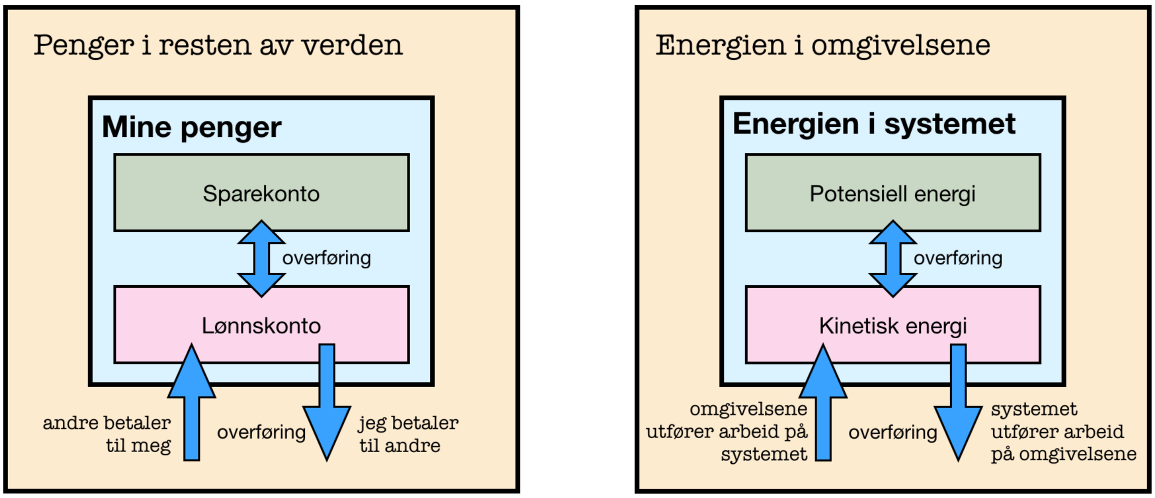
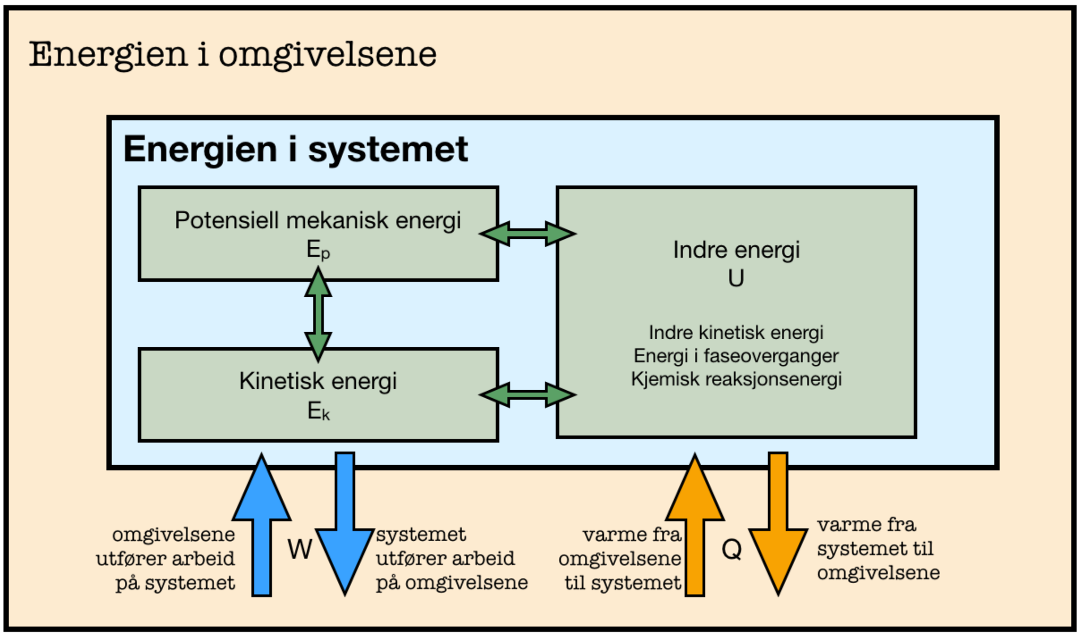
Hvordan kan bensin bli til bevegelse?

