1 Monochromatic light of wavelength 490 nm falls normally on a diffraction grating that has 6×10^5 lines per metre. Which one of the following is correct?

A The first order is observed at angle of diffraction of 17°. ⬭

B The second order is observed at angle of diffraction of 34°. ⬭

C The third and higher orders are not produced. ⬭

D A grating with more lines per metre could produce more orders. ⬭

(Total 1 mark)

2 Light of wavelength λ is incident normally on a diffraction grating for which adjacent lines are a distance 3λ apart. What is the angle between the second order maximum and the straight-through position?

A 9.6°

B 20°

C 42°

D There is no second order maximum.

(Total 1 mark)

3 A narrow beam of monochromatic light falls on a diffraction grating at normal incidence. The second order diffracted beam makes an angle of 45° with the grating. What is the highest order visible with this grating at this wavelength?

A 2

B 3

C 4

D 5

(Total 1 mark)

4 Light of wavelength λ is incident normally on a diffraction grating of slit separation 4λ. What is the angle between the second order maximum and third order maximum?

A 14.5°

B 18.6°

C 48.6°

D 71.4°

(Total 1 mark)

5 A diffraction grating has 300 lines per mm. It is illuminated with monochromatic light of wavelength 540 nm.

Calculate the angle of the 2nd order maximum, giving your answer to the appropriate number of significant figures.

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angle ..... degrees

(Total 4 marks)

6 A diffraction grating has 940 lines per mm.

(a) Calculate the distance between adjacent lines on the grating.

distance between lines .....

(1)

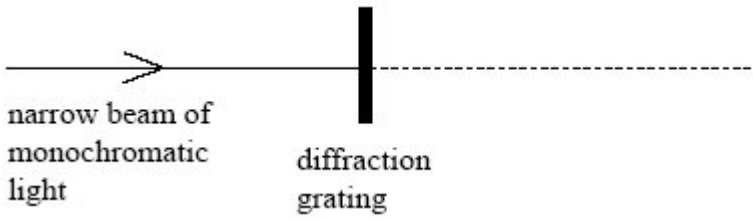
(b) Monochromatic light is incident on the grating and a second-order spectral line is formed at an angle of 55° from the normal to the grating. Calculate the wavelength of the light.

wavelength .....

(3)

(Total 4 marks)

7 A narrow beam of monochromatic light of wavelength 590 nm is directed normally at a diffraction grating, as shown in the diagram below.



(a) The grating spacing of the diffraction grating is 1.67×10^{-6} m.

(i) Calculate the angle of diffraction of the second order diffracted beam.

answer ..... degrees

(4)

(ii) Show that no beams higher than the second order can be observed at this wavelength.

(3)

(b) The light source is replaced by a monochromatic light source of unknown wavelength.
A narrow beam of light from this light source is directed normally at the grating.
Measurement of the angle of diffraction of the second order beam gives a value of 42.1°.

Calculate the wavelength of this light source.

answer ..... m

(2)
(Total 9 marks)

8 A scanning photometer is a device in which the voltage across an LDR (light dependent resistor) varies with the light intensity incident on the LDR.

Figure 1 shows a laser beam of wavelength 633 nm incidental normally on a diffraction grating. The LDR of a scanning photometer is moved across the diffracted beam and produces the scan shown in **Figure 2**. This shows the central bright fringe with one further maximum (the first order image) on each side of it. The distance from the diffraction grating to the LDR is 265 mm.

