$\boxed{\text{Isoterma}}$ $T = \text{cost}$

$pV = mRT \Rightarrow p_A V_A = mRT_A$

$p_B V_B = mRT_B$

$T_A = T_B \Rightarrow \boxed{p_A V_A = p_B V_B}$

$Q_{AB} = \Delta U_{AB} + W_{AB}$ $\qquad U = U(T)$

$\Rightarrow U_A = U_B \Rightarrow \Delta U_{AB} = 0$

$\Rightarrow \boxed{Q_{AB} = W_{AB}}$

Isoterma <u>reversibile</u> $\Rightarrow \delta W = p\,dV$

$$\underline{\underline{W_{AB}}} = \int_A^B p\,dV \overset{pV=mRT}{=} \int_A^B \frac{mRT}{V}\,dV \overset{T=\text{cost}}{=}$$

$$= mRT \int_{V_A}^{V_B} \frac{dV}{V} = mRT(\ln V_B - \ln V_A) = \underline{\underline{mRT \ln \frac{V_B}{V_A}}}$$

Adiabatica : $\boxed{Q = 0}$

$$\Rightarrow \quad W_{AB} + \Delta U_{AB} = 0$$

$$\Rightarrow W_{AB} = -\Delta U_{AB} = -mc_v(T_B - T_A)$$

$$pV = mRT \Rightarrow mT = \frac{pV}{R}$$

$$\Rightarrow W_{AB} = -\frac{c_v}{R}(p_B V_B - p_A V_A)$$

$$\frac{c_v}{R} = \frac{c_v}{c_p - c_v} = \frac{1}{\frac{c_p - c_v}{c_v}} = \frac{1}{\gamma - 1}$$

$$\Rightarrow \boxed{W_{AB} = \frac{1}{\gamma - 1}\left(p_A V_A - p_B V_B\right)}$$

Adiabatica reversibile $(\delta Q = 0)$

$$\Rightarrow dU + \delta W = 0 \Rightarrow n c_v dT + p dV = 0$$

$$\cancel{n} c_v dT + \frac{\cancel{n} RT}{V} dV = 0 \Rightarrow$$

$$\Rightarrow c_v \frac{dT}{T} + (c_p - c_v)\frac{dV}{V} = 0$$

$$\Rightarrow \frac{dT}{T} + \frac{c_p - c_v}{c_v}\frac{dV}{V} = 0$$

$$\Rightarrow (\gamma - 1)\frac{dV}{V} = -\frac{dT}{T}$$

$$\int_{V_A}^{V_B} (\gamma - 1) \frac{dV}{V} = - \int_{T_A}^{T_B} \frac{dT}{T} \qquad (\gamma = \text{cost})$$

$$\Rightarrow (\gamma - 1) \ln\left(\frac{V_B}{V_A}\right) = - \ln\left(\frac{T_B}{T_A}\right)$$

$$\Rightarrow \ln\left(\frac{V_B}{V_A}\right)^{\gamma - 1} = \ln\left(\frac{T_A}{T_B}\right)$$