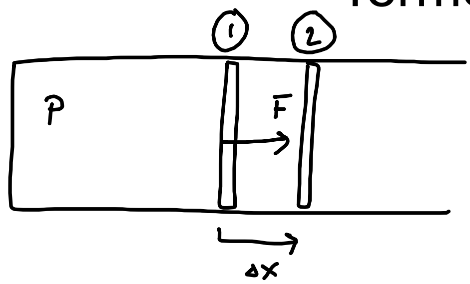
February 25, 2019



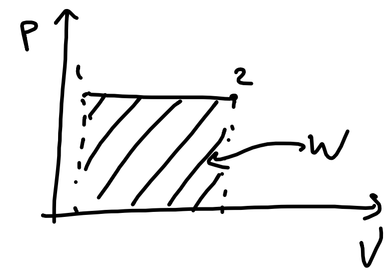


Energien i omgivelsene
Energien i systemet
Potensiell mekanisk energi
Ep
Kinetisk energi
Ek
Indre energi
U
Indre kinetisk energi
Energi i faseoverganger
Kjemisk reaksjonsenergi
omgivelsene utfører arbeid på systemet
W
systemet utfører arbeid på omgivelsene
varme fra omgivelsene til systemet
Q
varme fra systemet til omgivelsene

Termodynamisk arbeid



$F = pA$

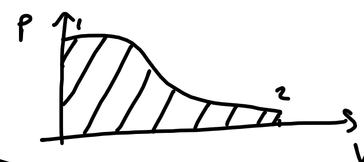


$W = F\Delta x$

$= pA\Delta x \qquad A\Delta x = \Delta V$

$$\boxed{W = p\Delta V}$$

← konstant trykk

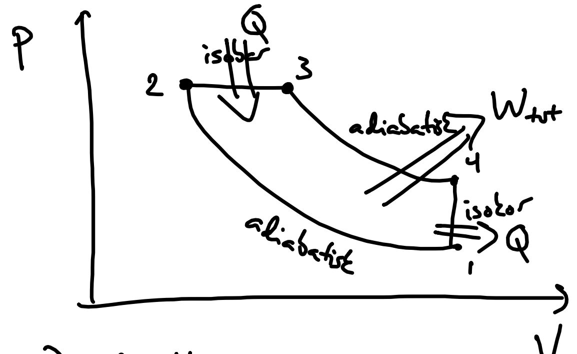


Definert:

$W > 0$

når systemet gjør arbeid på omgivelsene

pV-løkker



Diesel-syklus

	W	Q	ΔU
1-2	<0	0	>0
2-3	>0	>0	>0
3-4	>0	0	<0
4-1	=0	<0	<0
totalt	>0	>0	0

$$Q = \Delta U + W$$

1-2 ⇒ $0 = \Delta U + W$

2-3 ⇒

$pV = nRT$ $p_3 = p_2$, $V_3 > V_2$

$$\frac{V}{T} = \frac{nR}{p} = \text{konst.}$$

$$\frac{V_2}{T_2} = \frac{V_3}{T_3} = T_3 = \frac{V_3}{V_2} T_2 \Rightarrow T_3 > T_2$$

($\frac{V_3}{V_2}$ → øker, >1)

4-1:

$V_4 = V_1$

$p_4 > p_1$

$pV = nRT$

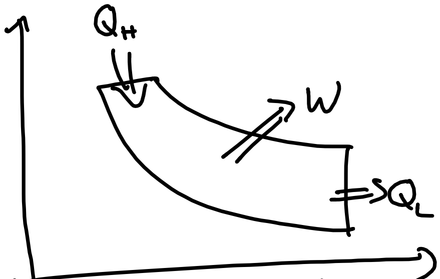
$$\frac{p}{T} = \frac{nR}{V} = \text{konst.}$$

$$\frac{p_4}{T_4} = \frac{p_1}{T_1} \Rightarrow T_4 = \frac{p_4}{p_1} T_1$$

($\frac{p_4}{p_1} > 1$)

