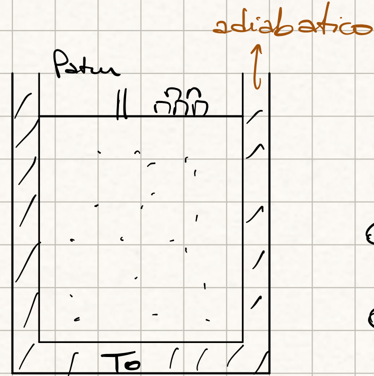
prima parte

2) $n = 10\ \text{mol}$
$V_i = 1\ m^3$
$V_f < V_i$
$m = 0{,}1\ \text{Kg}$
$T_0 = 0°C$
$\lambda_F = 80\ \text{Kcal/Kg}$



COMPRESSIONE ISOTERMA
REVERSIBILE — passa per $\to\infty$ stati di equilibrio $\Rightarrow$ processo lento

$\hookrightarrow T$ cost

$Q_{ext} = 0$

$\underset{<0}{Q_G} + \underset{>0}{Q_S} = 0$

$Q_G = \cancel{\Delta U} + \mathcal{L}$, con $\Delta U = n c_V \underbrace{\Delta T}_{=0}$

$\Rightarrow \underset{<0}{\mathcal{L}} = Q_G = -Q_S$; $Q_S = m\lambda_F = 8\ \text{Kcal} = 33{,}5\ \text{kJ}$

$\to \mathcal{L} = -Q_S = -33{,}5\ \text{kJ}$

$\mathcal{L} = \int p\, dV$; $pV = \underbrace{nRT}_{\text{costanti}} = \text{cost}$ (legge di Boyle)

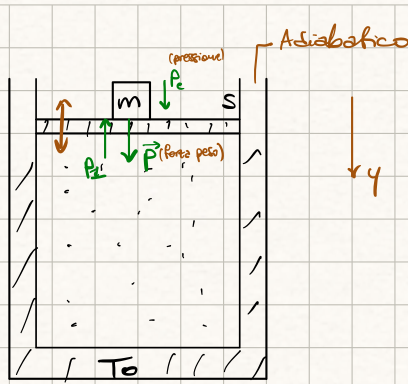
$\Rightarrow p_i V_i = p_f V_f$

<0 infatti $V_f < V_i \Rightarrow \frac{V_f}{V_i} < 1 \Rightarrow \ln(\,) < 0$

$\Rightarrow \mathcal{L} = \int \frac{nRT}{V}\, dV = nRT \int \frac{1}{V}\, dV = nRT \ln \frac{V_f}{V_i} = -Q = -m\lambda_F$

$\Rightarrow V_f = V_i\, e^{-\frac{m\lambda_F}{nRT}} \simeq 0{,}23\ m^3 < V_i$

3) $n = 2$ mol
MONOATOMICO
$S = 10\ cm^2$
$m = 20$ kg
$T = 100$ K
$p_e = 10^5$ Pa $= 1$ atm



b) tolgo blocco
↳ ESPANSIONE : (irreversibile)
nuovo equilibrio a p_e

$? T_2$

→ ESPANSIONE ADIABATICA IRREVERSIBILE

a) $? V_i$
Il pistone è in equilibrio
↳ termico + meccanico

a)
BILANCIO FORZE : $mg + P_e S - P_1 S = 0$

$$P_1 = \frac{mg}{S} + P_e \simeq 2{,}96 \cdot 10^5\ Pa$$

$$P_1 V_1 = nRT_1 \Rightarrow V_1 = \frac{nRT_1}{P_1} \simeq 5{,}6 \cdot 10^{-3}\ m^3$$

b) $\cancel{pV^\gamma = cost}$ NO

ma vale sempre: $PV = nRT$; $Q = \mathcal{L} + \Delta U = 0$ perchè adiabatico

$$\mathcal{L} = \Delta U = -nc_v(T_2 - T_1)$$

$$\delta\mathcal{L} = P_e\, dV \Rightarrow \underset{>0}{\mathcal{L}} = \int p_e\, dV = p_e \int_{V_1}^{V_2} dV = p_e \underbrace{\Delta V}_{>0\ \text{(espansione)}}$$

$$\Rightarrow \mathcal{L} = \underbrace{nc_v}_{\text{monoatomico: } = \frac{3}{2}R}(\overset{T_2 < T_1}{T_1 - T_2}) = p_2(V_2 - V_1)$$

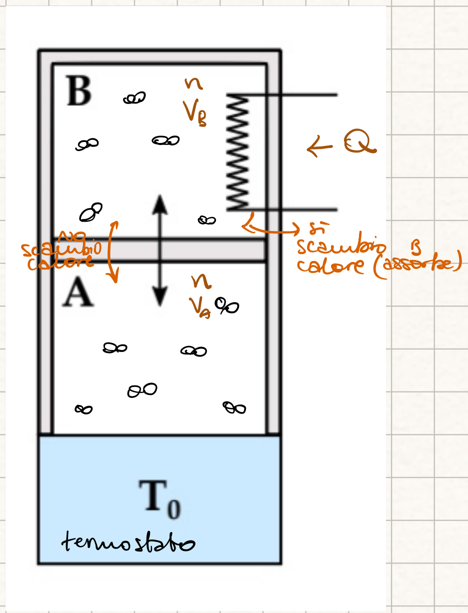
$$P_2 V_2 = nRT_2$$

$$\rightarrow \begin{cases} nc_v(T_1 - T_2) = P_2(V_2 - V_1) \\ V_2 = \dfrac{nRT_2}{P_2} \end{cases}$$

$$\Rightarrow P_2\left(\frac{nRT_2}{P_2} - \frac{nRT_1}{P_1}\right) = nc_v(T_1 - T_2) \Rightarrow T_2 = \frac{3P_1 + 2P_e}{5P_1} \cdot T_1 \simeq 73{,}5\ K \quad < T_1$$

ok

4)



