Lover

0. $A \sim B$ og $B \sim C$ gir $A \sim C$

1. $\Delta E = Q + W$

2. $\Delta S \geq 0$ Isolert system

3. $\lim_{\mathrm{T}\to 0} \Rightarrow S = \text{konstant}$

Mye brukte formler

$$F = E - TS \quad \text{Helmholtz}$$
$$G = E - TS + PV \quad \text{Gibbs}$$

$$F = -kT\ln(Z)$$
$$\left(P + \frac{aN^2}{V^2}\right)(V - Nb) = NkT$$
$$\ln N! \approx N\ln N - N$$
$$S \equiv k\ln\Omega$$
$$\Delta S_{\text{mixing}} = k\ln\binom{N}{N_A}$$
$$W_{AB} = W_B - W_A = \int_{V_A}^{V_B} P(V)DV$$
$$E = -kT^2\left(\frac{\partial \ln Z}{\partial T}\right)$$

Ideell gass

$$PV = NkT$$
$$\Delta S = \frac{dE}{T} = \frac{Q}{T} = \frac{C_V dT}{T}$$
$$S = Nk\left[\ln\left(\frac{V}{N}\left(\frac{4\pi mE}{3Nh^2}\right)^{3/2}\right) + \frac{5}{2}\right]$$

Multiplisitet

$$\Omega(N_\uparrow) = \binom{N}{N_\uparrow} = \frac{N!}{N_\uparrow! N_\downarrow} \quad \text{Paramagnet}$$
$$\Omega(N,q) = \binom{q+N-1}{q} = \frac{(q+N-1)!}{q!(N-1)!} \quad \text{Einsteinkrystall}$$
$$\Omega_N = \frac{1}{N!}\frac{V^N}{h^{3N}}\frac{2\pi^{3N/2}}{(3N/2-1)!}(\sqrt{2mE})^{3N-1} \quad \text{Ideell gass}$$

Varmeutveksling

$$e \equiv \frac{W}{Q_h} = 1 - \frac{Q_c}{Q_h} \quad \text{Effektivitet varmemaskin}$$
$$e \equiv \frac{Q_c}{W} = \frac{1}{Q_h/Q_c - 1} \quad \text{Effektivitet kjølemaskin}$$
$$\frac{dP}{dT} = \frac{S_g - S_l}{V_g - V_l} = \frac{L}{T\Delta V} \quad \text{Clausius-Clapeyron}$$

Kanonisk

$$P = \frac{1}{Z}\exp(-\epsilon_i/kT) \quad \text{Boltzmannsfordelingen}$$
$$Z = \sum_i \exp(-\epsilon_i/kT) \quad \text{Partisjonsfunksjonen}$$
$$Z_N = \frac{Z_1^N}{N!} \quad \text{Total partisjon}$$

Grand-kanonisk

$$\mathcal{Z} = \sum_i \exp -[\epsilon_i - N\mu]/kT \quad \text{Gibbs sum}$$
$$\bar{n}_{FD} = \frac{1}{\exp[(\epsilon-\mu)/kT] + 1} \quad \text{Fermi-Dirac}$$
$$\bar{n}_{BE} = \frac{1}{\exp[(\epsilon-\mu)/kT] - 1} \quad \text{Bose-Einstein}$$
$$\bar{n}_B = \exp[-(\epsilon-\mu)/kT] \quad \text{Boltzmann}$$
$$E = \int_0^\infty \epsilon f(\epsilon,\mu,T)D(\epsilon)d\epsilon$$
$$N = \int_0^\infty f(\epsilon,\mu,t)D(\epsilon)d\epsilon$$

Begreper

Isokor

Romlige dimensjoner (Volum, areal, lengde) holdes konstant

Isoterm

Temperaturen holdes konstant

Isobar

Trykket holdes konstant

Kvasistatisk

En prosess som skjer så sakte at systemet blir værende i likevekt.

Adiabatisk

Ingen endring i varme, i de fleste tilfeller heller ingen endring i entropi.

Isentropisk

Adiabatisk og kvasistatisk

Likevekt

- Mekanisk likevekt - $dP = 0$
- Termisk likevekt - $dT = 0$
- Diffusiv likevekt - $d\mu = 0$
- Kjemisk likevekt - $dG = 0$

Maxwellrelasjoner

Relasjoner bygget på Schwarz' teorem:

$$\frac{\partial}{\partial x}\left(\frac{\partial f}{\partial y}\right) = \frac{\partial}{\partial y}\left(\frac{\partial f}{\partial x}\right)$$

Eksempler:

$$\begin{aligned}
+\left(\frac{\partial T}{\partial V}\right)_S &= -\left(\frac{\partial P}{\partial S}\right)_V \\
+\left(\frac{\partial T}{\partial P}\right)_S &= +\left(\frac{\partial V}{\partial S}\right)_P \\
+\left(\frac{\partial S}{\partial V}\right)_T &= +\left(\frac{\partial P}{\partial T}\right)_V \\
-\left(\frac{\partial S}{\partial P}\right)_T &= +\left(\frac{\partial V}{\partial T}\right)_P
\end{aligned}$$

Nyttige sammenhenger:

- Konstant energi og volum
  $\Rightarrow \Delta S > 0$
- Konstant temperatur og volum
  $\Rightarrow \Delta F < 0$
- Konstant temperatur og trykk
  $\Rightarrow \Delta G < 0$

