UNIT IIIE

TRANSPORT PROCESSES

Whenever a gradient in a thermodynamic potential exists between one region and another, it induces heat, work, or the movement of matter between the two regions.[1] Determining the rate at which these *transport processes* proceed under given conditions is a central problem in the practice of each of the various fields of engineering. Specifically, temperature is the potential for heat transport, voltage is the potential for charge transport (i.e., electric current), pressure is the potential for the bulk transport and concentration is the potential for the transport of a specific species of matter, and velocity is the potential for the transport of momentum. In all of these processes the transported quantity is carried by *mobile "carrier" particles*. Different particles act as carriers for one or more transport processes to varying degrees in different substances.

Molecules (or atoms) are relatively mobile in liquids and gases. Thus they act as the principal carrier for heat, mass, momentum, and species. (Electric current is transported by ionized molecules.) In solids, lattice points have very limited mobility. Thus the molecules or atoms that occupy these sites are carriers only in the very limited diffusion processes.[2]

Free Electrons are the principal carriers of electric current. In condensed phase conductors, the highly mobile free electron gas is an important carrier of heat as well as charge.

Phonons Lattice vibrations in a condensed phase result in the generation of acoustical waves. This mobile phonon gas is a contributor to heat transport in condensed phases.[3] In liquids it is often more important than heat transport due to molecular motion.[4] However, in good conductors, phonon transport is often negligible in comparison to free electron transport.

Photons The mobile photon gas occupies all space. Its net contribution to heat transport is dependent on the presence and mobility of other carriers.[4] In their absence, as in a vacuum, photon heat transport is predominant.

If transport effects are to be predicted by microscopic means, one must determine at what rate the proposed carrier will move unimpeded in a given direction, how much of the transported quantity it would carry with it, and how frequently the particles would undergo collisions that inhibit the transport process.

---

[1]Each of the intrinsic, fundamentally intensive properties is a thermodynamic potential, see definitions 12 and 16, Unit IA.

[2]There is very limited momentum or mass transport within a solid.

[3]Neither photons nor phonons contribute to mass (or species) transport since they are massless. Their contribution to momentum transport is usually very low when compared to molecular transport.

[4]Recognize that we are comparing to molecular transport within the media, not to energy carried with the bulk motion, convection.