Diffraction notes and hints

Q1. What do you mean by dispersion? Find the answer.

Q2. Find an expression for dispersion.

Let us start with the equation for the locations of the lines in the diffraction pattern of a grating:

$d \sin \theta = m\lambda$ --- --- --- --- --- --- (i)

Let us regard θ and λ as variables and take differentials of this equation. We find

$d/d\lambda(\sin \theta) = m.d(\lambda)/d\lambda$

$d.(\cos \theta).d\theta/d\lambda = m$

$d.(\cos \theta).d\theta = m.d\lambda$

For small enough angles, we can write these differentials as small differences, obtaining

$d(\cos \theta)\ \Delta\theta = m.\Delta\lambda$

or, $\Delta\theta/\Delta\lambda = m/d\cos\theta$

So, dispersion $D = m/d\cos\theta$

X-ray diffraction:

Questions:

1. Why normal grating can't produce x-ray diffraction patterns
2. Why normal grating can't resolve x-rays?
3. What is Braggs' Law of X-ray diffraction?

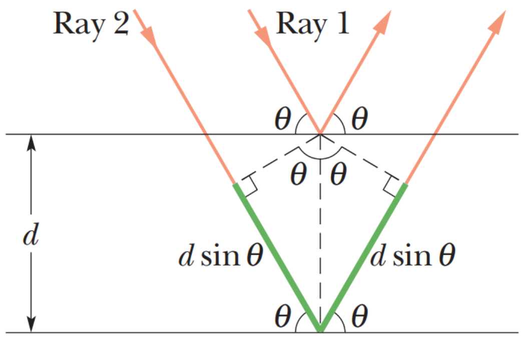
If we consider the condition for maxima in x-ray diffraction and use the wavelength of x-ray we may get,

$d \sin \theta = m\lambda$

If we use, λ = 1 Å (one Angstrom, which is equal to 0.1 nm) and d = 3000 nm, we can calculate the angle of diffraction $\theta = 0.0019^0$. That means the angle of diffraction is about 2/1000 degrees. In such a situation we can't separate the maxima from the central maxima. In other words, we will not be able to observe the diffraction phenomena.

So, we need a smaller grating to produce x-ray diffraction patterns. Atomic crystals give us this opportunity to observe the diffraction using x-rays.

When an x-ray beam enters a crystal such as NaCl, x rays are scattered —that is, redirected—in all directions by the crystal structure. In some directions the interference is constructive, resulting in intensity maxima. In other directions the scattered waves undergo destructive interference, resulting in intensity minima;



The extra distance of ray 2 determines the interference.

Let us consider the schematic diagram of the crystal structure where two rays r1 and r2 are incident. Ray1 is reflected from an atom on the first plane while ray 2 travels to the second plane and gets reflected. These two rays then interfere with each other and produce diffraction patterns. If we closely observe the figure we can see that ray2 travels an extra length equals to 2d sin θ (d sin θ + d sin θ). So we may write the condition for maxima using x-ray in atomic crystals as,

$$2d \sin \theta = m\lambda$$

This is also known as Braggs' Law of X-ray diffraction.

Use of x-ray diffraction:

- X-ray diffraction is a powerful tool for studying both x-ray spectra and the arrangement of atoms in crystals.
- Find other uses of x-ray diffraction and diffraction from Wikipedia or other reliable sources on the internet.