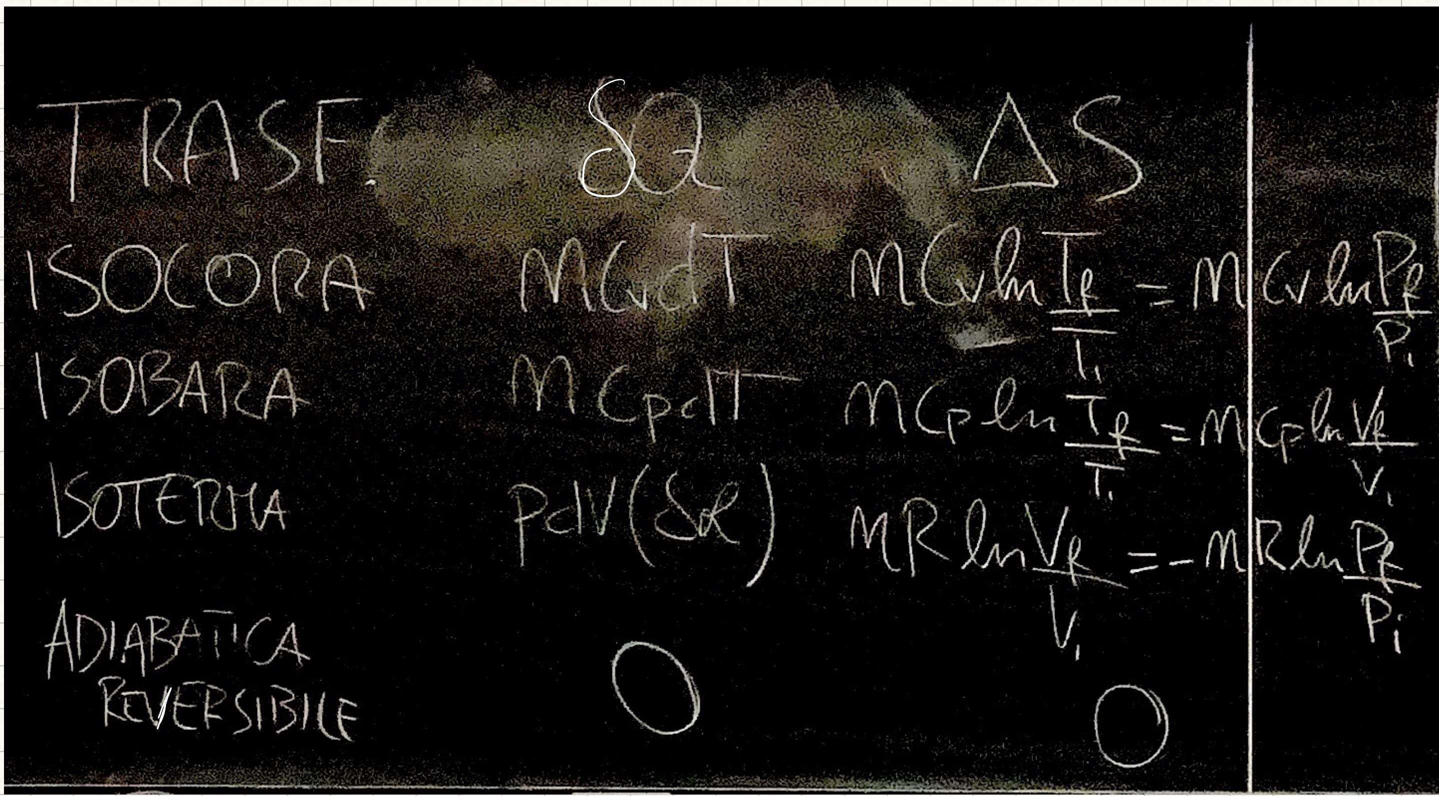
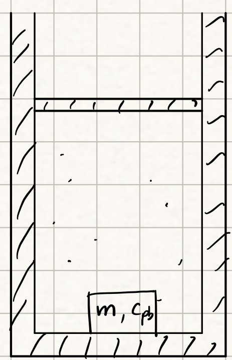


1)



$n = 1$ mol (monoat.)

