1)

A parallel beam of light from a hydrogen lamp is incident on a diffraction grating. The first order red spectral line at 6.56×10^{-7} m is seen at an angle of 11.4° as shown in Fig. 7.2.

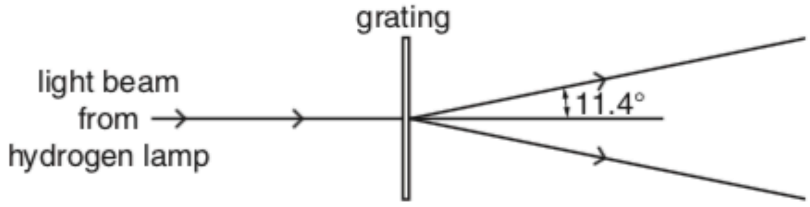

Fig. 7.2

(i) Calculate

1 the separation d of the lines on the grating

d = ... m **[3]**

2 the number of lines per millimetre on the grating.

number = ... lines mm^{-1} **[1]**

(ii) The hydrogen lamp also emits blue light at a wavelength of 4.86×10^{-7} m.

Draw rays on Fig. 7.2 to indicate roughly, that is without calculation, the direction of the **first** order blue spectral line as the rays leave the grating. **[1]**

2)

This question is about the light from low energy compact fluorescent lamps which are replacing filament lamps in the home.

(a) The light from a compact fluorescent lamp is analysed by passing it through a diffraction grating. Fig. 6.1 shows the angular positions of the three major lines in the first order spectrum and the bright central beam.

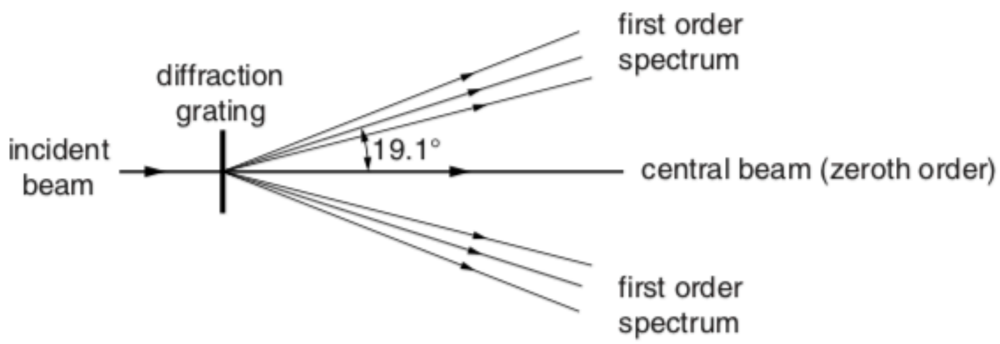

Fig. 6.1

(i) On Fig. 6.1 label one set of the lines in the first order spectrum **R**, **G** and **V** to indicate which is red, green and violet. **[1]**

(ii) Explain why the bright central beam appears white.

....

....

.... **[1]**

(iii) The line separation *d* on the grating is 1.67×10^{-6} m.

Calculate the wavelength λ of the light producing the first order line at an angle of 19.1° to the central bright beam.

λ = ... m **[3]**

3)

(a) A parallel beam of red light of wavelength 6.3×10^{-7} m from a laser is incident normally on a diffraction grating as shown in Fig. 6.1.

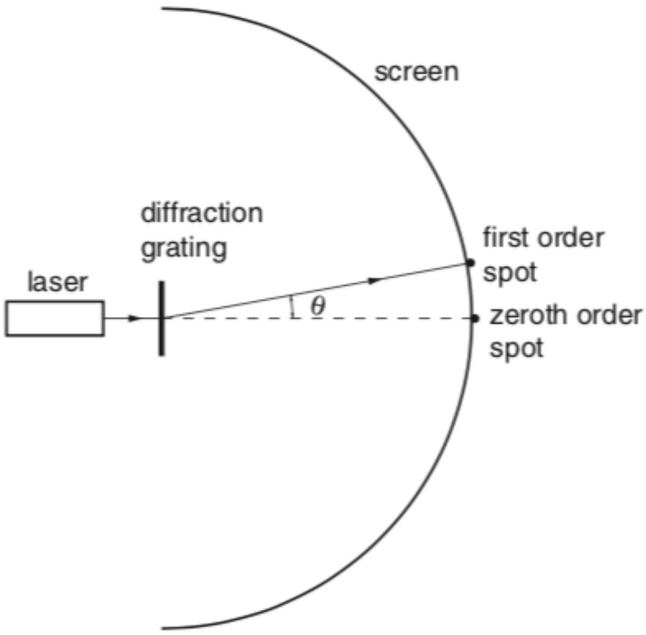

Fig. 6.1

Bright red spots are observed on the curved screen placed beyond the grating.

(i) The diffraction grating has 300 lines per millimetre. Show that the separation *d* between adjacent lines of the grating is 3.3×10^{-6} m.

