$$dU = T\cdot dS - p\cdot dV + \mu\cdot dN$$
$$dF = -S\cdot dT - p\cdot dV + \mu\, dN$$
$$dH = T\cdot dS + V\,dp + \mu\, dN$$
$$dG = -S\,dT + V\,dp + \mu\, dN$$
$$d\Omega = -S\,dT - p\,dV - N\,d\mu$$

$$\left(\frac{\partial T}{\partial V}\right)_S \overset{U}{=} -\left(\frac{\partial p}{\partial S}\right)_V \quad \left(\frac{\partial T}{\partial p}\right)_S \overset{H}{=} \left(\frac{\partial V}{\partial S}\right)_p$$
$$\left(\frac{\partial S}{\partial V}\right)_T \overset{F}{=} \left(\frac{\partial p}{\partial T}\right)_V \quad \left(\frac{\partial T}{\partial N}\right)_{V,S} = \left(\frac{\partial \mu}{\partial S}\right)_V$$
$$\left(\frac{\partial S}{\partial p}\right)_T \overset{G}{=} -\left(\frac{\partial V}{\partial T}\right)_p \quad \left(\frac{\partial N}{\partial V}\right)_{S,\mu} = -\left(\frac{\partial p}{\partial \mu}\right)_{V,S}$$

$$T = \left(\frac{\partial U}{\partial S}\right)_V = \left(\frac{\partial H}{\partial S}\right)_p$$
$$-p = \left(\frac{\partial U}{\partial V}\right)_S = \left(\frac{\partial F}{\partial V}\right)_T$$
$$V = \left(\frac{\partial H}{\partial p}\right)_S = \left(\frac{\partial G}{\partial p}\right)_T$$
$$-S = \left(\frac{\partial G}{\partial T}\right)_p = \left(\frac{\partial F}{\partial T}\right)_V$$

$$dU = \delta Q - \delta W$$
$$\delta Q = T\cdot dS$$
$$\delta W = p\cdot dV$$
$$\delta Q|_p = C_p\cdot dT$$

$$U(S,V,N) = TS - pV + \mu N$$
$$F(T,V,N) = U - TS = -pV + \mu N$$
$$H(S,p,N) = U + pV = TS + \mu N$$
$$G(T,p,N) = U - TS + pV = \mu N$$
$$\Omega(T,V,\mu) = F - \mu N = -pV$$

Gibbs-Duhem

$$0 = S\cdot dT - V\,dp + N\,d\mu$$

$$d(pV) = dH - dU = dG - dF$$
$$d(TS) = dU - dF = dH - dG$$

$$\mu = \left(\frac{(\partial U) \vee (\partial F) \vee (\partial H) \vee (\partial G)}{\partial N}\right)$$

$$C_V = \left(\frac{\delta Q}{dT}\right)_V = T\left(\frac{\partial S}{\partial T}\right)_V \quad C_p = \left(\frac{\delta Q}{dT}\right)_p = T\left(\frac{\partial S}{\partial T}\right)_p$$
$$\chi_S = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_S \text{ adiabat} \quad \chi_T = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_T \text{ isotherm}$$
$$\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p \quad C_p = C_V\frac{K_T}{K_S} \quad \beta = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_p$$
$$\frac{\partial}{\partial A}\left(\frac{\partial B}{\partial C}\right)_A = \frac{\partial}{\partial C}\left(\frac{\partial B}{\partial A}\right)_C \quad \eta = -\frac{\Delta W}{\Delta Q} \quad R = N_A\cdot k_B$$

$$dS = \frac{1}{T}dU + \frac{p}{T}dV \Rightarrow \left(\frac{\partial S}{\partial V}\right)_U = \frac{p}{T} \quad \left(\frac{\partial S}{\partial T}\right)_V = \frac{C_V}{T}$$
$$dS = \frac{C_V(T,V)}{T}dT + \left(\frac{\partial p}{\partial T}\right)_V dV \qquad \left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial p}{\partial T}\right)_V$$

einatomiges ideales Gas: $U = \frac{3}{2}N\cdot k_B\cdot T$

$$p = \frac{N\cdot k_B\cdot T}{V} \quad \left(\frac{\partial U}{\partial V}\right)_T = 0 \quad \frac{nR}{p} = \left(\frac{\partial V}{\partial T}\right)_p$$
$$\delta Q = C_V\cdot dT + p\,dV$$

$$S(T,V)\ \&\ U(T,V):\ \left(\frac{\partial S}{\partial T}\right)_V = \frac{1}{T}\left(\frac{\partial U}{\partial T}\right)_V$$
$$\left(\frac{\partial S}{\partial V}\right)_T = \frac{1}{T}\left[\left(\frac{\partial U}{\partial V}\right)_T + p\right] = \left(\frac{dp}{dT}\right)_V \quad \left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{dp}{dT}\right)_V - p$$

$$C_p - C_V = \left[\left(\frac{\partial U}{\partial V}\right)_T + p\right]\left(\frac{\partial V}{\partial T}\right)_p = T\left(\frac{\partial p}{\partial T}\right)_V\left(\frac{\partial V}{\partial T}\right)_p$$
$$C_V = \left(\frac{\partial U}{\partial T}\right)_V \quad C_p = \left(\frac{\partial U}{\partial T}\right)_V \cdot \left[\left(\frac{\partial U}{\partial V}\right)_T + p\right]\left(\frac{\partial V}{\partial T}\right)_p$$

1.H.S.: – iso. sys.: $dU = 0$

– geschl. sys.: $dU = \delta Q + \delta W$

– offenes sys.: $dU = \delta Q + \delta W + \sum \mu\, dN$

2.H.S.: $dS = \delta Q/T + \delta W/T$

3.H.S.: $\lim_{T\to 0} S(z_i, q_i) = S_0 = 0$

adiabate:

$\delta Q = 0$

$T\cdot V^{\gamma-1} = \text{const.}$

$p\cdot V^{\gamma-1} = \text{const.}$

isotherme:

$dT = 0$

$p\cdot V = \text{const}$

$U = U(T) \Rightarrow \Delta U = 0$

isobare:

$dp = 0$

$V/T = \text{const.}$

$W = -p\cdot\Delta V = -nR\cdot\Delta T$

isochore:

$dV = 0$

$p/T = \text{const.} \quad = C_V \Delta T$

$\delta W = 0 \Rightarrow dU = \delta Q$

$$\left(p + \frac{a n^2}{V^2}\right)(V - nb) = nRT$$
$$\Downarrow$$
$$\left(\pi + 3/\nu^2\right)(3\nu - 1) = 8t$$

Kalorische Z.G.:

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

thermische Z.G.:

$p = p(T,V,N)$

$$\delta W = -p\,dV = \vec{B}_0\cdot d\vec{m}$$
$$= \vec{E}\,d\vec{p} = \sigma\cdot dF$$

Clausius-Clapeyron

$$\frac{\Delta p}{\Delta T} = \frac{S_2 - S_1}{V_2 - V_1} = \frac{q}{T(V_2 - V_1)}$$