If we have a chemical system in which there is a concentration gradient of material A, the above criteria is sufficient to require: (1) material A to diffuse from a region of higher concentration to a region of lower concentration, (2) the system to be in equilibrium despite the presence of a concentration gradient, (3) material A to diffuse from a region of lower concentration to a region of higher concentration.[17] Case 1 is by far the most common, and is the one that applies to a silver-lead system.

3. Diffusion Equations

In the case of an isothermal, isobaric diffusion process, the chemical potential is a function of the entropy and volume of the system. These in turn are solely dependent upon the solute distribution. In particular, the differential equation governing the approach to equilibrium of an interdiffusing metallic system is[18]

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial x_i}\left(D_{ij}\frac{\partial c}{\partial x_j}\right) \qquad i,j = 1,2,3 \qquad (1)$$

where c is the concentration of the solute material, D_{ij}s are the components of the diffusion tensor, t is the time, and x_i are the position coordinates. In general, the D_{ij}s are functions of the concentration c.[19] However, in the case of extremely low solute concentrations, the D_{ij}s are approximately constants. Furthermore, if a principle axes system is used, equation 1 reduces to the much simpler Fick's law equation:

$$\frac{\partial c}{\partial t} = D_i \frac{\partial^2 c}{\partial x_i^2} \qquad (2)$$