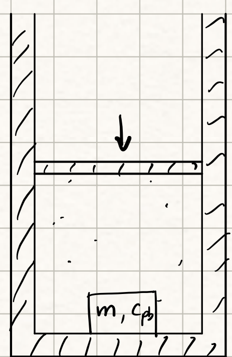
$m = 0{,}5\ \mathrm{Kg}$

$c_{pb} = 130\ \mathrm{J/Kg\,K}$

$T_f = T_i + 10\% = 1{,}1\ T_i$

? $\frac{P_f}{P_i}$ (ISOENTROPICO)

$\hookrightarrow \Delta S_{sist.} = 0$



$\Delta S_U = \Delta S_{sist} + \cancel{\Delta S_{amb}}$

perché NO scambio Q con ambiente (ADIAB.)

$\rightarrow \Delta S_U = 0$

$\Delta S_{sist} = \Delta S_{GAS} + \Delta S_{pb} = 0 \Rightarrow \Delta S_{GAS} = -\Delta S_{pb}$

$\Delta S_{pb} = \int_i^f \frac{\delta Q}{T} = \int_i^f m c_{pb} \frac{dT}{T} = m c_{pb} \ln \frac{T_f}{T_i}$

$\Delta S_{gas} = -nR \ln \frac{P_f}{P_i} + n c_p \ln \frac{T_f}{T_i}$

considero trasf. rev. equival.:

ISOTERMA: $P_i \rightarrow P_f$

ISOBARA: $T_i \rightarrow T_f$

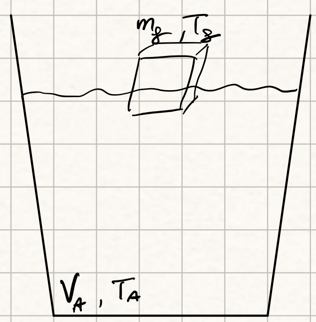
$\Rightarrow \Delta S_{pb} = -\Delta S_{gas}: \quad m c_{pb} \ln \frac{T_f}{T_i} = nR \ln \frac{P_f}{P_i} - n c_p \ln \frac{T_f}{T_i}$

$$\rightarrow \cancel{nR} \ln \frac{P_f}{P_i} = m c_{pb} \ln \frac{T_f}{T_i} + n c_p \ln \frac{T_f}{T_i}$$

$$= \frac{(m c_{pb} + n c_p)}{nR} \ln \frac{T_f}{T_i} \quad \Rightarrow \quad \ln \frac{P_f}{P_i} = \ln \left(\frac{T_f}{T_i}\right)^{\frac{m c_{pb} + n c_p}{nR}}$$

$$\Rightarrow \frac{P_f}{P_i} = \left(\frac{T_f}{T_i}\right)^{\frac{c_p}{R} + \frac{m c_p}{nR}} \quad \rightarrow \quad \frac{P_f}{P_i} = 1,1^{\frac{5}{2} + \frac{m c_{pb}}{nR}}$$

2)



$m_g = 20 g$
$T_g = -5°C$
$V_A = 200 ml$
$T_A = 25°C$

? ΔS_u

$\lambda_g = 3,3 \cdot 10^5 \ J/kg$
$c_g = 2090 \ J/kg\,K$
$c_A = 4187 \ J/kg\,K$

EQUILIBRIO TERMODINAMICO se stessa temperatura

GHIACCIO : $T_G \longrightarrow T_0 \longrightarrow T_f$
(fusione)

ACQUA : $T_A \longrightarrow T_f$
(raffreddamento : $< T_A$)

$$\boxed{\Delta Q = 0} \Rightarrow \underbrace{m_g c_g (T_0 - T_g)}_{\text{riscaldam. ghiaccio}} + \underbrace{m_g \lambda_g}_{\text{fusione ghiaccio}} + \underbrace{m_g c_A (T_f - T_0)}_{\text{riscaldamento ghiaccio diventato acqua}} + \underbrace{m_A c_A (T_f - T_A)}_{\text{raffreddamento acqua}} = 0$$

