Entropi til ideell gass

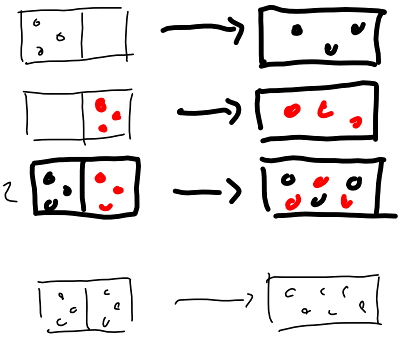
$$S = kN\left(\ln \frac{V}{N}\left(\frac{4\pi}{3h^2}\frac{E}{N}\right)^{3/2} + \frac{5}{2}\right)$$

$V = 2V_1 = 2V_2$

$N = N_1 + N_2$, $N_1 = N_2$

$E = E_1 + E_2$, $E_1 \neq E_2$

1, 2, 1+2



$\Delta S_i = kN \ln \frac{V}{V/2} = kN \ln 2$

$\Delta S_{tot} = \Delta S_1 + \Delta S_2 = 2kN \ln 2 > 0$

irreversibel prosess

Før: $S_{tot} = 2 \cdot S_1 = 2kN_1\left(\ln \frac{V_1}{N_1}\left(\frac{4\pi}{3h^2}\frac{E_1}{N_1}\right)^{3/2} + \frac{5}{2}\right)$

Etter: $N = 2N_1$, $V = 2V_1$, $E = 2E_1$

$\frac{V}{N} = \frac{2V_1}{2N_1} = \frac{V_1}{N_1}$, $\frac{E}{N} = \frac{2E_1}{2N_1} = \frac{E_1}{N_1}$

$S_{tot} = 2kN_1\left(\ln \frac{V_1}{N_1} \dots\right)$

$\Delta S_{tot} = 0$

Ideell blanding

N_1	N_2
V_1	V_2
E_1	E_2

$N = N_1 + N_2$

$V = V_1 + V_2$

$E = E_1 + E_2$

Termisk likevekt $T_1 = T_2$

Mekanisk likevekt $P_1 = P_2$

Ideell gass og ideell blanding (def)

Ingen volumendring ved blanding

$\rho_1 = \frac{N_1}{V_1} = \frac{N_2}{V_2} = \frac{N}{V}$

$$\Delta S_i = kN_i \ln \frac{V}{V_i}$$

$$\Delta S_{tot} = kN_1 \ln V/V_1 + kN_2 \ln V/V_2$$

$$= kN\left(\frac{N_1}{N}\ln\frac{N}{N_1} + \frac{N_2}{N}\ln\frac{N}{N_2}\right)$$

$$= kN\left(-x_1 \ln x_1 - x_2 \ln x_2\right)$$

$$= -kN(x_1 \ln x_1 + x_2 \ln x_2) \geq 0$$

$\frac{V}{V_1} = \frac{N}{N_1}$

$x_i = \frac{N_i}{N}$ antallsfraksjon, molfraksjon

$x_i < 1$, $\ln x_i < 0$

$$\mu_i = -T\left(\frac{\partial S}{\partial N_i}\right)_{E,V,N_{j \neq i}}$$

$\frac{\partial x_i}{\partial N_i} = \frac{\partial N_i/N}{\partial N_i} = \frac{1}{N}$

$\Rightarrow \partial N_i = N \partial x_i$

$$= -\frac{T}{N}\left(\frac{\partial S}{\partial x_i}\right)_{E,V,N_{j\neq i}}$$

$S_1 = S_{1,0} + \Delta S_1$

$$\mu_1 = -\frac{T}{N}\left(\frac{\partial S_{1,0}}{\partial x_1}\right)_{E,V,N_2} - \frac{T}{N}\left(\frac{\partial \Delta S}{\partial x_1}\right)_{E,V,N_2}$$

$$= \mu_{1,0} + TkN\left(\frac{\partial x_1 \ln x_1}{N \partial x_1}\right)_{E,V,N_2} = \mu_{1,0} + Tk(\ln x_1 + 1)$$

$$\mu_1 = \mu_{1,0}^* + \boxed{kT \ln x_1}$$

$$\underline{\Delta\mu_1 = kT \ln x_1}$$

Kjemisk likevekt

$$\boxed{\mu_1 = \mu_2}$$

$$\ln x_1 = \ln x_2$$

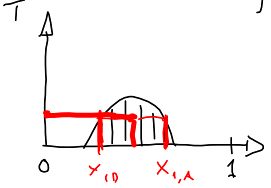
$$x_1 = x_2$$

$$\underline{c_1 = c_2}$$

$c_1 = \frac{N_1}{V}$

Diffusjon

Irreversibel blandingsprosess mot likevekt $\cancel{\mu_1 = \mu_2}$



$x_1 = \frac{N_1}{N_1+N_2}$

Def som driver mot likevekt

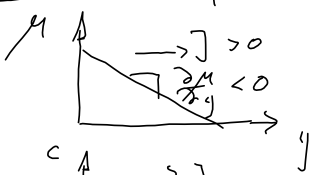
$\cancel{\Delta\mu} = \cancel{\mu_1 - \mu_2}$

