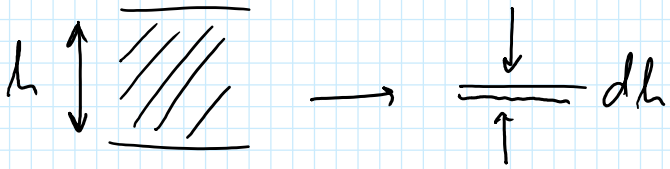
Gase $\rho \neq \text{const}$

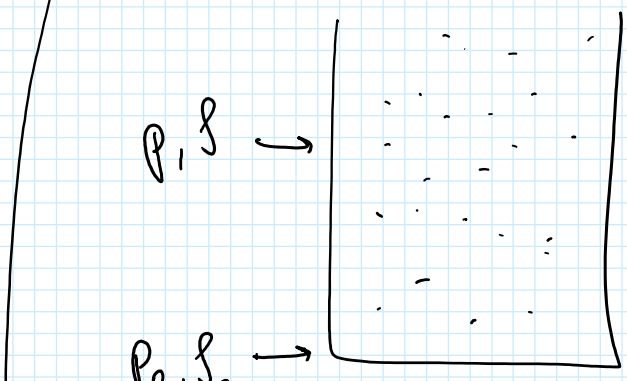
$p = \frac{F}{A} = \rho g h$ (Flüssigkeiten)

$h \rightsquigarrow dh$ (Differential)



$dp = -\rho g\, dh$ in einer (infinitesimal) dünnen Schicht

$\frac{dp}{dh} = -\rho g$



Boyle: $p \sim \frac{1}{V}$

$p \sim \frac{\rho}{m}$

$p \sim \rho$

$\frac{p}{\rho} = \frac{p_0}{\rho_0}$

$\rho = \rho_0 \frac{p}{p_0}$

$$\rho = \rho_0 \frac{p}{p_0}$$

$$\frac{dp}{dh} = \left(-g \frac{\rho_0}{p_0}\right) p$$

Diff. gleichung 1. Ordnung

Anm.: $A \rightarrow B$

$$\frac{dc_A}{dt} = -c_A k$$

$$\frac{dp}{p} = \left(-g \frac{\rho_0}{p_0}\right) dh$$

$$\int_{p_0}^{p} \frac{1}{p} dp = \int_{0}^{h} -g \frac{\rho_0}{p_0} dh$$

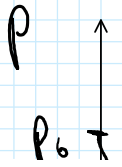
$$\ln p - \ln p_0 = -g \frac{\rho_0}{p_0} h$$

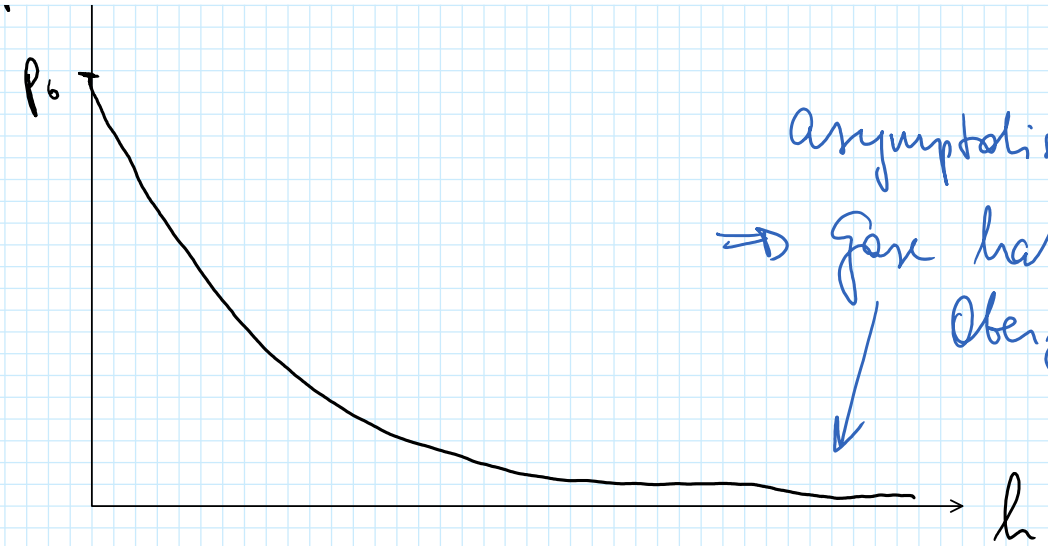
$$\ln \frac{p}{p_0} = -g \frac{\rho_0}{p_0} h \qquad \left(\ln x = y \rightarrow x = e^y\right)$$

