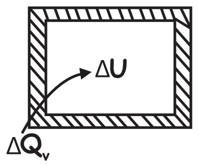
THERMODYNAMICS

Internal Energy(U)

(1) $\Delta U=\Delta Q_v=nC_v\Delta T=n\frac{f}{2}R\Delta T$

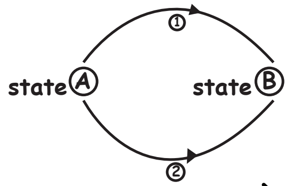
$=\frac{nR\Delta T}{\gamma-1}=\frac{\Delta(PV)}{\gamma-1}$

$=\frac{P_fV_f-P_iV_i}{\gamma-1}$



(Internal Energy is a function of temperature)

- First law of T.D ⟹ $\Delta Q=\Delta U+\Delta W$
- $\Delta Q,\Delta W$ ⟹ path functions
- ΔU ⟹ state function



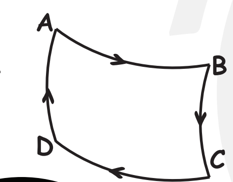
- $W_1\neq W_2$
- $Q_1\neq Q_2$
- $\Delta U_1=\Delta U_2=U_B-U_A$

Isothermal process ⇒ $\Delta T=0\rightarrow\Delta U=0$

Cyclic process

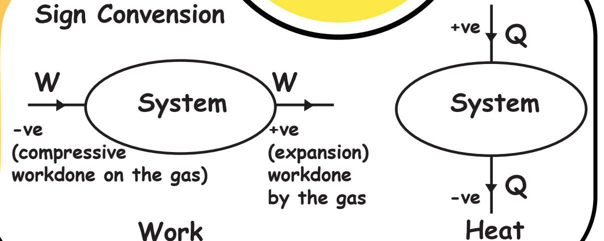
$A\rightarrow B\rightarrow C\rightarrow D\rightarrow A$

$\Delta U=U_A-U_A=0$

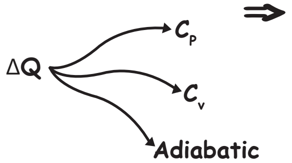


Work done: path function
$\Delta W=F.dx=\int Pdv$
•1cal=4.2 Joule

Sign Convention



Heat: path function
⇒ unit:calorie/Joule

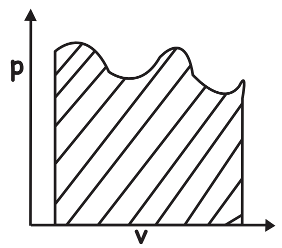


Adiabatic process ⇒ $\Delta Q=0$ [No heat transfer]

At constant volume ⇒ $\Delta Q_v=\Delta U=nC_v\Delta T$

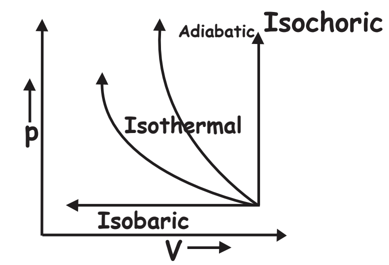
At constant presence ⇒ $\Delta Q_p=\Delta U+\Delta W=nC_p\Delta T$

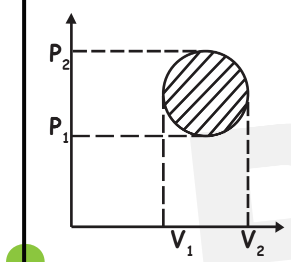
Work done from P-V Graph



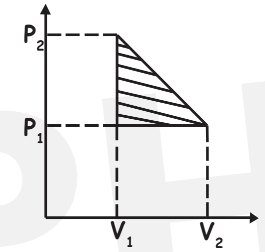
Area under P-V diagram gives work done by the gas