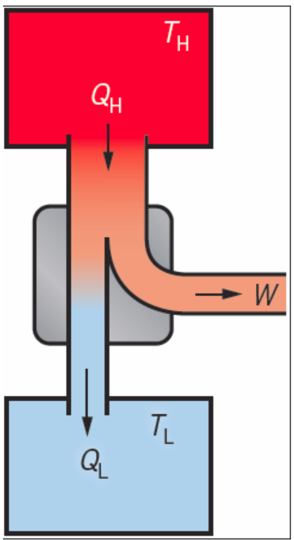
$T_4 > T_1$

Diesel-syklusen



$$Q_H = W + Q_L$$

Varmemaskiner



$$Q_H = W + Q_L$$

virkningsgrad

$$\eta = \frac{W}{Q_H}$$

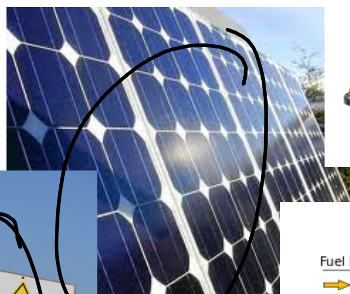
$\eta_{dieselmotor} = 35-40\%$

$\eta_{bensinmotor} = 20-30\%$

$\eta_{el} = 90-99\%$

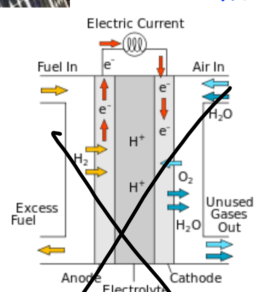
Hvilke av disse er varmemaskiner?

Bilmotor



Solceller

Kjernekraftverk

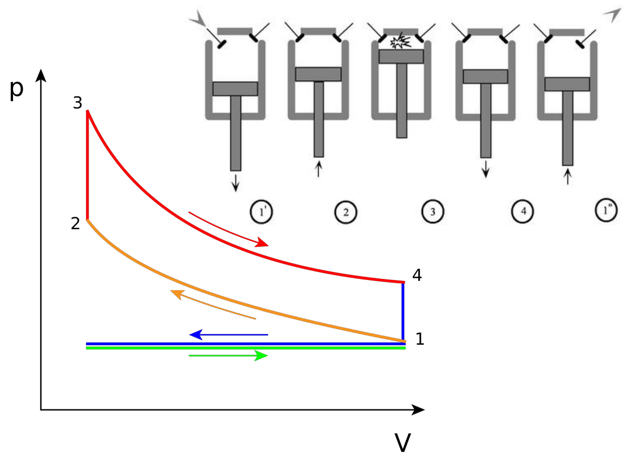


Brenselscelle

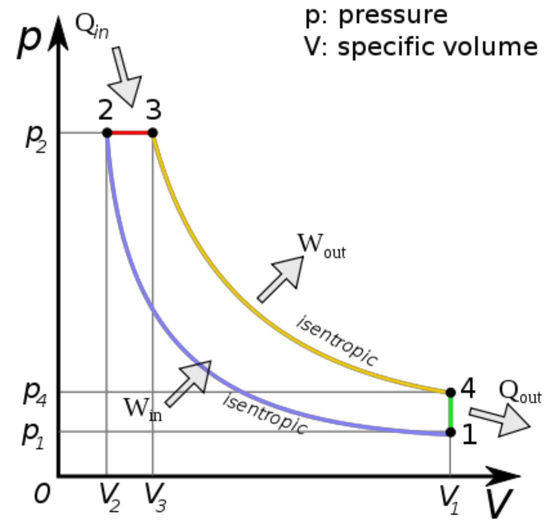
Elektromotor

Kroppen vår

Forbrenningsmotorer



Bensinmotor: Ottosyklus



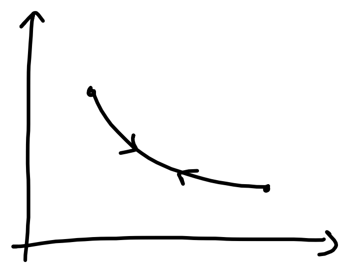
Dieselsyklus

Reversibilitet

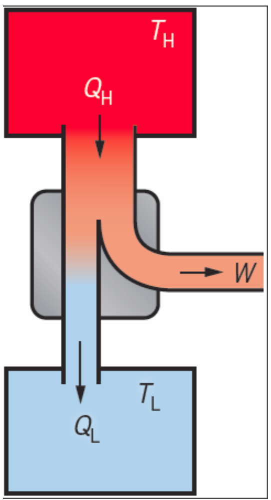
En termodynamisk prosess er reversibel dersom man kan komme tilbake til nøyaktig den samme tilstanden som man startet fra ved å kjøre prosessen baklengs.