$$\Rightarrow \boxed{T_B V_B^{\gamma - 1} = T_A V_A^{\gamma - 1}}$$

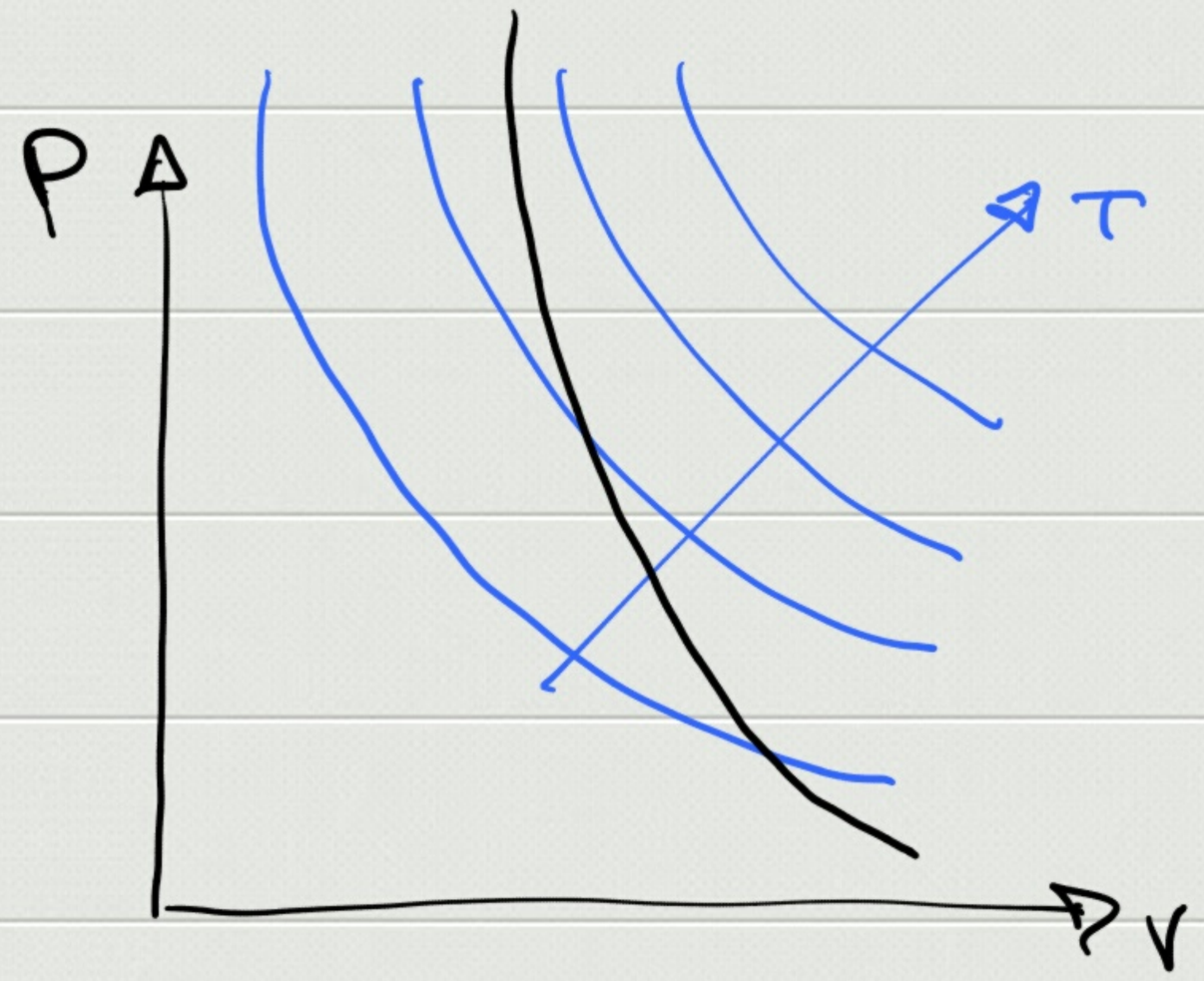
$$\Rightarrow \boxed{T V^{\gamma - 1} = \text{cost}}$$

$$pV = MRT \Rightarrow T = \frac{pV}{MR} \Rightarrow \frac{pV}{MR} V^{\gamma - 1} = \text{cost}$$

$$\Rightarrow \boxed{p V^{\gamma} = \text{cost}}$$

$$\Rightarrow V = \frac{MRT}{p} \Rightarrow T \left(\frac{MRT}{p}\right)^{\gamma - 1} = \text{cost} \Rightarrow T^{\gamma} p^{1 - \gamma} = \text{cost}$$

