MIND MAP

Thermodynamics

Molar Heat Capacity of Gas (C)

$C = \frac{\Delta Q}{n\Delta T}$ It depends on process

$C_P - C_V = R$ Mayor's equation

$\frac{C_P}{C_V} = \gamma$ Adiabatic constant

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

Atomicity of gas	f	C_v	C_p	γ
Monoatomic	3	$\frac{3}{2}R$	$\frac{5}{2}R$	$\frac{5}{3} = 1.67$
Diatomic or Triatomic linear	5	$\frac{5}{2}R$	$\frac{7}{2}R$	$\frac{7}{5} = 1.40$
Polyatomic or Triatomic Non-linear	6	$\frac{6}{2}R = 3R$	$\frac{8}{2}R = 4R$	$\frac{4}{3} = 1.33$

$f = \frac{2}{\gamma - 1}$ $C_V = \frac{R}{\gamma - 1}$ $C_P = \frac{R\gamma}{\gamma - 1}$

First Law of thermodynamics

$\Delta Q = \Delta U + W$

Based on Conservation of Energy

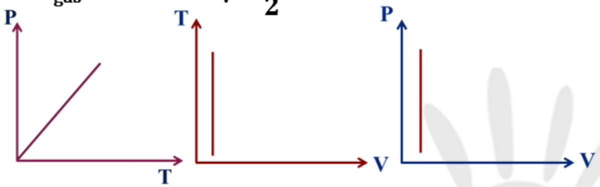
	Definition	+ve	-ve
ΔQ	Heat supplied to gas	If heat is supplied to gas	Heat is taken from gas
ΔU	Change in U	If U increases	If U decreases
W	Work done by gas	If V increases	If V decreases

Thermodynamic Processes

1. Isochoric Process

$V = \text{Constant}$ $\Delta Q = n\,C_V\,\Delta T$ Bulk modulus is not defined

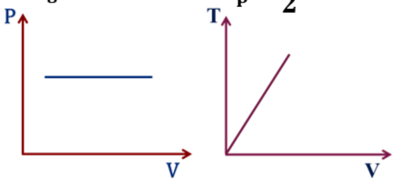
$W_{gas} = 0$ $C_V = \frac{f}{2}R$



2. Isobaric Process

$P = \text{constant}$ $\Delta Q = n\,C_P\,\Delta T$ Bulk modulus

$W_{gas} = n\,R\,\Delta T$ $C_p = \frac{f}{2}R + R$ $B = 0$



3. Isothermal Process

$T = \text{constant}$

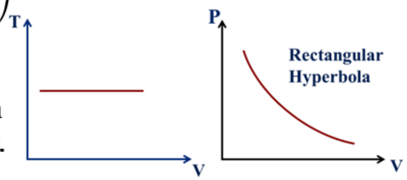
$W_{gas} = n\,R\,T\,\ell n\left(\frac{V_f}{V_i}\right)$

C of this process is not defined

Bulk modulus

$B = P$

Two isotherms for a gas do not intersect.



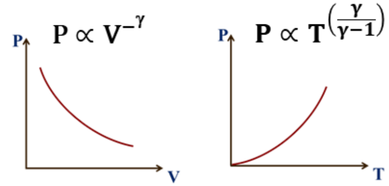
4. Adiabatic Process

$dQ = 0 \Rightarrow \Delta Q = 0$ $P\,V^{\gamma} = \text{Constant}$ $B = \gamma P$ $C = 0$

$W = -\Delta U$

$W_{gas} = -\frac{f}{2}n\,R\,\Delta T = \frac{n\,R\,\Delta T}{1-\gamma} = \frac{P_f V_f - P_i V_i}{1-\gamma}$

Two adiabatic curves for a particular gas do not intersect.



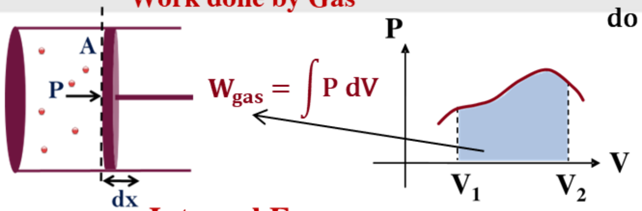
5. Polytropic Process

$P\,V^x = \text{Constant}$ $W_{gas} = \frac{n\,R\,\Delta T}{1-x}$

Slope of P–V curve $= -\frac{xP}{V}$ $B = -xP$

$C = R\left(\frac{1}{\gamma - 1} - \frac{1}{x - 1}\right)$

Work done by Gas



Internal Energy

It is sum of molecular kinetic and potential energies in the reference relative to which COM (Centre of Mass) of the system is at rest.

