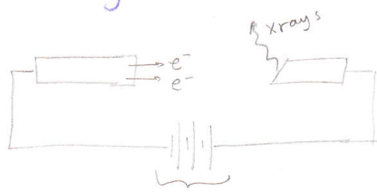
X - Rays

W. K. Roentgen (1895)



X rays
- no deflection in $\vec{B}$
- was not able to see diffraction, interference
- most materials – transparent to it → decreases with material density

→ found medical application (activate photographic film)

hard to see diffraction (bending of waves caused by obstacle) because $\lambda = 1 Å$

↳ need slit $\sim 1 Å$

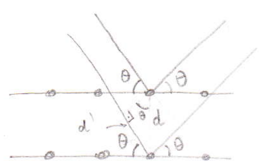
↳ crystal (array of atoms separated $\sim 1 Å$) ⇒ diffraction

↓

confirmed that X rays are electromagnetic waves

Bragg (1912)

↳ use of x rays to determine the structure of crystals



- treat atomic plates as reflecting mirrors
- assume ∡ of incidence = ∡ of reflection

$\sin\theta = \frac{d'}{d}$ path difference: $\Delta = 2d' = 2d\sin\theta$

interference is constructive if $\Delta = n\lambda$ $n = 1, 2, 3 \ldots$

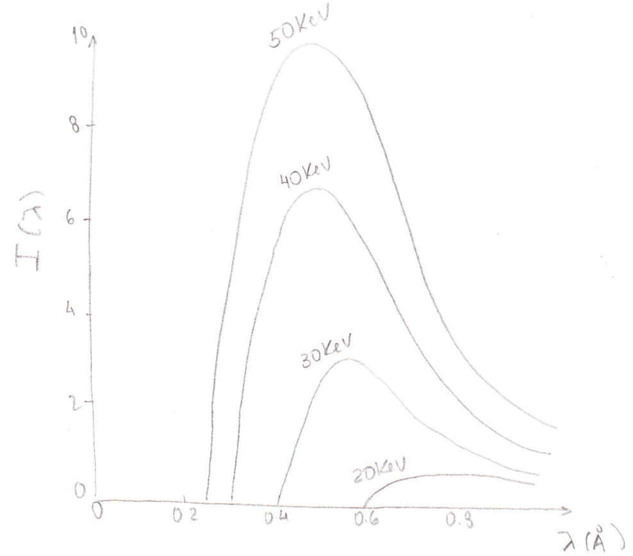
$$\boxed{2d\sin\theta = n\lambda}$$ Bragg's law

λ is known, θ from experiment ⇒ can obtain the interplanar distance d

sc bcc fcc

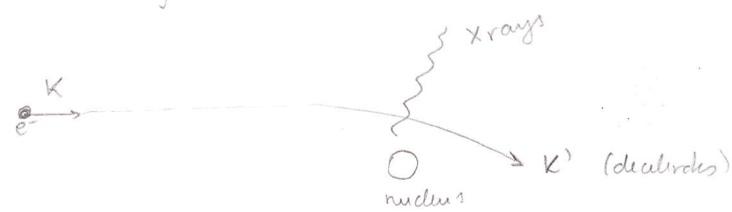
Study of the X-ray spectrum

↳ depends on the accelerating voltage and material



(1) continuous X radiation

bremsstrahlung
(brems = decelerating, strahlung = radiation)



(2) sharp lines (NOT shown)

(3) cutoff λ_{min}
↳ indep of material
dep on energy of e^- / the potential

$h\nu = K - K'$ { an inverse photoelectric effect

photoelectric → photon absorbed / E, p go to e^-

$\frac{hc}{\lambda} = K - K'$ bremsstrahlung: photon created / E, p from e^- colliding with nucleus

$K' = 0 \Rightarrow \boxed{K = \frac{hc}{\lambda_{min}}}$ (electron loses all its kinetic energy)

$K = eV \Rightarrow eV = \frac{hc}{\lambda_{min}} \Rightarrow \boxed{\lambda_{min} = \frac{hc}{e}\frac{1}{V}}$ ← voltage

$\frac{hc}{e}$ → $\frac{1240\,(eV)\,(nm)}{1.60\times10^{-19}\,C}$ → $\frac{1240 \times 1.60\times10^{-19}\,J}{1.60\times10^{-19}\,C}(nm) = 1.24\times10^{3}\ V\cdot nm$ (unit)

Exercise: Determine h from the fact that $\lambda_{min} = 3.11\times10^{-11}\,m$ for 40.0 KeV electrons.

$K = h\nu = \frac{hc}{\lambda} \Rightarrow h = \frac{K\lambda}{c}$

$h = \frac{40.0\times10^{3}\,eV \times 1.6\times10^{-19}\,J \times 3.11\times10^{-11}\,m}{3\times10^{8}\,m/s}$

$\boxed{= 6.64\times10^{-34}\ J.s}$