3.020 – Thermodynamics of Materials Recitation 3

Problem 1

In this problem we will calculate and sketch a unary phase diagram of water using the equation of Clausius-Clapeyron and thermodynamic data given in the table below. We will integrate the equation of Clausius-Clapeyron using appropriate approximations to find the analytical expressions P(T) for three phase transformations in water.

ΔH_{fus}=6.01kJ/mol	V^s=1.958*10^-5m3/mol (=1.09cm3/g)	T_{tri}=273.16K
ΔH_{vap}=44.0kJ/mol	V^l=1.802*10^-5m3/mol (=1.00cm3/g)	P_{tri}=611.73Pa
ΔH_{sub}=51.1kJ/mol	V^v=RT/P	

a) Solid to liquid transformation:
   1. What are the required approximations for this transformation?
   2. Find the analytical expression P(T) that describes the two-phase equilibrium conditions after indefinite integration of the Clausius-Clapeyron equation for this transformation?
   3. Use the derived relation to verify the melting temperature of water at atmospheric pressure.

b) Liquid to vapor transformation:
   1. What are the required approximations?
   2. Find analytically the P(T) two-phase equilibrium conditions for this transformation?
   3. Use the derived relation to verify the boiling temperature of water at atmospheric pressure.

c) Solid to vapor transformation:
   1. Required approximations?
   2. Find the analytical P(T) equilibrium conditions?
   3. We do not know the sublimation temperature of water at atmospheric pressure, why?

d) Sketch a ln(P)-T diagram of water around the triple point using the above derived analytical expressions for the three two-phase coexisting lines.

   You have drawn your first (approximate) unary phase diagram!

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