

Physics 10262 - Chapter 2 – Homework

1. Calculate the x-ray K absorption edge for lead ($Z=82$) and mercury ($Z=80$) and compare it with the absorption edge for carbon ($Z=6$) and aluminum ($Z=13$).
2. You want to perform a radiography analysis of a Byzantine icon, which has a gold layer of $d=0.3$ mm thickness. The attenuation coefficient of X-rays in gold is $\mu_{\text{Au}}=19.5\text{cm}^{-1}$. Determine the fraction of the transmitted x-ray intensity.
3. In a radiograph of an oil painting with a $d_1=0.2$ mm layer of oil paint (carbon), a $d_2=0.05$ mm underground of white lead paint and a wood backing of $d_3=2$ cm thickness the initial x-ray intensity is reduced by a significant fraction. Calculate the total absorption and the absorbed (not transmitted) fraction of X-ray intensity for each layer.
4. Calculate the wavelength and the energy of the characteristic L ($n_i=3\Rightarrow n=2$) and K ($n_i=2,3,\Rightarrow n=1$) X-rays transitions for iron Fe ($Z=26$), copper Cu $Z=29$, silver Ag ($Z=47$), gold Au ($Z=79$), mercury Hg ($Z=80$), and lead Pb ($Z=82$). Assume an effective charge reduction term $\sigma=1$ for K-transitions and $\sigma=9$ for L-transitions. Compare the results with the observed characteristic x-ray energies that can be found at the web: <http://www.csrii.iit.edu/mucal.html>!
5. What distinguishes the red color vermilion from minium? What characteristic x-ray lines would you expect for these pigments in x-ray fluorescence analysis?
6. Calculate the range of 3 MeV protons for a PIXE analysis of a gold layered iron cup. Your energy loss of the protons in gold is about $290\text{MeV}/\text{mm}$. If the gold layer is 0.005 mm thin, how deep will the protons penetrate into the iron.
7. What characteristic x-ray transition do you expect to show in a PIXE analysis of Gall-ink? What x-ray lines would you see in a PIXE analysis of the color pigments azurite, ultramarine, yellow ochre, and cerulean blue?