① ② ③ ④

→ trasformato in acqua

λ_g: calore latente di fusione

$T_f = 288,5 \ K$

$$\Delta S_u = \Delta S_{sist} + \cancel{\Delta S_{amb}} = \Delta S_1 + \Delta S_2 + \Delta S_3 + \Delta S_4$$

↳ sistema isolato

$$\Delta S_1 = \int_i^f \frac{\delta Q}{T} = \int_{T_g}^{T_0} m_g c_g \frac{dT}{T} = m_g c_g \ln \frac{T_0}{T_g}$$

$$\Delta S_2 = \int_i^f \frac{\delta Q}{T} = \frac{1}{T} \int_i^f \delta Q = \frac{m_g \lambda_g}{T_0}$$

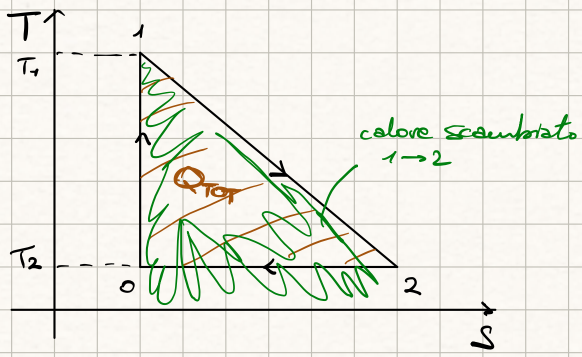
la fusione avviene a temp. cost

$$\Delta S_3 = m_g c_A \ln \frac{T_f}{T_0}$$

$$\Delta S_4 = m_A c_A \ln \frac{T_f}{T_A}$$

$$\Rightarrow \Delta S_u = 1,87 \ J/K$$

3) PIANO S-T



$T_1 = 500K$
$T_2 = 300K$

? η

? P (durante intervallo τ)
↳ potenza

$$Q_{TOT} = \frac{(S_2-S_1)(T_1-T_2)}{2} \quad ; \quad \Delta U_{ciclo} = 0 \quad \Rightarrow \quad Q_{TOT} = \mathcal{L}$$

$$\eta = \frac{\mathcal{L}}{|Q_{ASS}|}$$

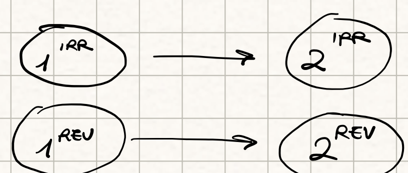
- $0 \to 1$: ISOENTROPICO $\Rightarrow \Delta S = 0 \Rightarrow Q = 0$
- $1 \to 2$: $Q_{12} = \frac{(T_1+T_2)(S_2-S_1)}{2} \underline{\underline{>0}}$ calore assorbito dalla macchina
- $2 \to 0$: ISOTERMA $\to$ $Q_{20} = (\underline{\underline{S_1-S_2}})T_2 < 0$ calore ceduto

! attenta al verso della trasformaz.

$$\Rightarrow \eta = \frac{\mathcal{L}}{Q_{12}} = \frac{(\cancel{S_2-S_1})(T_1-T_2)}{\cancel{2}} \frac{\cancel{2}}{(T_1+T_2)(\cancel{S_2-S_1})} = \frac{T_1-T_2}{T_1+T_2} = 0{,}25$$

$$P = \frac{\mathcal{L}}{\tau} = \frac{(S_2-S_1)(T_1-T_2)}{2\tau}$$

4) $V_1^{IRR} = V_1^{REV} = V_1$
$T_1^{IRR} = T_1^{REV} = T_1$
$V_2^{IRR} = V_2^{REV} = V_2$



? $\frac{T_2^{IRR}}{T_2^{REV}}$

REVERSIBILE : $TV^{\gamma-1} = cost \to T_1V_1^{\gamma-1} = T_2^{REV}V_2^{\gamma-1} \Rightarrow T_2^{REV} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} T_2$; $\gamma-1 = \frac{R}{c_V}$ (Mayer)