$$\Rightarrow \boxed{T p^{\frac{1 - \gamma}{\gamma}} = \text{cost}}$$



isot : $pV = cost$

adiab : $pV^{\gamma} = cost$

Isocora $\quad V = cost$

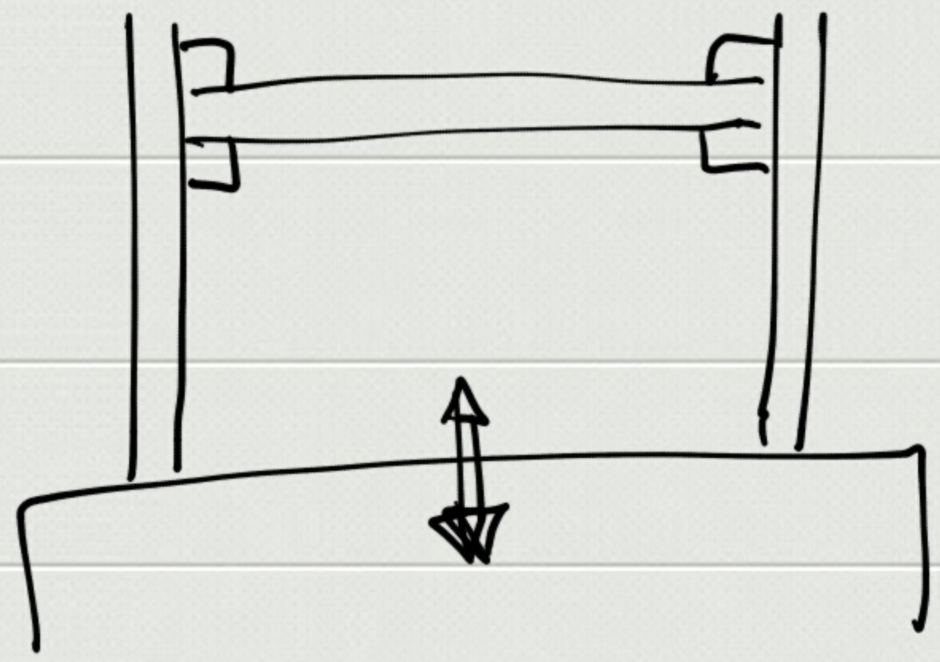
$$p_A V_A = mRT_A$$
$$p_B V_B = mRT_B$$

$$V_A = V_B \Rightarrow \frac{p_A}{p_B} = \frac{T_A}{T_B}$$

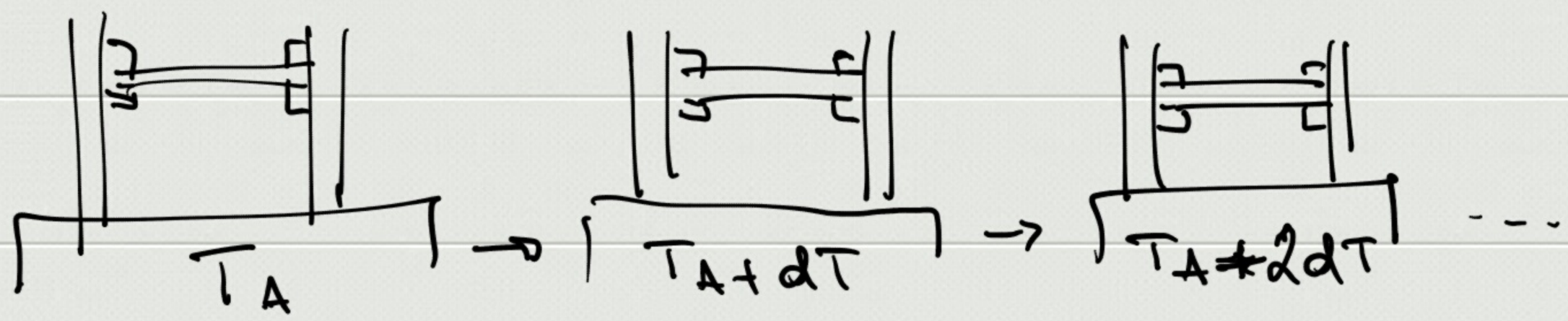
$$\Rightarrow \boxed{\frac{p_A}{T_A} = \frac{p_B}{T_B}}$$