I Carnotsyklusen er alle prosessene reversible.

Slike prosesser finnes ikke i virkeligheten.



Maksimal virkningsgrad

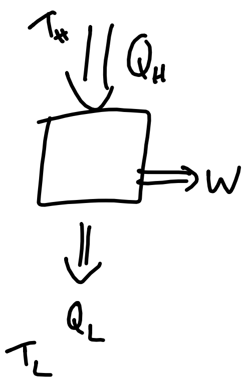


Carnotvirkningsgrad

$$\eta_c = 1 - \frac{T_L}{T_H}$$

En varmemaskin opererer mellom 100 og 0 °C,
med Q_H = 100 J, Q_K = 70 J og W_{ut} = 30 J.

Er dette mulig?



$$Q_H = W + Q_L$$

$$\eta = \frac{W}{Q_H} \qquad \eta_c = 1 - \frac{T_L}{T_H} \qquad \eta < \eta_c$$

$$T_H = 100^\circ C = 100 + 273\,K = 373\,K$$

$$T_L = 0^\circ C = 273\,K$$

$$\eta_c = 1 - \frac{273\,K}{373\,K} = 0{,}27$$

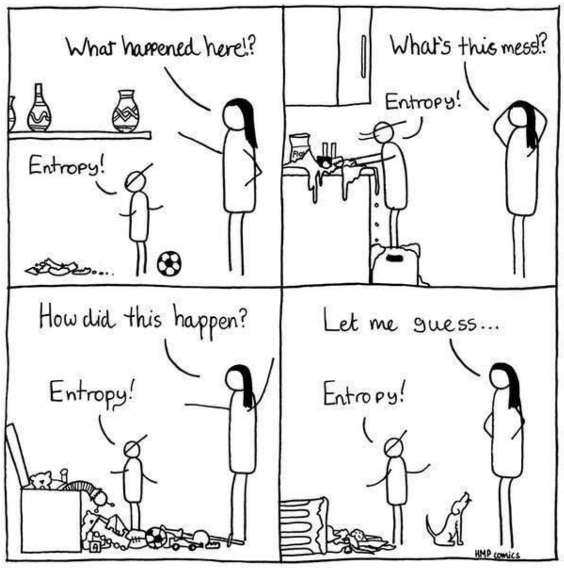
$$\eta = \frac{30\,J}{100\,J} = 0{,}30$$

<u>nei</u>

February 25, 2019

Hvordan kan bensin bli til bevegelse?

Kan du kjøle ned kjøkkenet ved å åpne kjøleskapet?



This is why we don't teach our children about entropy until much later...