Figure 1

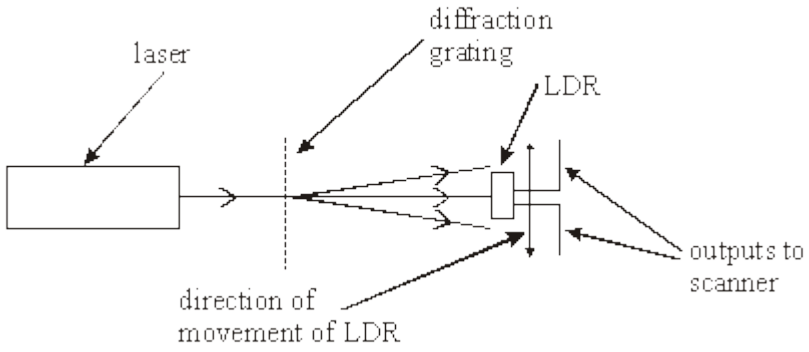
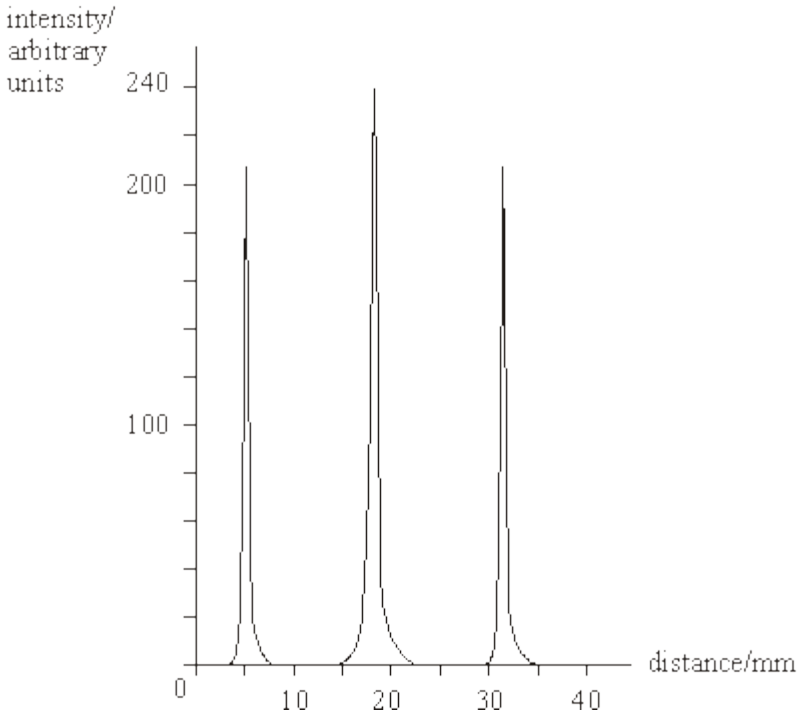


Figure 2



(i) Show that the angle of the first order image measured from the straight through position is approximately 3°.

(ii) Calculate the number of lines per mm on the diffraction grating.

(Total 6 marks)

9 Light from a laser has a wavelength of 6.30×10^{-7} m. When the laser light is incident normally on a diffraction grating the first order maximum is produced at an angle of 12°.

(a) Calculate the spacing between the lines on the grating.

spacing of lines .....

(2)

(b) Calculate the number of positions of maximum light intensity that are produced when the laser light is incident on the grating.
Show your reasoning clearly.

number of positions .....

(3)
(Total 5 marks)

10 A white-light source illuminates a diffraction grating that has 6.30×10^5 lines per metre. The light is incident normally on the grating.

(a) Show that adjacent lines in the grating are separated by a distance of about 0.0016 mm.

(1)

(b) The table below shows the diffracting angles measured from the normal for the visible spectral orders using this grating. The angles are given for the red and blue ends of each spectrum.

	First order	**Second order**	**Third order**
red	25.4°	59.0°	not possible
blue	15.0°	31.1°	50.0°

(i) Use the value for the first order diffracting angle to calculate the wavelength of the red light.

Wavelength of the red light .....

(3)

(ii) Describe carefully the appearance of the complete diffraction pattern on the screen. You may draw a sketch of the pattern to help your explanation if you choose.

