Hlutapróf 2, 25. okt., 10:00-12:30

Leyfð hjálpargögn: tvær A4 blaðsíður sem hver nemandi hefur skrifað sjálfur og reiknivél.

Problem 1: Consider the Gibbs free energy, G, of a closed system located in a container where pressure and temperature can be varied.

(a) Write an expression for the change in Gibbs free energy in a reversible process, dG, in terms of changes in temperature, dT, and pressure, dp.

(b) Experimental measurements have been carried out to determine the variation in G with temperature over a certain temperature interval at fixed pressure, p_0, and the results are summarized in the expression

$$G = \alpha + \beta T + \gamma/T$$

where α, β and γ are constants. Obtain an expression showing how the entropy of this system varies with temperature at this pressure.

(c) Obtain an expression showing how the enthalpy, H, of this system varies with temperature at this pressure.

(d) The measurements are now extended to include variations in G with pressure over a certain pressure interval and the results are summarized in the expression

$$G = \alpha + \beta T(p - p_0) + \gamma/T + \nu(p - p_0)$$

Obtain a value for the thermal expansion of the system, i.e. change in volume as temperature is increased (making use of the experimental results).

(e) Derive a general expression, independent of the measurements described above, for the variation of the Gibbs free energy with pressure in a reversible adiabatic process.

Problem 2: Consider an equilibrium between a solid and a gas of atoms. Assume the entropy of the solid can be neglected in comparison with the entropy of the gas and that the energy per atom in the gas is higher by ϵ with respect to an atom in the solid. Assume the gas is ideal and that the volume of the solid is negligible in comparison with the volume of the gas. Let N_g be the number of atoms in the gas phase and N_s be the number of atoms in the solid phase. The total number of atoms, $N = N_s + N_g$, is fixed. In parts (a-d) take the volume of the system to be fixed, but in part (d) assume the volume is flexible and the gas pressure equals the external pressure.

(a) Write an expression for the entropy of the gas (Sackur-Tetrode equation).

(b) Write an expression for the Helmholtz free energy of the system $F = F_g + F_s$ as a function of N_g.

(c) Find the value of N_g at equilibrium if the volume is fixed.

(d) Find the equilibrium vapor pressure of the solid (i.e. pressure of the gas in equilibrium with the solid).

(e) Repeat the the calculation of N_g, now taking the pressure to be fixed rather than the volume.