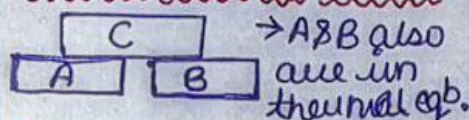


Branch of science with conversion of heat and work.

# THERMO-DYNAMICS

## \* Zeroth Law of Thermo:

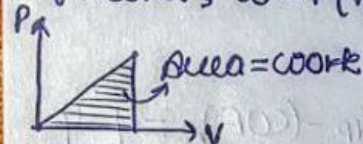


## \* First Law of Thermodynamics:

$$\rightarrow \{dQ = dw + \Delta u\}$$

• Work done  $\Rightarrow dw = \int P dv$

• If  $P$  const;  $w = P(V_2 - V_1)$



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

$$\bullet \{\Delta u = n C_v \Delta T\}$$

$$\bullet \{\Delta u = \frac{n R \Delta T}{\gamma - 1}\} \frac{f}{2} = \frac{1}{\gamma - 1}$$

$$\{\Delta u = \frac{P_2 V_2 - P_1 V_1}{\gamma - 1}\}$$

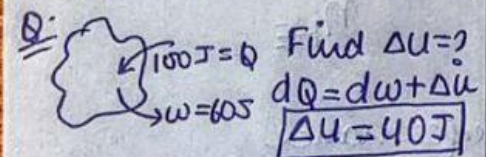
## \* Sign Conventions:

→ Heat in, work out

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

$T \uparrow \rightarrow \Delta T \uparrow \therefore \Delta u \Rightarrow +ve$

$T \downarrow \rightarrow \Delta T (-ve) \therefore \Delta u = -ve$

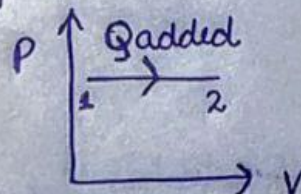


$$Q_{out} = -ve \quad Q_{in} = +ve$$

(i) Isochoric: ( $P=C$ )

$$P V = n R T \rightarrow V \propto T$$

$$V/T = \text{constant}$$



$$w = \int P \cdot dv \Rightarrow w = P(V_2 - V_1)$$

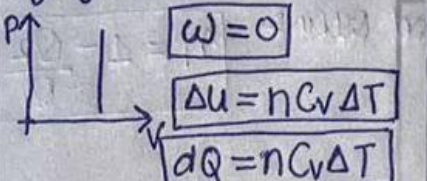
$$\Delta u = n C_v \Delta T \text{ for all paths}$$

$$dq = n C_p \Delta T$$

(ii) Isochoric; vol const

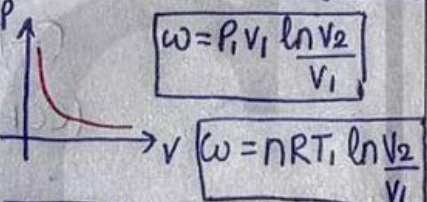
$$P \propto T \rightarrow P/T = \text{constant}$$

→ Gay Lussac law.



(iii) Isothermal (Boyle's law)

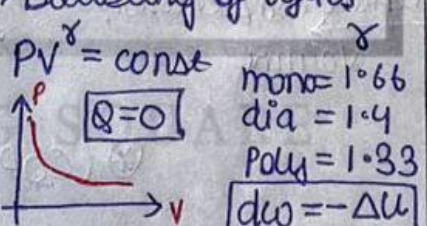
$$P V = \text{constant}, xy = \text{const}$$



$$\Delta u = 0 \quad dq = dw$$

(iv) Adiabatic  $Q=0$

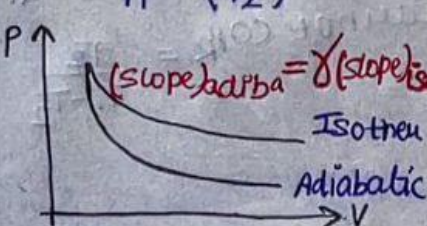
→ Bursting of tyres



$$\Delta u = n C_v \Delta T$$

$$\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^\gamma, \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

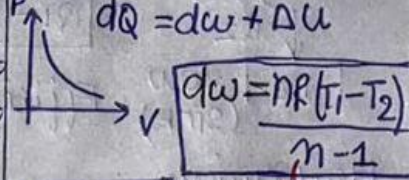
$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$$



