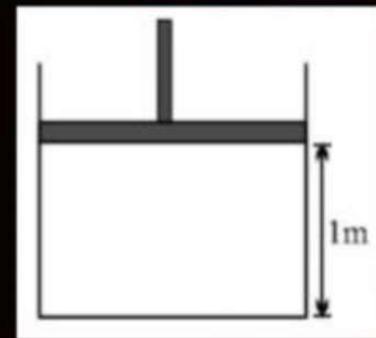
$$P = \frac{PM}{RT}$$

$$\frac{P_1}{P_2} = \frac{P_1}{P_2} \cdot \frac{m_1}{m_2} \cdot \frac{T_2}{T_1} = \frac{4}{3} \times \frac{2}{3} = \left(\frac{8}{9} \right)$$

Ans : (D)

5. The piston cylinder arrangement shown contains a diatomic gas at temperature 300 K. The cross-sectional area of the cylinder is 1 m^2 . Initially the height of the piston above the base of the cylinder is 1 m. The temperature is now raised to 400 K at constant pressure. Find the new height of the piston above the base of the cylinder. If the piston is now brought back to its original height without any heat loss, find the new equilibrium temperature of the gas. You can leave the answer in fraction.

[JEE' 2004]



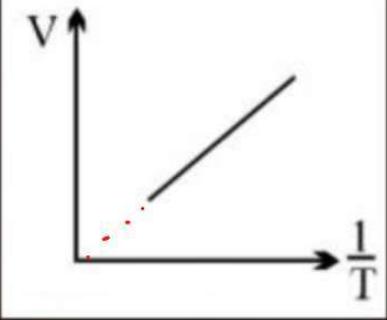
Ans : (a) $\frac{4}{3}$ m, (b) $T_3 = 400 \left(\frac{4}{3}\right)^{0.4} \text{ K}$

14. One mole of an ideal monoatomic gas undergoes a process as shown in the figure. Find the molar specific heat of the gas in the process.

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

$$y = mx$$

$$V = m \times \frac{1}{T}$$



$$PV = nRT$$

$$VT = \text{const}$$

$$C = \frac{3R}{2} + \frac{R}{1-2}$$

$$V \cdot \frac{PV}{nR} = \text{const}$$

$$PV^2 = \text{const}$$

Ans : R/2

12. An adiabatic cylinder has 8 gram of helium. A light smooth adiabatic piston is connected to a light spring of force constant 300 N/m . The other end of the spring is connected with a block of mass 1 kg kept on a rough horizontal surface of coefficient of friction $\mu = 0.3$. Area of cross-section of cylinder is $A = 25 \text{ cm}^2$. Initially the spring is in a relaxed position and the temperature of the gas is 400 K . The gas is heated slowly for some time by means of an electric heater so as to bring the block M on the verge of motion. Take $P_{\text{atm}} = 10^5 \text{ N/m}^2$. Find
 (a) the work done by the gas $\Sigma \text{ इरका } \rightarrow$
 (b) the final temperature
 (c) heat supplied by the heater $\Delta Q = \Delta U + \Delta W = n F R \Delta T + w_g$

when mass is just abt to move \Rightarrow

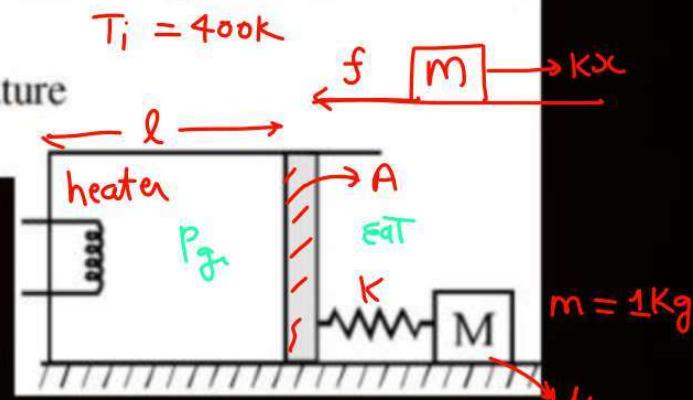
$$w_g + w_{\text{ext}} + w_{\text{sp}} = \Delta K.E.$$

