061004 XRD Quiz 2

1) Sketch an X-ray tube showing the a) source of electrons, b) source of X-rays, and c) explain how the two knobs on the front of the X-ray generator control the X-ray output in the tube.

2) a) Explain the difference between bremstralung radiation, white radiation and the continuous spectrum. b) Are these radiations made in an X-ray tube? c) How or Why?

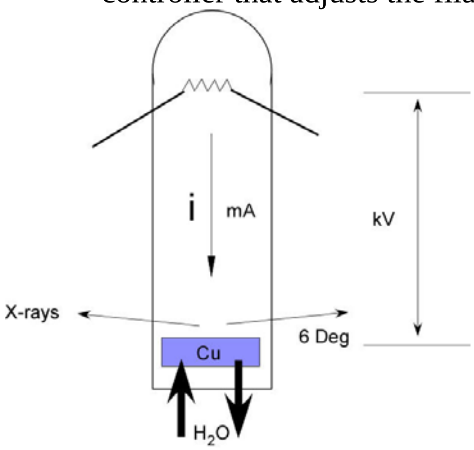
3) a) What is the dependence of X-ray absorption coefficient on wavelength? b) In order to calculate the thickness of lead needed to shield an X-ray generator using a copper target and running at 20 mA and 50 kV what wavelength would you used to determine the absorption coefficient.

4) a) If the intensity of diffracted X-rays is proportional to the thickness of the sample, for a pinhole measurement, and the diffracted X-rays must obey Beer's Law, show how you can determine the optimum thickness for a transmission sample. b) If the optimum thickness for a polymer sample is 2 mm what is the linear absorption coefficient?

5) For a copper anode show a plot of intensity versus wavelength (the emission spectrum) for an X-ray tube for excitation at 3kV 100 mA; 6kV 100 mA; and 30 kV 100 mA. Give the wavelength of the characteristic lines and of the short wavelength limit as well as the relative intensity of the characteristic lines for $K\alpha$ and $K\beta$ radiation.

ANSWERS: 061004 XRD Quiz 2

1) Filament at the top is the source of electrons. The target (anode) at the bottom is the source of X-rays. The voltage knob adjusts the potential drop from the filament to the anode. The current knob adjusts the tube current from the filament to the anode through a servo controller that adjusts the filament current.



2) a) Bremstralung, white and continuous radiation are the same thing. b) c) This refers to the spectrum produced by electrons as they impact the target (anode) atoms and convert their momentum to X-rays in the process. Yes they are made in the X-ray tube.

3) a) $\mu = k\, \rho\, \lambda^3\, Z^3$ between absorption edges. At the absorption edge the coefficient drops in a step manner

b) λ_{SWL} =12.4/50kV = 0.25 Å. This is the highest energy radiation to shield.

4) a) $I_{diffraction} = C\ x\ \exp(-\mu x)$. At the optimal thickness, x*, $dI_{diffraction}/dx = 0$.

$dI_{diffraction}/dx = C(\exp(-\mu x^*) - \mu x^* \exp(-\mu x^*)) = 0$

or

$1 - \mu x^* = 0$

so

$x^* = \mu$.

b) 0.5 mm^{-1}

5) $\lambda_{SWL,3kV}$ =12.4/3kV = 4.1 Å; $\lambda_{SWL,6kV}$ =12.4/6kV = 2.1 Å; $\lambda_{SWL,30kV}$ =12.4/30kV = 0.41 Å

$\lambda_{K\alpha}$ = 1.54 Å and $\lambda_{K\beta}$ = 1.4 Å and these are about 100x and 20x the intensity of the white radiation.