$n = 1{,}2$ mol

BIATOMICO → $C_V = \frac{5}{2}R$

$P_0 = 1$ atm

$T_0 = 300K$

a) $?V_0$

b) $P_f = 1{,}3$ atm REVERSIBILE

$?V_{f,A}$, $?V_{f,B}$

c) $?Q_A$ ($<$ o >0 ?)

d) $?Q_B$

a) $P_0 V_0 = nRT_0 \Rightarrow V_0 = \frac{nRT_0}{P_0} = \boxed{2{,}55 \cdot 10^{-3}\ m^3}$

b) TRASFORMAZIONE REVERSIBILE GENERICA (B)

TRASFORMAZIONE ISOTERMA (A) - REVERSIBILE

$T_A = T_0 = cost$; $P_A V_A = cost$

$\Rightarrow P_0 V_0 = P_f V_{Af} \Rightarrow V_{Af} = \frac{P_0 V_0}{P_f} \simeq 2{,}27 \cdot 10^{-3}\ m^3$ $< V_0$

$V_{Bf} = 2V_0 - V_{Af} = 3{,}63 \cdot 10^{-2}\ m^3$ $> V_0$ (espande)

c) GAS B : $Q_B > 0$ (assorbe calore dalla resistenza termica)

$\Rightarrow \underbrace{\mathcal{L}_B}_{>0} + \underbrace{\Delta U_B}_{= n c_V \Delta T > 0} > 0$

$Q_A = \underbrace{\mathcal{L}_A}_{<0} + \cancel{\Delta U}$

(subisce lavoro) ↳ compressione

Isoterma $\Delta T = 0$

$\mathcal{L}_A = \int P_A dV = \int \frac{nRT_A}{V_A} dV = nT_A R \int \frac{1}{V_A} dV = nRT_0 \ln\left(\frac{V_{Af}}{V_0}\right) = Q_A = -785\ J$

($T_A = T_0$; $\ln\left(\frac{V_{Af}}{V_0}\right) < 0$)

A cede calore al serbatoio

d) $Q_B = \underbrace{\mathcal{L}_B}_{= -\mathcal{L}_A} + \underbrace{\Delta U_B}_{= n c_V (T_{Bf} - T_0)} = -\mathcal{L}_A + n c_V \left(\frac{P_f V_{Bf}}{nR} - T_0\right) \approx 5{,}2 \cdot 10^3\ J$

($\mathcal{L}_B > 0$)

$T_{Bf} = \frac{P_f V_{Bf}}{nR}$

5) $C_m = 1\ J/°C$

$T_m = 100°C$

$n = 1\ mol$

MONOATOMICO

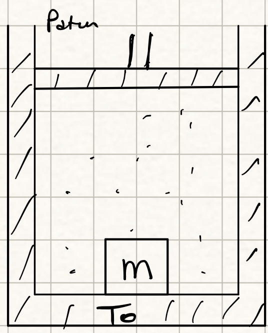
$T_a = 25\ °C$

a) ? T_{eq} con pistone fermo

b) ? Q

Pistone libero c) ? T_{eq}

d) ? $\mathcal{L}_G$ in entrambi i casi



a) ISOCORA

$\Delta V = 0$

$Q_{ext} = 0$

$Q_G + Q_m = 0$

$Q_m = C_m(T_{eq} - T_m) = -Q_G = -\Delta U_G = -nc_v(T_{eq} - T_a)$

$Q_G = \underbrace{\cancel{\mathcal{L}}}_{\substack{=0 \\ \Delta V = 0}} + \Delta U$

$\Rightarrow T_{eq} = \dfrac{C_m T_m + nc_v T_a}{C_m + nc_v} = \boxed{303{,}7\ K}$

b) $Q_m = C_m(T_{eq} - T_m) = \boxed{-68{,}44\ J}$

c) ESPANSIONE IRREVERSIBILE (LIBERA)

$\mathcal{L} + \Delta U = Q_G = -Q_m = -C_m(T_{eq} - T_m)$

$\mathcal{L} = \int p_e\, dV = p_e \Delta V = p_e(V_f - V_i) = nR(T_{eq} - T_a)$

$p_e V_f = nRT_{eq}$ $\qquad p_e V_i = nRT_a$

$\Rightarrow nR(T_{eq} - T_a) + nC_v(T_{eq} - T_a) = C_m(T_m - T_{eq})$

$\rightarrow n(T_{eq} - T_a)\underbrace{(c_v + R)}_{c_p} = C_m(T_m - T_{eq}) \qquad (= Q_G)$

↳ se pressione esterna cost

$\Rightarrow T_{eq} = \dfrac{C_m T_m + nc_p T_a}{C_m + nc_p} = \boxed{301{,}65\ K} \qquad$ < caso a)

d) caso 2: $\mathcal{L}_G = nR(T_{eq} - T_a) = \boxed{28{,}1\ J}$

caso 1: $\mathcal{L}_G = 0$ perché pistone fermo $\Rightarrow \Delta V = 0$

XCASA es 6:

$\mathcal{L}$ = area sottesa

$\mathcal{L} = \int p\, dV$

$C_{AB} = \dfrac{1}{n} \dfrac{dQ}{dT}$