$$w_g - P_0 A x - \frac{1}{2} k(x^2 - x_0^2) = 0 - 0$$

(a) $w_g = \checkmark$

(b) $n_i = n_f$

$$\frac{P_0 A l}{400} = \frac{P_f \cdot A (l+x)}{T_f}$$

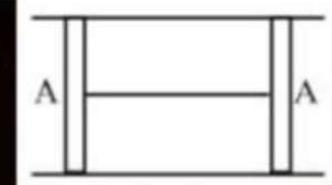


$$\Delta P_f = \frac{P_g A}{T_f} - \frac{P_0 A}{T_f} = \frac{(P_g - P_0)A}{T_f}$$

Ans : $2.515, 404.8 \text{ K}$,

11. A cylindrical tube of cross-sectional area A has two air tight frictionless pistons at its two ends. The pistons are tied with a straight piece of metallic wire. The tube contains a gas at atmospheric pressure P_0 and temperature T_0 . If temperature of the gas is doubled then the tension in the wire is

- (A) $4 P_0 A$ (B) $P_0 A/2$ (C) $P_0 A$ (D) $2 P_0 A$



Ans : (C)

17. In thermodynamic process pressure of a fixed mass of gas is changed in such a manner that the gas releases 30 joule of heat and 18 joule of work was done on the gas. If the initial internal energy of the gas was 60 joule, then, the final internal energy will be :
- (A) 32 joule (B) 48 joule (C) 72 joule (D) 96 joule

Ans : (B)

23. The adiabatic Bulk modulus of a diatomic gas at atmospheric pressure is

- (A) 0 Nm^{-2} (B) 1 Nm^{-2} (C) $1.4 \times 10^4 \text{ Nm}^{-2}$ (D) $1.4 \times 10^5 \text{ Nm}^{-2}$

Ans : (D)

24. A given quantity of an ideal gas is at pressure P and absolute temperature T . The isothermal bulk modulus of the gas is :

(A) $2P/3$ (B) P (C) $3P/2$ (D) $2P$



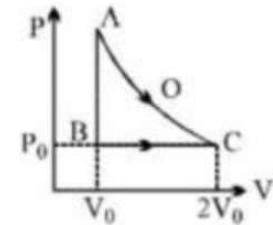
Ans : (B)

27. 2 moles of a monoatomic gas are expanded to double its initial volume, through a process $P/V = \text{constant}$. If its initial temperature is 300 K, then which of the following is not true.

- (A) $\Delta T = 900 \text{ K}$ (B) $\Delta Q = 3200 \text{ R}$ (C) $\Delta Q = 3600 \text{ R}$ (D) $W = 900 \text{ R}$

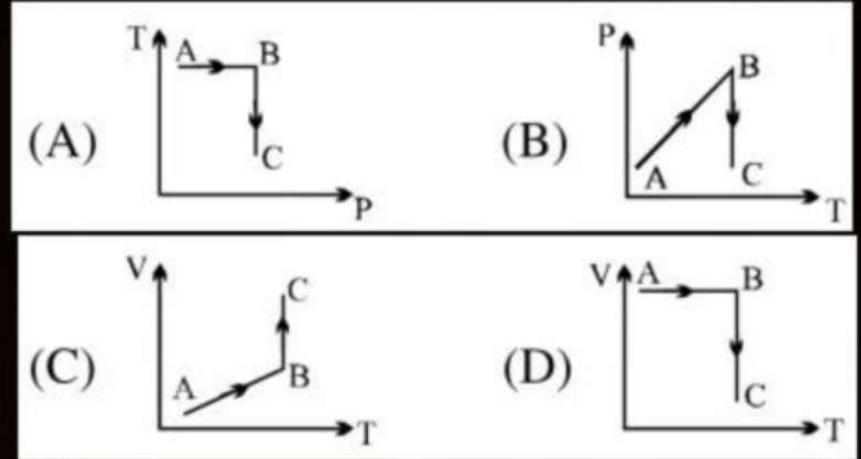
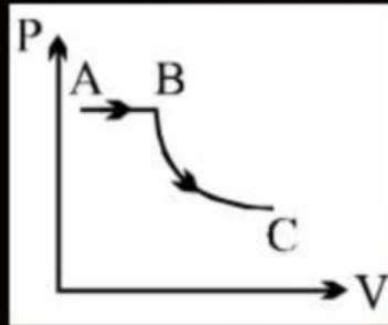
Ans : (B)

30. An ideal gas is taken from point A to point C on P-V diagram through two process AOC and ABC as shown in the figure. Process AOC is isothermal
- (A) Process AOC requires more heat than process ABC.
 - (B) Process ABC requires more heat than process AOC.
 - (C) Both process AOC & ABC require same amount of heat.
 - (D) Data is insufficient for comparison of heat requirement for the two processes.



