K.T.G. and Thermodynamics

$$\boxed{V_{rms} = \sqrt{\frac{3RT}{M}}} = \sqrt{\frac{V_1^2 + V_2^2 + \ldots + V_n^2}{n}}$$

$$\boxed{\langle speed \rangle = \sqrt{\frac{8RT}{\pi M}}} = \frac{|V_1|^2 + |V_2|^2 + \ldots + |V_n|^2}{n}$$

$$\boxed{V_{mp} = \sqrt{\frac{2RT}{M}}}$$

$$V_{rms} > \langle speed \rangle > V_{mp}$$

$$\boxed{\begin{aligned} PV &= nRT \\ PM &= \rho RT \end{aligned}}$$

Degree of freedom

1 molecule kitni tarah se apne andar energy rakh sakta hai

monoatomic ⇒ $f = 3$ (V_x, V_y, V_z)

Diatomic ⇒ $f = 5$ $(V_x, V_y, V_z, \omega_z, \omega_y)$

Triatomic → linear $= 5$ $(V_x, V_y, V_z, \omega_z, \omega_y)$

↳ Planar $= 6$ $(V_x, V_y, V_z, \omega_z, \omega_y, \omega_x)$

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- $V\uparrow \rightarrow$ gas expands $\rightarrow$ $W_{gas} > 0$
- $V\downarrow \rightarrow$ gas compress $\rightarrow$ $W_{gas} < 0$
- $V \rightarrow$ const. $\rightarrow$ $W = 0$
- $W_{gas} = \int P_g \, dV$

- $\Delta U = \frac{n f R \Delta T}{2}$ ← (नफरत बट्टे 2) $\boxed{\Delta U = n C_v \Delta T}$

- $T\uparrow \rightarrow \Delta U > 0$
- $T\downarrow \rightarrow \Delta U < 0$
- $T = 0 \Rightarrow U = 0$

- $\Delta Q = \Delta U + \Delta W$ ← 1^{st} law.
- $\boxed{\Delta Q = n C_p \Delta T}$

- PV ka product jitna guna hoga temp. bhi utna hi guna ho jiega.
- Ushma aa rahi hai $\rightarrow$ $\Delta Q = +ve$ ← (system me)
- Ushma ja rahi hai $\rightarrow$ $\Delta Q = -ve$ ← (system se)
- Isochoric $\rightarrow$ $W_g = 0$ $(V \rightarrow \text{const})$
- Isothermal $\rightarrow$ $W_g = nRT \ln\left(\frac{V_2}{V_1}\right)$ $(T \rightarrow \text{const.})$

- Isobaric $\rightarrow$ $W_g = W_g = P\Delta V = nR\Delta T$ $(P \rightarrow \text{const.})$
- Adiabatic $\Rightarrow$ $W_g = \frac{nR\Delta T}{1-\gamma}$ $(PV^\gamma = \text{const.})$
  $(\Delta Q = 0)$

- Polytropic Process $\rightarrow$ $PV^x = \text{const.}$ $\Rightarrow$ $W_{gas} = \frac{nR\Delta T}{1-x}$

- $C = \frac{\Delta Q}{n \Delta T}$ (molar specific Heat)

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

- $C_p - C_v = R$

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- **Adeabatic Process** $(\Delta Q = 0)$ $(\Delta U = -\Delta W)$

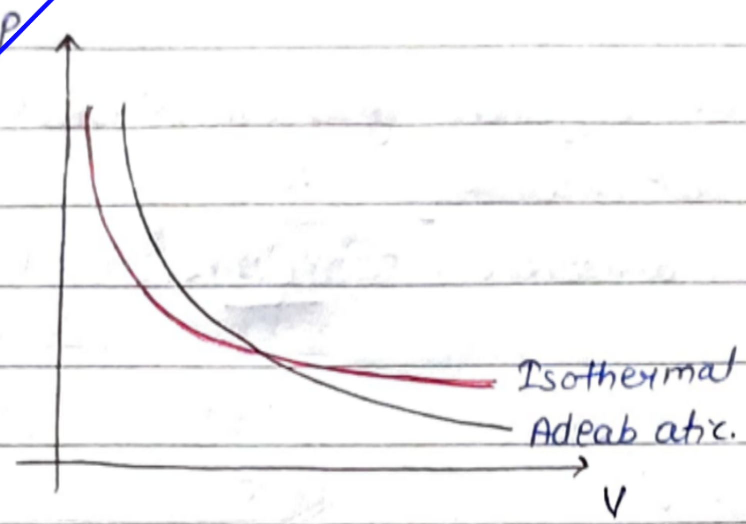
  * $PV^{\gamma} = \text{const.}$
  * $TV^{\gamma-1} = \text{const}$
  * $P^{1-\gamma}T^{\gamma} = \text{const.}$

