Latent heat quantities:

Requires transition of a certain quantity of matter starting from phase i towards phase k with heat quantity Q_{ik}

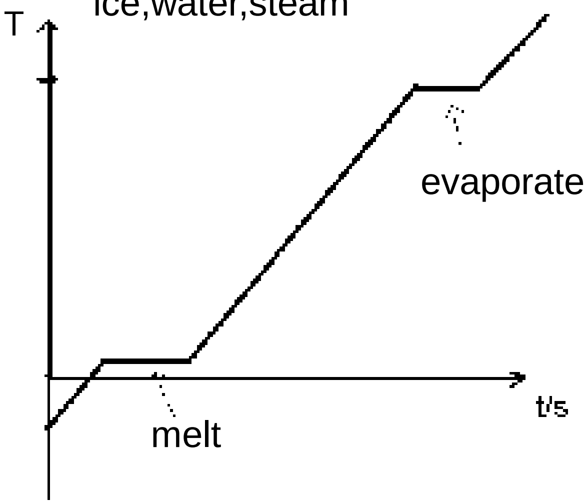
reverse from phase k into phase i a heat quantity Q_{ki}, to obtain $Q_{ki} = -Q_{ki}$

At k→i gets (latent) heat free again!

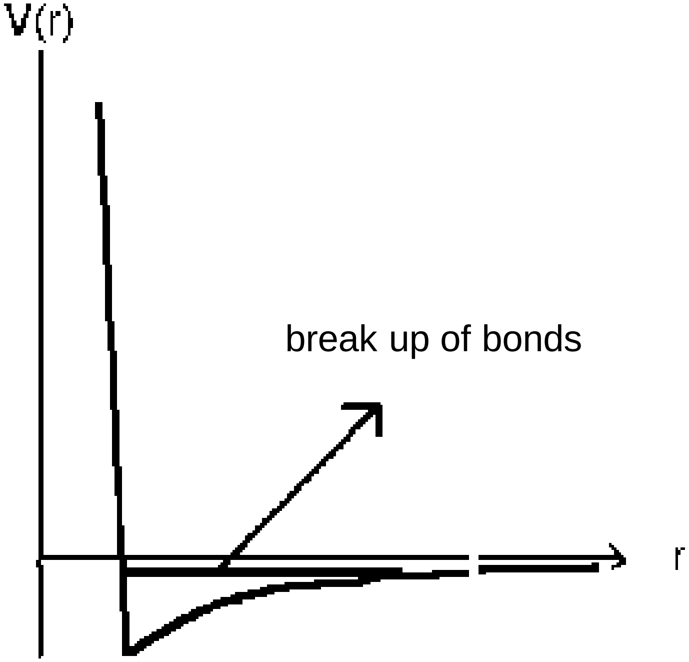
$\lambda_{ik} = \frac{Q_{ik}}{m}$: specific melt- $(\lambda_{solid,liquid})$,-vapor- $(\lambda_{liquid,steam})$

and heat of sublimation $(\lambda_{solid,steam)})$ $(\lambda_{solid,steam)})$: $[\lambda_{ik}] = \frac{J}{kg}$

constant addition of heat
ice,water,steam



Because within a time region ΔT=0 →
the added heat quantity
increases potential energy



heat of evaporation comes out of surroundings

Exp.:
Äthyläther (5.87 $\cdot 10^4 Pa, T = 20^0$)

Example: Water:

$\lambda_{solid,liquid} = 3.3 \cdot 10^5, \lambda_{liquid,steam} = 2.3 \cdot 10^6$