Compression

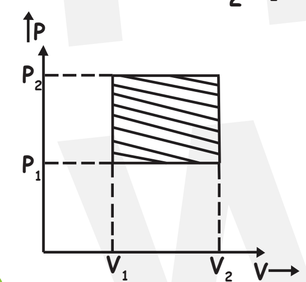




$W=\frac{\pi}{4}(P_2-P_1)(V_2-V_1)$

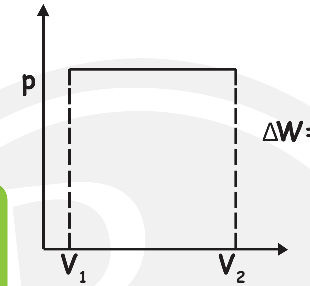


$W=\frac{1}{2}(P_2-P_1)(V_2-V_1)$



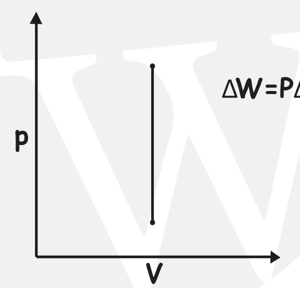
$W=(P_2-P_1)(V_2-V_1)$

Isobaric process

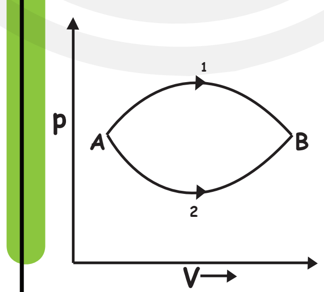


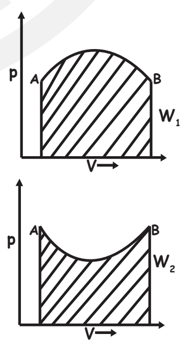
$\Delta W=P(V_2-V_1)$

Isochoric process



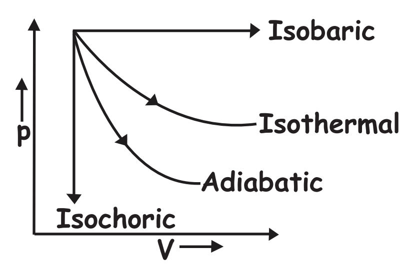
$\Delta W=P\Delta V=0$





$W_1\neq W_2$
$W_1>W_2$

Expansion



$W_{isobaric}>W_{isothermal}>W_{adiabatic}>W_{Isochoric}$

Thermodynamic process

01 Adiabatic process

- $\Delta Q=0$ [no exchange of heat]
- Rapid or spontaneous process/insulated vessel
- FLOT ⟹ $\Delta Q=\Delta U+\Delta W$

