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3.21 Kinetics of Materials—Spring 2006

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Lecture 2: Irreversible thermodynamics: entropy production; conjugate driving forces and fluxes; basic postulates; linear irreversible thermodynamics; the diffusion potential; Onsager's symmetry principle.

References

1. Balluffi, Allen, and Carter, *Kinetics of Materials*, Chapter 2.
2. Christian, J.W., *Phase Transformations in Metals and Alloys—Part I*, Pergamon Press, 1975, Chapter on Irreversible Thermodynamics.

Key Concepts

- The local entropy production can be expressed as a sum of terms, each of which is a product of a flux and a conjugate "force" (see KoM Eq. 2.15).
- Familiar empirical laws are linear relationships between fluxes and their conjugate forces: Fourier's law of heat conduction, Fick's law for diffusion, and Ohm's law for electrical conduction (see KoM Table 2.1).
- The basic postulate of irreversible thermodynamics is that, near equilibrium, the local entropy production is non-negative (see KoM Eq. 2.16).
- When more than one force is active, each force will generally cause a flux of its corresponding quantity. There are both *direct* couplings between forces and conjugate fluxes, and *cross* terms that may also contribute to fluxes.
- When several forces are active and a system is "near" equilibrlum, the flux of a given quantity is postulated to be linearly related to *all* of the forces (see KoM Eqs. 2.20–21).
- The potential which appears in the total conjugate force acting on a component in a material is called the *diffusion potential*, Φ (see KoM Eqs. 2.40–41).
- According to Onsager's symmetry principle, the matrix of coupling coefficients $L_{\alpha\beta}$ in the system of linear equations $J_\alpha = L_{\alpha\beta}X_\beta$ is postulated to be symmetric, that is, $L_{\alpha\beta} = L_{\beta\alpha}$.

Related Exercises in *Kinetics of Materials*

Review Exercises 2.1–2.4, pp. 36–38.