

Homework 8 solutions

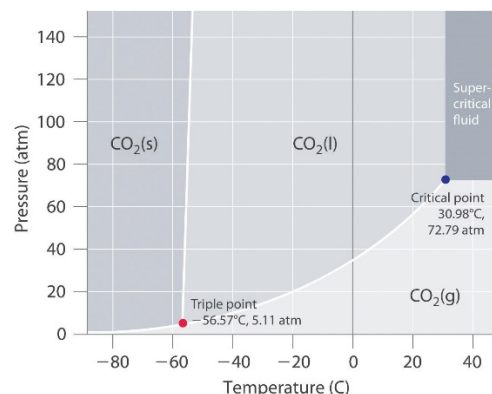
Exercise 1

Why do spray cans get cold? Explain why an aerosol spray can gets cold when you spray the contents.

Exercise 2

In this exercise, we try to better understand the phase diagram of a typical material.

- Consider the three coexistence lines of fusion, melting and vaporization. Based on your thermodynamic understanding, which of these is going to have the largest slope? Please explain your reasoning.
- Let us assume that we know the pressure p_{triple} and temperature T_{triple} at the triple point. For a given latent heat L_{vap} of vaporization (between the liquid and gas phase), calculate approximately the function $p_{vap}(T)$ that describes the pressure of Carbon dioxide along the vaporization line. Explain the used approximations.
- For a given latent heat L_{subl} of sublimation, calculate approximately the function $p_{subl}(T)$ that describes the pressure along the sublimation line.
- For a given latent heat L_{fus} of fusion, calculate approximately the function $p_{fus}(T)$ that describes the pressure along the fusion line. Explain the used approximations.
- For Carbon dioxide, the explicit values are given by:
Triple point at $p_{triple} = 5.1 \text{ atm}$ and temperature $T_{triple} = -57^\circ\text{C}$.
Molar volumes: $v_s = 28 \text{ ml/mol}$, $v_l = 40 \text{ ml/mol}$, $v_g = 221 \text{ l/mol}$
Latent heats: $L_{subl} = 8.8 \text{ kJ/mol}$, $L_{vap} = 13 \text{ kJ/mol}$, $L_{fus} = 25 \text{ kJ/mol}$
Plot the complete phase diagram of the system and compare it to the experimental phase diagram shown below:



- Explain why or why not using the ideal gas approximation for the calculations done in this exercise are justified from a conceptual point of view.

Exercise 3

An element x exists in nature in two different solid forms, x^α and x^β . The molar Gibbs energy of x^α and x^β at 298 K and atmospheric pressure (also called the standard Gibbs energy of formation) are 510 J/mol and 485 J/mol, respectively.

- a) Plot the molar Gibbs free energy of x^α and x^β as a function of temperature at constant pressure. The standard molar entropies of x^α and x^β are 23.6 J/mol K and 34.8 J/mol K, respectively.
- b) Under atmospheric pressure, does the increase in temperature make x^α more stable than x^β ? If so, at what temperature will the transition occur? Which form of x is the more stable at 298 K?
- c) Plot the molar Gibbs free energy of x^α and x^β as a function of pressure at constant temperature. The molar volumes of x^α and x^β are 25 cm³/mol and 30 cm³/mol, respectively.
- d) Keeping the temperature constant at 298 K, does the increase in pressure make x^α more stable than x^β ? If so, at what pressure will the transition occur?