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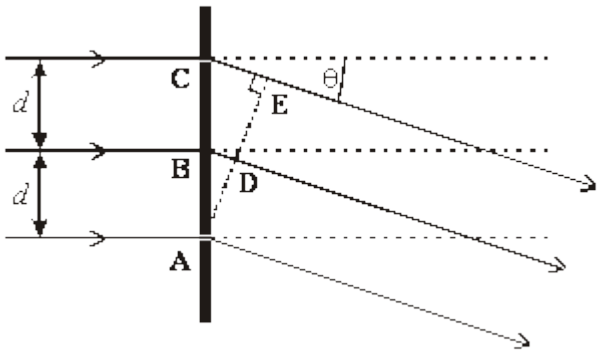
(4)
(Total 8 marks)

11 The diagram below shows a section of a diffraction grating. Monochromatic light of wavelength λ is incident normally on its surface. Light waves diffracted through angle θ form the **second** order image after passing through a converging lens (not shown). **A**, **B** and **C** are adjacent slits on the grating.



(a) (i) State the phase difference between the waves at **A** and **D**.

.....

(ii) State the path length between **C** and **E** in terms of λ.

.....

(iii) Use your results to show that, for the second order image, $2\lambda = d \sin \theta$, where d is the distance between adjacent slits.

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(3)

(b) A diffraction grating has 4.5×10^5 lines m^{-1}. It is being used to investigate the line spectrum of hydrogen, which contains a visible blue-green line of wavelength 486 nm. Determine the highest order diffracted image that could be produced for this spectral line by this grating.

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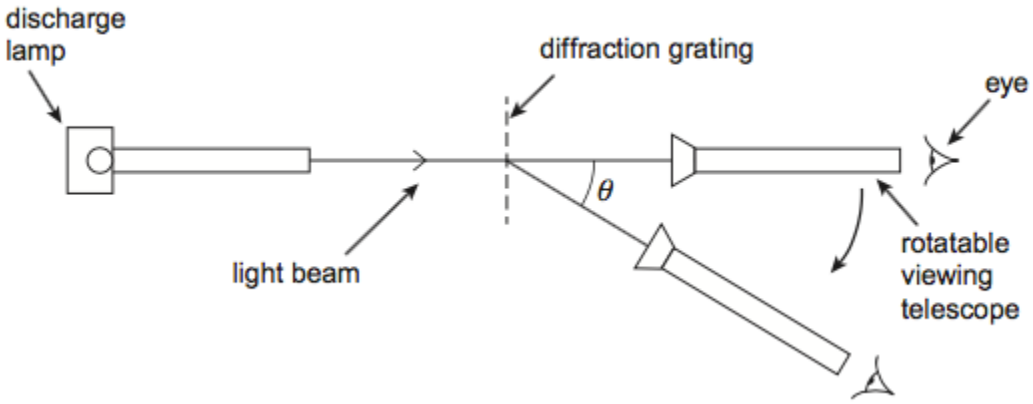
(2)
(Total 5 marks)

12 A discharge lamp emits light of four colours: red, green, blue and violet. The diagram shows light from the lamp incident normally on a diffraction grating with slit separations of 1.8×10^{-6} m. The light is viewed through a telescope which can be rotated as shown.



As the telescope is rotated from the straight-through position, each of the four colours is observed as a bright line at its corresponding first-order diffraction angle.

(a) Which colour would be observed first as the telescope is rotated from the straight-through position?

Place a tick (✓) in the right-hand column to show the correct answer.

	✓ if correct
red	
green	
blue	
violet	

(1)

(b) Explain how a bright line is formed by the diffraction grating at the first-order diffraction angle.

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(3)

(c) (i) The wavelength of the green light is 5.3×10^{-7} m.

Calculate the first-order diffraction angle for this colour.

angle = ... degree

(2)

(ii) As the telescope is rotated further, higher-order diffraction maxima are observed. Calculate the highest order observed for the green light.

highest order = ...

(3)

(Total 9 marks)

13 The figure below shows a spectrometer that uses a diffraction grating to split a beam of light into its constituent wavelengths and enables the angles of the diffracted beams to be measured.

(a) Give **one** possible application of the spectrometer and diffraction grating used in this way.

