$U_2 - U_1 = W_{v12} + Q_{12} + W_{diss12}$ $\qquad W_{v12} = -\int_1^2 p\,dV$

$H_2 - H_1 = W_{t12} + Q_{12} + W_{diss12}$ $\qquad W_{t12} = \int_1^2 V\,dp$

$U(T, V)$ kalorische Zustandsgleichung

$H(T, p)$ "

$H = U + p \cdot V$

T, p , $U(T,V)$

↳ V (thermische Zustandsgl.)

↳ $U(T,V)$ (kal. ")

H

spezifische Größen

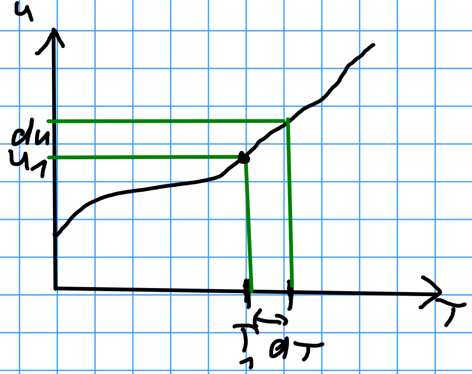
$u(T,v)$ bzw. $h(T,p)$

$$du = \underbrace{\left(\frac{\partial u}{\partial T}\right)_v}_{c_v} dT + \left(\frac{\partial u}{\partial v}\right)_T \cdot dv$$

$$dh = \underbrace{\left(\frac{\partial h}{\partial T}\right)_p}_{c_p} dT + \left(\frac{\partial h}{\partial p}\right)_T \cdot dp$$

$u(T)$

$$du = u'(T)\, dT = \left(\frac{du}{dT}\right) \cdot dT$$



$c_v := \left(\frac{\partial u}{\partial T}\right)_v \qquad c_p := \left(\frac{\partial h}{\partial T}\right)_p \qquad [c_v] = \frac{J}{kg\,K}$

c_v aus Wärmemessungen:

$du = \frac{1}{m} dU = \frac{1}{m}\left(dQ + dW_{diss} - p\,dV\right)$

Messung bei konstantem Volumen, also $dV = 0$ (isochor)

$= \frac{1}{m}\left(dQ + dW_{diss}\right)$

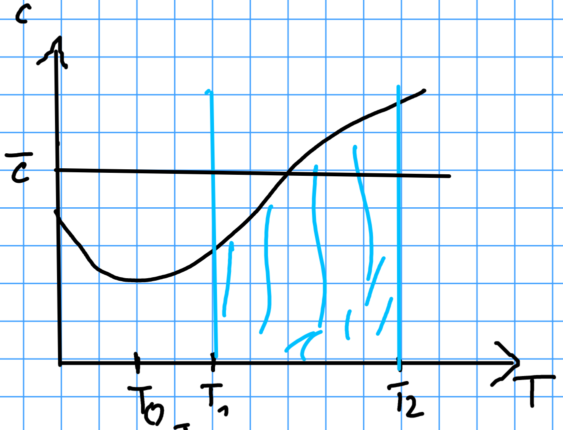
$= c_v\,dT$

$\Rightarrow \quad m\int_1^2 c_v\,dT = Q_{12} + W_{diss12}$ (isochor) $\quad\Big|\quad m\int_1^2 c_p\,dT = Q_{12} + W_{diss12}$ (isobar)

Spezialfall: reversibel, c_v hänge nicht von T ab $\qquad c_p$ hänge nicht von T ab

$m\,c_v \int_{T_1}^{T_2} dT = Q_{12}$

$m\,c_v\,(T_2 - T_1) = Q_{12} \qquad\qquad m\,c_p\,(T_2 - T_1) = Q_{12}$



$$\bar{c}\Big|_{T_1}^{T_2} := \frac{1}{T_2 - T_1} \int_{T_1}^{T_2} c(T)\, dT$$

<u>reversibel</u>:

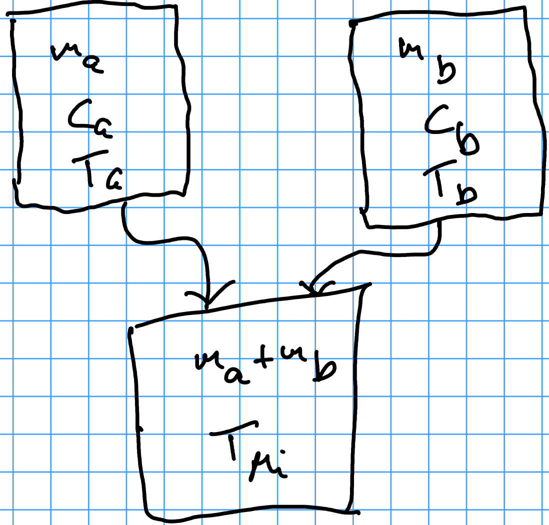
$$Q_{12} = m \int_{T_1}^{T_2} c(T)\, dT = m\,(T_2 - T_1) \cdot \frac{1}{T_2 - T_1} \cdot \int_{T_1}^{T_2} c(T)\, dT = m\,(T_2 - T_1)\, \bar{c}\Big|_{T_1}^{T_2}$$

$$Q_{12} = m\, \bar{c_v}\Big|_{T_1}^{T_2} (T_2 - T_1)$$ isochor + reversibel

$$Q_{12} = m\, \bar{c_p}\Big|_{T_1}^{T_2} (T_2 - T_1)$$ isobar + reversibel

$$\int_{T_1}^{T_2} c\, dT = \int_{T_0}^{T_2} c\, dT - \int_{T_0}^{T_1} c\, dT$$

Tabellen für $\bar{c_p}\Big|_{T_0}^{T}$, T_0 fest



$$Q_{b,mi} + Q_{a,mi} = 0$$

$$0 = m_b \bar{c}_b \Big|_{T_b}^{T_{mi}} (T_{mi} - T_b) + m_a \bar{c}_a \Big|_{T_a}^{T_{mi}} (T_m - T_a)$$