$$\frac{p}{p_0} = e^{-g \frac{\rho_0}{p_0} h}$$

$$\boxed{p(h) = p_0 \cdot e^{-g \frac{\rho_0}{p_0} h}}$$

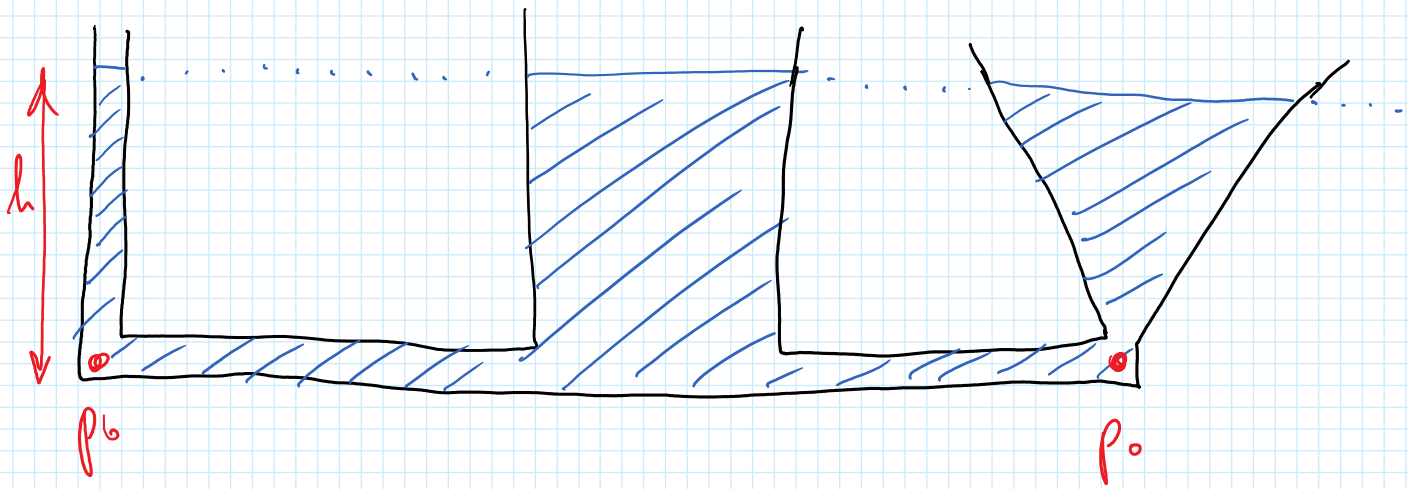
barometrische Höhenformel





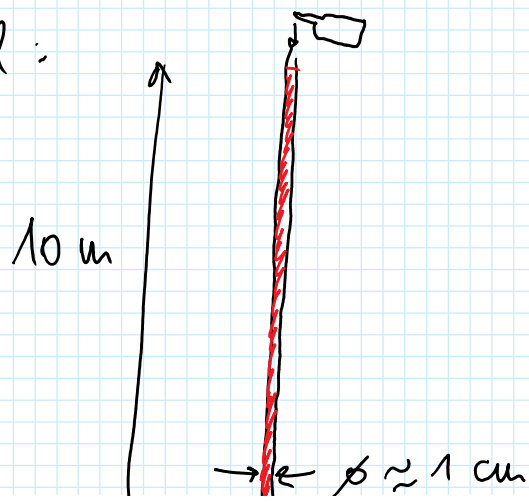
asymptotisch
⇒ ganz hoher kein Oberfläche

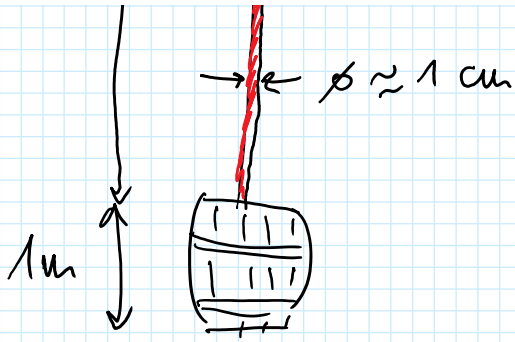
Hydrostatisches Paradoxon



$$p = \rho g h$$

Versuch von Pascal:

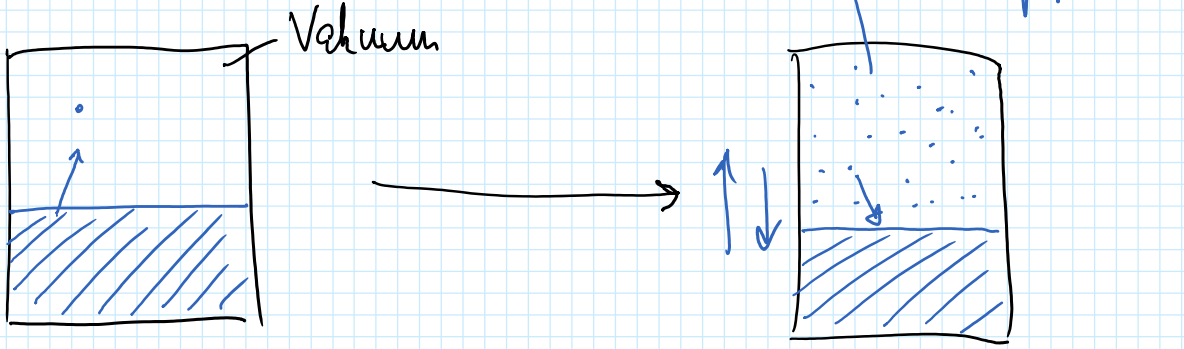


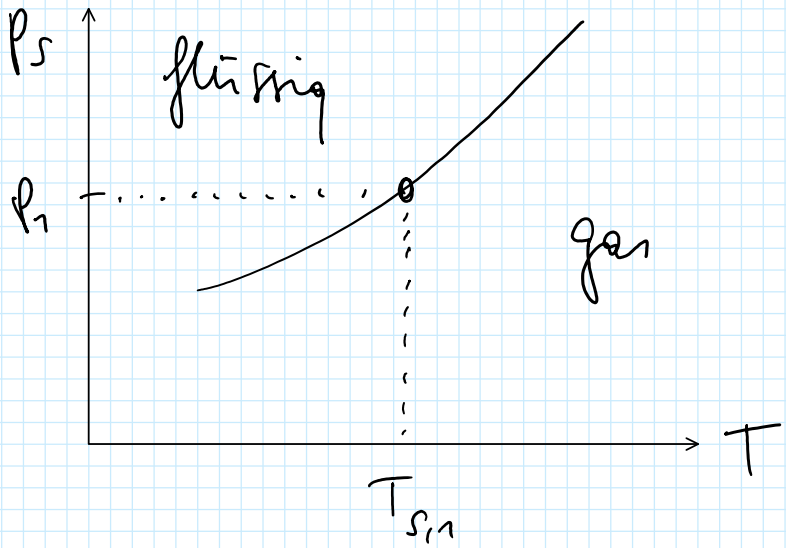


$p_0 \rightarrow 11\, p_0$

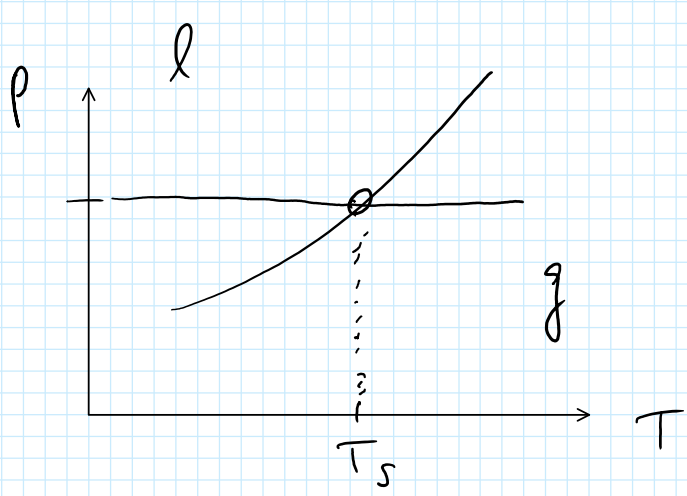
$V_0 \rightarrow 1{,}01\, V_0$

Dampfdruck





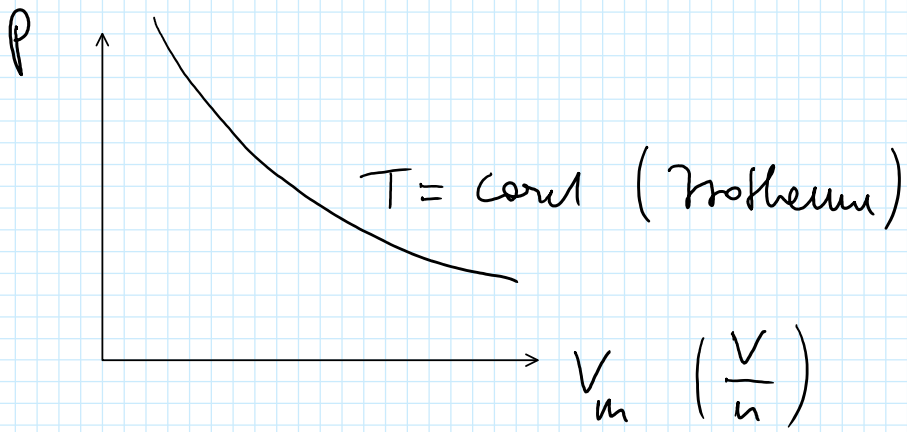
Sieden / Verdampfen

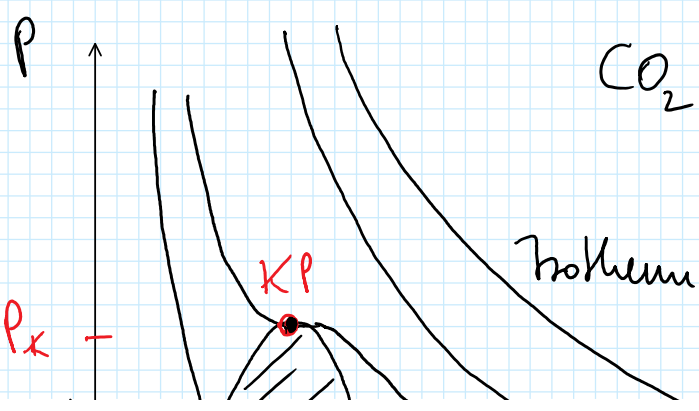


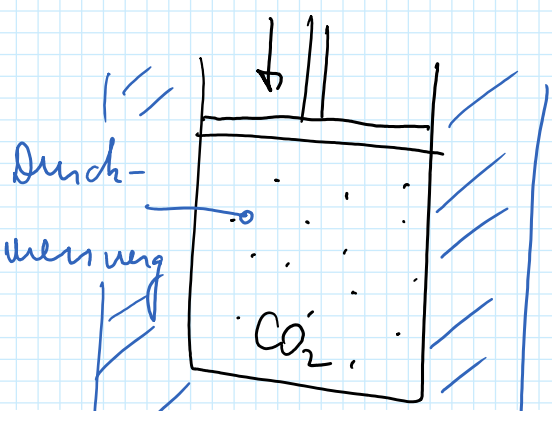
Verdunstung

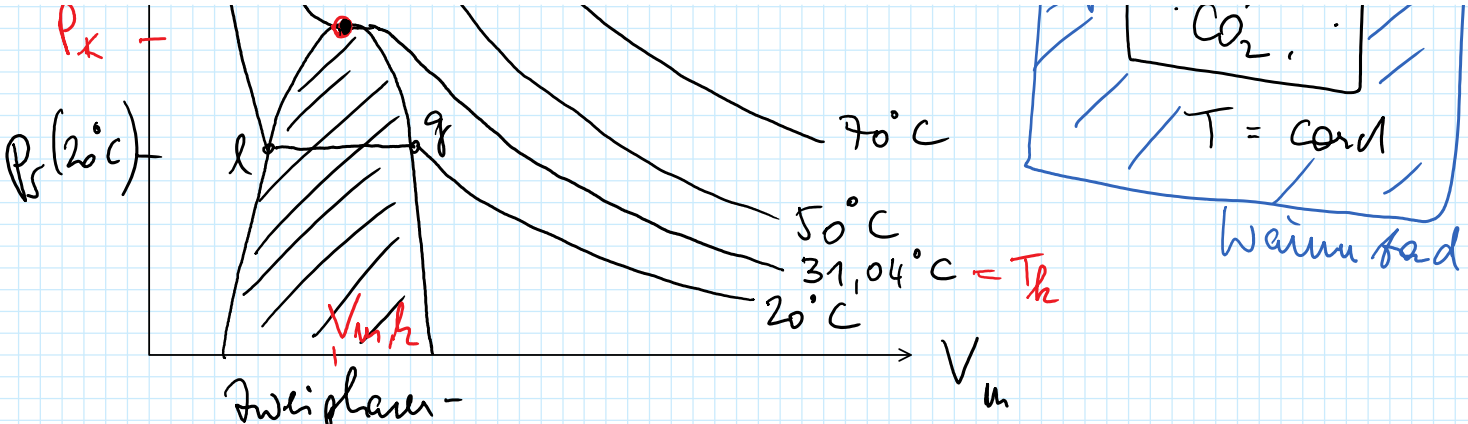
$l \rightarrow g$ für $T < T_S$

II.4 Kritische Zustandsgrößen









Zweiphasen-koexistenz-gebiet (l + g)

KP: kritischer Punkt { T_k, p_k, $V_{m,k}$

$T > T_k$: keine Flüssigkeiten

$T = T_k$: überkritisches Fluid

