(N3) Trasf. adiabatica → $Q = 0$ → NON ci è CALORE TRASFERITO !

esp. libera → $Q = 0$ $W = 0$

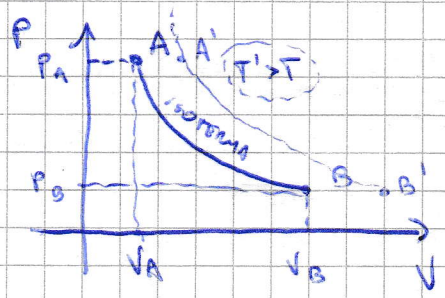
isobara → $P = cost.$

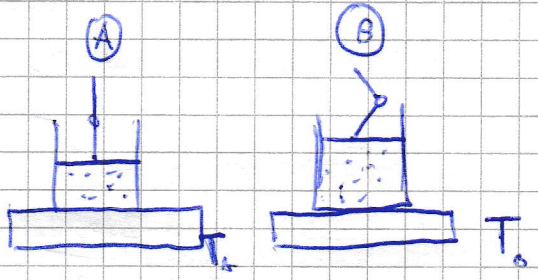
isocora → $V = cost.$

isoterma → $Q = -W$

(N3) ISOTERMICA → $Q \neq 0$ → $W = 0$

$$pV = nRT$$



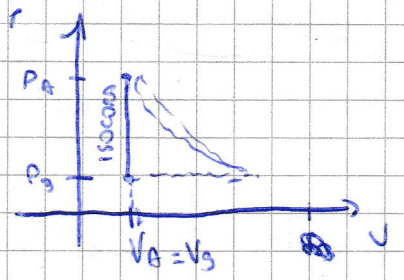

$T_A = T_B$

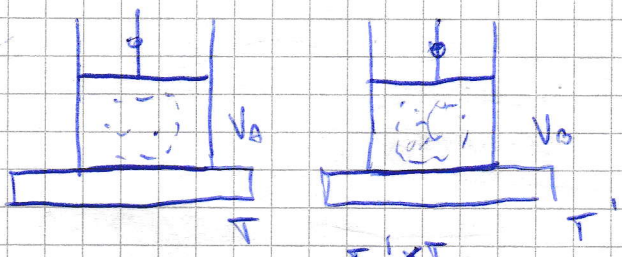
ISOTERMA

T cost.