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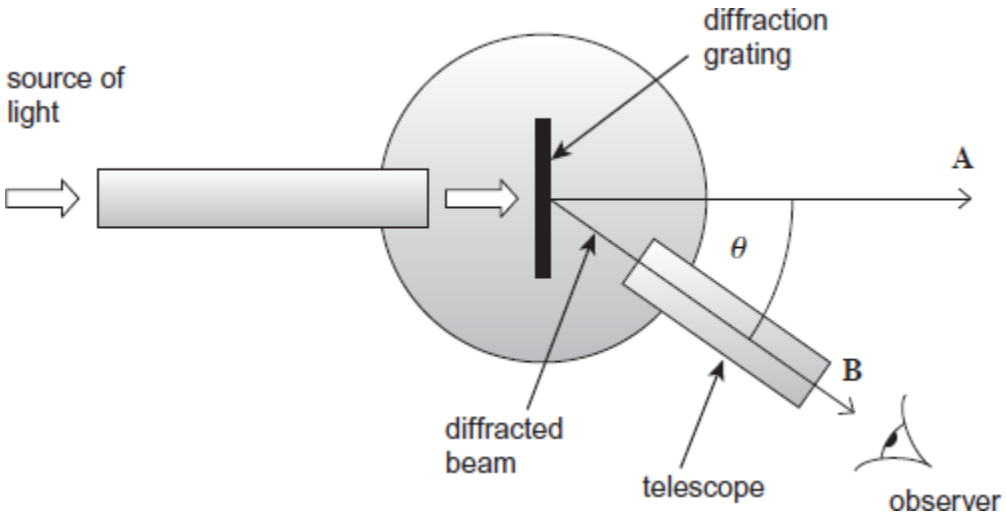

(1)

(b) (i) When the spectrometer telescope is rotated from an initial angle of zero degrees, a spectrum is not observed until the angle of diffraction θ is about 50°. State the order of this spectrum.

.....

(1)

(ii) White light is directed into the spectrometer. Light emerges at **A** and **B**. State **one** difference between the light emerging at **B** compared to that emerging at **A**.

.....

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(1)

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(c) The angle of diffraction θ at the centre of the observed beam **B** in the image above is 51.0° and the grating has 1480 lines per mm.

Calculate the wavelength of the light observed at the centre of beam **B**.

wavelength ..... m

(3)

(d) Determine by calculation whether any more orders could be observed at the wavelength calculated in part (c).

(2)
(Total 8 marks)

14 A student has a diffraction grating that is marked 3.5×10^3 lines per m.

(a) Calculate the percentage uncertainty in the number of lines per metre suggested by this marking.

percentage uncertainty = ... %

(1)

(b) Determine the grating spacing.

grating spacing = ... mm

(2)

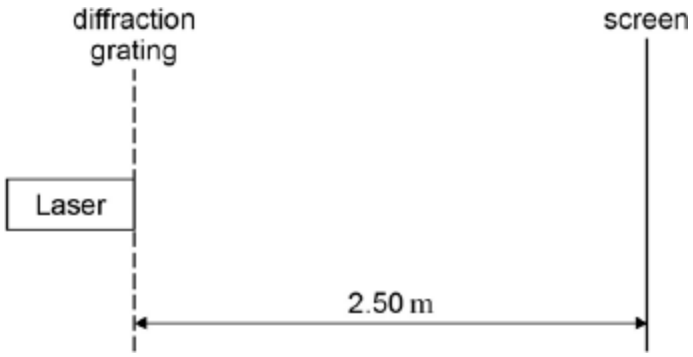
(c) State the absolute uncertainty in the value of the spacing.

absolute uncertainty = ... mm

(1)