[1]

(ii) Calculate the angle θ at which the first order red spot is seen. This is the first spot away from the straight through position.

θ = ... degrees **[3]**

(iii) The screen curves around the full 180° in front of the grating. Explain why there are eleven bright red spots on the screen.

....

....

....

....

.... **[3]**

(b) Calculate

(i) the energy of each photon of light emitted by the laser at a wavelength of 6.3×10^{-7} m

energy = ... J **[2]**

(ii) the number of photons emitted each second to produce a power of 0.50 mW.

number = ... **[2]**

(c) **(i)** A beam of electrons in a vacuum can travel through a thin sheet of graphite perpendicular to the beam to produce a diffraction pattern of rings on a fluorescent screen beyond the graphite sheet. Explain why this pattern is produced.

....

....

....

....

.... **[3]**

(ii) Calculate

1 the speed *v* of electrons with a de Broglie wavelength of 5.0×10^{-11} m

v = ... $m\,s^{-1}$ **[2]**

2 the potential difference *V* required to accelerate the electrons to this speed.

V = ... V **[3]**

[Total: 19]

4)

(a) A diffraction grating is used to determine the wavelengths emitted by a light source.

Fig. 4.1 shows light being diffracted through an angle θ at a tiny length of a grating.

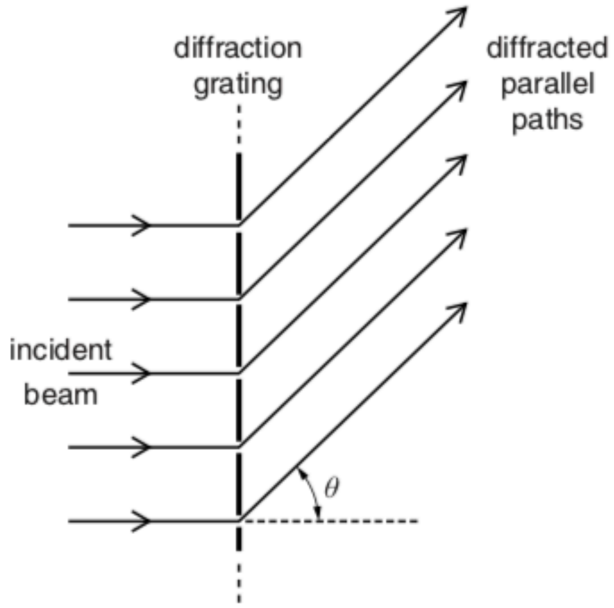

Fig. 4.1

Light of a given wavelength is observed only at particular angles through the grating. Use the ideas of wave superposition and interference to explain why light of that wavelength is observed only at certain angles.
You may find it useful to use Fig. 4.1 to illustrate your answer.

In your answer you should state clearly the conditions for the beam of coherent light at angle θ to produce a bright spectral line.

....

....

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....

.... **[4]**

(b) Fig. 4.2 shows the positions of the five strongest lines in the emission spectrum of mercury when light from a mercury lamp is passed through a diffraction grating. The lines are labelled **A** to **E** and their wavelengths are shown on the diagram in nanometres.

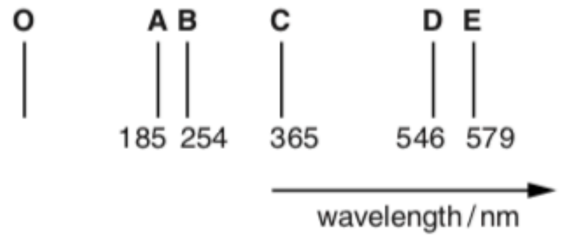

Fig. 4.2

(i) Fig. 4.3 shows the angular position of line **E** in the first order spectrum and the bright central beam **O** caused by the incident beam of mercury light passing through the grating.

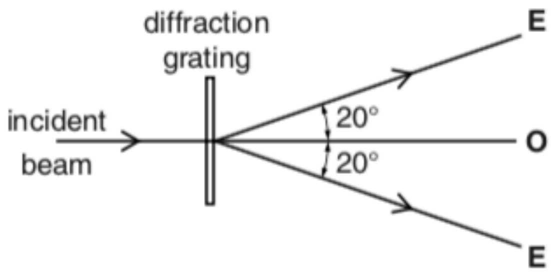

Fig. 4.3

1 On Fig. 4.3 add and label the approximate angular position of spectral line **C** in the first order spectrum. **[1]**

2 Use data from Figs 4.2 and 4.3 to calculate the line separation *d* for the grating.

$d =$ .... m **[3]**

(ii) State which **one** of the wavelengths, **A** to **E**, in Fig. 4.2 has the lowest photon energy.

.... **[1]**

(iii) State which of the wavelengths, **A** to **E**, in Fig. 4.2 are in the visible region of the spectrum.

.... **[1]**