Ans :(A)

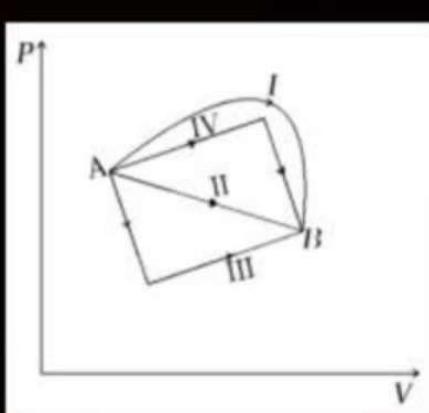
8. A process is shown in the diagram. Which of the following curves may represent the same process?



Ans : (C)

19. Figure shows the P - V diagram of an ideal gas undergoing a change of state from A to B. Four different parts I, II, III and IV as shown in the figure may lead to the same change of state.

- (A) Change in internal energy is same in IV and III cases, but not in I and II.
- (B) Change in internal energy is same in all the four cases.
- (C) Work done is maximum in case I
- (D) Work done is minimum in case II.



Ans : (B, C)

MATRIX MATCH TYPE QUESTION

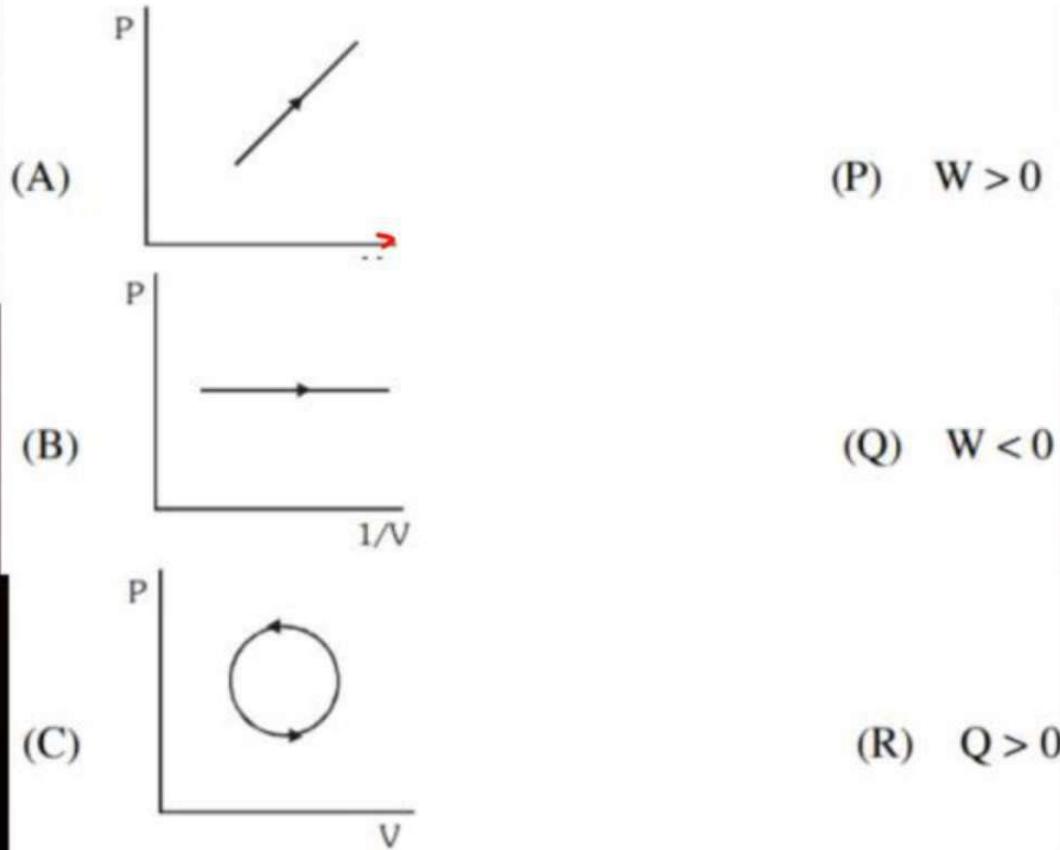
23.

