Thermodynamics.

(1) $Q = nC(T_2 - T_1)$

(2) $Q_v = \Delta H_v = \Delta U = nC_v \Delta T$

(3) $Q_p = \Delta H_p = nC_p \Delta T$.

$$C_v = \frac{f}{2} R.$$

$f = 3,\ 5,\ 6,\ 5$

- 3 → mono-atomic
- 5 → diat.
- 6 → polyat. (non-linear)
- 5 → polyat. (liner)

(6) For ideal gases

$PV = nRT$

$C_p - C_v = R$

(7) for real gases

$C_p - C_v \neq$ const.

(4) $U = \frac{f}{2} nRT$

(5) $dU = nC_v dT$

(8) C_p and C_v for a gaseous mixture :-

no. of moles	C_v	C_p
n_1	C_{v_1}	C_{p_1}
n_2	C_{v_2}	C_{p_2}
:		
:		

8(i) $C_{v_{eq}} = \dfrac{nC_{v_1} + nC_{v_2} + \ldots\ldots}{n_1 + n_2 + \ldots\ldots}$

8(ii) $C_{v_{eq}} \propto$ Degree of freedom).

8(iii) $C_{p_{eq}} = \dfrac{n_1 C_{p_1} + n_2 C_{p_2} + \ldots}{n_1 + n_2 + \ldots}$

8(iv) $\dfrac{n_1 + n_2 + \ldots}{\gamma_{eq} - 1} = \dfrac{n_1}{\gamma_1 - 1} + \dfrac{n_2}{\gamma_2 - 1} + \ldots$

$C_p = \gamma R / \gamma - 1$

$C_v = \dfrac{R}{\gamma - 1}$

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

$\gamma = \dfrac{C_p}{C_v}$

$\dfrac{C_p}{C_v} = 1 + \dfrac{2}{f}$

(9) $U = \frac{f}{2} KT$ where K is Boltzmann const. and T is absolute temp.

(10) $\boxed{K = \frac{R}{N_A}}$ ← Universal gas const, ← Avogadro's no.

pnemonic $\boxed{\text{Karan}}$.

(11) $U_{n\ moles} = \frac{nf}{2} RT = \frac{nf}{2} KT N_A$

no. of moles — Total no. of molecules.

N_A ← Avogadro's no.

TD Processes :-

(12) Isothermal

(i) $P_1V_1 = P_2V_2$

(ii) $\Delta T = 0$

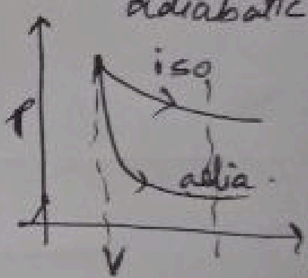
$\Delta U = nC_v \Delta T = 0$

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

(iii) $Q = W = nRT \log_e\left(\frac{V_2}{V_1}\right) = nRT \log_e\left(\frac{P_1}{P_2}\right)$

and $\frac{P_1}{P_2} = \frac{V_2}{V_1}$ and $nRT = PV$.

(14) Relatⁿ b/w slope of isothermal & adiabatic curves



$\left(\frac{dP}{dV}\right)_{adia} = \gamma \left(\frac{dP}{dV}\right)_{iso}$.

(13) Adiabatic

$Q = 0$

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

$W = -\Delta U$.

(i) $PV^{\gamma} = \text{const}.$

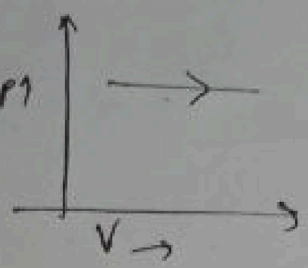
$P_1V_1^{\gamma} = P_2V_2^{\gamma}$

(ii) $TV^{\gamma-1} = \text{const}.$ $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

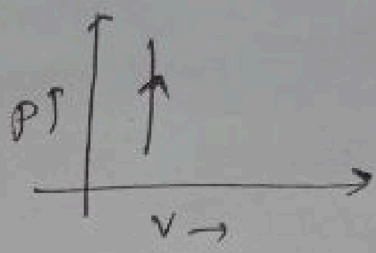
(iii) $P^{1-\gamma}T^{\gamma} = \text{const}.$ $P_1^{1-\gamma}T_1^{\gamma} = P_2^{1-\gamma}T_2^{\gamma}$

(iv) $W = -\Delta U = \frac{nR(T_2 - T_1)}{1-\gamma} = \frac{P_2V_2 - P_1V_1}{1-\gamma}$

(15) Isobaric



(16) Isochoric.



