UNIT IIIE

TRANSPORT PROCESSES

Conserved quantities are transported by mobile carrier particles. These include gas molecules, free electrons, phonons, and photons whose speed distributions and average speeds are developed in the unit. The equilibrium flux of the mobile carrier particles is related to their mean speed and particle density. Two transport limits are identified: the limit dominated by particle-particle collisions, the continuum regime; and the limit dominated by wall-particle collisions, the free particle regime. The Knudsen number is introduced to discriminate between the two regimes. Photon heat transport through a low density gas is analyzed as an example of free particle transport. The result of this analysis is an expression for the limiting black body emission from a surface, the Stefan-Boltzmann law, and an introduction to the concept of surface absorptance and emittance. Molecular heat and momentum transport through a gas are analyzed as examples of continuum transport. The result of this analysis is a prediction of gaseous thermal conductivity and viscosity. Heat and charge transport through a solid are analyzed as a second example of continuum transport. This yields a qualitative description of the dependence of thermal conductivity on temperature in insulators and metals, as well as a description of the temperature dependence of electrical conductivity in metals and semiconductors.

Objectives

1. Determine the mean, most probable, and rms speeds of gaseous molecules, free electrons, phonons, and photons for given equilibrium conditions.

2. Determine the probability that a gaseous particle will have speeds above or below a specified speed.

3. Specify the mean free path, mean free time, or Knudsen number of molecular gas particles under specified conditions.

4. Evaluate the maximum possible, or black body, photon energy flux at a specified temperature.

5. Interpret the distribution of black body radiation, Planck's law, to evaluate the relative emission at different wavelengths.

6. Determine the viscosity or thermal conductivity of a molecular gas. Interpret the effect of temperature and pressure on these properties.

7. Describe the temperature dependence of the thermal conductivity of metallic and nonmetallic solids. Discuss the effect of impurities, defects, and annealing.

8. Differentiate between electrical insulators, conductors, and semiconductors. Discuss the effect of temperature on electrical conductivity in each of these materials.

9. Determine thermal conductivity from the electrical conductivity of a metal using the Wiedemann-Franz law. Discuss the authenticity of this result for specific cases.