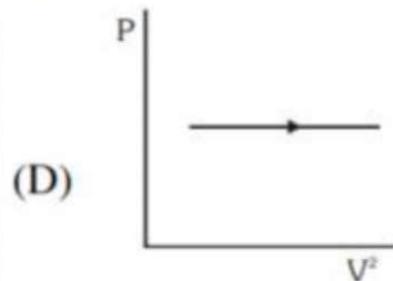
Column I/स्तम्भ-I
(Pressure volume graph)

Column II/स्तम्भ-II

(W is work done by gas,
 Q heat supply to gas)

Hω



Column I/स्तम्भ-I**Column II/स्तम्भ-II**(S) $Q < 0$

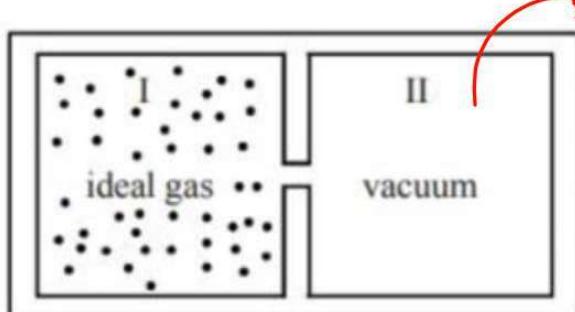
Ans : (A) \rightarrow (P,R) ; (B) \rightarrow (Q, S) ; (C) \rightarrow (Q, S) ; (D) \rightarrow (P, R)

9. **Column I** contains a list of processes involving expansion of an ideal gas. Match this with **Column II**, describing the thermodynamic change during this process. Indicate your answer by darkening the appropriate bubbles of the 4×4 matrix given in the ORS.

[JEE 2008]

Column I

- (A) An insulated container has two chambers separated by a valve. Chamber I contains an ideal gas and the chamber II has vacuum. The valve is opened..



Column II

- (P) The temperature of the gas decreases

$$\begin{aligned} W_g &= 0 \\ \Delta Q &= 0 \\ T &\rightarrow \text{Const} \end{aligned}$$

- (B) An ideal monoatomic gas expands to twice its original volume such that pressure

- (Q) The temperature of the gas increases or remains constant

Column I

$$PV^2 = \text{const}$$

$$\begin{array}{l} T \rightarrow T/2 \\ V \rightarrow 2V \\ P \rightarrow P/4 \end{array}$$

$P \propto \frac{1}{V^2}$, where V is the volume of the gas.

- (C) An ideal monoatomic gas expands to twice its

$$w_g = \frac{nR\Delta T}{1-2} = -nR\Delta T$$

original volume such that its pressure $P \propto \frac{1}{V^{4/3}}$,

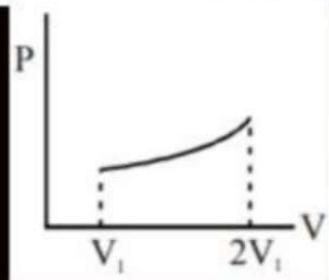
where V is its volume.

- (D) An ideal monoatomic gas expands such that its pressure P and volume V follows the behaviour shown in the graph.

Column II

- (R) The gas loses heat

- (S) The gas gains heat



Ans : (A) q (b) p,r (c) p,s (d) q,s

10. C_v and C_p denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then [JEE-2009]

- (A) $C_p - C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
- (B) $C_p + C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas
- (C) C_p / C_v is larger for a diatomic ideal gas than for a monoatomic ideal gas
- (D) $C_p \cdot C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas

Easy

$$\underline{C_p = C_v + R}$$

$$\underline{C_p > C_v}$$

Ans : (B, D)

$$\gamma = 1 + \frac{2}{5} = 5/3$$

21. One mole of a monatomic ideal gas is taken along two cyclic processes E→F→G→E and E→F→H→E as shown in the PV diagram. The processes involved are purely isochoric, isobaric, isothermal or adiabatic.

