Long Wave

IR  Visible  UV  X-rays

Gamma rays

$10^{12}$ $10^{6}$ $10^{3}$ 10 1 $10^{-1}$ $10^{-3}$

wavelength (nm)

X-rays absorption
Absorption

\[ \frac{I}{I_0} = e^{-\mu^* x} = \frac{1}{e^{\mu^* x}} = \frac{1}{e^{\mu \rho x}} \]

\( \mu^* \) = linear attenuation coefficient

\( \mu \) = mass attenuation coefficient

\( \rho \) = density of absorber
Absorption

μ - values for elements listed in various texts & International Tables for Crystallography

Note that μ changes with X-ray wavelength

Higher atomic no. --> larger μ, in general
Absorption

What element used for X-ray tube windows?

What element used for protection from X-rays?
Absorption

\[ \frac{I}{I_0} = e^{-\mu_x x} = \frac{1}{e^{\mu_x x}} = \frac{1}{e^{\mu \rho x}} \]

For compounds & mixtures, calculate \( \mu \) from

\[ \mu_{\text{compd or mixture}} = \sum (\text{wt. fraction})_{\text{element}} \times \mu_{\text{element}} \]
Absorption

\[ \frac{I}{I_o} = e^{-\mu^* x} = \frac{1}{e^{\mu^* x}} = \frac{1}{e^{\mu \rho x}} \]

Example for NaCl (CuKα):

\begin{align*}
(\text{wt. fraction})_{\text{Na}} &= \frac{23}{58.5} = 0.393, \quad (\text{wt. fraction})_{\text{Cl}} = 0.607 \\
\mu_{\text{Na}} &= 30.1, \quad \mu_{\text{Cl}} = 106
\end{align*}

\[ \mu_{\text{NaCl}} = (\text{wt. fraction})_{\text{Na}} \times \mu_{\text{Na}} + (\text{wt. fraction})_{\text{Cl}} \times \mu_{\text{Cl}} \]

\[ \mu_{\text{NaCl}} = 0.393 \times 30.1 + 106 \times 0.607 = 76.2 \]
Absorption

Mass attenuation coefficient for an element changes with X-ray wavelength (energy) like this:

\[ \text{mass attenuation coefficient} \]

\[ \lambda_{\text{Kedge}} \]

Good news/bad news
Absorption

Bad news

Absorbed energy re-emitted as fluorescent X-rays

Suppose:

Then:

Absorption high

Lots of fluorescence
Absorption

Bad news

X-ray fluorescence radiation emitted at all angles

X-rays

specimen

detector

instead of this:

get this:
**Absorption**

**Good news - β-filters**

β-filter materials have atomic nos. 1 or 2 less than anode

50-60% beam attenuation
Absorption

**Good news - β-filters**

placing after specimen/before detector
filters most of specimen fluorescence

X-rays

specimen

filter

detector