$pV = cost. \Rightarrow p = \frac{nRT}{V} = \frac{cost}{V}$

$pV = nRT$




$V_A = V_B$

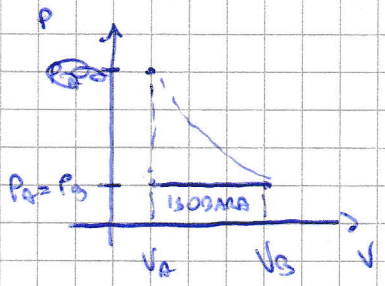
ISOCORA

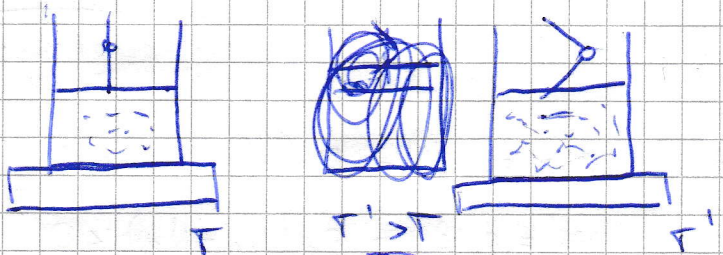
V cost

$T' < T$

$p_B < p_A$

$$\frac{p}{T} = \frac{nR}{V} = cost$$




$p_A = p_B$

ISOBARA

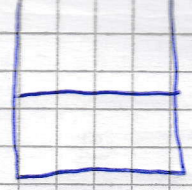
p cost

$T' > T$

$p_A = p_B$

$V_A < V_B$

$$\frac{V}{T} = \frac{nR}{p}$$



$p_i =$

$V_i =$

$\boxed{V_f = 2V_i}$

cost ↓ ↑

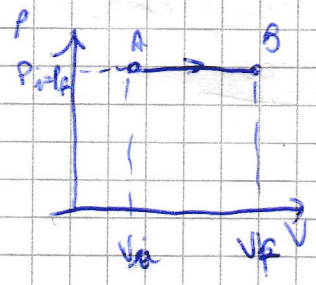
$T_i = \frac{p_i V_i}{nR}$

$p_f V_f = nRT_f$

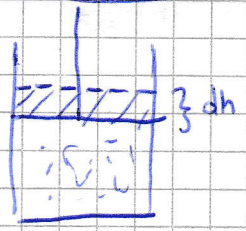
cost ↓ $2V_i$

$2\left(\frac{p_i V_i}{nR}\right) = T_f$

$\boxed{T_f = 2T_i}$




## LAVORO TERMODINAMICO



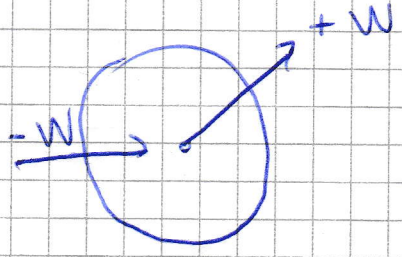

$\boxed{p \text{ cost}}$ ISOCORA

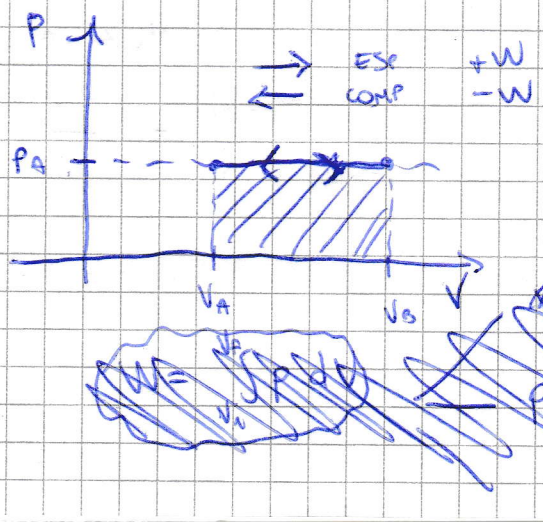
$W = \int F_{tangente}\, dh = \int pS\, dh = pS \int dh = pS\Delta h = p\Delta V$

$\boxed{dW = p\,dV}$

ESPANSIONE $W = p_A \Delta V = p_A (V_B - V_A) > 0$

COMPRESSIONE $W' = p_A \Delta V = p_A (V_A - V_B) < 0$

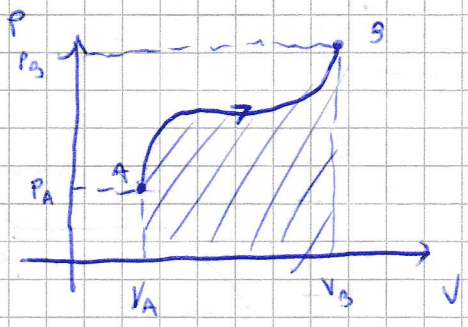


$p = p(V)$

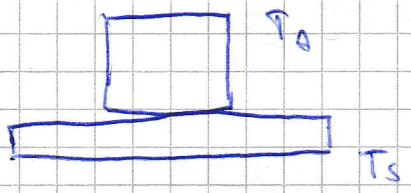
$dW = p\,dV$

$W = \int_{V_A}^{V_B} p(V)\,dV$ $(>0)$




ESPANSIONE

## CALORE e CALORE SPECIFICO

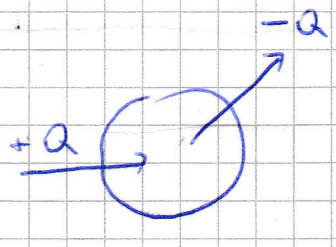



$T_A \longrightarrow T_S$

| calore | var. temp. |
|---|---|
| $Q$ | $\Delta T$ |

$\frac{Q}{\Delta T} = C$ capacità termica

$\Delta T \rightarrow T_S - T_A$




$Q = C \cdot \Delta T$ $\begin{cases} T_S - T_A > 0 & Q \text{ POS} \\ T_S - T_A < 0 & Q \text{ NEG} \end{cases}$

