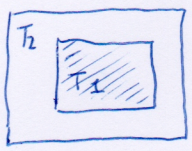
SCHEMA RIASSUNTIVO

- T → temperatura $\quad [K] = [°C] + 273.15$

Q → calore $\quad [J]$ → energia scambiata



$T_1 > T_2 \quad Q < 0$ calore ceduto

$T_1 = T_2 \quad Q = 0$ equilibrio termico

$T_1 < T_2 \quad Q > 0$ calore assorbito

c → calore specifico (dipende da P, V ...)

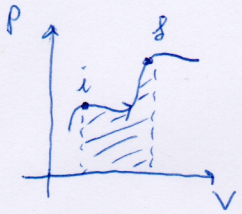
$c \stackrel{def}{=} \frac{Q}{m\,\Delta T} \rightarrow Q = c\,m\,\Delta T$ | cambio fase $Q = \pm m\lambda$

$[c] = \frac{J}{kg \cdot K}$

λ → calore latente → $\frac{J}{kg}$

- Trasformazioni termodinamiche (gas perfetto)

variabili: $P, T, V, n \rightarrow PV = nRT \qquad R = 8.31 \frac{J}{K \cdot mol}$



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

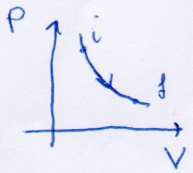
$W = \int_{V_i}^{V_f} P\,dV \qquad W > 0$ lavoro fatto dal gas

$W < 0$ lavoro fatto sul gas

$\Delta E_{int} = Q - W$ (per lavoro fatto dal gas)

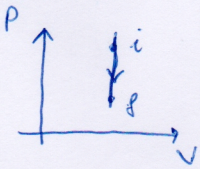
↓ dipende solo da ΔT

- isoterma: T = costante



$Q = W = nRT \ln \frac{V_f}{V_i} \Rightarrow \Delta E_{int} = 0$

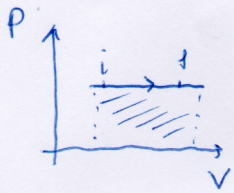
- isocora: V = costante



$W = 0 \Rightarrow Q = \Delta E_{int}$

$\Delta E_{int} = n c_V \Delta T$ → sempre vera

- isobara: P = costante

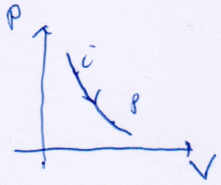


$\Delta E_{int} = Q - W$

$W = (V_f - V_i)P$

vale: $R = c_p - c_V$

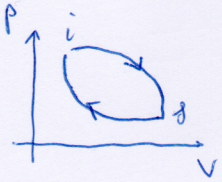
- adiabatica: $Q = 0$



$\Delta E_{int} = -W$

$PV^{\gamma} = \text{costante}$ $\qquad \gamma = \frac{c_p}{c_v}$

- cicliche

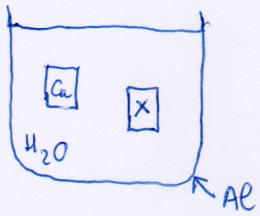


$Q = W \Rightarrow \Delta E_{int} = 0$

GAS MONOATOMICO: $\quad c_v = \frac{3}{2}R \qquad c_p = \frac{5}{2}R \qquad \gamma = 1.67$

GAS BIATOMICO: $\quad c_v = \frac{5}{2}R \qquad c_p = \frac{7}{2}R \qquad \gamma = 1.40$

ESERCIZIO 1



$m_{Al} = 100\,g$ $\quad T_{eq} = 10°C$

$m_{H_2O} = 250\,g$

$m_{Cu} = 50\,g$ $\quad T_{Cu} = 80°C$ $\quad T'_{eq} = 20°C$

$m_x = 70\,g$ $\quad T_x = 100°C$

$? = C_x, X$

All'equilibrio (T'_{eq})

$$Q_{Al} + Q_{H_2O} + Q_{Cu} + Q_x = 0$$

$$Q_x = -(Q_{Al} + Q_{H_2O} + Q_{Cu}) \qquad \text{dove} \quad Q = mc\Delta T$$

$$m_x C_x (T'_{eq} - T_x) = -\left[m_{Al} C_{Al} (T'_{eq} - T_{eq}) + m_{H_2O} C_{H_2O} (T'_{eq} - T_{eq}) + m_{Cu} C_{Cu} (T'_{eq} - T_{Cu})\right]$$

$$m_x C_x (T'_{eq} - T_x) = -\left[(m_{Al} C_{Al} + m_{H_2O} C_{H_2O})(T'_{eq} - T_{eq}) + m_{Cu} C_{Cu} (T'_{eq} - T_{Cu})\right]$$

$$C_x = -\frac{(m_{Al} C_{Al} + m_{H_2O} C_{H_2O})(T'_{eq} - T_{eq}) + m_{Cu} C_{Cu} (T'_{eq} - T_{Cu})}{m_x (T'_{eq} - T_x)}$$

$$C_x = -\frac{\left(100\,g \cdot 0.9 \frac{J}{g°C} + 250\,g \cdot 4.18 \frac{J}{g°C}\right)(20°C - 10°C) + 50\,g \cdot 0.385 \frac{J}{g°C}(20°C - 80°C)}{70\,g \cdot (20°C - 100°C)}$$

