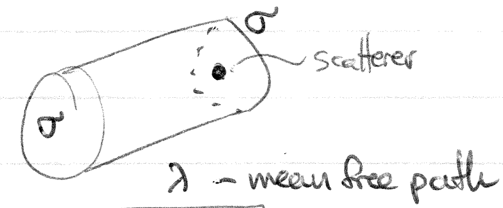
Conduction

* free electron gas scatters from lattice irregularities

$$\tau = \lambda / \langle v \rangle_{rms} \quad \text{interaction time}$$



$$\boxed{n \lambda \sigma \equiv 1}$$

* $$I = \frac{Q}{t} = \frac{\#}{V} \cdot A \frac{l}{t} \cdot e = nAe\, v_d$$

$$v_d = \frac{\frac{1}{2} a \langle t^2 \rangle}{\langle t \rangle} = \frac{1}{2} \frac{a \cdot 2\tau^2}{\tau} = a\tau = \frac{a\lambda}{\langle v \rangle}$$

$$ma = eE = e\frac{V}{l}$$

$$I = nAe \frac{eV}{ml} \frac{\lambda}{\langle v \rangle} = V \cdot \overbrace{\frac{A}{l} \underbrace{\frac{ne^2\lambda}{mv_F}}_{\sigma = 1/\rho}}^{1/R} \qquad \boxed{\text{Drude}}$$

* thermal conductivity

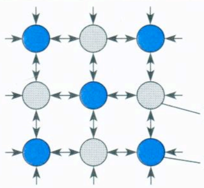
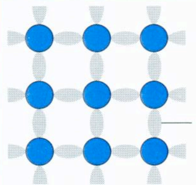
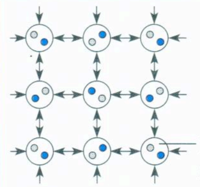
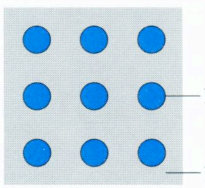
$$\frac{\Delta Q}{\Delta t} = -\Delta T \cdot \frac{A}{l} K \qquad K = \frac{k n v_{rms} \lambda}{2} \qquad \left(\text{diffusion equation}\right)$$

$$\frac{K}{\sigma} = \frac{\frac{k n v_{rms} \lambda}{2}}{\frac{n e^2 \lambda}{m v_F}} = \frac{k}{e^2} \cdot \underbrace{\frac{1}{2} m v_{rms}^2}_{\bar{\varepsilon} = 3/2\, kT}$$

$$\frac{K}{\sigma T} = \underbrace{\frac{3k^2}{2e^2}}_{\text{classical}} \rightarrow \underbrace{\frac{\pi^2 k^2}{3e^2}}_{\text{F-D dist.}}$$

$$\boxed{\text{Weidemann-Franz Law}}$$

Table 10.1 Types of Crystalline Solids. The cohesive energy is the work needed to remove an atom (or molecule) from the crystal and so indicates the strength of the bonds holding it in place.

Type	Ionic	Covalent	Molecular	Metallic
Lattice				
Bond	Electric attraction	Shared electrons	Van der Waals forces	Electron gas
Properties	Hard; high melting points; may be soluble in polar liquids such as water; electrical insulators (but conductors in solution)	Very hard; high melting points; insoluble in nearly all liquids; semiconductors (except diamond, which is an insulator)	Soft; low melting and boiling points; soluble in covalent liquids; electrical insulators	Ductile; metallic luster; high electrical and thermal conductivity
Example	Sodium chloride, NaCl $E_{cohesive}$ = 3.28 eV/atom	Diamond, C $E_{cohesive}$ = 7.4 eV/atom	Methane, CH_4 $E_{cohesive}$ = 0.1 eV/molecule	Sodium, Na $E_{cohesive}$ = 1.1 eV/atom