$\boxed{Q = m c_s \Delta T}$ CORPI

$\boxed{Q = n c_s^* \Delta T}$ GAS

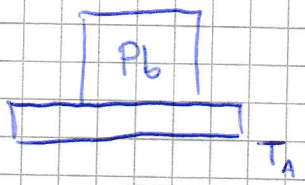
$c_s^*$ = cal. spec. molare

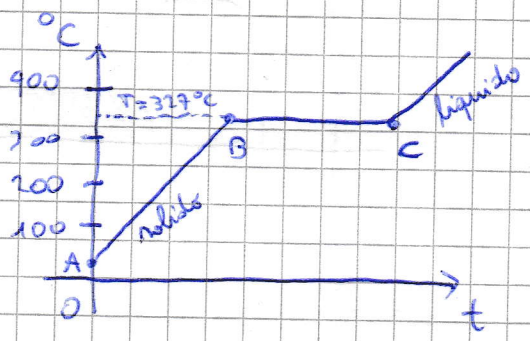
$n$ = n. di moli

1 cal = (4,186 J) → quantità di lavoro necessaria per far andare l'acqua su di un grado celsius

# TRASFORMAZIONI DI FASE

NO




→ T di FUSIONE

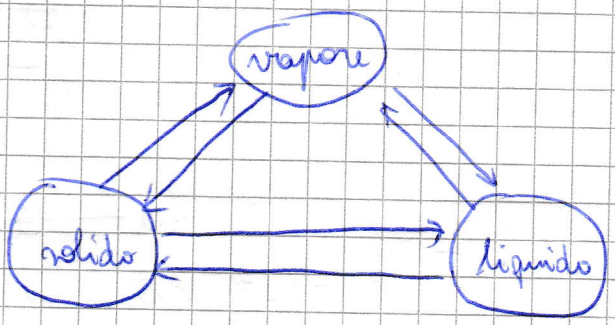
$$Q = m\, c_s\, \Delta T$$

CALORIMETRIA

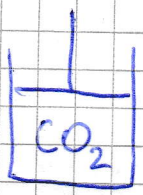
$$Q = \lambda\, m$$

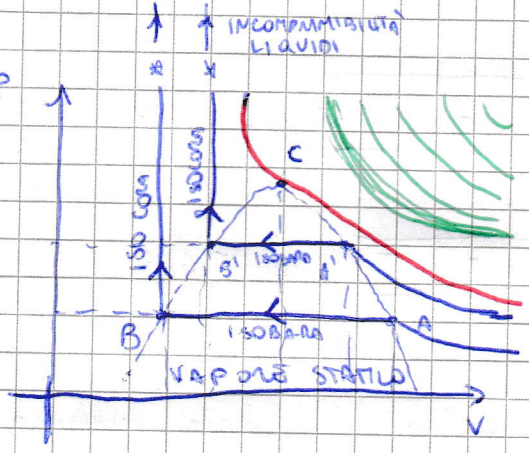
(DI FUSIONE nel NOSTRO CASO)

TRASFORMAZIONE DI FASE




CALORI LATENTI DI FUSIONE




$T > T_{critica}$ ISOTERME

$T = 31\,°C = T_{critica}$

$T = 15\,°C$

$T = 10\,°C$

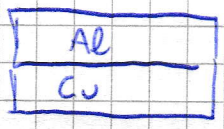
$C = A'' = B''$

GAS ≠ VAPORE

═ = NON C'È TRANSIZIONE DI FASE ⇒ NON È POSSIBILE LIQUEFARE

— = C'È TRANSIZIONE DI FASE ⇒ SI PUÒ LIQUEFARE LA $CO_2$

es.




$T_{eq} = ?$

$m_{cu} = 0,5\ kg$ $\quad m_{al} = 1\ kg$

$T_{cu} = 873\ K$ $\quad T_{al} = 300\ K$

$c_{s_{cu}} = 385\ \frac{J}{kg\,K}$ $\quad c_{s_{al}} = 896\ \frac{J}{kg\,K}$

$$\boxed{Q_{cu} + Q_{al} = 0}$$

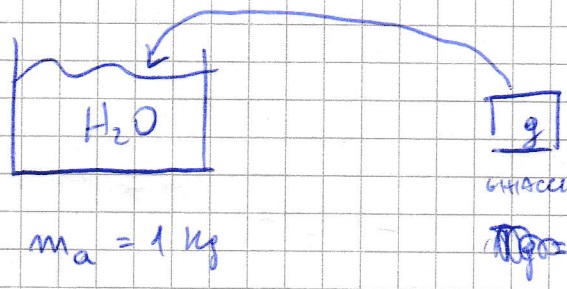
$Q_{cu} < 0$ $\quad Q_{al} > 0$

$$m_{cu}\, c_{s_{cu}} (T_f - T_{cu}) + m_{al}\, c_{s_{al}} (T_f - T_{al}) = 0$$

$$m_{cu}\, c_{s_{cu}}\, T_{cu} + m_{al}\, c_{al}\, T_{al} = m_{cu}\, c_{cu}\, T_f + m_{Al}\, c_{Al}\, T_f$$