ow $\Rightarrow \dfrac{p}{T} = cost$

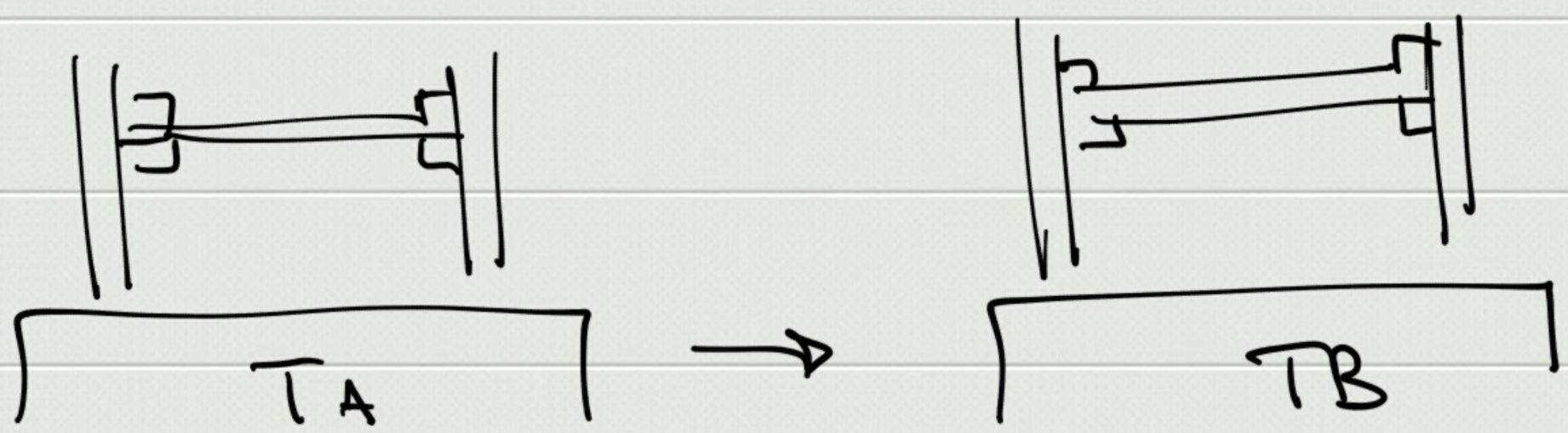
$$\Rightarrow W = 0 \quad \Rightarrow \boxed{Q_{AB} = \Delta U_{AB} = m c_V (T_B - T_A)}$$



Reversible



Irreversible



$\boxed{\text{Isobare}}$ $\qquad p = \text{cost}$

$p_A V_A = nRT_A$

$p_B V_B = nRT_B$

$p_A = p_B \Longrightarrow \dfrac{V_A}{V_B} = \dfrac{T_A}{T_B}$

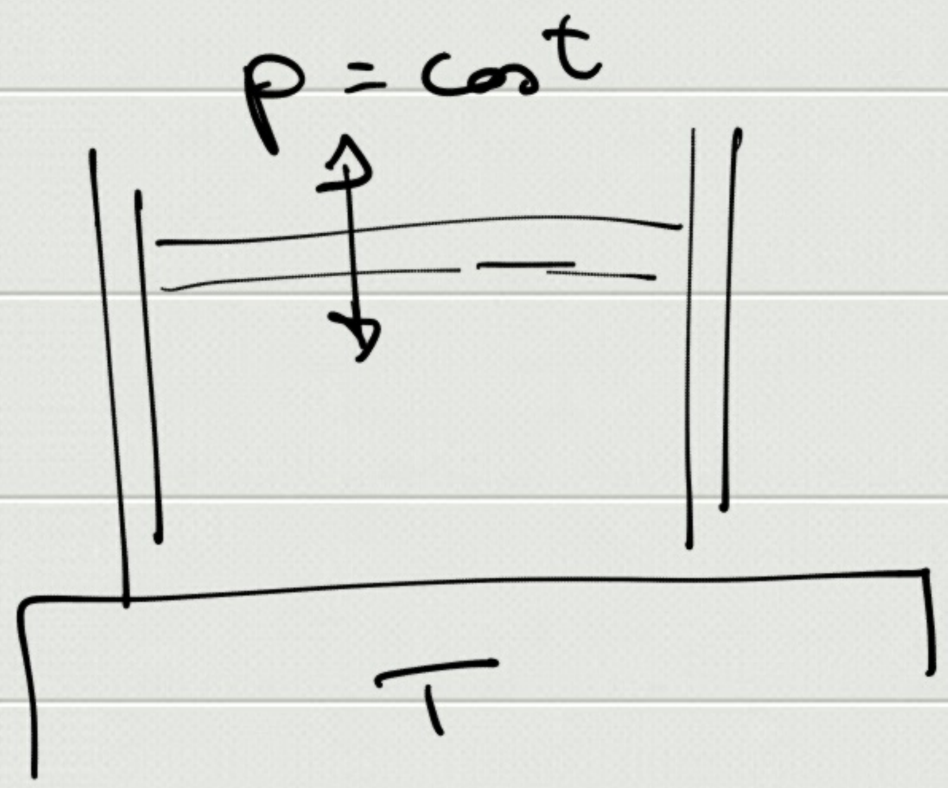
$$\Rightarrow \boxed{\frac{V_A}{T_A} = \frac{V_B}{T_B}} \qquad \text{w} \Rightarrow \boxed{\frac{V}{T} = \text{cost}}$$

