More

Heat Conduction

If we replace $\langle v \rangle$ by u_F, Equation 10-25 for the thermal conductivity of a gas becomes

$$K = \frac{1}{3} C u_F \lambda = \frac{1}{3} \frac{n u_F \lambda C_v}{N_A}$$

Substituting $C_v = \frac{1}{2}\pi^2 RT/T_F = \frac{1}{2}\pi^2 RkT/E_F$ from Equation 10-45, this becomes

$$K = \frac{1}{3} \frac{n u_F \lambda}{N_A} \frac{\pi^2}{2} \frac{RkT}{E_F}$$

Writing $R = N_A k$ and $E_F = \frac{1}{2} m u_F^2$ gives for the thermal conductivity

$$K = \frac{n\lambda \pi^2 k^2 T}{3 m u_F} \qquad \textbf{10-46}$$

From Equations 10-28 and 10-46 we obtain for the Lorentz number

$$L = \frac{K}{\sigma T} = \frac{\pi^2 k^2}{3e^2} = 2.45 \times 10^{-8}\ \mathrm{W \cdot \Omega / K^2} \qquad \textbf{10-47}$$

Thus the Wiedemann-Franz law is also predicted by the quantum calculation, and the value of the Lorentz number $K/\sigma T = 2.45 \times 10^{-8}\ \mathrm{W \cdot \Omega / K^2}$ is in good agreement with the experimental values listed in Table 10-2.