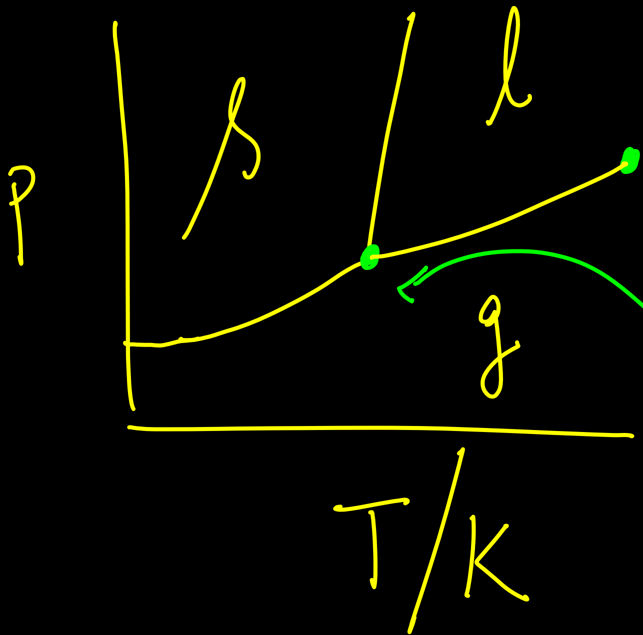



critical temp. $T_c$

Triple point $T_{tp}$

invariant

water : 273.16 K

611 Pa

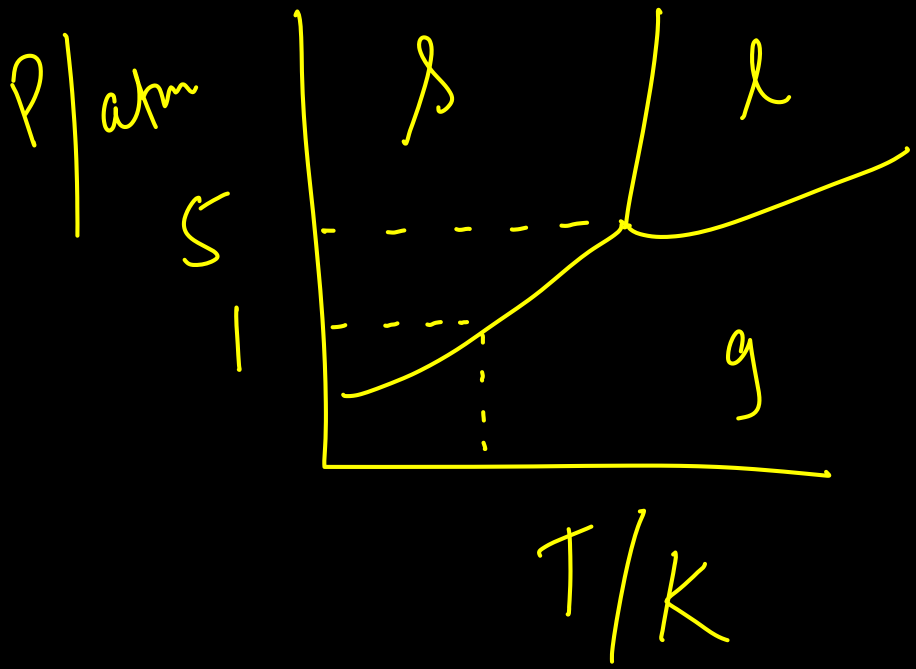
$$F = C - P + 2$$

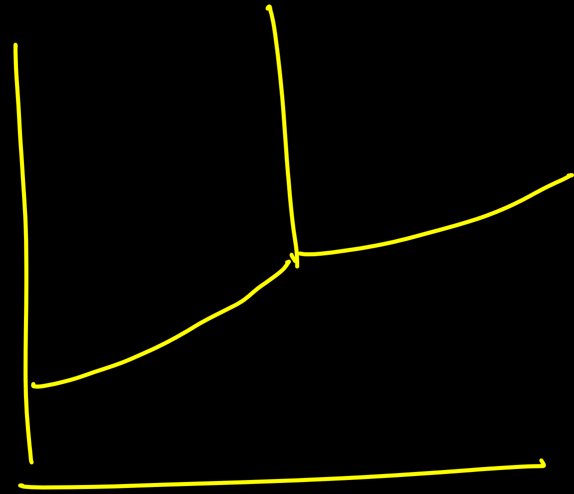
degrees of freedom

components

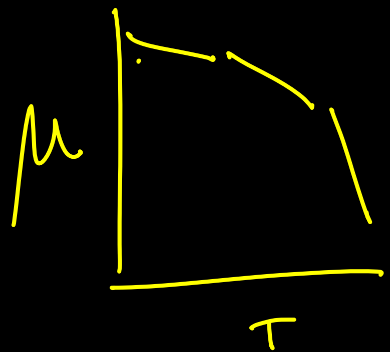
phases

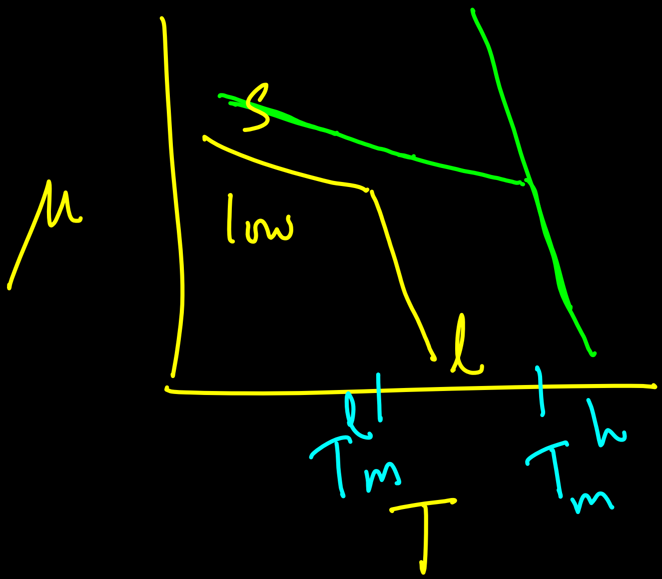
$$F = 3 - P$$



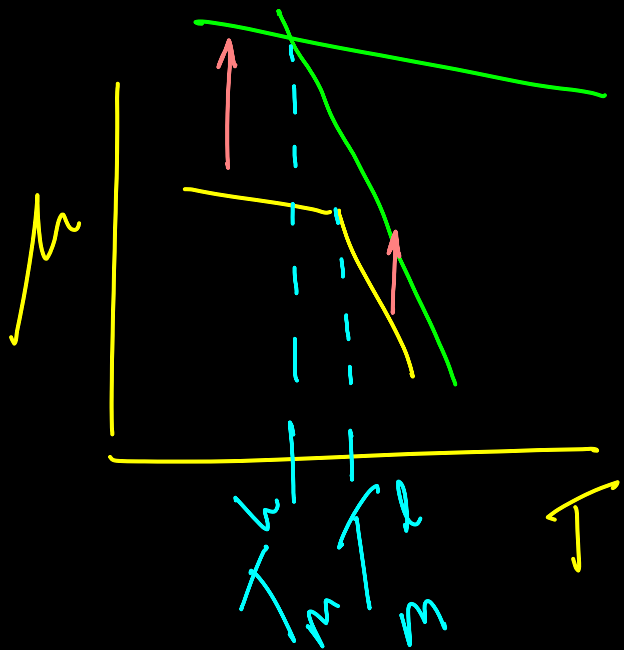



$$G_m = \mu \qquad \left(\frac{\partial G}{\partial T}\right)_p = -S \qquad \left(\frac{\partial \mu}{\partial T}\right)_p = -S_m$$



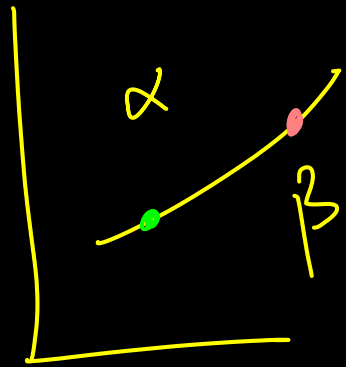



$$\left(\frac{\partial \mu}{\partial p}\right)_T = V_m$$



$$\frac{dp}{dT}$$

p




T

$$\mu_\alpha(p,T) = \mu_\beta(p,T)$$

$$d\mu_\alpha = d\mu_\beta$$

$$-S_m^\alpha \, dT + V_m^\alpha \, dp = -S_m^\beta \, dT + V_m^\beta \, dp$$

$$\left(-S_m^\alpha + S_m^\beta\right) dT = \left(V_m^\beta - V_m^\alpha\right) dp$$

$$\Delta S_{trs} \, dT = \Delta V_{trs} \, dp$$

$$\boxed{\frac{dp}{dT} = \frac{\Delta S_{trs}}{\Delta V_{trs}}}$$

Clapeyron Eqn.

