Question Sheet 2

1. Prove that in the regular solution model, the molar enthalpy of mixing is given by,

$$\Delta H_M = zN_a(x)(1-x)\omega$$

given that $\omega = \epsilon_{AA} + \epsilon_{BB} - 2\epsilon_{AB}$, N_a is Avogadro's number and z is a coordination number.

2. Give three examples of cases where the rate of energy dissipation is given by the product of the "flux" (J) and a corresponding "force", (X), *i.e.*

$$T\sigma = JX$$

where T is the absolute temperature and σ is the rate of entropy production. How could this relationship be generalised for multiple dissipation processes?

Using the concept of forces and fluxes in the theory of irreversible thermodynamics, deduce the relationship between the velocity V of a grain boundary and the free energy change ΔG accompanying it motion. State any assumptions involved in this derivation.

Prove that the general relation between V and ΔG should in fact be as follows:

$$V \propto \exp\{-Q/kT\}[1 - \exp\{-\Delta G/kT\}]$$

where Q is the activation energy for the transfer of atoms across the grain boundary, k is the Boltzmann constant and T is the absolute temperature.

Is it possible to reconcile this equation with the relationship deduced from irreversible thermodynamics?

3. This question relates to the 3–dimensional thermal profile in a coherent solid material: is the thermal profile in a plane independent of the thermal profile in the direction of the normal to that plane, provided steady–state has been reached?