Adiabatic

$$dU = \cancel{đQ}^{\,0} + đW$$

$$dU = đW = -p\,dV$$

$$\Rightarrow \frac{F}{2}\cancel{Nk}\,dT = -\frac{\cancel{Nk}T}{V}\,dV$$

$$\Rightarrow \frac{F}{2}\frac{dT}{T} = -\frac{dV}{V}$$

Integrating

$$\frac{F}{2}\ln\left(\frac{T_f}{T_i}\right) = -\ln\left(\frac{V_f}{V_i}\right)$$

Consider ideal gas.

$$U = \frac{F}{2}NkT \qquad P = \frac{NkT}{V}$$

$$dU = \frac{f}{2}Nk\,dT \qquad T = \frac{PV}{Nk}$$

$$\Rightarrow V_i T_i^{F/2} = V_f T_f^{F/2} \qquad PV^{\gamma} = \text{const}$$

$$\gamma = 1 + \frac{2}{F}$$

$$\Rightarrow \underline{V T^{F/2} = \text{const.}}$$

$$\Rightarrow V(PV)^{F/2} = \text{const.} \quad \Rightarrow V^{F/2+1} P^{F/2} = \text{const.}$$

$$\Rightarrow PV^{\left(\frac{F/2+1}{F/2}\right)} = \text{const}$$

isothermal compressibility

$$K = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$$

$$\Rightarrow \left(\frac{\partial V}{\partial P}\right)_T = -KV$$

$$đW = -đQ$$

$$V = V(P,T)$$

$$dV = \left(\frac{\partial V}{\partial P}\right)_T dP + \underline{\left(\frac{\partial V}{\partial T}\right)_P dT}$$

isothermal,

$$dV = \left(\frac{\partial V}{\partial P}\right)_T dP = -KV\,dP$$

$$W = -\int P\,dV = \int_{P_1}^{P_2} KPV\,dP$$

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$$dU = \text{đ}Q - P\,dV$$

$$\text{đ}Q = dU + P\,dV$$

$$\Rightarrow \text{đ}Q = \left(\frac{\partial U}{\partial T}\right)_V dT + \left\{\left(\frac{\partial U}{\partial V}\right)_T + P\right\} dV$$

$PV = RT$

$$\left(\frac{\partial V}{\partial T}\right)_P = \frac{R}{P}$$

$V = \text{cont}$

$$c_V = \left(\frac{\partial Q}{\partial T}\right)_V = \left(\frac{\partial U}{\partial T}\right)_V$$

$$U = U(T, V) \qquad U = \frac{f}{2} NKT$$

$$dU = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV$$

$P = \text{cont}$

$$C_P = \left(\frac{\partial Q}{\partial T}\right)_P = \underbrace{\left(\frac{\partial U}{\partial T}\right)_V}_{C_V} + \left\{\left(\frac{\partial U}{\partial V}\right)_T + P\right\}\left(\frac{\partial V}{\partial T}\right)_P$$