$U = \frac{f}{2}nRT$

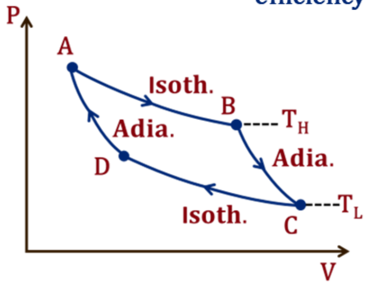
$\Delta U = U_f - U_i = \frac{f}{2}nR\Delta T$

$= \frac{f}{2}(P_f V_f - P_i V_i)$

MIND MAP

Thermodynamics

Carnot cycle



efficiency $'\eta' = \frac{W_{net}}{Q_{in}}$

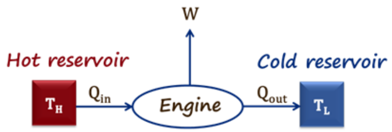
$$= \frac{|Q_{in}| - |Q_{out}|}{|Q_{in}|}$$

$$= 1 - \frac{|Q_{out}|}{|Q_{in}|}$$

$$\eta = 1 - \frac{T_L}{T_H}$$

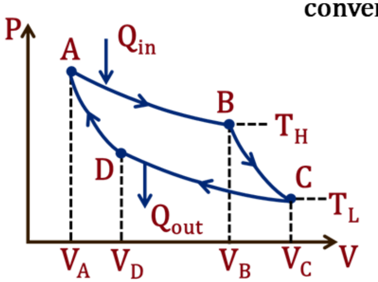
	W	ΔU	ΔQ
AB	$nRT_H \ell n\left(\frac{V_B}{V_A}\right)$	0	$nRT_H \ell n\left(\frac{V_B}{V_A}\right)$
BC	$\frac{nR(T_L - T_H)}{1-\gamma}$	$-\frac{nR(T_L - T_H)}{1-\gamma}$	0
CD	$nRT_L \ell n\left(\frac{V_D}{V_C}\right)$	0	
DA	$\frac{nR(T_H - T_L)}{1-\gamma}$	$-\frac{nR(T_H - T_L)}{1-\gamma}$	0

Heat Engine

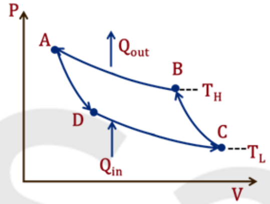


$W = |Q_{in}| - |Q_{out}|$

Efficiency $= \frac{W_{net}}{Q_{in}} = 1 - \frac{|Q_{out}|}{|Q_{in}|}$



Reverse Carnot



Coefficient of performance (α)

$$\alpha = \frac{|Q_{in}|}{|Q_{out}| - |Q_{in}|} = \frac{T_L}{T_H - T_L}$$

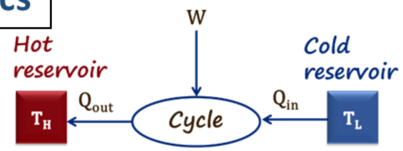
Second Law of Thermodynamics

No process is possible whose sole result is the absorption of heat from a reservoir and the complete conversion of heat to work.

Efficiency $= \frac{W_{net}}{Q_{in}} = 1 - \frac{|Q_{out}|}{|Q_{in}|}$

$$\eta = 1 - \frac{T_L}{T_H}$$

Heat Pump



Coefficient of performance (α)

$$= \frac{Q_{out}}{W}$$

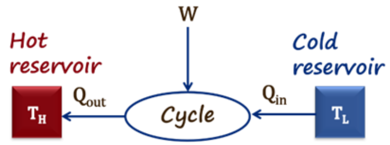
Entropy

Related to disorder in system.

$$dS = \frac{dQ}{T}$$

$$\Delta S = \int dS = \int \frac{dQ}{T}$$

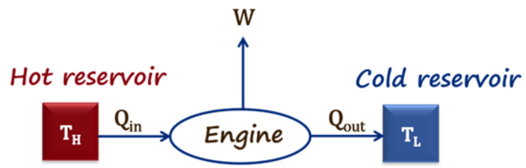
Refrigerator



Coefficient of performance (α) $= \frac{Q_{in}}{W}$

$$= \frac{|Q_{in}|}{|Q_{out}| - |Q_{in}|}$$

For adiabatic process $\Delta S = 0$



Efficiency of Cyclic process must be less than 1.