I. PROBLEM SESSION 4

A. Problem 4.1

Show from thermodynamic considerations that the concentration of point defects in a crystal at equilibrium is:

$$\frac{n}{N} = e^{\frac{E_v + PV_o}{k_b T}} \tag{1}$$

Where $E_V = \frac{\delta U}{\delta n}$ is the change in potential energy (at zero temperature) required to remove a single impurity.
Hint: Minimize the free energy $G = U - TS + PV$, expressed as a function of the number of impurities. The relation $ln\ X! \approx X(ln\ X\ -\ 1)$, valid for large X, might be useful.

B. Problem 4.2

Suppose that the energy required to remove a sodium atom from the inside of a sodium crystal to the boundary is $1eV$. Calculate the concentration of Schottky vacancies at $300K$. What happens with the concentration of impurities if the pressure is varied.

C. Problem 4.3

The rate of cluster formation is described by the differential equation given in the lectures:

$$\frac{\delta V_n}{\delta t} = 4\pi R D v [V_{n-1}][V] - [V_N] C_0 e^{-E_b/kT}. \tag{2}$$

Explain the physics behind the different terms and quantities in the equation. In what temperature interval would you expect the cluster concentration to vary steeply.