  * $\boxed{W_g = \dfrac{nR\Delta T}{1-\gamma}}$

- **Polytoopic Process**

  * $PV^{x} = \text{const.}$
  * $C = \left(C_v + \dfrac{R}{1-x}\right) = \left(\dfrac{bR}{2} + \dfrac{R}{1-x}\right)$

  * $\boxed{W_g = \dfrac{nR\Delta T}{1-x}}$



Adeabatic process me P-V graph me slope ka magnitude Isothermal ke slope ke magnitude se γ times Jyada hota hai

Bulk modulus $B = -\dfrac{dP}{dV/V}$

for isothermal $\dfrac{dP}{dV} = -\dfrac{P}{V}$

$B = -\dfrac{-P/V}{1/V}$

$\Rightarrow \boxed{B = P}$

for Adeabatic

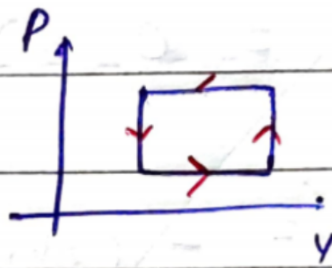
$\boxed{B = \gamma P}$

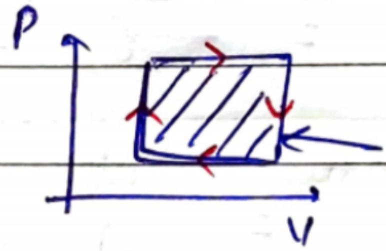
Important for JEE Mains.

~~For~~ cyclic process:

$ACW \rightarrow W_g < 0$

$CW \rightarrow W_g > 0$





W.D. in cyclic process.
(loop ka area)

Kisa bhi cyclic process ho
for cyclic process $(\underline{\Delta U = 0})$ hoga.

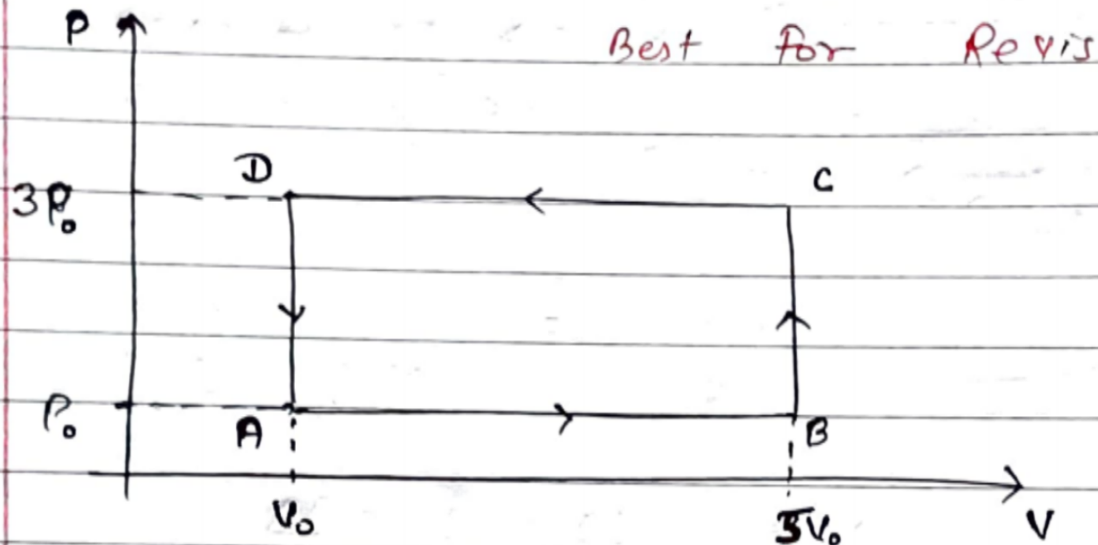
PV graph me area bounded by cyclic graph $(WD)_{by}$ gas dega.

$\Delta Q = \Delta W$ ← for every cyclic process.

* P V/s Vol. graph ka area = $|W_{gas}|$

Q)

Best for Revision



2-mole monoatomic Gas

$T_A = T_0 = 100\ k$ (given)

find every things.