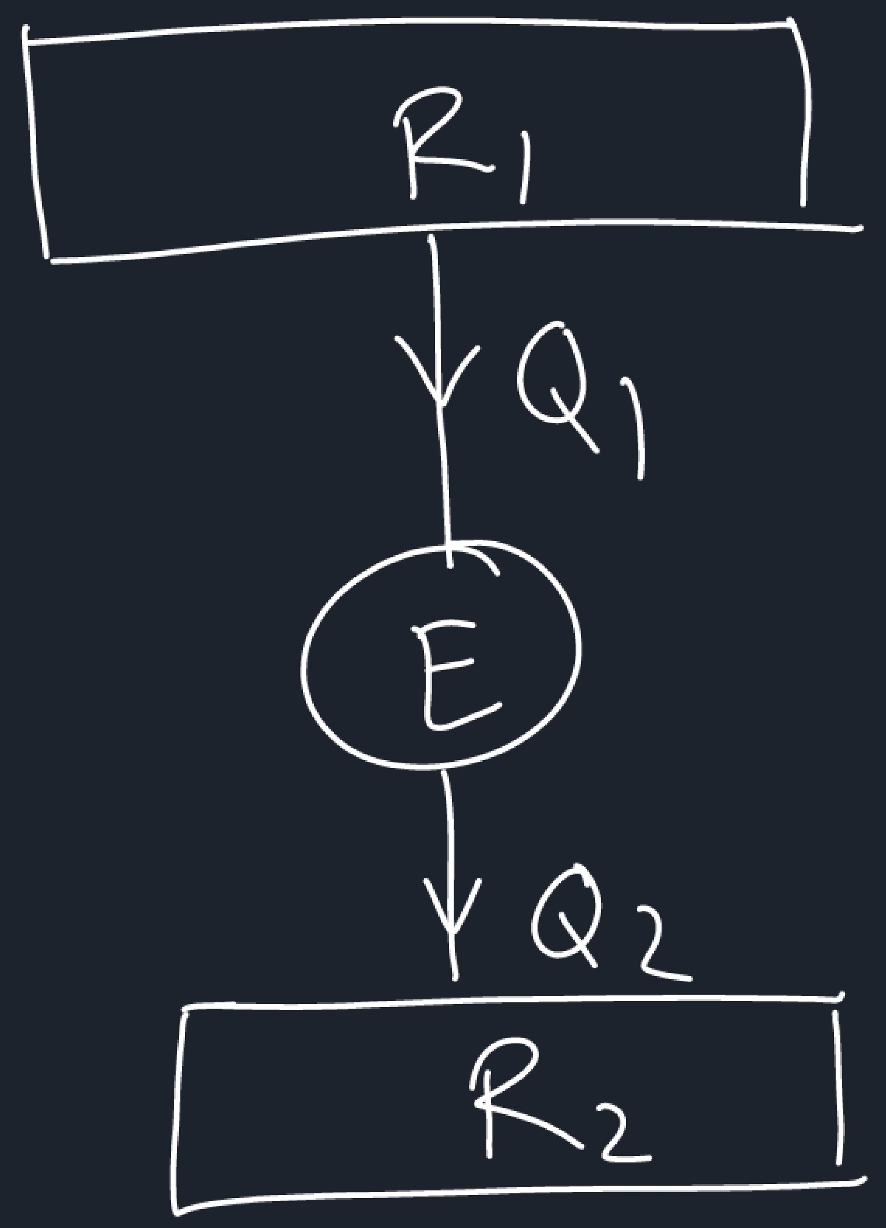
$$\Rightarrow C_P - C_V = \left\{\left(\frac{\partial U}{\partial V}\right)_T + P\right\}\left(\frac{\partial V}{\partial T}\right)_P$$

For ideal gas, $\left(\frac{\partial U}{\partial V}\right)_T = 0 \quad \Rightarrow C_P - C_V = P \cdot \frac{R}{P} = R$