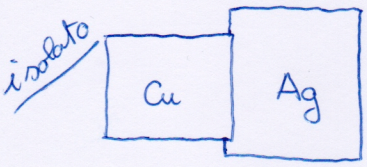
$$C_x = 1.82 \ \frac{J}{g°C}$$

nota: $\frac{J}{g°C} \Leftrightarrow \frac{J}{g\,K}$

$[°C] = [K] - 273.15$

$x = Be$

ESERCIZIO 2



$\Delta T_{Cu} = 16°C$

$T_{Ag}^i = +30°C$

$m_{Cu} = 9g \quad | \quad c_{Cu} = 387 \frac{J}{kg°C}$

$m_{Ag} = 14g \quad | \quad c_{Ag} = 234 \frac{J}{kg°C}$

equilibrio in $\Delta t = 3.2\,s$

$? = T_{Cu}^i, \Delta T_{Ag}$

$? = v_{Ag} \left[{}^{°C}/_{s} \right]$

All'equilibrio

$$Q_{Cu} + Q_{Ag} = 0$$

$$m_{Cu} c_{Cu} (T_{eq} - T_{Cu}^i) + m_{Ag} c_{Ag} (T_{eq} - T_{Ag}^i) = 0$$

$$m_{Ag} c_{Ag} (T_{eq} - T_{Ag}^i) = - m_{Cu} c_{Cu} \Delta T_{Cu}$$

$$T_{eq} - T_{Ag}^i = - \frac{m_{Cu} c_{Cu} \Delta T_{Cu}}{m_{Ag} c_{Ag}}$$

$$T_{eq} = T_{Ag}^i - \frac{m_{Cu} c_{Cu} \Delta T_{Cu}}{m_{Ag} c_{Ag}} = +30° - \frac{9g \cdot 387 \frac{J}{kg°C} \cdot 16°C}{14g \cdot 234 \frac{J}{kg°C}} = 13°C$$

$$\Delta T_{Cu} = T_{eq} - T_{Cu}^i \Rightarrow T_{Cu}^i = T_{eq} - \Delta T_{Cu} = 13°C - 16°C = -3°C$$

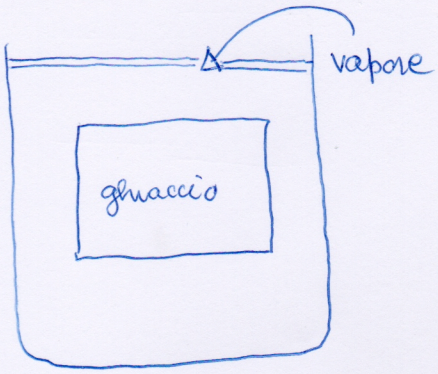
$$\Delta T_{Ag} = T_{eq} - T_{Ag}^i = 13°C - 30°C = -17°C$$

$$Q_{Cu} = - Q_{Ag} \Rightarrow \frac{d}{dt} Q_{Cu} = - \frac{d}{dt} Q_{Ag}$$

$$- \frac{d}{dt} (m_{Ag} c_{Ag} T_{Ag}) = \frac{d}{dt} (m_{Cu} c_{Cu} T_{Cu})$$

$$v = \frac{dT_{Ag}}{dt} = - \frac{m_{Cu} c_{Cu}}{m_{Ag} c_{Ag}} \frac{dT_{Cu}}{dt} = - \frac{9g \cdot 387 \frac{J}{kg°C}}{14g \cdot 234 \frac{J}{kg°C}} \cdot \frac{16°C}{3.2\,s} = -0.532 \frac{°C}{s}$$

ESERCIZIO 3



$T_v = 100°C$

$T_g = 0°C$

$m_v = 1\,g$

$m_g = 50\,g$

$? = T_{eq}$

$? = m_{fuso}$

$\lambda_g = 3.33 \cdot 10^5 \frac{J}{Kg}$

$Q_1 \rightarrow$ quantità di calore per fondere il ghiaccio (tutto)

$$Q_1 = m_g \lambda_g = 50 \cdot 10^{-3} kg \cdot 3,33 \cdot 10^5 \frac{J}{kg} = 1.67 \cdot 10^4 J$$

$Q_2 \rightarrow$ quantità di calore rilasciata dal vapore che si condensa

$$Q_2 = m_v \lambda_v = 10^{-3} kg \cdot 2.26 \cdot 10^6 \frac{J}{kg} = 2,26 \cdot 10^3 J$$

$Q_3 \rightarrow$ quantità di calore rilasciata quando il vapore condensato si raffredda ($0°$)

$$Q_3 = m_v C \Delta T = 10^{-3} kg \cdot 4186 \frac{J}{kg \cdot C} \cdot (100°C - 0°C) = 419\,J$$

noticiamo $Q_1 > Q_2 + Q_3 \Rightarrow$ non scioglo tutto il ghiaccio!

$$m_g \lambda_g = Q_2 + Q_3 \rightarrow m_g = \frac{Q_2 + Q_3}{\lambda_g} = \frac{2.26 \cdot 10^3 J + 419\,J}{3,33 \cdot 10^5 \frac{J}{kg}} = 8.04\,g$$

$T_{eq} = 0$ sempre finché $Q_1 > Q_2 + Q_3$

Esaurita la quantità di calore disponibile rimangono $\sim 42\,g$ a $0°C$.