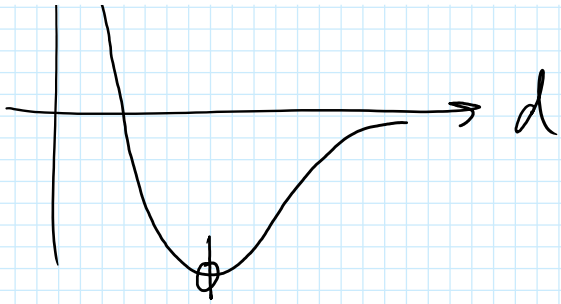
II.5 Reales Gas

$pV = nRT$ gilt v.a. bei großem T und großen V_m

⇓ reales Gas

1) Wechselwirkungen (anziehend / abstoßend)

V



2) Eigenvolumen

II.6 van der Waals Gleichung

1873 Johannes van der Waals

$$p \cdot V = nRT$$

$$\left(p + \left(\frac{n}{V}\right)^2 a\right) \cdot (V - nb) = nRT$$

a, b: van der Waals Koeffizienten

Binnendruck

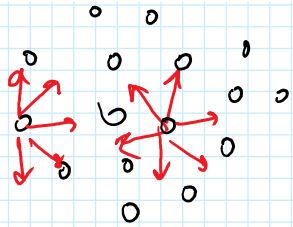
Kovolumen

Molekülradius

$\sim n$

Einheiten: $\left(\frac{[n]}{[V]}\right)^2 \cdot [a] = Pa$

$\rightarrow Pa \cdot m^6$



$$[a] = \frac{Pa \cdot m^6}{mol^2}$$

Anzahl der Teilchen $\sim \frac{n}{V}$

$$[a][b] = m^3$$

$$[b] = \frac{m^3}{mol}$$

$$\frac{\text{Kraft}}{\text{Teilchen}} \sim \frac{n}{V}$$

$$\text{Wandkraft} = \frac{\text{Kraft}}{\text{Teilchen}} \times \text{Anzahl der Teilchen}$$

$$\sim \left(\frac{n}{V}\right)^2$$

Virialgleichungen

Potenzreihenentwicklung:

$$f(x) = 1 + A_1 x + A_2 x^2 + A_3 x^3 + \ldots$$

$$f(x) = 1 + \sum_{n=1}^{\infty} x^n A_n$$

$$pV = nRT \qquad \left(\frac{n}{V}\right)$$

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

$$p = RT\frac{n}{V} \cdot f\left(\frac{n}{V}\right)$$

$$\boxed{p = RT\frac{n}{V}\left(1 + B\frac{n}{V} + C\left(\frac{n}{V}\right)^2 + \ldots\right)}$$

gewichten die Beiträge