February 25, 2019

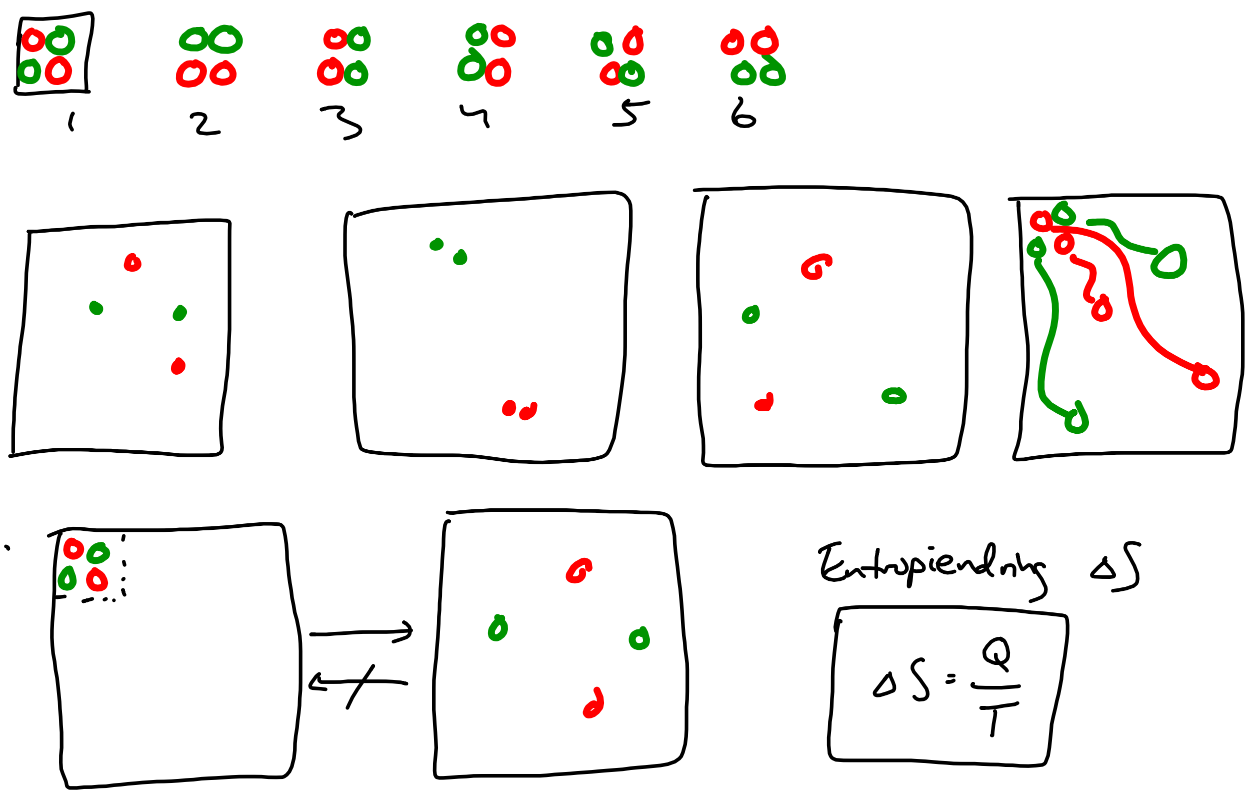
tilstand: rotete

mange muligheter

tilstand: ryddig

bare en (eller få) mulige

Entropi: Mål på antall mulige tilstander
(antall frihetsgrader)



Termofysikkens 2. lov

Ingen syklisk varmemaskin kan ha som eneste resultat at varme blir fullstendig omformet til arbeid.

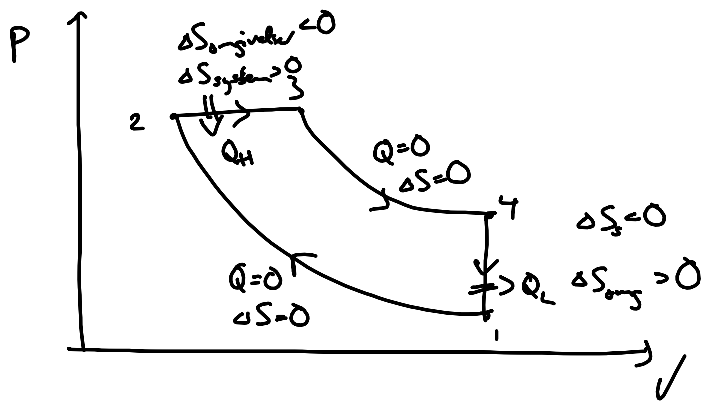
I alle prosesser blir den samlede energikvaliteten lavere.

Varme går ikke av seg selv fra et legeme med lav temperatur til et legeme med høy temperatur.