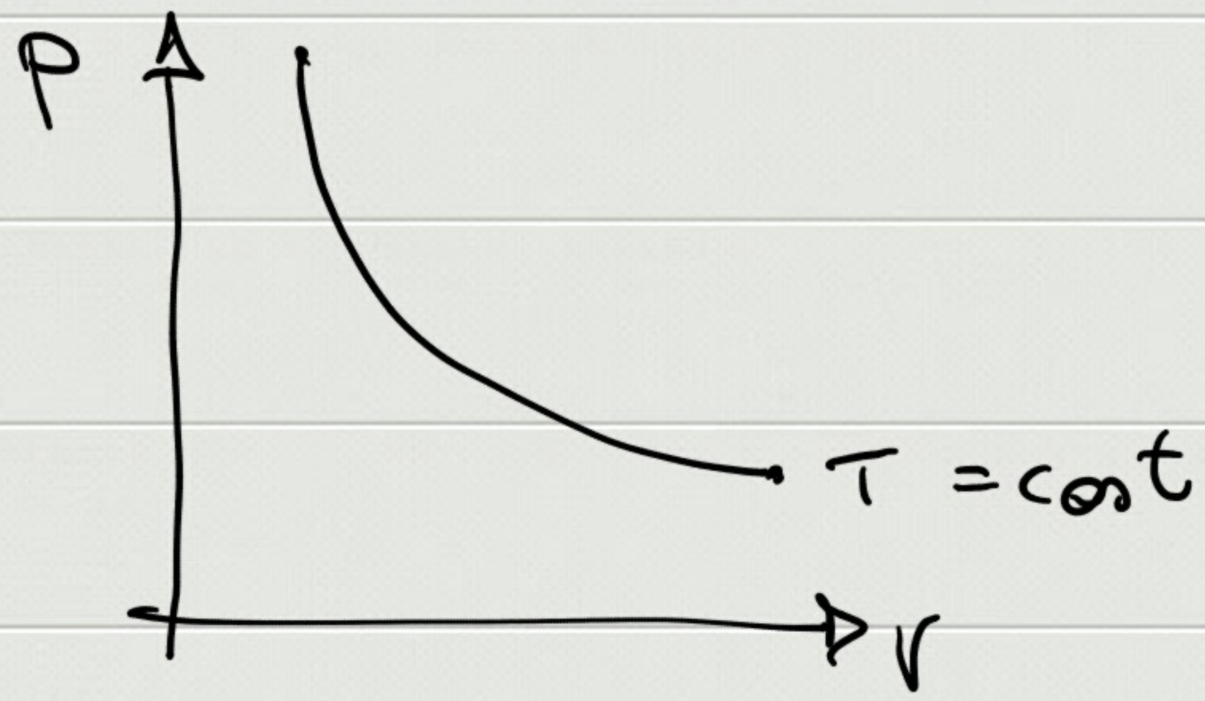
$$Q_{AB} = \Delta U_{AB} + W_{AB}$$

$$Q_{AB} = m c_p (T_B - T_A) \qquad \Delta U_{AB} = m c_v (T_B - T_A)$$