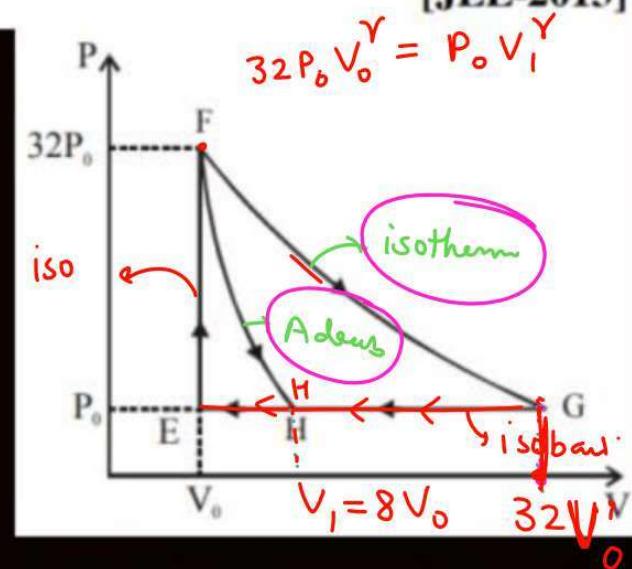
[JEE-2013]

List I/सूची I				List II/सूची II					
P.	G → E	Q.	G → H	R.	F → H	S.	F → G	1.	$160 P_0 V_0 \ln 2$
P.	G → E	Q.	G → H	R.	F → H	S.	F → G	2.	$36 P_0 V_0$
								3.	$24 P_0 V_0$
								4.	$31 P_0 V_0$

Codes :

P	Q	R	S
(A) 4	3	2	1
(B) 4	3	1	2
(C) 3	1	2	4
(D) 1	3	2	4

$$\begin{aligned}V_1^{\frac{5}{3}} &= 32 V_0^{\frac{5}{3}} \\V_1^{\frac{5}{3}} &= 2^5 V_0^{\frac{5}{3}} \\V_1 &= 8 V_0\end{aligned}$$



E

Ans : (A)

25. A container of fixed volume has a mixture of one mole of hydrogen and one mole of helium in equilibrium at temperature T. Assuming the gases are ideal, the correct statement(s) is (are) :-

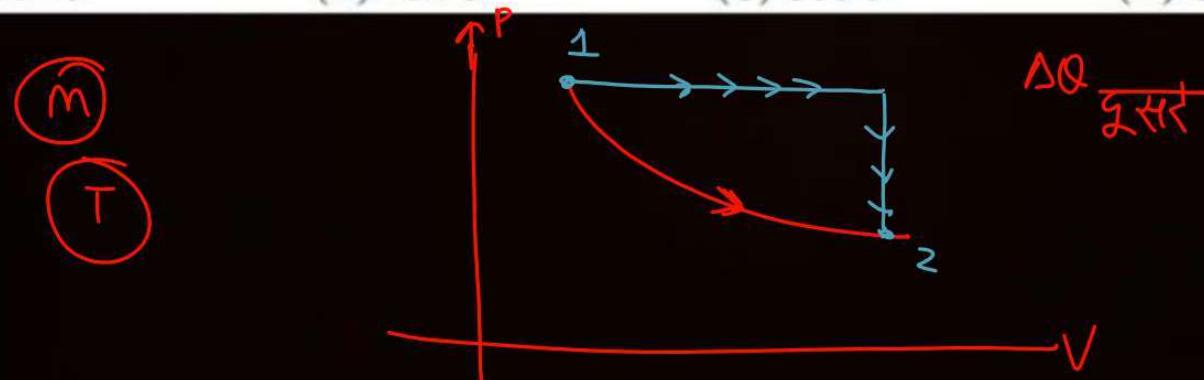
[JEE-Advance-2015]

- (A) The average energy per mole of the gas mixture is $2RT$.
- (B) The ratio of speed of sound in the gas mixture to that in 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 $1/\sqrt{2}$.