$$T_f = \frac{m_{cu}\, c_{s_{cu}}\, T_{cu} + m_{Al}\, c_{s_{Al}}\, T_{Al}}{m_{cu}\, c_{s_{cu}} + m_{al}\, c_{s_{Al}}} = 401\ K$$

es.




$m_a = 1\ kg$

$T_a = 310\ K$

$c_a = 4,186\ \frac{kJ}{kg\,K}$

$m_g = 0,4\ kg$

$T_g = 273\ K$

$\lambda_f = 333\ \frac{kJ}{kg}$

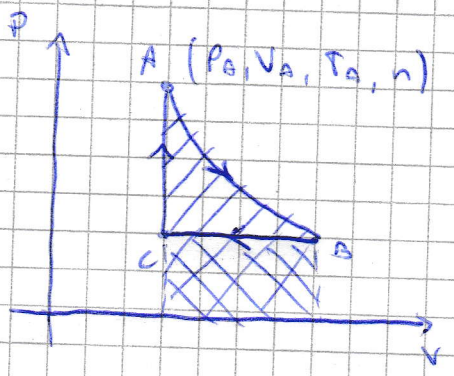
$$Q_f = \lambda_f\, m_g = 133\ kJ$$

$Q_{acqua\ ridotta}$ $\quad Q_{acqua\ cont.}$ $\quad Q_{trans.\ fase}$

$$m_g\, c_a (T_f - T_g) + m_a\, c_a (T_f - T_a) + Q_f = 0$$

$$T_f = \frac{m_g\, c_a\, T_g + m_a\, c_a\, T_a - Q_f}{m_g\, c_a + m_a\, c_a} = 276,7\ K$$

# PRIMO PRINCIPIO TERMODINAMICA



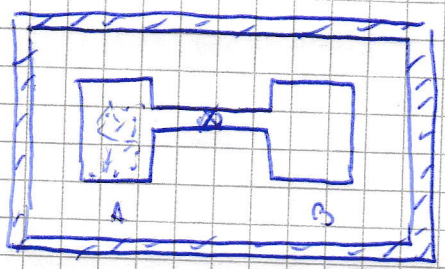

$Q > W$

$Q - W = 0$

$\boxed{Q - W = U_B - U_A}$ / ciclo $\rightarrow Q - W = 0$ \ non ciclo $\rightarrow Q - W \neq 0$

$\boxed{Q - W = \Delta U}$

## Espansione libera




Dopo aver aperto la valvola

$V_i < V_f$

$P_i > P_f$

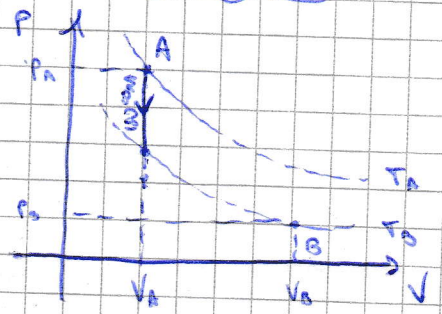
$T_i = T_f$

$$Q - W = \Delta U = U_f(P_f, V_f, T_f) - U_i(P_i, V_i, T_i) = 0$$

$$\boxed{\Delta U = U(T_f) - U(T_i) = 0} \quad (T_f = T_i)$$

Energia interna di un gas ideale dipende UNICAMENTE dalla sua TEMP

Andare da A a B




$U = \{U(T) + U_0$

$U_B - U_A = \Delta U$

- SCELGO UN ISOCORA PER SPOSTARMI SULL'ISOTERMA $T_B$

$Q - \cancel{W} = \Delta U \Rightarrow \underline{\Delta U} = Q = \underline{n c_v^* (\Delta T)}$

↳ NON C'È LAVORO NELL'ISOCORA

↳ $T_B - T_A$