Vapor pressures (saturated vapor): p_s water
(0 ^{0}) : $610 Pa,$

P_s water(20 ^{0}) : $2337 Pa$

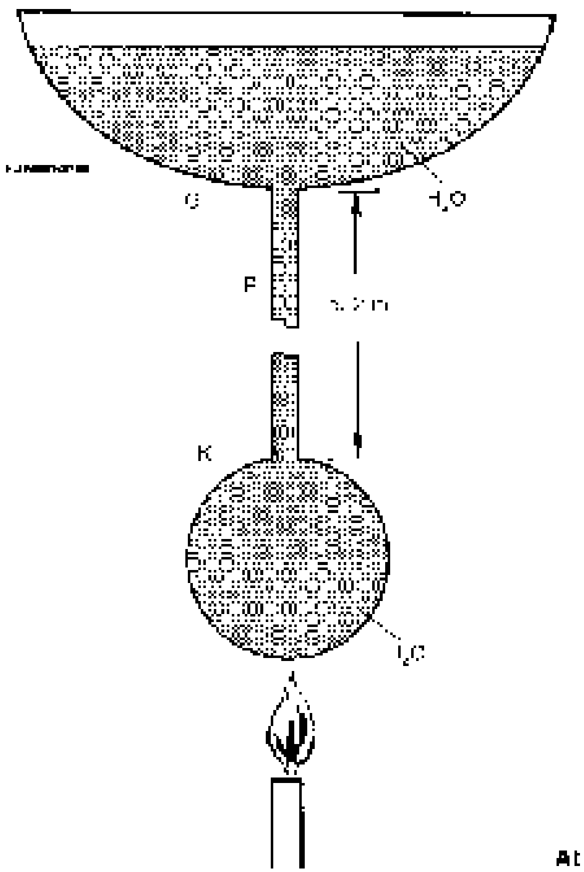
Equilibrium of phases at interfaces e.g:
liquid - steam , all the same molecules come in and out.

Boil/Condensation

given $p_s \succ$ outer pressure → steam-bubbles inside

if vapor pressure of liquid =outer pressure → boil!

e.g: Geyser (changing pressure on piston)



changes of phases need seeds of condensation / cristallisations

Therefore, one observes by missing of those:

delay of condensation and boil

If $p_s \prec$ Outer vapor pressure : Condensation
e.g.:
Air humidity

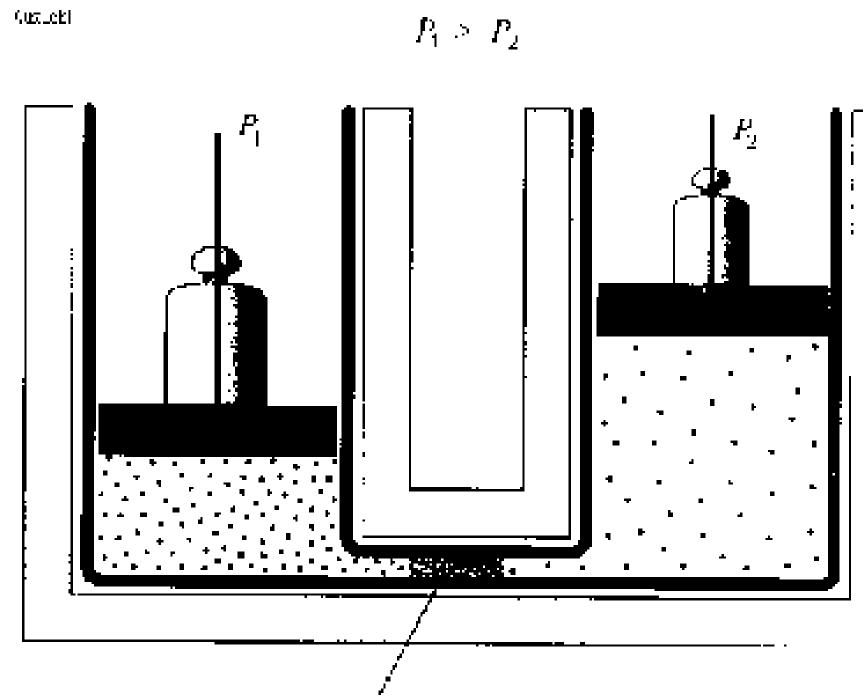
$$\varphi_{rel} = \frac{\varphi_a}{\varphi_S} = \frac{P_W}{P_S}$$ with φ_a absolute humidity(g/m^3

$\varphi_S =$ Saturated humidity(g/m^3)

