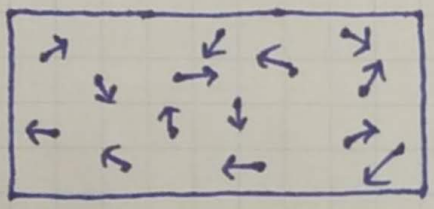
The Drude Model

- "Free electron" theory of metals
- Metals: → excellent electrical & thermal conductors
  → ductile (not brittle)
  → high lustre (shiney)
- Drude Model → almost, but-not-completely useless
  (think $v = \frac{d}{t}$ of SSP)

Basic Idea: 'Free Electron Gas'



'gas of e^-'s'

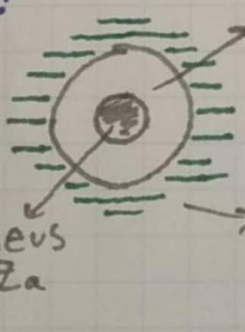
- apply theory of gases to e^-'s in metal.

→ free e^-'s 'bounce' around

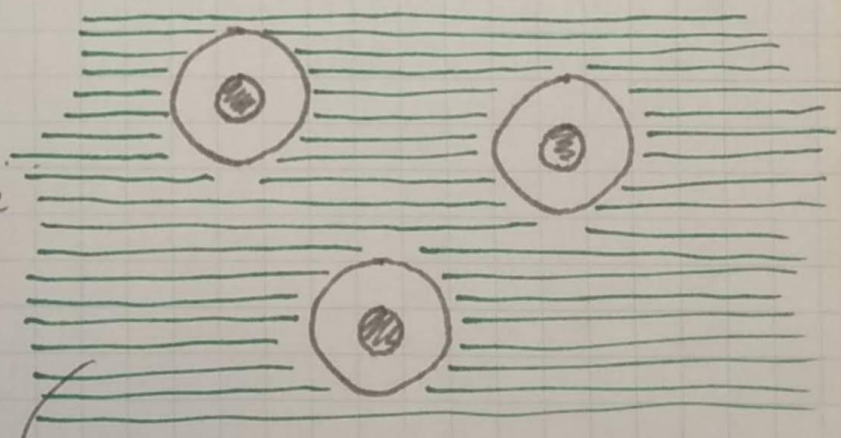
Remember: $PV = nRT$

WHY?

atom



metal



delocalized valence e^-'s
conduction e^-'s

Note: - Structure of the atom was unknown at the time (1900)

- Model assumes stationary (+) charges to balance the current-carrying $\bar{e}$'s

How dense is our $\bar{e}$ gas? (ie. # $\bar{e}$'s / cm^3) → about the same as the metal (atoms / cm^3)

$$n = \frac{N}{V} = \frac{\#\text{atoms}}{\text{mole}} \times \frac{\#\text{moles}}{cm^3} \times \frac{\#\text{Valence } \bar{e}}{\text{atom}}$$

$$\boxed{n = N_A \rho_m \frac{Z}{A}}$$

N_A → Avogadro's # 6.022×10^{23}
ρ_m → mass density
Z → # valence $\bar{e}$
A → atomic mass

$n \sim 10^{22}\ \bar{e} / cm^3$

→ Compare to ideal gas @ STP: $n \sim 10^{19}$ atom/cm^3

- Unsurprisingly, this corresponds to a volume per $\bar{e}$ similar to the Bohr atom.

Important Assumptions of the Drude Model

1.) Between collisions:

a) Neglect $\bar{e}$-$\bar{e}$ interactions

Independent Electron Approx.

b) Neglect $\bar{e}$-ion interactions

Free Electron Approx.

c) Newton's laws govern $\bar{e}$ movement

2.) Collisions are instantaneous & alter the $\bar{e}$ velocity

3.) Average time between collisions is τ:

Probability that $\bar{e}$ collides in time dt is $\sim \frac{dt}{\tau}$

4.) Electrons achieve thermal equilibrium w surroundings only through collisions

a) velocity of $\bar{e}$ after collision is NOT related to it's velocity before the collision

b) direction of $\bar{e}$ after collision is random

c) magnitude of velocity related to temperature:

hot: v ↑

cold: v ↓

We will use the Drude Model to 'explain' four important phenomena:

1) DC electrical conductivity
2) Hall Effect & Magnetoresistance
3) AC electrical conductivity
4) Thermal conductivity