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

Compression

$\Delta W=-ve\quad \Delta U=+ve$

$\Delta U\uparrow$ ⟹ Temperature$\uparrow$
⇒ Pressure$\uparrow$

Expansion

$\Delta W=-ve\quad \Delta U=+ve$

$\Delta U\downarrow$ ⟹ Temperature$\downarrow$
⇒ Pressure$\downarrow$

Equation of state

PV^{γ}=a constant

$TV^{\gamma-1}$=a constant

$P\propto T^{\left[\frac{\gamma}{\gamma-1}\right]}$

Workdone by the gas

$\Delta W=-\Delta U=nC_v(T_1-T_2)$

$=n\frac{f}{2}R(T_i-T_f)$

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

$\Delta W=\frac{P_iV_i-P_fV_f}{\gamma-1}$

Slope of adiabatic process
$=\gamma$ slope of isothermal process

specific heat of gas ⟹ $C=0$

$C=\frac{\Delta Q}{\Delta t}\rightarrow\Delta Q=0\qquad C=0$

02 Isothermal process

⇒ $\Delta T=0$ ⇒ $\Delta U=0$

eg:- perfectly conducting slow process

FLOT ⟹ $\Delta Q=\Delta U+\Delta W$

$\Delta Q=\Delta W$

equation of states ⇒ $P_1V_1=P_2V_2$

Workdone by the gas

$W=2.303\ nRT\ \log\left(\frac{V_2}{V_1}\right)$

$W=2.303\ nRT\ \log\left(\frac{P_1}{P_2}\right)$

Slope ⇒

Slope of adiabatic process
$=\gamma\times$ slope of isothermal process

specific heat $\quad C=\infty$

03 Isobaric process

$\Delta P=0$

FLOT ⟹ $\Delta Q=\Delta U+\Delta W$

equation of states ⇒ $V\propto T$

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

Workdone by the gas

$\Delta W=P\Delta V=P(V_2-V_1)=nR(T_2-T_1)$

specific heat of gas

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

04 Isochoric process

$\Delta V=0$ or V=constant

equation of states ⇒ $P\propto T\quad\frac{P_1}{P_2}=\frac{T_1}{T_2}$

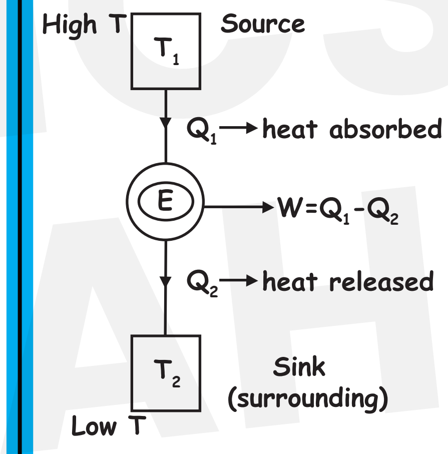
Workdone by the gas

$\Delta V=0\quad\Delta W=0$

specific heat of gas ⇒ $C_v=\frac{f}{2}R=\frac{R}{\gamma-1}$

Heat Engine

'Devices that convert heat into work'



efficiency(η)

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

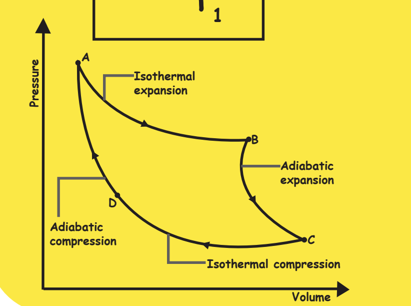
$\eta=\frac{T_1-T_2}{T_1}=1-\frac{T_2}{T_1}$

η_{max} ⟹ Where $Q_2=0$ or $T_2=0K$ (not possible)

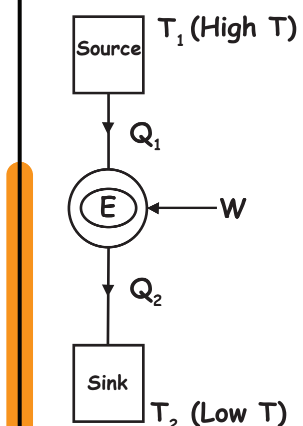
Carnot Engine

→ Ideal engine

→ $\boxed{\eta=\frac{T_1-T_2}{T_1}}$



Refrigerator



Coefficient of performance (β)

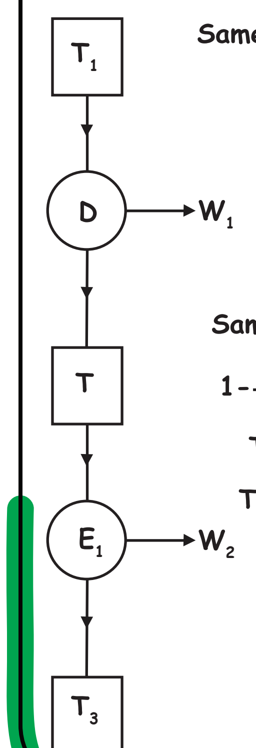
$\beta=\frac{Q_2}{W}=\frac{Q_2}{Q_1-Q_2}$

$\beta=\frac{T_2}{T_1-T_2}$

Relationship between η&β

$\beta=\frac{1-\eta}{\eta}$

Cascaded engine



Same work output

$W_1=W_2$

$T_1-T=T+T_3$

$2T=T_1+T_3$

$T=\frac{T_1+T_2}{2}$

Same efficiency

$1-\frac{T}{T_1}=1-\frac{T_3}{T}$

$T^2=T_1T_3$

$T=\sqrt{T_1T_3}$

PHYSICS WALLAH
https://t.me/neetwallahpw