Massachusetts Institute of Technology
Thermodynamics of Materials
3.00 Fall 2002

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Problem Set 8: Due Tues. Nov. 25, Before 5PM in in 13-5114

Exercise 8.1

Demonstrate that Poisson's ratio, ν, cannot exceed $\frac{1}{2}$ by finding particular value of strain ϵ_{ij} (for an isotropic material with elastic Young's modulus $E_{el} > 0$) that makes the stored elastic strain energy negative.

Exercise 8.2

Starting with the Gibbs-Duhem expression for phases with fixed composition, derive the Clausius-Clapeyron relation $dP = (\Delta\overline{S}/\Delta\overline{V})dT$.

Using a carefully worded sentence or two, describe what this Clausius-Clapeyron means physically.

Exercise 8.3

Consider a binary alloy with components A and B, let X_A^α, X_A^β, and X_A^γ represent the compositions of three phases α, β, and γ that coexist at a triple point at $P = P_{tp}$ and $T = T_{tp}$.

Note that, for each phase in a binary alloy, the composition is given by one variable only because $X_A^\alpha = 1 - X_B^\alpha$, $X_A^\beta = 1 - X_B^\beta$, and $X_A^\gamma = 1 - X_B^\gamma$.

Starting with the Gibbs-Duhem expression, derive a relationship for the change in the triple point $dP_{tp} = (\text{material properties})dT_{tp}$.

Also for the triple point, find a relationship between the change in the chemical potential of A ($d\mu_A$) and the change in the chemical potential of B ($d\mu_B$).

Exercise 8.4

In Homework problem 5.2, you found the equilibrium temperature and length of a thermally expanding in contact with a thermostat.

Using the engineering solution in the solution set, determine whether that stability is locally stable or unstable.