Diffraction Grating **_SOLUTIONS_**

1. a) A symmetrical pattern of thin "maxima" (bright areas) separated by large areas of darkness. The central maximum is the brightest, then the maxima become more separated and fainter as they get further out from the central maximum. The reason for the large areas of dark is that the large number of slits increases the chances of destructive interference at any given point – so there are more places where complete destructive interference occurs.

b) $\lambda = 5.1\times10^{-7}\,\text{m} \qquad m = 2 \qquad \theta = 20°$

$d\sin\theta = m\lambda$

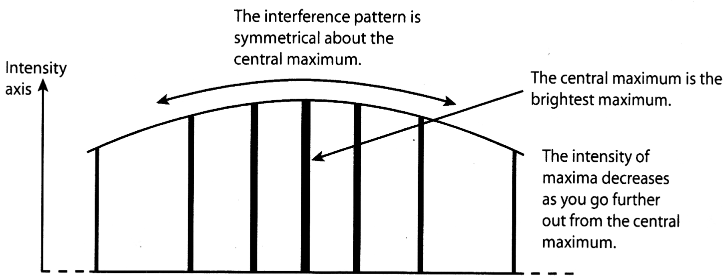
$$d = \frac{m\lambda}{\sin\theta} = \frac{2\times5.1\times10^{-7}}{\sin 20°} = 3.0\times10^{-6}\,\text{m}$$

$$N = \frac{1}{d} = \frac{1}{3.0\times10^{-6}} = 330000\ \text{m}^{-1} = 3300\ \text{cm}^{-1}$$

2. See textbook for details, but the gist of it:
- assume L is large compared to d so that the lines from slit to screen are approx. parallel
- triangle with path difference forms equation using trigonometry
- show this applies for all slits

3.

a)



b) $\lambda = 5.1\times10^{-7}\,\text{m} \qquad m = ? \qquad \theta = 90° \qquad d = \dfrac{1}{N} = \dfrac{1}{430000}\,\text{m}$

$d\sin\theta = m\lambda$

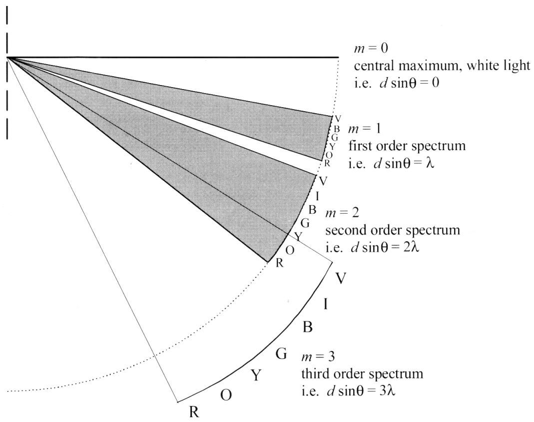
$$m = \frac{d\sin\theta}{\lambda} = \frac{2.3\times10^{-6}}{5.1\times10^{-7}} = 4.6$$

Therefore maximum 4 orders. Total maxima $2\times4 + 1 = 9$

4. By passing it through a diffraction grating with a known distance between slits, and measuring the angles of the maxima. Each maxima corresponds to a value of *m*, so the formula $d\sin\theta = m\lambda$ can be used.

5.

a)



- central maximum is white because light of every colour reinforces there ($d\sin\theta = 0$)
- next to the central maximum is a dark area because light of all wavelengths will destructively interfere there
- next is a continuous spectrum, starting at violet because it has the smallest wavelength therefore smallest θ for constructive interference
- next is another area of annulment followed by another spectrum and so on. These spectra will be fainter and fainter and start to overlap (no area of annulment) by the third order.

b) Diffraction gratings are useful for a process called *spectroscopy* (study of electromagnetic spectra) for the following reasons:

- for close slits, the angular deflection is very large and therefore the angle of any given wavelength can be measured with low error (high precision). The spectrum is clearer and more dispersed than for a triangular prism
- diffraction gratings can spread out the wavelengths of light, allowing for identification of wavelengths for a source that is not monochromatic (this allows for identification of individual atoms and elements since each produce their own spectral lines)
- the grating formula $d\sin\theta = m\lambda$ makes it easy to calculate the wavelengths