Den samlede entropien til et system og dets omgivelser øker i alle naturlige (irreversible) prosesser

$$\Delta S_{system} + \Delta S_{omgivelsene} > 0$$

Entropistrøm i varmemaskin



totalt

$\Delta S_{omgivelser} > 0$

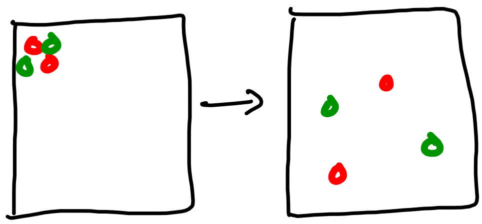
$\Delta S_{systemet} = 0$

$$\Delta S_{omgivelse} = -\frac{Q_H}{T_H} + \frac{Q_L}{T_L}$$

$\Delta S = 0$ (reversibel)

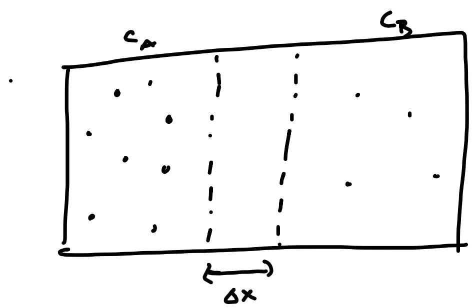
$\Longrightarrow \eta_c$

Diffusjon: Ficks lov



Diffusjonsfluks

$$J = \frac{\text{partikler}}{\text{areal} \cdot \text{tid}}$$



konsentrasjon

$$c = \frac{N}{V}$$

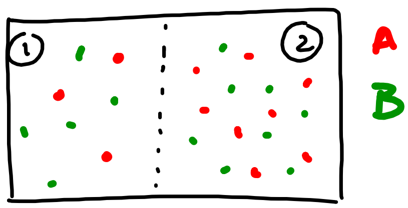
$$J = -D \frac{\Delta c}{\Delta x}$$

$$D_{O_2} \text{ i luft} = 0{,}176 \text{ cm}^2/\text{s}$$

$$D_{O_2} \text{ i vann} = 2{,}10 \cdot 10^{-5} \text{ cm}^2/\text{s}$$

https://en.wikipedia.org/wiki/Fick%27s_laws_of_diffusion#/media/File:DiffusionMicroMac

