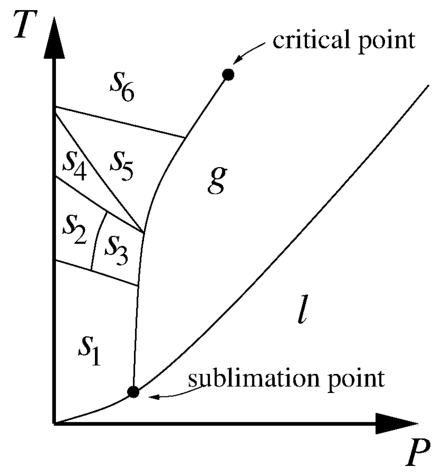
Tutorials 2 Thermodynamics 2, 2024/2025

Exercise 5

Problem 1d of exam 2008.
In the figure below the (P, T) phase diagram of a pure compound is shown. There are 5 mistakes in the diagram. Find these 5 mistakes and sketch the corrected phase diagram.



Exercise 6

Dichloromethane has a vapour pressure of 400 Torr at 24.1 °C and an enthalpy of vaporization of $\Delta_{\text{vap}}H =$ 28.7 kJ/mol.
Estimate the temperature at which the vapour pressure equals 500 Torr. Assume that the vapour behaves as a perfect gas and that the enthalpy of vaporization is independent of the temperature in this pressure range.

Exercise 7

Construct and sketch a phase diagram of benzene near its triple point (36 Torr and 5.50 °C).
Use the following data, $\Delta_{\text{fus}}H = 10.6$ kJ/mol, $\Delta_{\text{vap}}H = 30.8$ kJ/mol, $\rho(\text{s}) = 0.891$ g/cm^3 and $\rho(\text{l}) =$ 0.879 g/cm^3.
Hint: use the Clapeyron equation for the three relevant phase transitions, and assume that ΔH and ΔV hardly change around the triple point.

Exercise 8

Mercury has an enthalpy of fusion of $\Delta_{\text{fus}}H = 2.292$ kJ/mol and a melting point (at 1 atm) of $T_{fus} =$ 234.3 K. The volume change upon freezing is $\Delta_{\text{fus}}V = 0.517$ cm^3/mol and the liquid has a density of $\rho(\text{l}) = 13.6$ g/cm^3.
At what temperature will the bottom of a mercury column of 10.0 m freeze?
Hint: Start from the Clapeyron equation and use $\Delta_{\text{fus}}G = \Delta_{\text{fus}}H - T_{\text{fus}}\Delta_{\text{fus}}S = 0$ and realize that $\Delta_{\text{fus}}H$ and $\Delta_{\text{fus}}V$ will hardly change for the small temperature difference that you will find. The pressure difference over a column of height Δh is given by $\Delta P = \rho g \Delta h$, where ρ is the mass density and g is the free fall acceleration.

Exercise 9

One mole of liquid (molar mass $M = 200$ g/mol, density $\rho = 2 \cdot 10^3$ gl^{-1} and a thermal expansion coefficient $\alpha = \frac{1}{V}\left(\frac{\partial V}{\partial T}\right)_P = 2 \cdot 10^{-3}$ K^{-1}) is isothermally pressurised from $P_1 = 1$ bar to $P_2 = 100$ bar at 27 °C. The volume change in this process is negligible.
Calculate the change in

a) Entropy; use a Maxwell relation between S, P, V and T.

b) Internal energy

c) Enthalpy

d) Helmholtz free energy

e) Gibbs free energy