(v) Polytropic:

$$P V^n = \text{const.}$$

$$Q \neq 0 \quad dQ = dw + \Delta u$$



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

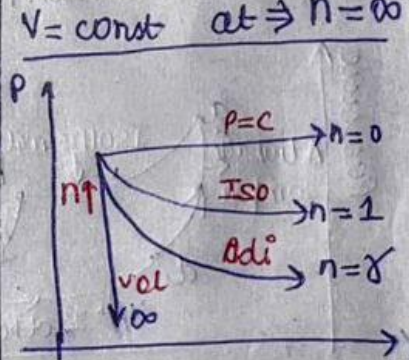
or  $\Delta u = n C_v \Delta T$

$P = \text{const}$  at  $n = 0$

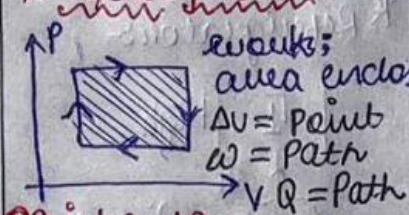
$P V = \text{const}$  at  $n = 1$

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

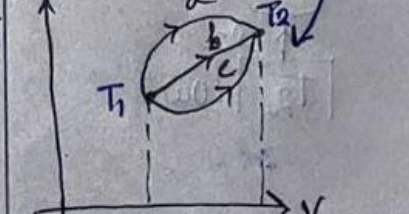
$V = \text{const}$  at  $n = \infty$



## \* Cyclic Process:



Point and Path:



$$w_a > w_b > w_c \text{ (Path)}$$

$$\Delta u_a = \Delta u_b = \Delta u_c \text{ (Point)}$$

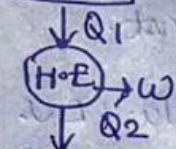
$$\therefore P_{initial} = P_{final}$$

$$\Delta u = 0$$

$$dq = dw$$

# \* Second law of thermodynamic :-

$T_1$  High



$T_2$  Low (Sink)

Heat engine

\* first law :-

$$dQ = dW$$

$$Q_1 - Q_2 = W$$

Efficiency  $\eta = \frac{\text{output}}{\text{input}} = \frac{W}{Q_1}$

~~Second law~~

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

\* Can not cycle :-

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

$\eta_{\text{maximum}}$

ideal or reversible

$$\{(COP)_{HP} - (COP)_R = 1\}$$

\* Heat Pump :-

$$(COP)_{HP} = \frac{\text{desired}}{\text{work}}$$

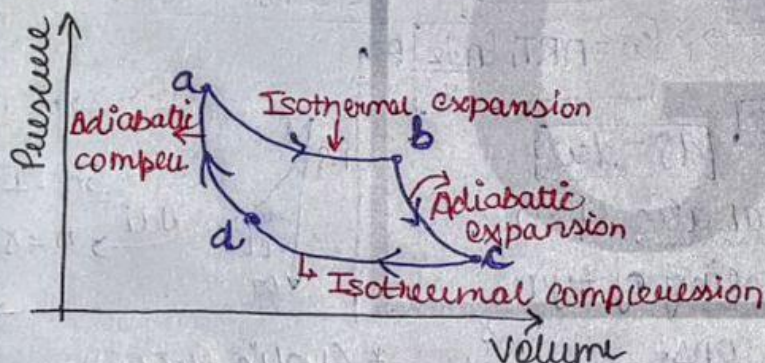
$$COP_{HP} = \frac{Q_1}{W}$$

$$COP_{HP} = \frac{Q_1}{Q_1 - Q_2}$$

cannot

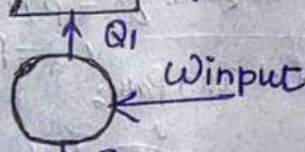
$$(COP)_{HP} = \frac{T_1}{T_1 - T_2}$$

$$(COP)_{HP} \propto \frac{1}{\eta_{HE}}$$



\* Refrigerator :-

$T_1$  High



$T_2$  Low

$$Q_1 - Q_2 = W$$

COP = coefficient of performance

$$COP = \frac{\text{Desired effect}}{\text{work input}}$$

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

$$\text{cannot } COP_R = \frac{T_2}{T_1 - T_2}$$