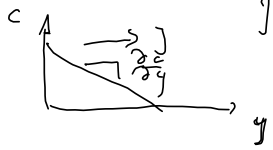
$[J] = \frac{\# part}{A t}$

Linear transport

$$\boxed{\vec{J} = -L \nabla \mu_i}$$

L - diffusjonskoeffisient





$$J_1 = -D\frac{\partial c_1}{\partial y} = -DN\frac{\partial x_1}{\partial y}$$

$$= -DN\frac{\partial x_1}{\partial \mu_1}\cdot\frac{\partial \mu_1}{\partial y}$$

$$= -\frac{DNx_1}{kT}\cdot\frac{\partial \mu_1}{\partial y} = -\frac{DN_1}{kT}\frac{\partial \mu_1}{\partial y}$$

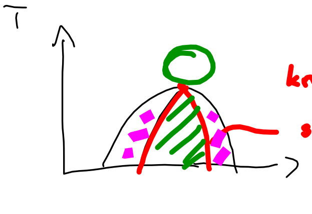
$[D] = \frac{m^2}{s}$

$$\boxed{\frac{\partial \mu_1}{\partial x_1} = \frac{kT}{x_1}}$$ ideell blanding

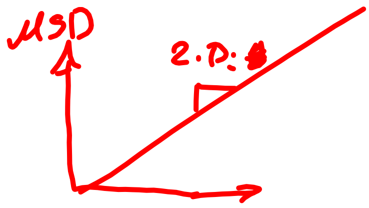
$L = \frac{DN_1}{kT}$

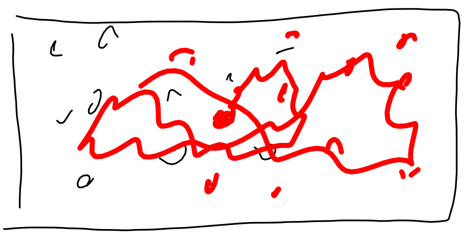
ideell blanding

$$D = \frac{1}{N}\left(\frac{\partial \mu_1}{\partial x_1}\right)L \to 0$$



$\frac{\partial \mu_1}{\partial x_1} = 0$





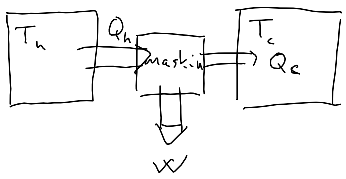
Vi ser vandrer $\langle (r(t) - r_0)^2 \rangle = MSD$

D_1, D_2 selvdiffusjon

D - diffusjon for blanding

$D = f(D_1, D_2)$

Carnot & kjølemaskiner, varmemaskiner



Reservoir T endres ikke

Syklisk $dU = 0$
$dS = 0$

Kan vi få $W = Q_h$?

effektivitet $e = \frac{W}{Q_h} \leq 1$

1. lov: $Q_h = Q_c + W$

2. lov: Entropien som følger varmefluks $dS = \frac{Q}{T}$

$dS_{maskin} = 0 \qquad S_{ut} \geq S_{inn}$ Entropiproduksjon

$$\frac{Q_c}{T_c} \geq \frac{Q_h}{T_h}$$

$$W = Q_h - Q_c$$

$$e = \frac{W}{Q_h} = \frac{Q_h - Q_c}{Q_h} = 1 - \frac{Q_c}{Q_h} \leq 1 - \frac{T_c}{T_h}$$

Hva bør temperaturen være for best effekt.

?

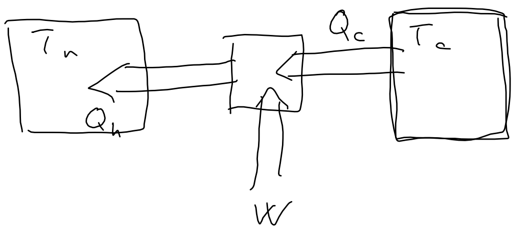
1 * Størst mulig $\Delta T = T_h - T_c$

2 * Minst — " —

3 * $T_h \to \infty$

4 * $T_h \to 0$

$$e \leq \frac{T_c}{T_h - T_c}$$



$dU = 0$
$dS = 0$

1. lov $W = Q_h - Q_c$

2. lov $\frac{Q_h}{T_h} \geq \frac{Q_c}{T_c} \Rightarrow \frac{Q_h}{Q_c} \geq \frac{T_h}{T_c}$

$$e = \frac{Q_c}{W} = \frac{Q_c}{Q_h - Q_c} = \frac{1}{\frac{Q_h}{Q_c} - 1} \leq \frac{1}{\frac{T_h}{T_c} - 1}.$$

$$e \leq \left(\frac{T_h}{T_c} - 1\right)^{-1} = \frac{T_c}{T_h - T_c}$$