IRREVERSIBILE : tr. eq. rev. $\rightarrow$ ISOTERMA $V_1 \to V_2$
ISOCORA : $T_1 \to T_2^{IRR}$

$$\Delta S = nR\ln\frac{V_2}{V_1} + nc_v\ln\frac{T_2^{IRR}}{T_1} \rightarrow \ln\frac{T_2^{IRR}}{T_1} = \frac{\Delta S}{nc_v} + \ln\left(\frac{V_2}{V_1}\right)^{\frac{\cancel{n}R}{\cancel{n}c_v}}$$

$$\rightarrow \frac{T_2^{IRR}}{T_1} = \left(\frac{V_2}{V_1}\right)^{\frac{R}{c_v}} e^{\frac{\Delta S}{nc_v}} \Rightarrow T_2^{IRR} = T_1\left(\frac{V_2}{V_1}\right)^{\frac{R}{c_v}} e^{\frac{\Delta S}{nc_v}}$$

$\Delta S^{IRR} > 0$

$$\Rightarrow \frac{T_2^{IRR}}{T_2^{REV}} = e^{\frac{\Delta S}{nc_v}} \rightarrow T_2^{IRR} > T_2^{REV}$$

5) $T_2 = 800\ °C$
$T_1 = 300\ °C$
$P = 10\ W$
$x = 60\%$
$\eta = x\eta_c$
$\Delta t = 1h$

a) $?Q_{ASS}$ $?Q_{ced}$

b) $?\Delta S_U$

$$\eta_c = 1 - \frac{T_1}{T_2} \quad ; \quad \eta = x\left(1 - \frac{T_1}{T_2}\right) = \frac{\mathcal{L}}{|Q_{ASS}|} \rightarrow |Q_{ASS}| = \frac{\mathcal{L}}{x\left(1 - \frac{T_1}{T_2}\right)}$$

$$\mathcal{L} = P\Delta t \Rightarrow |Q_{ASS}| = \frac{P\Delta t}{x\left(1-\frac{T_1}{T_2}\right)} = 1{,}3 \cdot 10^8\ J$$

$$\Delta U_{ciclo} = 0 \quad ; \quad Q = \mathcal{L} + \Delta U \Rightarrow \mathcal{L} = +Q_{TOT} \Rightarrow$$

$$\mathcal{L} = |Q_{ASS}| - |Q_{ced}| \rightarrow |Q_{ced}| = |Q_{ASS}| - Q_{TOT} = |Q_{ASS}| - P\Delta t = 5.4 \cdot 10^7\ J$$

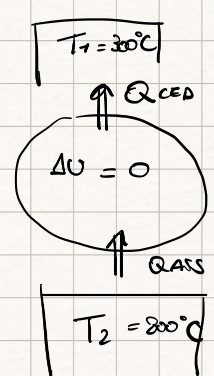
oppure $\eta = 1 - \frac{|Q_{ced}|}{|Q_{ASS}|} \Rightarrow |Q_{ced}| = \dots$

! Trasf. ciclica rev. $\Delta S_{sist} = 0$

$$\Delta S_U = \Delta S_{amb} = \Delta S_1 + \Delta S_2 = \frac{Q_{S1}}{T_1} + \frac{Q_{S2}}{T_2}$$

$Q_{S,1} = -Q_{CED} = |Q_{ced}|$

$Q_{S,2} = -Q_{ASS} = -|Q_{ASS}|$



$$\rightarrow \Delta S_U = \frac{|Q_{ced}|}{T_1} - \frac{|Q_{ASS}|}{T_2} = 4{,}3\,10^4\ J/K$$