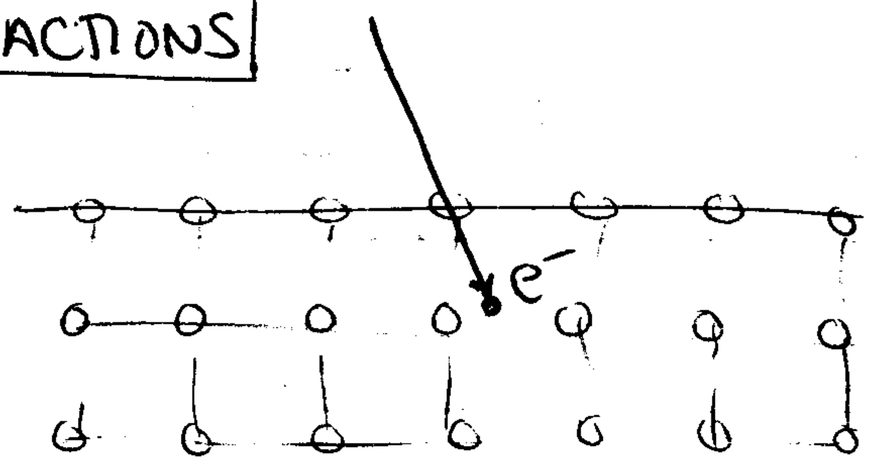
ELECTRON - MATERIAL INTERACTIONS

- Electron enters Lattice with E_0 10-200 keV



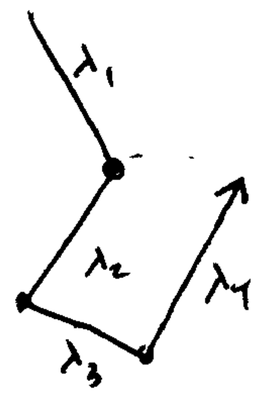
- Continuous energy loss (inelastic scattering)

$$\frac{\partial E}{\partial x} = -2\pi e^4 N_A \frac{Z\rho}{M E_m} \ln\left(1.66 \frac{E_m}{J}\right)$$

Z = atomic number
M = molar mass $\left[\frac{g}{mol}\right]$, E_m = mean kinetic energy

$$J = \left(9.76Z + 5.85 Z^{-0.19}\right)10^{-3}$$ IONIZATION POTENTIAL [keV]

- Electron travels mean distance λ before deflection

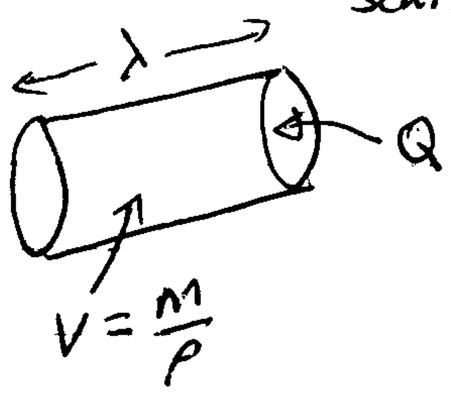


$$\lambda_{\text{mean free path}} = \frac{\Sigma \lambda}{n_{\text{collisions (elastic)}}}$$

$$\lambda = \frac{M\left[\frac{g}{mol}\right]}{N_A\left[\frac{atoms}{mol}\right]\rho\left[\frac{g}{cm^3}\right]Q_{cm}}$$

For all possible events scattering

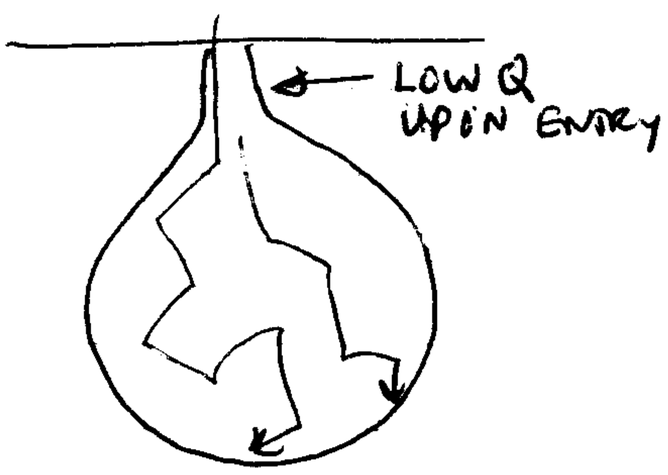
$$\frac{1}{\lambda_{TOT}} = \frac{1}{\lambda_A} + \frac{1}{\lambda_B} + \cdots \left[\frac{1}{cm}\right]$$



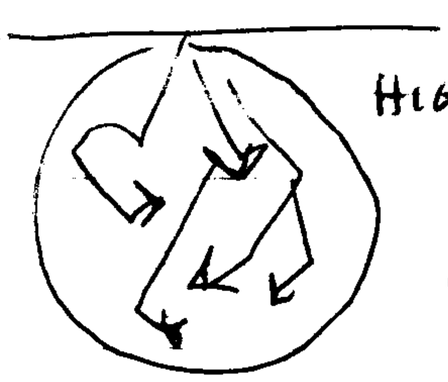
- Atom sweeps out cylindrical volume V with length λ before collision with nucleus (cross section Q)

- Stopping power $S = -\frac{1}{\rho}\frac{\partial E}{\partial x} \propto \frac{Z}{m}\ln\left[\frac{C}{F(Z)}\right]$ (C = const)

* High energy electrons travel further without deflection



INTERACTION VOLUME



INTERACTION VOLUME

- AS Z ↓ volume ↑
- AS Z ↓ penetration ↑
- $Q \propto \frac{1}{E^2}$ so as E↑, Q↓
- $\frac{dE}{dx} \propto \frac{1}{E}$ so as E↑, $\frac{dE}{dx}$↓ (less inelastic effect)

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BETHE RANGE

$$R = \int_{E_0}^{0} \frac{1}{\frac{dE}{dx}} dE \quad , \quad \rho R_B = \int_{E_0}^{0} \frac{1}{S} dE$$

KANAYA-OKAYAMA RANGE $\quad R_{KO} = \frac{0.027\, A E_0^{1.67}}{\left(Z^{0.889} \rho\right)}$ [μm]

■ BACKSCATTERED ELECTRONS

$$\eta = \frac{n_{BS}}{n_{beam}} = \frac{i_{bs}}{i_{beam}} \qquad i_{beam} = i_{bs} + i_{sc} + i_{secondary\ electron}$$

specimen current

$$P = Q \left[\frac{\text{events}}{e^- (\mu m/cm^2)}\right] \cdot N_A \cdot \frac{1}{m} \cdot \rho \cdot t_{thickness}$$

(probability to backscatter)

- as $Z \uparrow$, $\eta \uparrow$, $\eta = -0.0254 + 0.016Z - 1.86E^{-4}Z^2 + 8.3E^{-7}Z^3$
- as $E \uparrow$, penetration $\uparrow$ so $\eta \downarrow$
- as $E \uparrow$, elastic scattering $\uparrow$, $\eta \uparrow$) → effects largely cancel.