THERMODYNAMICS

1st Law of Thermodynamics

$$\boxed{dQ = dW_{by\ gas} + dU}$$

$$\boxed{dU = \frac{f}{2} nRdT}$$

$$\boxed{W_{by\ gas} = \int P_{gas}\, dV}$$

Thermodynamics Processes

1) **Isochoric Process :-**

[V = const.]

$$\boxed{dU = n C_v dT = \frac{f}{2} nR dT}$$

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

2) **Isobaric Process :-**

[P = const.]

$$\boxed{n C_v \Delta T = U}$$

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

$$\boxed{W = P dV}$$

$$\boxed{C_p - C_v = R}$$

$$\boxed{W = \frac{f}{2} nR dT}$$

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

3.) Isothermal Process :-

$[T = \text{const.}]$ $\boxed{dU = 0}$

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

$$\boxed{\Delta Q = W_{by\ gas} = nRT \log_e \frac{V_2}{V_1}}$$

$$\boxed{P_1V_1 = nRT = P_2V_2}$$

4.) Adiabatic Process :- $\boxed{P \propto T^{\gamma/\gamma-1}}$

$\boxed{PV^{\gamma} = \text{Const.}}$ $\boxed{TV^{\gamma-1} = \text{Const}}$

$$\boxed{\gamma = \frac{C_P}{C_V} = \frac{C_V + R}{C_V} = 1 + \frac{R}{C_V}}$$

$\boxed{C_V = \frac{R}{\gamma - 1}}$ $\boxed{C_{Adiabatic} = 0}$

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

$$\boxed{\Delta U = nC_v\Delta T}$$

$$\boxed{W_{\text{by gas}} = \frac{nR\Delta T}{\gamma - 1}}$$

$$\boxed{W_{\text{by gas}} = \frac{P_1V_1 - P_2V_2}{\gamma - 1}}$$

Gas	f	$C_v = \frac{fR}{2}$	$C_p = C_v + R$	γ
1.) Mono atomic	3	$\frac{3R}{2}$	$\frac{5R}{2}$	$\frac{5}{3}$
2.) Di-Atomic (Linear)	5	$\frac{5R}{2}$	$\frac{7R}{2}$	$\frac{7}{5}$
3.) Poly-atomic (Non-Linear)	6	$\frac{6R}{2}$ = 3R	4R	$\frac{4}{3}$

→ Diatomic ~~linear~~ or

Polyatomic Linear

Polytropic Process $\boxed{PV^x = \text{const.}}$

$$\boxed{C_{process} = C_v + \frac{R}{1-x}}$$

$$\boxed{C_{process} = C_v + \frac{PdV}{ndT}}$$

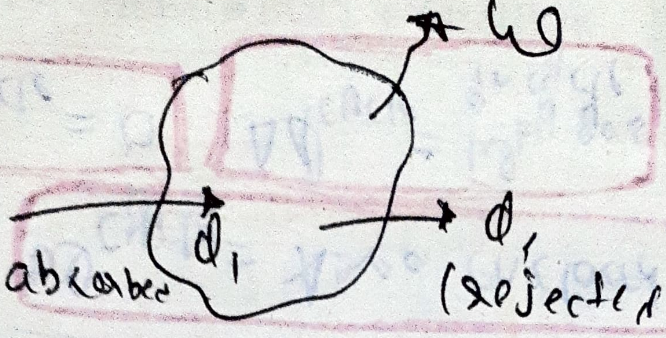
~~$C_{process} = C_v +$~~ $\boxed{W = \frac{-nR\Delta T}{x-1}}$

Mono Atomic, $f = 3$
Diatomic Rigid molecules, $f = 5$
Diatomic non-rigid molecule, $f = 7$
Triatomic rigit molecule, $f = 6$

Cyclic Process :-

$$\boxed{W_{cycle} = \text{Area enclosed by cycle}}$$

$\boxed{\Delta U_{cycle} = 0}$ $\boxed{\Delta Q_{cycle} = W_{\text{by gas in cycle}}}$



$$\Delta Q_{cycle} = Q_1 - Q_2 = W_{by\ gas}$$

Carnot Cycle

↓

(Maxi- Efficieny)

$$\frac{Q_1}{T_H} = \frac{Q_2}{T_L}$$

High temp

Low Temp.

Also known as Entropy.

Heat Engine

$$\eta = \frac{W_{by\ gas}}{Q_1} \times 100$$

$$W_{by\ gas} = Q_1 - Q_2$$

For any cycle

$$\boxed{\eta = \left(1 - \frac{Q_2}{Q_1}\right) \times 100}$$

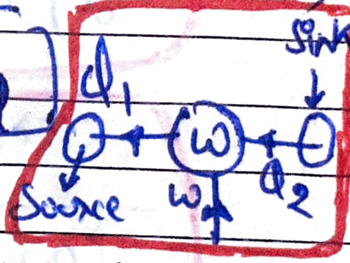
Only for carnot engine

$$\boxed{\eta_{carnot} = \left(1 - \frac{T_L}{T_H}\right) \times 100}$$

Refrigerator :-

(Anticlockwise cycle Required)

$$\boxed{W_{on\ gas} = Q_1 - Q_2}$$



Coefficient of performance —

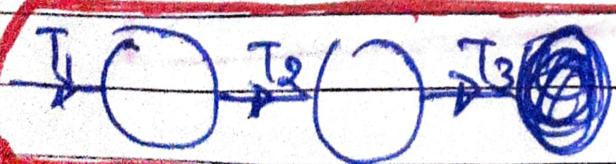
$$\boxed{\beta_{carnot} = \frac{T_L}{T_H - T_L}}$$

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

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

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

$$\boxed{\frac{Q_1}{W} = \frac{Q_2 + W}{W}}$$



$$T_2 = \frac{T_1 + T_3}{2}$$

Mixture of Gases

$n_1 M_1 + n_2 M_2 = M_{mix} = ?$

$$\boxed{M_{mix} = \frac{n_1 M_1 + n_2 M_2}{n_1 + n_2}}$$

$$\boxed{T = \frac{n_1 C_{V_1} T_1 + n_2 C_{V_2} T_2}{n_1 C_{V_1} + n_2 C_{V_2}}}$$

$$\boxed{C_{V_{mix}} = \frac{n_1 C_{V_1} + n_2 C_{V_2}}{n_1 + n_2}}$$

$$\boxed{C_{P_{mix}} = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 + n_2}}$$

$$\boxed{f_{mix} = \frac{n_1 f_1 + n_2 f_2}{n_1 + n_2}}$$

$$\boxed{\frac{n_1 + n_2}{\gamma_{mix} - 1} = \frac{n_1}{\gamma_1 - 1} + \frac{n_2}{\gamma_2 - 1}}$$

Relaxation Time

$$\boxed{\tau = \frac{\lambda}{v} = \frac{1}{\sqrt{2}\, N \pi d^2 v}}$$

No. of molecules per unit volume

ESTIMATE

$$\boxed{C_{frequency} = \frac{1}{\tau} = \frac{v}{\lambda}}$$

For Diatomic gas (not a vibrational mode)

$$\boxed{f = 5}$$

For Diatomic gas (vibrational mode)

$$\boxed{f = 7}$$