Differentiate electrical and thermal conductivity

Electrical conductivity	Thermal conductivity
Electrical conductivity (σ) is the ratio between the current density (J) and the applied electric field strength (E)	Thermal conductivity (K) is the amount of heat conducted per unit volume per unit time , per unit thermal gradient.
Electrical conductivity of a metal is purely determined by the number of free electrons present in the metal	The major part thermal conductivity of a metal is determined by the free electron density, but phonons or lattice vibrations also contribute to the thermal conductivity
Electrical conductivity of a metal is determined by the electron density, relaxation time of electrons, and the effective mass of electrons in lattice	Thermal conductivity of a metal is determined by the mean free path of electrons area of cross section, temperature gradient and their specific heat

Failures of Classical Free Electron Theory:

- The classical free electron theory could successfully explain electrical and thermal conduction in metals.

- But it could not account for specific heat of metals,
- temperature dependence of σ=1/T and
- the dependence of electrical conductivity on free electron concentration $\boldsymbol{\sigma} = \frac{\boldsymbol{ne^2\tau}}{\boldsymbol{m}}$

Problems on Electrical conductivity

Problem 1

The mean free collision time of copper at 300K is equal to 2×10^{-14} s. Determine its electrical conductivity. Given that free electron density,

$n = 8.5\times10^{28}\ m^{-3}$.

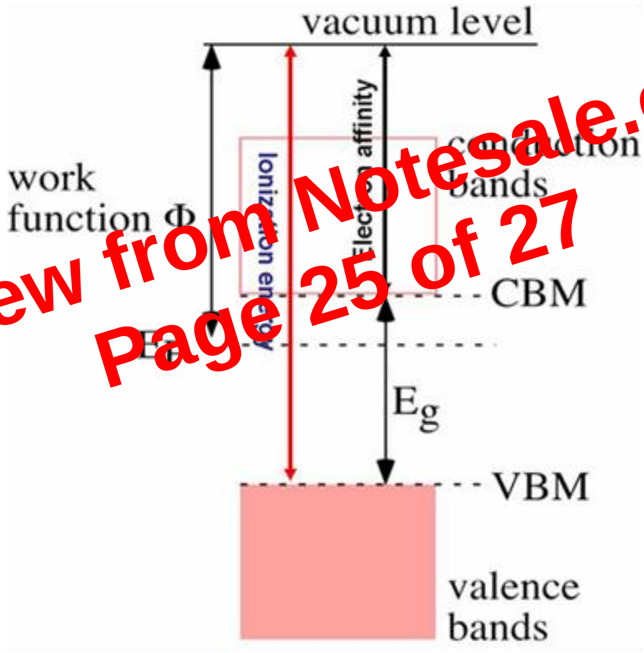
Collision time, $\tau = 2\times10^{-14}$ s

Free electron density $n = 8.5\times10^{28}\ m^{-3}$

electrical conductivity $\sigma = (ne^2\ \tau)/m$

$$\sigma = \frac{8.5\times10^{28}\times(1.6\times10^{-19})^2\times2\times10^{-14}}{9.1\times10^{-31}} = 4.789\times10^{7}\ \mathrm{ohm}^{-1}\mathrm{m}^{-1}$$

Metal Surface



Thermionic Work Function in Metals

Minimum amount of heat energy imparted to an electron to make it leave the surface of metal is called **thermionic work function (ϕ).**

$$K_B T = \phi + 1/2mv^2$$