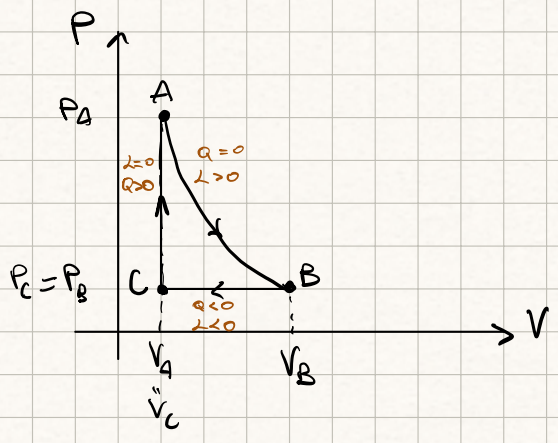
TRASFORMAZ.	ΔU	Q	L	LEGGE
isoterma	0	$nRT\ln\left(\frac{V_f}{V_i}\right)$ $(Q=L)$	$nRT\ln\left(\frac{V_f}{V_i}\right)$	$PV = cost$
isocora	$nC_v\Delta T$ $(\Delta U = Q)$	$nC_v\Delta T$	0	$\frac{P}{T} = cost$
isobara	$nC_v\Delta T$	$nC_p\Delta T$ $(C_p = C_v + R)$	$P\Delta V$ $= nR\Delta T$	$\frac{V}{T} = cost$
adiabatica	$nC_v\Delta T$	0	$-nC_v\Delta T$ $(L = -\Delta U)$	$TV^{\gamma-1} = cost$ $PV^{\gamma} = cost$ $TP^{\frac{1-\gamma}{\gamma}} = cost$ $\gamma = \frac{C_p}{C_v}$

1) $n = 10\ mol$
$P_A = 10^5\ Pa$
$V_A = 1\ m^3$
reversibile:
$P_C = \frac{1}{2} P_A$

A ⟶ B ⟶ C ⟶ A
ESPANSIONE ADIABATICA — COMPRESSIONE ISOBARA — TRASF. ISOCORA

grafico



b) ?Q ?L

A: $T_A = \frac{P_A V_A}{nR} = 1203,4\ K$

B: $P_B = P_C = \frac{1}{2} P_A = 5 \cdot 10^4\ Pa$

$PV^{\gamma} = cost \Rightarrow P_B V_B^{\gamma} = cost = P_A V_A^{\gamma}$
$\gamma = \frac{C_p}{C_v}$

$\Rightarrow V_B = V_A \left(\frac{P_A}{P_B}\right)^{\frac{1}{\gamma}} = 1,52\ m^3$

$T_B = \frac{P_B V_B}{nR} = 912\ K$

C: $P_C = P_B = \frac{P_A}{2}$; $V_C = V_A$

$$T_C = \frac{\frac{1}{2}P_A V_A}{nR} = \frac{1}{2}T_A = 601,7\ K$$

AB: $Q_{AB} = 0 \Rightarrow L_{AB} = -\Delta U_{AB} = -nC_v(T_B - T_A) = 3,63 \cdot 10^4\ J$ positivo ✓ (espansione)

$Q = L + \Delta U$

BC: $Q_{BC} = nC_p\Delta T = n(C_v + R)(T_C - T_B) = -6,45 \cdot 10^4\ J$

$$L_{BC} = \int_B^C p_c\,dV = p_c\Delta V = \frac{P_A}{2}(V_C - V_B) = \frac{P_A}{2}(V_A - 2V_A) = -2,6 \cdot 10^4\ J$$ negativo ✓ (compressione)

CA: $L_{CA} = 0 \Rightarrow Q_{CA} = \Delta U_{CA} = nC_v\Delta T = nC_v(T_A - T_C) = 7,5 \cdot 10^4\ J$

© $?\eta$

$$\eta = \frac{\text{LAVORO PRODOTTO}}{\text{CALORE ASSORBITO}} = \frac{L}{|Q_{ASS}|} = \frac{L}{|Q_{CA}|} = \frac{|Q_{ASS}| - |Q_{CED}|}{|Q_{ASS}|} = 1 - \frac{|Q_{CED}|}{|Q_{ASS}|} = 1 - \frac{|Q_{BC}|}{|Q_{CA}|} = 0,14$$