Differensialer

$$\begin{aligned}
\frac{1}{T} &\equiv \left(\frac{\partial S}{\partial E}\right)_{N,V} \\
C_V &\equiv \left(\frac{\partial E}{\partial T}\right)_{N,V} \\
P &= +T\left(\frac{\partial S}{\partial V}\right)_{E,N} = -\left(\frac{\partial F}{\partial V}\right)_{T,N} \\
\mu &= -T\left(\frac{\partial S}{\partial N}\right)_{E,V} = +\left(\frac{\partial F}{\partial N}\right)_{T,V} = \left(\frac{\partial G}{\partial N}\right)_{T,P} \\
S &= -\left(\frac{\partial F}{\partial V}\right)_{T,N} = -\left(\frac{\partial F}{\partial T}\right)_{V,N} = -\left(\frac{\partial G}{\partial T}\right)_{P,N} \\
V &= \left(\frac{\partial G}{\partial P}\right)_{T,N}
\end{aligned}$$

Identiteter

$$
\begin{aligned}
dE &= TdS - PdV + \mu dN \\
dF &= -SdT - PdV + \mu dN \\
dG &= -SdT + VdP + \mu dN
\end{aligned}
$$

Utledninger

Den termodynamiske identitet

$$dQ = TdS$$

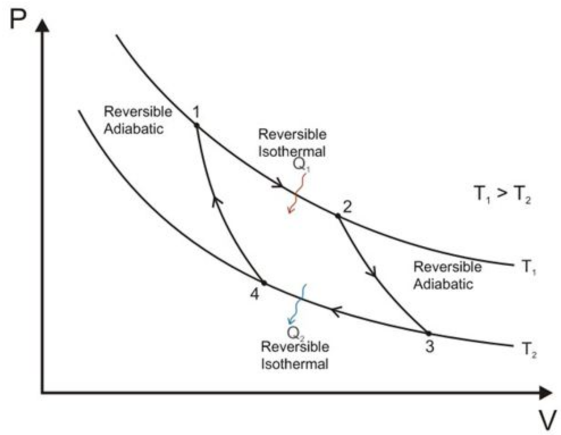

Figure 1: Carnotsyklusen

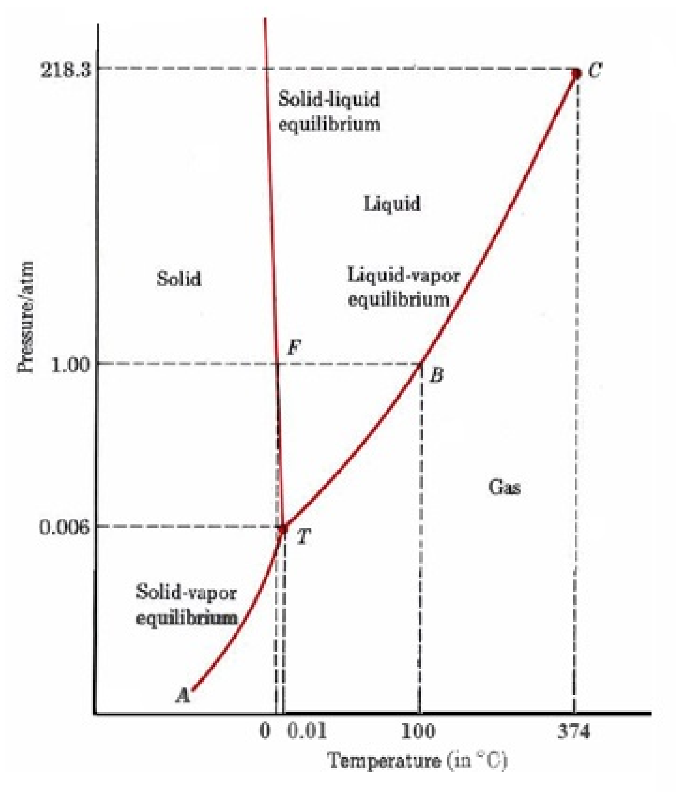

Figure 2: Faseoverganger for rene substanser

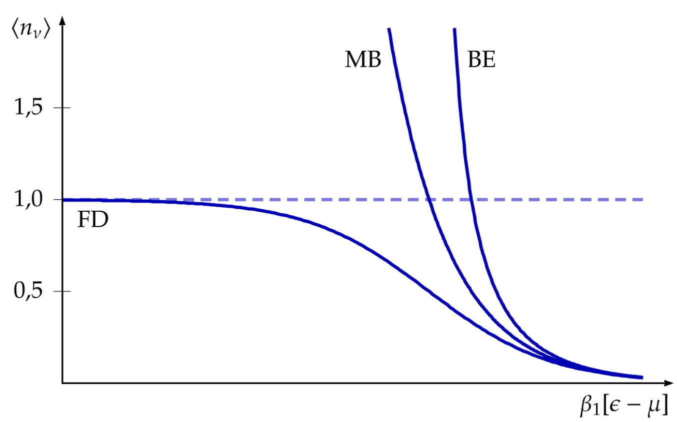

Figure 3: Fordelingsfunksjoner (Fermi-Dirac, Boltzmann, Bose-Einstein)