Osmose



$pV = nRT$

$\frac{n}{V} = c$

$p = \frac{n}{V}RT = cRT$

① $p_1 = p_{A1} + p_{B1} = (c_{A1} + c_{B1})RT$

② $p_2 = p_{A2} + p_{B2} = (c_{A2} + c_{B2})RT$

Bare A slipper gjennom

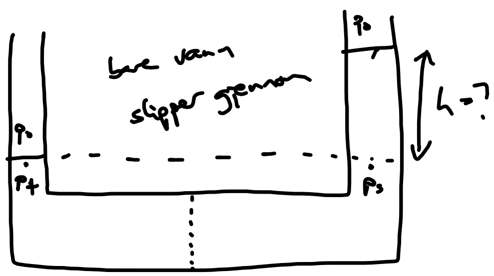
Likevekt $p_{A1} = p_{A2}$

$\Delta\Pi = p_2 - p_1 = (c_{B2} - c_{B1})RT$

Van't Hoffs lov

osmotisk trykk

Osmotisk trykk



ferskvann saltvann

$c_s = 0$ $c_s = 1{,}13\ \mathrm{mol/L}$

$= 1{,}13 \cdot 10^3\ \mathrm{mol/m^3}$

$$\Delta\Pi = p_s - p_f = c_s RT = \rho g h$$

$$h = \frac{c_s RT}{\rho g}$$

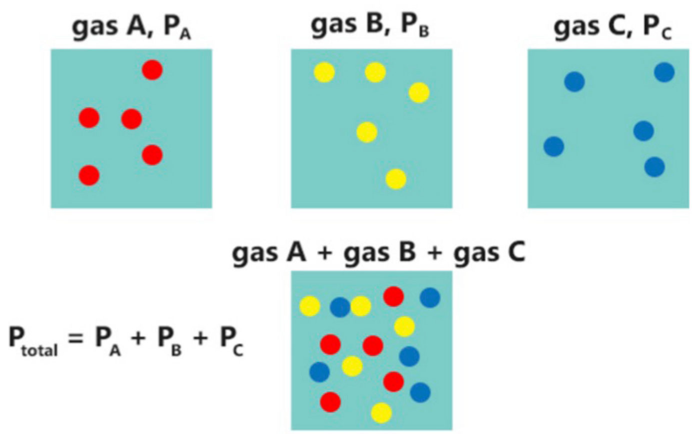
$R = 8{,}31\ \mathrm{J/K\,mol}$

$\rho_s = 1029\ \mathrm{kg/m^3}$

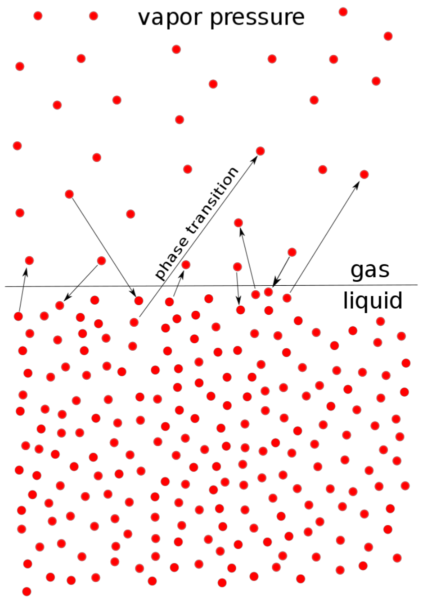
$T = 293\ \mathrm{K}$

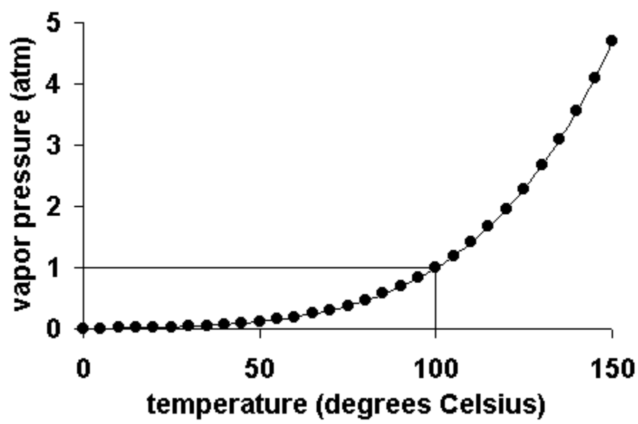
$h = 273\ \mathrm{m}$