(17) W expansion order

$W_{isobaric} > W_{isoth} > W_{adia} > W_{isochor} (=0)$.

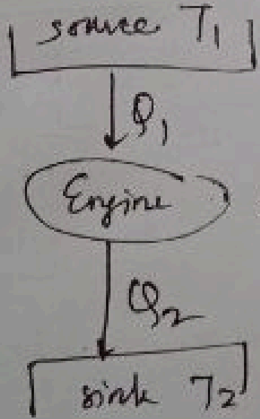
(18) W compression order.

$W_{adia} > W_{isoth} > W_{isobaric} > W_{isocho} (=0)$

2nd LOTD:-

Heat engine.

(19)



$T_1 > T_2$

$W = Q_1 - Q_2$

(20) efficiency $(\eta) = \frac{\text{work done}}{\text{Heat given}} \times 100$

$$= \frac{W}{Q_1} \times 100.$$

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

Note :- No heat engine with 100% efficiency or $Q_2 = 0$ is not possible.

(22) Carnot's Thm $\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$

Note:-

(expansive work)

Heat engine ← ⊕ work → work done by system → if clockwise cycle.

(compressive work)

Refrigerator ← ⊖ work → " " on " → " anticlockwise "

(23) for heat engine,

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

(24) for Refrigerator.

$$\frac{Q_1}{Q_2} = \frac{T_1}{T_2}$$

(25) Coefficient of performance :-

$$K = \frac{Q_2}{W} = \frac{Q_2}{Q_1 - Q_2} = \frac{T_2}{T_1 - T_2}.$$

(26) Reversible Polytropic process :-

(i) $PV^{n} = \text{const}$ ← n: Polytropic const.

(ii) $C = C_v + \frac{R}{1-n}$. ← C: Specific Molar Heat capacity.

(iii)

Process	n	C
a) Isochoric	∞	C_v
b) Isobaric	0	$C_p (= C_v + R)$
c) Isothermal	1	∞
d) Adiabatic	γ	0 $\left[C = C_v + \frac{R}{1-n} , n \to \gamma;\ C_v \to R/\gamma-1 \right]$

(27) $\gamma_m = 1.67$

$\gamma_d = 1.4$

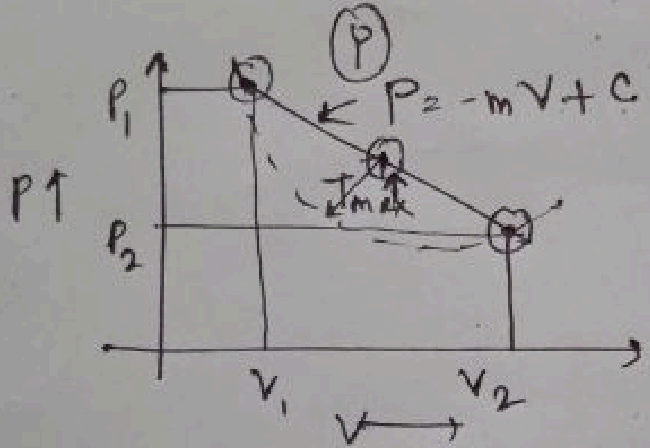
$\gamma_p = 1.33$.

(28) Order of γ :-

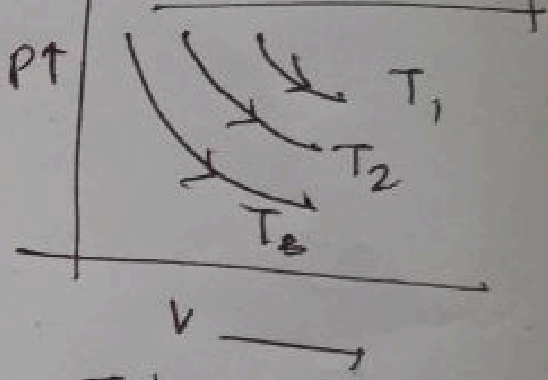
$\gamma_m > \gamma_d > \gamma_p$.

For adiabatic process, greater value of γ, greater is the slope.

(29) Temperature variatⁿ in linear process :-



family of Isotherms.



$T_1 > T_2 > T_3$.

(ii) Temp. of gas

$$T = \frac{PV}{nR} = \frac{(-mV+c)V}{nR}.$$

(iii) for T_{max}

$$\frac{dT}{dV} = 0.$$