Quiz 1 XRD 092706

Diffraction involves constructive interference between waves that emanate from structurally organized matter such as from atoms in a crystal. X-ray diffraction uses a relationship of the angle that radiation is diffracted and the wavelength of the radiation to describe the structural size, d-spacing, associated with a diffraction peak.

1) Write Bragg's Law and sketch the diffraction experiment showing source, collimation (pinholes), sample, detector and the scattering angle.

2) Using the example of a halogen lamp and a pen laser, explain what a collimated beam of electromagnetic radiation is. Why is collimation important to Bragg's Law?

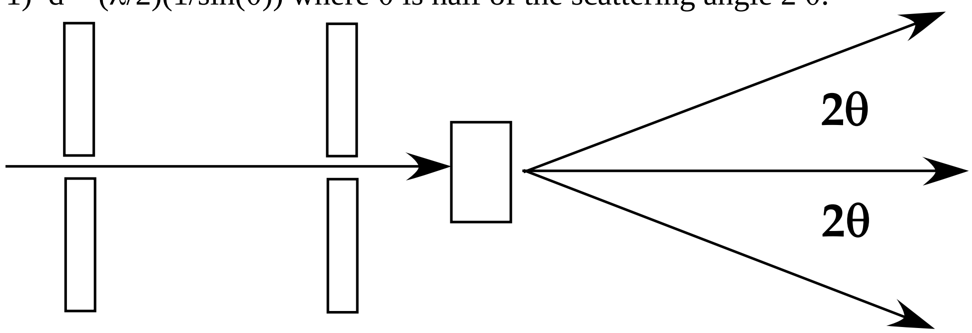
3) Explain the error in the following statement: "a laser beam is a focused beam of monochromatic light".

4) X-rays are electromagnetic radiation of higher energy compared to visible light. If you could see X-rays in the same way you can see light would they appear brighter than light? Explain.

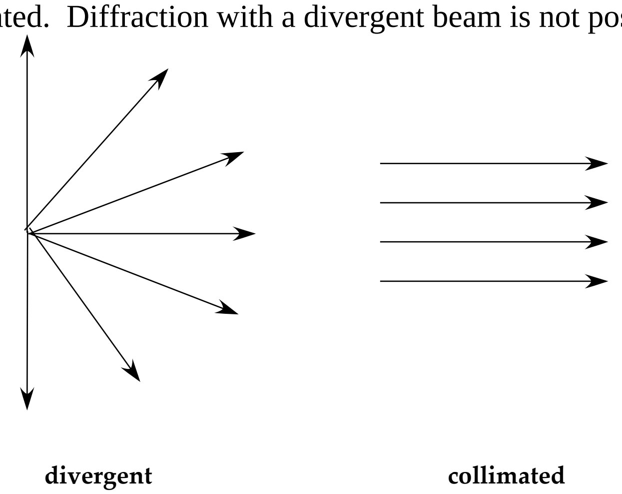
5) Write an equation for the amplitude (electric field vector) for a wave based on complex numbers and show that the intensity $I = AA^*$ is not a complex number (A^* is the complex conjugate of A).

ANSWERS: Quiz 1 XRD 092706

1) $d = (\lambda/2)(1/\sin(\theta))$ where θ is half of the scattering angle 2θ.



2) Collimated means that the component beams all travel in the same direction. A halogen lamp has divergent beams meaning that the beams emit in directions that serve to spread out the light. Collimation is important to Bragg's Law since the angle can only be measured with precision if the beam is well collimated. Diffraction with a divergent beam is not possible.



3) A laser is not focused. Focused means convergent so the beams concentrate to a focal point.

4) Energy, $E = h\nu$, reflects the capacity of a photon of the radiation to do work. Since the interaction of radiation with matter involves collisions of photons with atoms and molecules and transfer of this energy, the energy decides what the radiation can physically do. The brightness or flux is the number of photons per area per time. The energy does not have to do with the brightness.

5) $A = A_0 (\sin(\delta) - i \cos(\delta))$ where $d = 2\pi(t\nu + x/\lambda)$

$$AA^* = A_0^2 (\sin(\delta) - i\cos(\delta))(\sin(\delta) + i\cos(\delta))$$
$$= A_0^2 (\sin(\delta)^2 + i\sin(\delta)\cos(\delta) - i\sin(\delta)\cos(\delta) - i^2\cos(\delta)^2)$$
$$= A_0^2 (\sin(\delta)^2 + \cos(\delta)^2) = A_0^2$$