$Q = L + \Delta U$

↳ $T_C = T_A \Rightarrow \Delta T = 0 \Rightarrow \Delta U = 0 \Rightarrow Q = L + \cancel{\Delta U}$

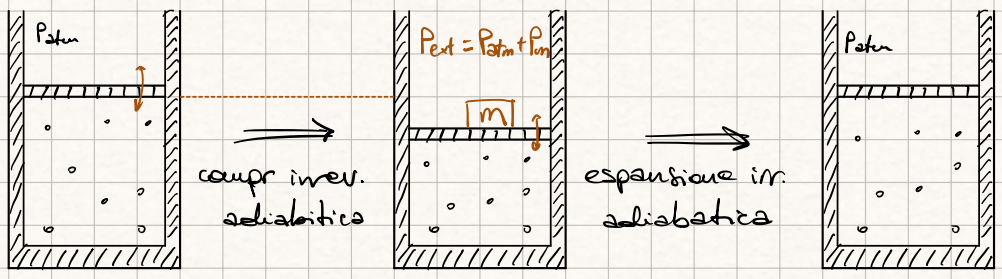
MACCHINA DI CARNOT operante tra le temperature estreme del ciclo:

$T_{MAX} = T_A = 203,4\ K$
$T_{min} = T_C = 601,7\ K$ $\Rightarrow \eta = 1 - \frac{T_{MIN}}{T_{MAX}} = 0,5$

CLAUSIUS: $\sum_{i=1}^{N} \frac{Q_i}{T_i} \leq 0$

$\eta \leq \eta_C$

2) n (monoatomico)
T_0
$P_1 = 6P_0$



a) $?T_1$

$$Q = \Delta U + \mathcal{L} = 0$$

$$\Rightarrow \mathcal{L} = -\Delta U = -nC_V(T_1 - T_0) = P_{ext}\Delta V = P_1(V_1 - V_0)$$

$V = \frac{nRT}{P}$

$$= P_1 nR\left(\frac{T_1}{P_1} - \frac{T_0}{P_0}\right)$$

$$= 6P_0 nR\left(\frac{T_1}{6P_0} - \frac{T_0}{P_2}\right) \Rightarrow \boxed{T_1 = 3T_0}$$

b) $?\Delta U$

$$\begin{cases} \mathcal{L}_{12} = -\Delta U_{12} = -nC_V(T_2 - T_1) \\ \mathcal{L}_{12} = \int p\,dV = P_{atm}(V_2 - V_1) = P_0 nR\left(\frac{T_2}{P_0} - \frac{T_1}{6P_0}\right) \end{cases}$$

$$\Rightarrow T_2 = 2T_0$$

$$\Delta U_{02} = nC_V(T_2 - T_0) = nC_V T_0$$

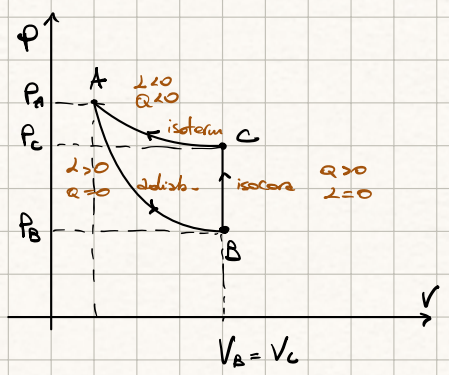
3) $P_A = 10^3$ kPa
$V_A = 2\,m^3$
$T_A = 120$ K