Ans : (A, B, D)

27. A gas is enclosed in a cylinder with a movable frictionless piston. Its initial thermodynamic state at pressure $P_i = 10^5 \text{ Pa}$ and volume $V_i = 10^{-3} \text{ m}^3$ changes to a final state at $P_f = \left(\frac{1}{32}\right) \times 10^5 \text{ Pa}$ and $V_f = 8 \times 10^{-3} \text{ m}^3$ in an adiabatic quasi-static process, such that $P^3V^5 = \text{constant}$. Consider another thermodynamic process that brings the system from the same initial state to the same final state in two steps: an isobaric expansion at P_i followed by an isochoric (isovolumetric) process at volumes V_f . The amount of heat supplied to the system in the two step process is approximately

- (A) 112 J (B) 294 J (C) 588 J (D) 813 J [JEE-Advance 2016]



Ans : (C)

Answer Q.29, Q.30 and Q.31 by appropriately matching the information given in the three columns of the following table.

An ideal gas is undergoing a cyclic thermodynamics process in different ways as shown in the corresponding P–V diagrams in column 3 of the table. Consider only the path from state 1 to state 2. W denotes the corresponding work done **on** the system. The equations and plots in the table have standard notations as used in thermodynamics processes. Here γ is the ratio of heat capacities at constant pressure and constant volume. The number of moles in the gas is n. [JEE-Advance 2017]

Column-1

$$(I) W_{1 \rightarrow 2} = \frac{1}{\gamma - 1} (P_2 V_2 - P_1 V_1)$$

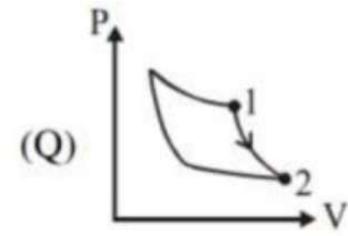
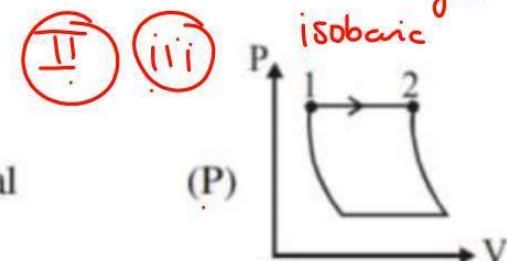
$$(II) W_{1 \rightarrow 2} = -PV_2 + PV_1$$

Column-2

(i) Isothermal

(ii) Isochoric

Column-3 $\stackrel{(W)}{\text{ga}} = P(V_2 - V_1)$



Column-1

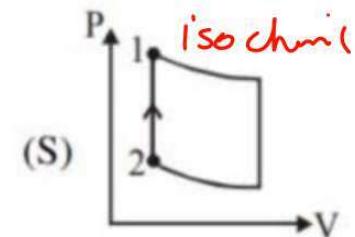
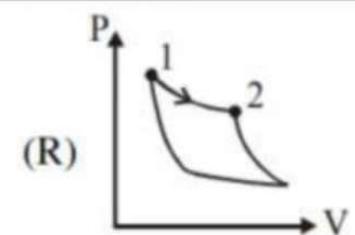
(III) $W_{1 \rightarrow 2} = 0$

(IV) $W_{1 \rightarrow 2} = -nRT \ln \frac{V_2}{V_1}$

Column-2

(iii) Isobaric

(iv) Adiabatic

Column-3

(S), III (ii)



29. Which of the following options is the only correct representation of a process in which $\Delta U = \Delta Q - P\Delta V$?

- (A) (II) (iv) (R) (B) (II) (iii) (P) (C) (II) (iii) (S) (D) (III) (iii) (P)

Ans : (B)

30. Which one of the following options is the correct combination ?

- (A) (III) (ii) (S) (B) (II) (iv) (R) (C) (II) (iv) (P) (D) (IV) (ii) (S)

Ans :(A)

31. Which one of the following options correctly represents a thermodynamics process that is used as a correction in the determination of the speed of sound in an ideal gas ?

- (A) (III) (iv) (R) (B) (I) (ii) (Q) (C) (IV) (ii) (R) (D) (I) (iv) (Q)

Ans : (D)