$$\Rightarrow W_{AB} = m c_p (T_B - T_A) - m c_v (T_B - T_A) =$$

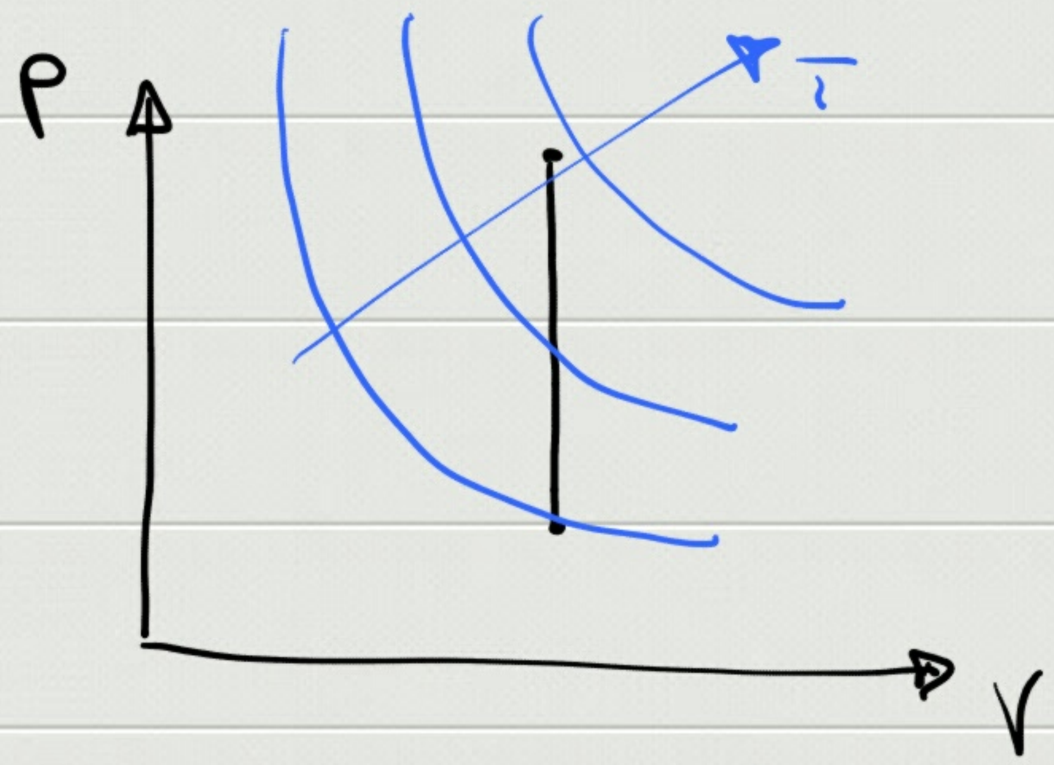
$$= m R (T_B - T_A)$$





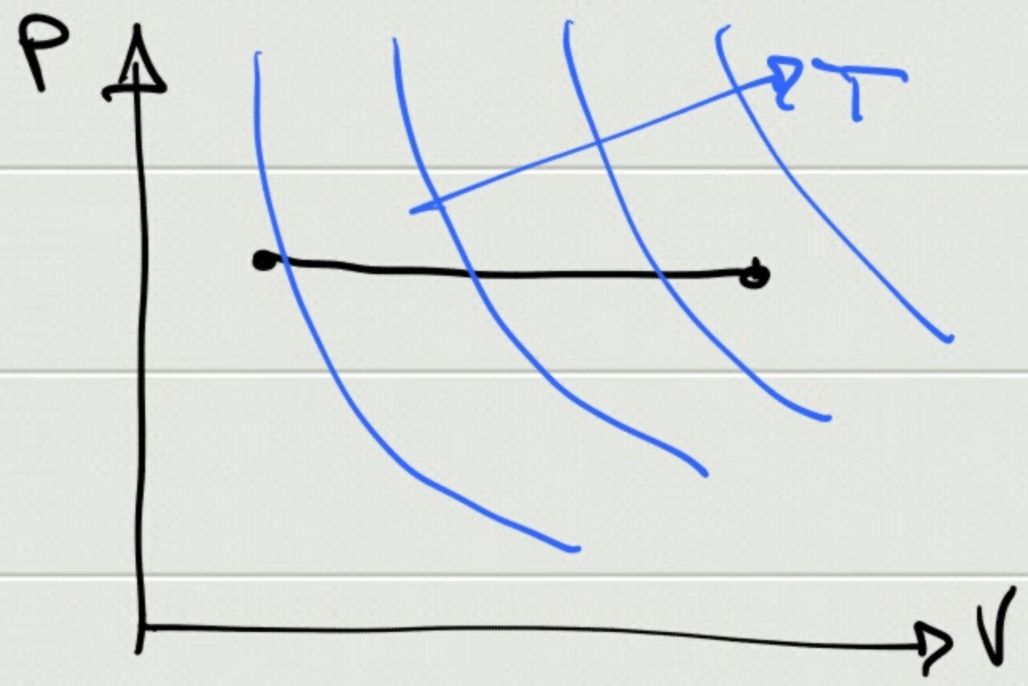
isoterma $\Delta U = 0$

