Appendix A employs a similar procedure to predict the rate at which one species diffuses through another within a continuum fluid. When applied to a perfect gas the resulting diffusion coefficients have a form similar to that for μ^* and K^*. All of the molecular transport coefficients within a perfect gas continuum are *independent of pressure.*[18] Recognize that this means there is no inherent reduction in viscous drag associated with flight at higher altitudes and there is no inherent reduction in the rate of molecular heat conduction obtained by evacuation.[19] These transport processes are only indirectly affected by pressure as long as the gas remains within the continuum regime, see Exmp. 6.

B. Transport Properties of Solids

There are two carrier particles that dominate the transport processes that occur in solids— free electrons and phonons.[20] Since phonons are uncharged, only free electrons participate in charge transport. And, to the extent that free electrons are present, they tend to dominate heat transport as well. However, since phonons contribute in a manner similar to heat transport in both conductors and nonconductors, we will first determine the form and magnitude of the phonon conductivity. Ultimately, we will see how both free electron and phonon contributions can be superposed to determine the total heat transport in a solid.

The phonon contribution to thermal conductivity is predicted directly from eqn. IIIE-20a.

$$K_{phn} = \frac{\rho c_s \lambda_{c,phn} c_{v,phn}}{3}$$

where ρ is the lattice density and $c_{v,phn}$ is the Debye continuum portion of the specific heat.[21] The difficulty in employing this result is associated with specifying the phonon mean free path.

Phonon Collision Processes. As phonons propogate through the crystal they carry their energy with them. However, if that energy is to be delivered from one region to another, the carrier phonons must exchange energy in different locations of the crystal. Thus, phonon collisions are necessary for phonon heat transport,

[18]The pressure independence is a result of the cancellation of the pressure dependences of the number density and mean free path, $n_v \lambda_c \sim p^{-1} p \alpha p^{\circ}$.

[19]Total drag may well be reduced at higher altitudes since density is a factor in the "form"drag associated with separated flow. Similarly, the net rate of heat transport under evacuated conditions changes with pressure since the free convective flow that causes "convective" augmentation is a result of density changes.

[20]Diffusion in solids is very minimal; but atoms or molecules would be the carrier particles. Photon heat transport is also present; but it is almost always negligible in comparison to phonon or free electron processes.

[21]The internal mode components of the specific heat (see Appendix A, Unit IIID) do not participate in phonon transport. This energy is localized within each specific lattice point.