$\underline{\underline{Sol^n:}}$ ①

$P \quad T_B = 5T_0 = 500\,k.$

$P_c = 15T_0 = 1500\,k.$

$T_D = 3T_0 = 300\,k.$

② Find $\Delta W,\ \Delta U,\ \Delta Q$ for all process.

$$(W_g)_{A\to B} = \int P\,dV$$

$$= \cancel{nRT\int \frac{1}{V}dV} \qquad P\Delta V = nR\Delta T$$

$$2\times R\times$$

$$= (5V_0 - V_0)\,P_0 \quad \leftarrow (\text{Area})$$

$$= 4P_0V_0 = 800R$$

$$W_{B\to C} = 0 \qquad (V\to \text{const})$$

$$W_{C\to D} = -(5V_0-V_0)(3P_0)$$

$$-12V_0P_0 = -2400R$$

$$W_{D\to A} = 0$$

$$W_{A\to B\to C\to D} = W_{A\to B} + W_{B\to C} + W_{C\to D} + W_{D\to A}$$

$$= 4P_0V_0 + 0 - 12P_0V_0 + 0$$

$$= \underline{-8P_0V_0} = -1600R$$

$$\Delta U_{A\to B} = +\frac{nfR}{2}(400) = 2\times 3\times R\times 200 = 1200R$$

$$\Delta U_{B\to C} = +\frac{nfR}{2}(1000) = 3000R$$

$$\Delta U_{C\to D} = -\frac{nfR}{2}(1200) = -3600\,R$$

$$\Delta U_{D\to A} = -\frac{nfR}{2}(200) = -600\,R$$

$$\Delta U_{A\to B\to C\to D} = \Delta U_{A\to B} + \Delta U_{B\to C} + \Delta U_{C\to D} + \Delta U_{C\to A} = 0$$

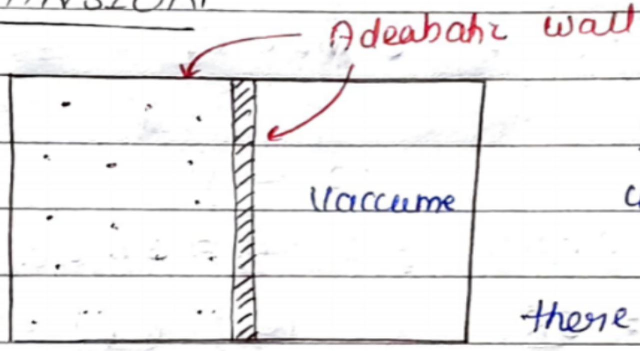
$$\Delta Q_{A\to B} = 4P_0V_0 + \frac{nfR}{2}(400)$$

$$\Delta Q_{B\to C} = 0 + \frac{nfR}{2}(1000)$$

$$\Delta Q_{C\to D} = -12P_0V_0 - \frac{nfR}{2}(1200)$$

$$\Delta Q_{D\to A} = 0 - \frac{nfR}{2}(200)$$

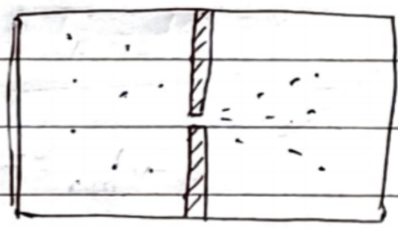
FREE EXPANSION



In free expansion, work done by the gas is 0. bcoz there is no W.D. against it.

$W_g = 0$ (there is Vaccume)

⇓



$\boxed{\Delta W = 0}$

$\Delta Q = \cancel{\Delta U}^{0} + \cancel{\Delta W}^{0}$

$T \to$ const

$\boxed{\Delta Q = 0}$

$n \to$ same

$PV = nRT$

$V \to 2V$

$P \to \frac{P}{2}$

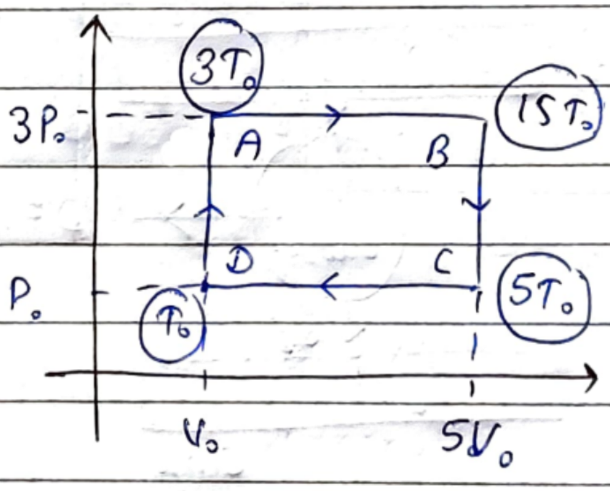
$$(C_v)_{mix} = \frac{n_1 C_{v_1} + n_2 C_{v_2} + n_3 C_{v_3} + \ldots}{n_1 + n_2 + n_3 + \ldots}$$

$$(C_p)_{mix} = \frac{n_1 C_{p_1} + n_2 C_{p_2} + n_3 C_{p_3} + \ldots}{n_1 + n_2 + n_3 + \ldots}$$

$$\gamma_{mix} = \frac{(C_p)_{mix}}{(C_v)_{mix}}$$

Efficiency in cyclic Process.