$$\frac{dp}{dT} = \frac{\Delta H_{trs}}{T \, \Delta V_{trs}}$$

# s-l phase transition

$$\frac{dp}{dT} = \frac{\Delta H_{fus}}{T \, \Delta V_{fus}}$$

$$\int_{p^*}^{p} dp = \frac{\Delta H_{fus}}{\Delta V_{fus}} \int_{T^*}^{T} \frac{dT}{T}$$

$$p - p^* = \frac{\Delta H_{fus}}{\Delta V_{fus}} \ln T/T^*$$

$$\ln\left(1 + \frac{T - T^*}{T^*}\right)$$

$$\boxed{p = p^* + \frac{\Delta H_{fus}}{\Delta V_{fus}} \left(\frac{T - T^*}{T^*}\right)}$$

## l-g transition

a) ignore vol. of liq. $\Delta V_{trs} = V_{m,g}$

b) assume I.G. $RT/p$

$$\frac{dp}{dT} = p\frac{\Delta H_{vap}}{T^2 R}$$

$$\frac{d\ln p}{dT} = \frac{\Delta H_{vap}}{RT^2}$$

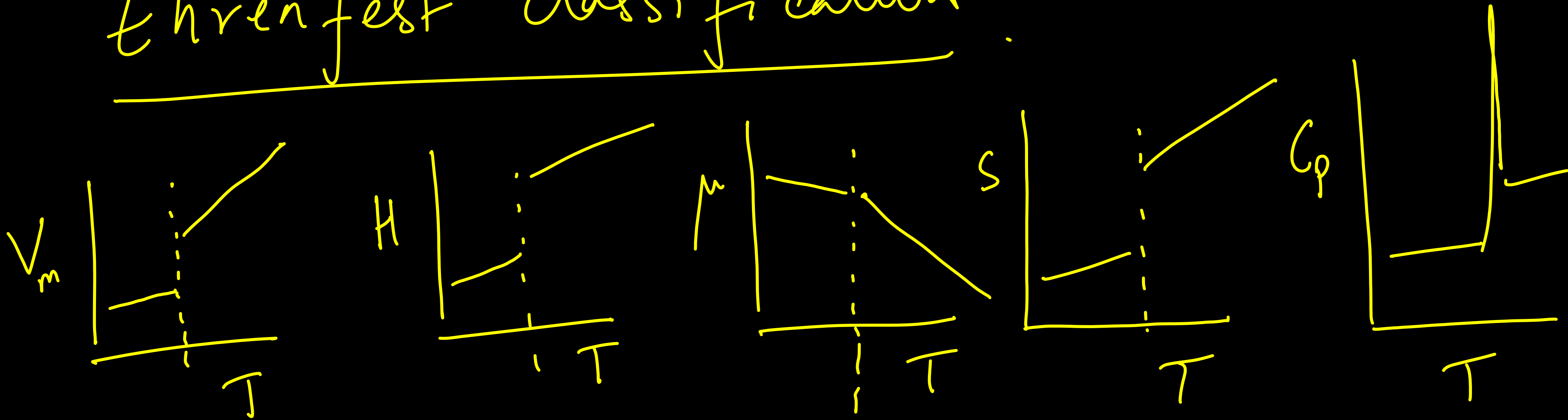
Clausius Clapeyron Eqn.

$$\int_{p^*}^{p} d\ln p = \frac{\Delta H_{vap}}{R}\int_{T^*}^{T}\frac{dT}{T^2}$$

$$p = p^* e^{-\chi}$$

$$\chi = \frac{\Delta H_{vap}}{R}\left[\frac{1}{T} - \frac{1}{T^*}\right]$$

# Ehrenfest classification



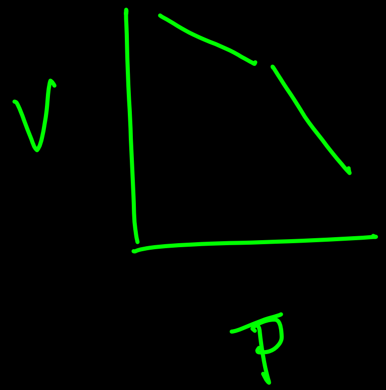

$\mu \to$ continuous

$\dfrac{\partial \mu}{\partial t} \to$ discontinuous

either T or P

First Order phase transition

$$\left(\frac{\partial \mu}{\partial p}\right)_T$$




# Second Order Phase transformations

$1^{st}$ deriv. of $\mu$ $\rightarrow$ continuous

$2^{nd}$ deriv. $\rightarrow$ discontinuous