$$dU = \bar{d}Q + \bar{d}W$$

$$\bar{d}Q = -\bar{d}W$$

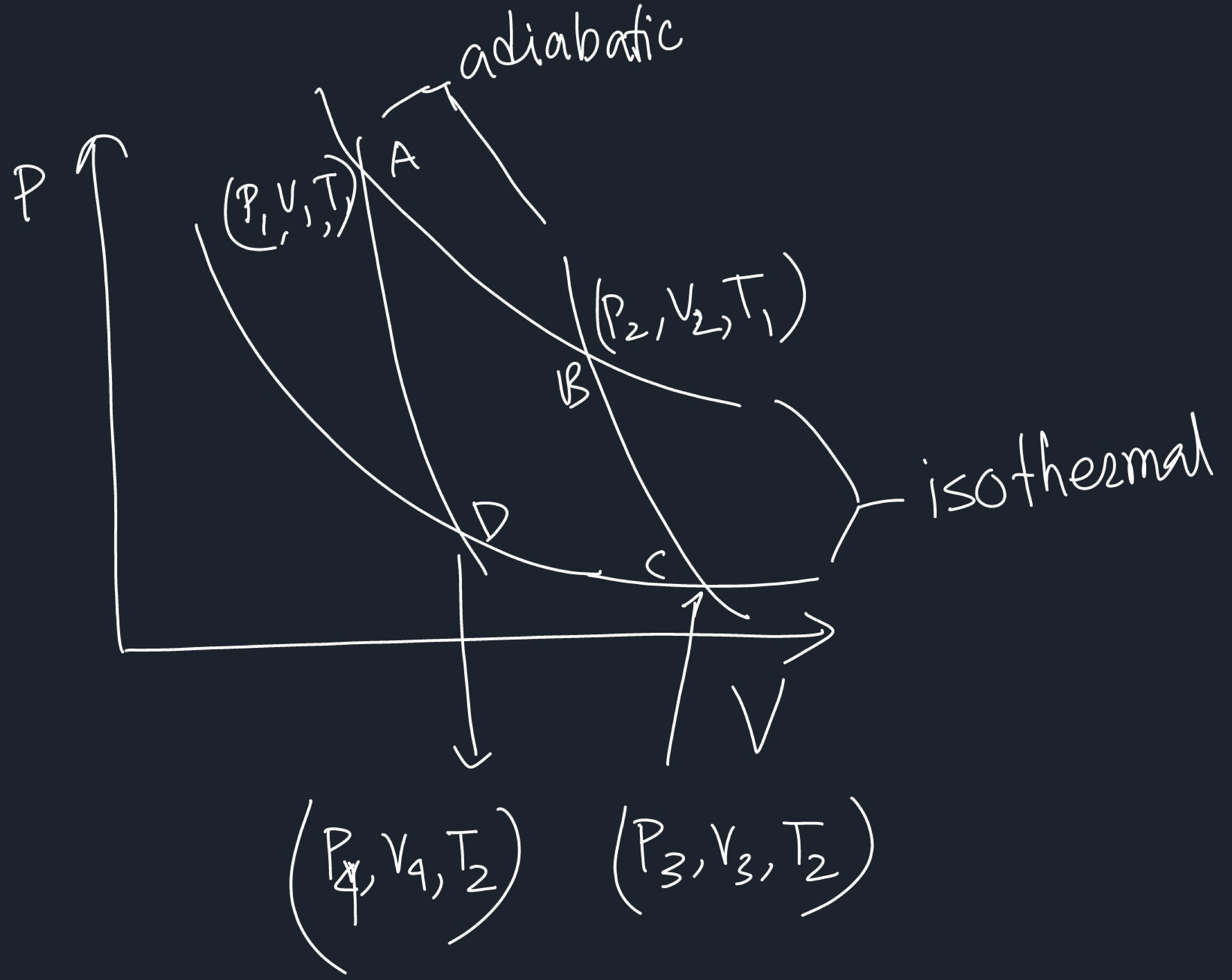
Carnot engine



Heat absorbed Q_1

Work done $W = Q - Q_2$

efficiency $\eta = \dfrac{W}{Q_1} = 1 - \dfrac{Q_2}{Q_1}$



Step 1 $(A \to B)$

$$đQ_1 = -đW_1 = NkT_1 \ln\left(\frac{V_2}{V_1}\right)$$

Step 2 $(B \to C)$ $\qquad đQ = 0$

$$đW_2 = dU_2 = \frac{3}{2} Nk\left(T_2 - T_1\right)$$

$$T_1^{3/2} V_2 = T_2^{3/2} V_3$$

$$\left(\frac{T_1}{T_2}\right)^{3/2} = \frac{V_3}{V_2}.$$

Step 3 $(C - D)$

$$đQ_3 = -đW_3 = NkT_2 \ln\left(\frac{V_4}{V_3}\right)$$

Step 4 $(D \to A)$

$$dW_4 = dU_4 = \frac{3}{2} Nk (T_1 - T_2)$$

$$T_2^{3/2} V_4 = T_1^{3/2} V_1$$

$$\Rightarrow \left(\frac{T_1}{T_2}\right)^{3/2} = \frac{V_4}{V_1}$$

$$\frac{V_3}{V_2} = \frac{V_4}{V_1} \Rightarrow \frac{V_4}{V_3} = \frac{V_1}{V_2}$$