$$\boxed{\eta = \frac{(WD)}{Q_{\text{ane wali}}}}$$



$(W_g) = 8P_0V_0$ (area)

$$\eta = \frac{8P_0V_0}{\Delta Q_{AB} + \Delta Q_{DA}}$$

$A \to B \Rightarrow W > 0,\ \Delta U > 0 \Rightarrow \Delta Q > 0$

$B \to C \Rightarrow W = 0,\ \Delta U < 0 \Rightarrow \Delta Q < 0$

$C \to D \Rightarrow W < 0,\ \Delta U < 0 \Rightarrow \Delta Q < 0$

$D \to A \Rightarrow W = 0,\ \Delta U > 0 \Rightarrow \Delta Q > 0$

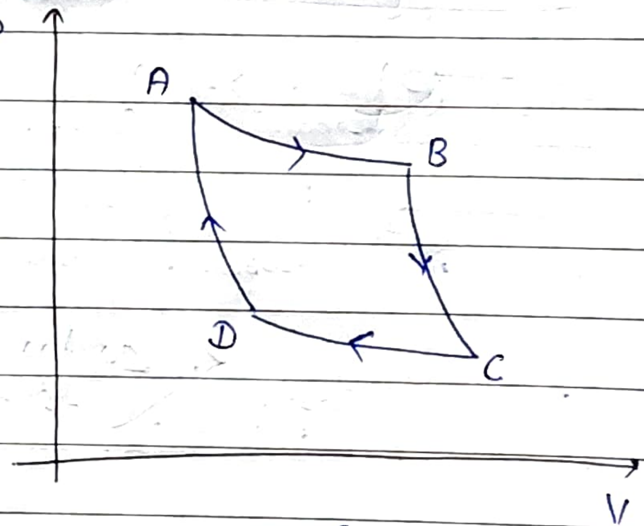
2nd Law of Thermodynamics.

* 100% conversion of Heat to mechanical work is not possible.

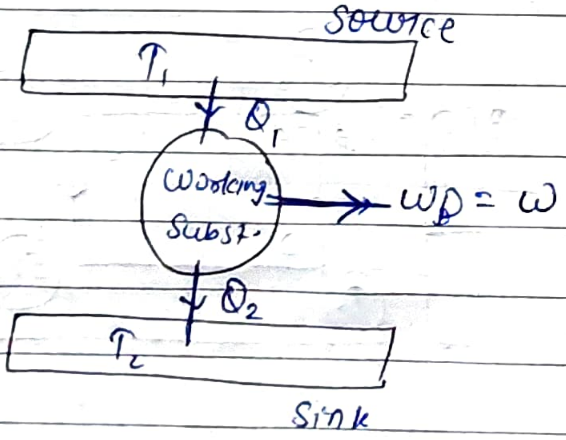
* Heat can not flow itself from cold body to hot body.

Carnot cycle.

$A \to B \Rightarrow$ Isothermal exp.
$B \to C \Rightarrow$ Adeabatic exp.
$C \to D \Rightarrow$ Isothermal comp.
$D \to A \Rightarrow$ Adeabatic comp.



Heat Engine.



$\Delta Q = \cancel{\Delta U}^{0} + \Delta W$

$Q_1 - Q_2 = \Delta W$

$Q_1 = W + Q_2$

$\eta = \frac{W}{Q^{+}} = \frac{Q_1 - Q_2}{Q_1}$

$\eta = 1 - \frac{Q_2}{Q_1}$ $\qquad \frac{Q_2}{Q_1} = \frac{T_2}{T_1}$

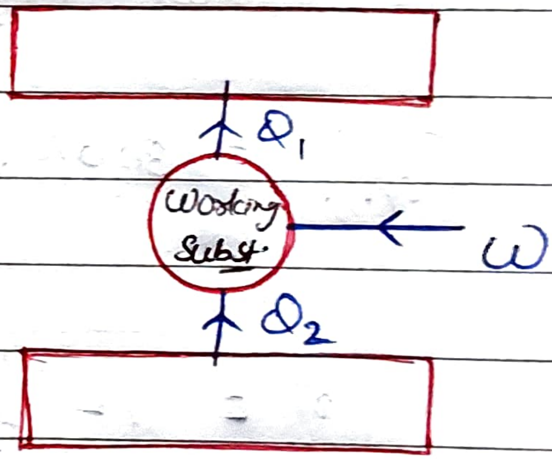
$T_1 > T_2$

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

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

$$\boxed{\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{Q_2}{Q_1} = \frac{W}{Q_1} = \frac{T_{chota}}{T_{Bada}}}$$

Refrigerator



→ It is reverse process of Heat engine.

$$W + Q_2 = Q_1$$

$$W = Q_1 - Q_2$$

COP ≡ coefficient of performance.

$$\boxed{COP = \frac{Q_2}{W}}$$