$Q = W \gtrless 0$



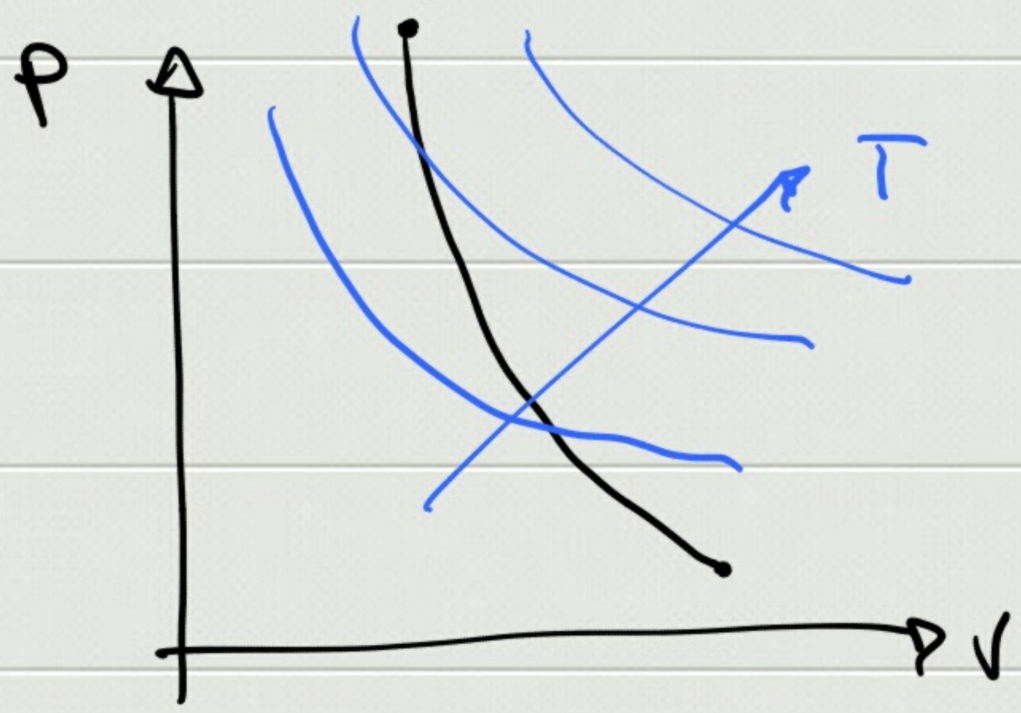
isocora $W = 0$

$\Delta U = Q \gtrless 0$



isobara

$Q = \Delta U + W$



adiabatica $Q = 0$

$W = -\Delta U$