Partialtrykk

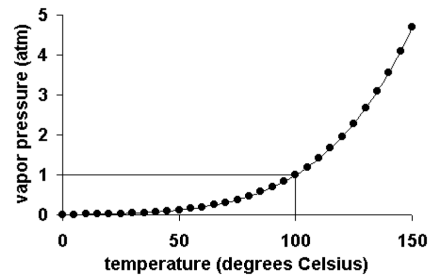


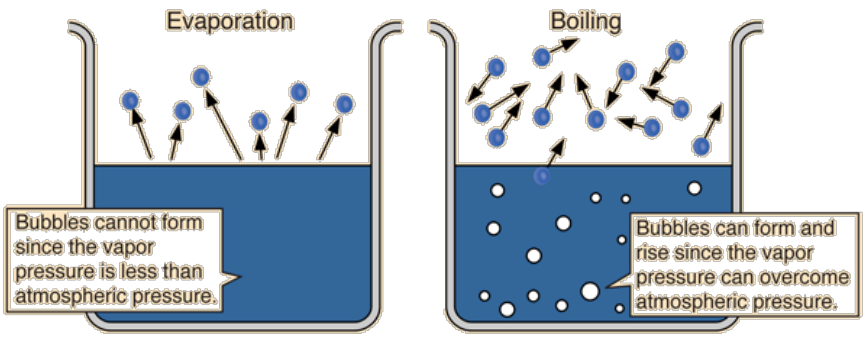
Damptrykk


vapor pressure
phase transition
gas
liquid


vapor pressure (atm)
temperature (degrees Celsius)
0
1
2
3
4
5
0
50
100
150

Kokepunkt og trykk





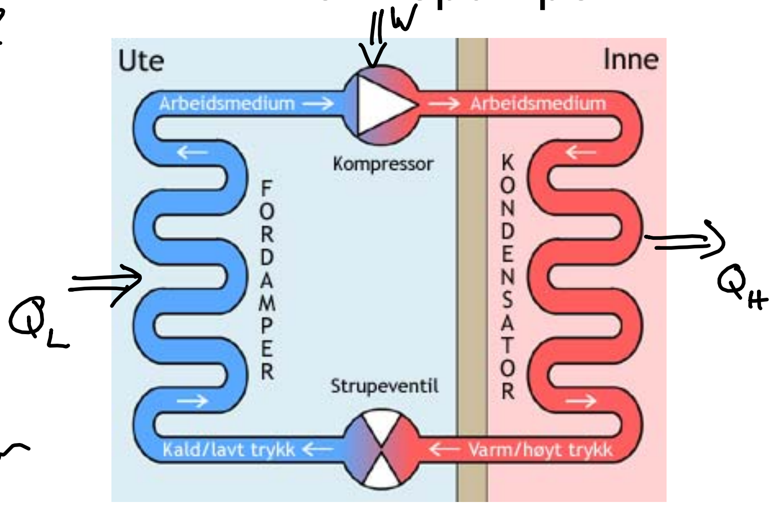
Varmepumpe

Fasevarme ℓ

$Q = \ell m$

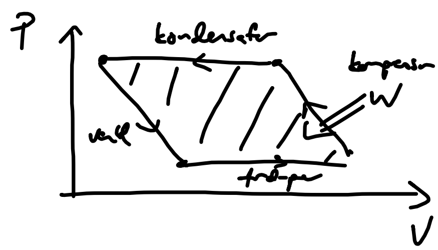
$Q_L + W = Q_H$

$Q_H = W + Q_L$



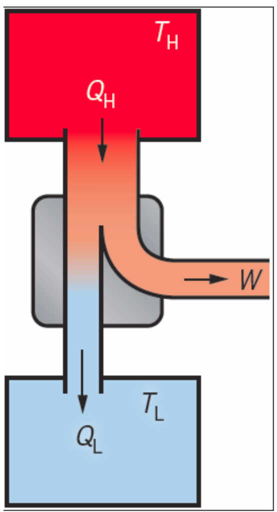
Effektfaktor

$f = \frac{Q_H}{W}$ typisk 2-5

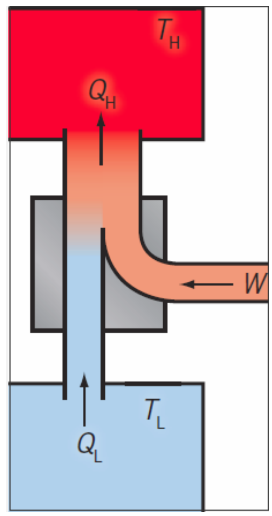


totalt $W < 0$

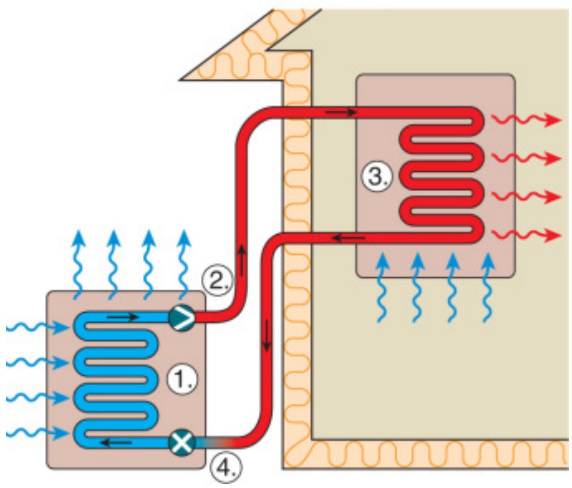
Varmemaskin



Varmepumpe



Varmepumpe



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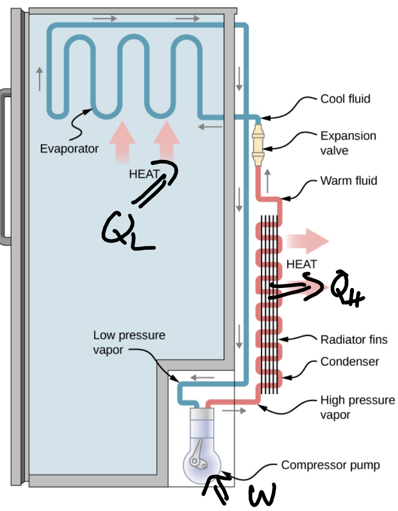

$$Q_H = Q_L + W$$