$P_B = 68$ kPa
$V_B = 10\,m^3$
$T_B = 68{,}4$ K

A → B → C → A

reversibile adiabatica | isocora $Q \neq 0$, $P_C > P_B$ | $T_C = T_A$ | isoterma

a) grafico



b) ? n
? C_V

$$P_A V_A = nRT_A \Rightarrow n = \frac{P_A V_A}{RT_A} = 1{,}2 \cdot 10^3 \text{ mol}$$

$$PV^\gamma = \text{cost} \quad ; \quad \gamma = \frac{c_p}{c_v} = \frac{c_v + R}{c_v}$$

$$\Rightarrow P_A V_A^\gamma = P_B V_B^\gamma \Rightarrow \left(\frac{V_B}{V_A}\right)^\gamma = \frac{P_A}{P_B} \Rightarrow \gamma = \log_{\frac{V_B}{V_A}}\left(\frac{P_A}{P_B}\right) = \frac{\ln \frac{P_A}{P_B}}{\ln \frac{V_B}{V_A}}$$

$$= 1{,}67 \sim \frac{5}{3}$$

$$\gamma = \frac{c_p}{c_v} = \frac{5}{3} = 1 + \frac{R}{c_v} \Rightarrow c_v = \frac{3}{2}R = 12{,}47 \text{ J/molK}$$

c) ? ε ciclo frigorifero: efficienza $\varepsilon = \frac{|Q_{ASS}|}{|L|}$ $\quad L = L_{AB} + L_{BC} + L_{CA}$

AB: $Q_{AB} = 0$; $L_{AB} = -\Delta U_{AB} = nc_v(T_B - T_A) = 1{,}87 \cdot 10^6$ J >0 (espansione)

BC: $L_{BC} = 0$; $Q_{BC} = \Delta U_{BC} = nc_v(T_A - T_B) = 1{,}87 \cdot 10^6$ J

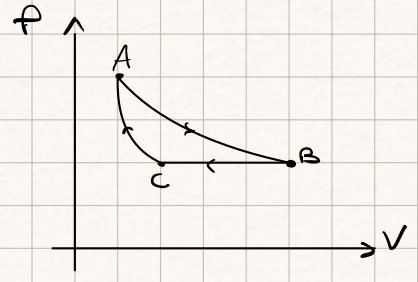
CA: $\Delta U_{CA} = 0$; $Q_{CA} = L_{CA} = nRT_A \ln \frac{V_A}{V_C = V_B} = -3{,}21 \cdot 10^6$ J

$$\varepsilon = \frac{|Q_{BC}|}{|L|} = 1{,}6$$

4) $P_A = 1$ atm
$V_A = 20$ dm^3
$V_B = x^2 V_A$
$x = 1{,}1$

? V_C
? L

A → (esp. isoterma reversibile) B → (compr. isobara rev.) C → (rev. $PV^2 = \text{cost}$ (POLITROPICA)) A



$$P_A V_A^2 = P_C V_C^2$$

$$P_C = P_B \quad ; \quad P_A V_A = P_B V_B$$

$$V_C = x V_A = 22 \text{ dm}^3$$

$$L = L_{AB} + L_{BC} + L_{CA}$$

$$dQ = dU + pdV = nc_v dT + pdV$$

$$c_Q = \frac{1}{n}\frac{dQ}{dT}\Big|_Q = c_v + \frac{p}{n}\frac{dV}{dT}\Big|_Q = c_v + \frac{RT}{V}\frac{dV}{dT}\Big|_Q$$

$PV^\alpha = cost \quad ; \quad PV = nRT$

$TV^{(\alpha-1)} = cost = C$

$V = \frac{C^{\frac{1}{\alpha-1}}}{T^{\frac{1}{\alpha-1}}} \quad \Rightarrow \quad \frac{dV}{dT} = -\frac{1}{\alpha-1} \frac{C^{\frac{1}{\alpha-1}}}{T^{\frac{1}{\alpha-1}}}$

$\Rightarrow C_\alpha = C_V + \frac{R}{1-\alpha}$

$Q = n C_\alpha \Delta T = \underbrace{nC_V\Delta T}_{\Delta U} + \frac{nR\Delta T}{1-\alpha}$

$\mathcal{L}_\alpha = Q - \Delta U = \frac{nR\Delta T}{1-\alpha}$

$\mathcal{L}_{CA} = -nR(T_C - T_A) = P_A V_A \left(\frac{1-x}{x}\right) = -183,6\ J$

$\mathcal{L}_{TOT} = 17,8\ J$