One has an air humidity of 40% , if the partial pressure reaches

$$P_W = 0.4 \cdot P_S(H_2O)$$

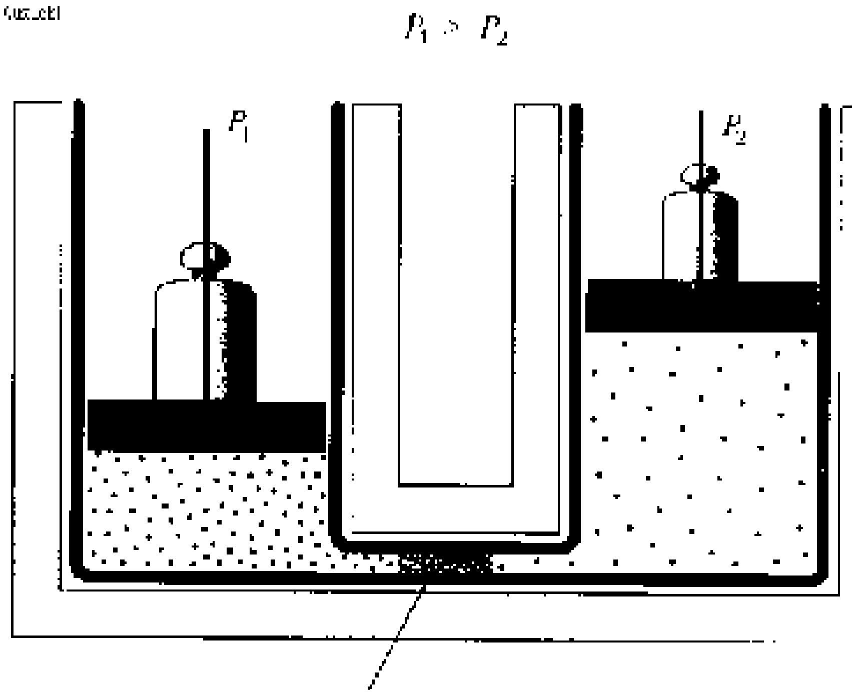
$\varphi_{rel} = 1$: Dew point !



Drop in pressure via e.g. cotton wool

Joule-Thomson-Effect and liquifaction of gases

Considered are adiabatic, throttelt decompression of gases:



Drop in pressure via e.g. cotton wool

Adiabatic expansion via Throttling valve (here wool)

Beginning: Gas $V_1, V_2 = 0$

vessel walls athermanous

$$\Delta Q = 0$$

Final: Gas completely in V_2

1. Fundamental law $\Delta U = -P_2 * V_2 + P_1 * V_1$

or

$$U_2 - U_1 = -P_2 \bullet V_2 + P_1 \bullet V_1 \Leftrightarrow$$

$$\boxed{U_1 + P_1 \bullet V_1 = U_2 + P_2 \bullet V_2 = H; Enthalpy}$$

Or (ideal gas):

On the left of the picture added displacement work

$$P_1 \bullet V_1 = P_2 \bullet V_2,$$

$$\rightarrow U_1 = U_2 \leftarrow > T_1 = T_2$$

Ideal gas: $U = c_V \bullet T, P \bullet V = R \bullet T \Rightarrow$

H= $(c_V + R) \bullet T = c_P \bullet T \Rightarrow dT = 0$

Changes with real gas?

1.Internal pressure $\frac{a}{V^2}$:

After throttling work against van der Waals - forces

$$\Rightarrow U_1 \succ U_2 \Rightarrow T_2 \prec T_1$$

2.Covolume b:

$$P = \frac{\nu \cdot R \cdot T}{V-b}$$

larger compared to ideal gas:

Equal number of particles N pressure of real gases

$$\Rightarrow P_1 \cdot V_1 \succ P_2 \cdot V_2 \Rightarrow U_1 \prec U_2$$

or $T_2 \succ T_1$

Calculation :Van der Waals-equation

$$P = \frac{RT}{V-b} - \frac{a}{V^2};$$

U can be written as

$$U = "E_{kin}" + E_{pot} = \frac{f(\text{degrees of freedom})}{2} RT + \int_{\infty}^{V_1} \frac{a}{V^2}\, dV = -a/V_1$$

$$\Rightarrow H = U + P \bullet V = \frac{f \cdot RT}{2} - \frac{a}{V} + \left(\frac{RT}{V-b} - \frac{a}{V^2}\right) \bullet V$$

$$= RT\left(\frac{f}{2} + \frac{V}{V-b}\right) - \frac{2a}{V}$$

$$\boxed{dH = \frac{\partial H}{\partial V} \bullet dV + \frac{\partial H}{\partial T} \bullet dT = 0}$$

$$\Rightarrow dT = -\frac{\frac{\partial H}{\partial V} \cdot dV}{\frac{\partial H}{\partial T}} = \frac{\frac{bT}{(V-b)^2} - \frac{2a}{R \cdot V^2}}{\frac{f}{2} + \frac{V}{V-b}} dV$$

with approx. $V \approx V - b$

$$\Rightarrow dT \approx \frac{b \cdot R \cdot T - 2a}{\left(\frac{f}{2} + 1\right) R \cdot V^2} dV \Rightarrow$$

Inversion temperature:

$$\boxed{T_I = \frac{2a}{bR}}$$

e.g. for

$T \prec T_I$: cooling

$T \succ T_I$: heating

Examples:

Temperature of inversion

CO_2	N_2	O_2	He	H_2
2050K	850K	1040K	35K	35K

Observations: air out of a tire with quick release >
Valve cools, would the tire be filled with helium,
the valve would grow warm !