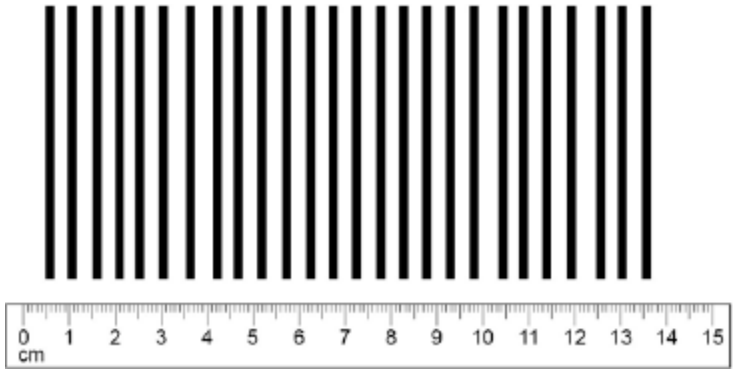
(d) The student sets up the apparatus shown in **Figure 1** in an experiment to confirm the value marked on the diffraction grating.

Figure 1



The laser has a wavelength of 628 nm. **Figure 2** shows part of the interference pattern that appears on the screen. A ruler gives the scale.

Figure 2



Use **Figure 2** to determine the spacing between two adjacent maxima in the interference pattern. Show all your working clearly.

spacing = ... mm

(1)

(e) Calculate the number of lines per metre on the grating.

number of lines = ...

(2)

(f) State and explain whether the value for the number of lines per m obtained in part (e) is in agreement with the value stated on the grating.

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(2)

(g) State **one** safety precaution that you would take if you were to carry out the experiment that was performed by the student.

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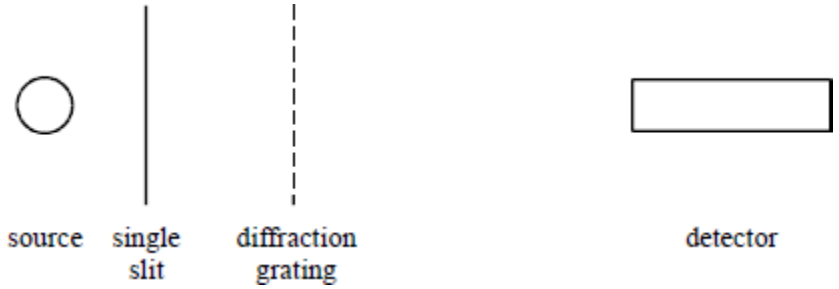
(1)

(Total 10 marks)

15 The diagram below is an arrangement for analysing the light emitted by a source.



(a) Suggest a light source that would emit a continuous spectrum.

.....

(1)

(b) The light source emits a range of wavelengths from 500 nm to 700 nm. The light is incident on a diffraction grating that has 10 000 lines per metre.

(i) Calculate the angle from the straight through direction at which the first order maximum for the 500 nm wavelength is formed.

Angle = ...

(3)

(ii) Calculate the angular width of the first order spectrum.

Angular width .....

(1)

(iii) The detector is positioned 2.0 m from the grating. Calculate the distance between the extreme ends of the first order spectrum in this position.

Distance = ...

(1)

(c) The single slit is initially illuminated by light from a point source that is 0.02 m from the slit.

State and explain how the intensity of light incident on the single slit changes when the light source is moved to a position 0.05 m from the slit.

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(4)
(Total 10 marks)

16 (a) A double slit interference experiment is set up in a laboratory using a source of yellow monochromatic light of wavelength 5.86×10^{-7} m. The separation of the two **vertical** parallel slits is 0.36 mm and the distance from the slits to the plane where the fringes are observed is 1.80 m.

(i) Describe the appearance of the fringes.

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(ii) Calculate the fringe separation, and also the angle between the middle of the central fringe and the middle of the second bright fringe.

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(iii) Explain why more fringes will be seen if each of the slits is made narrower, assuming that no other changes are made.

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(8)

(b) Light of wavelength 5.86×10^{-7} m falls at right angles on a diffraction grating which has 400 lines per mm.

(i) Calculate the angle between the straight through image and the first order image.

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.....

(ii) Determine the highest order image which can be seen with this arrangement.

.....

.....

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(5)

(c) Give **two** reasons why the diffraction grating arrangement is more suitable for the accurate measurement of the wavelength of light than the two-slit interference arrangement.

.....

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(2)
(Total 15 marks)

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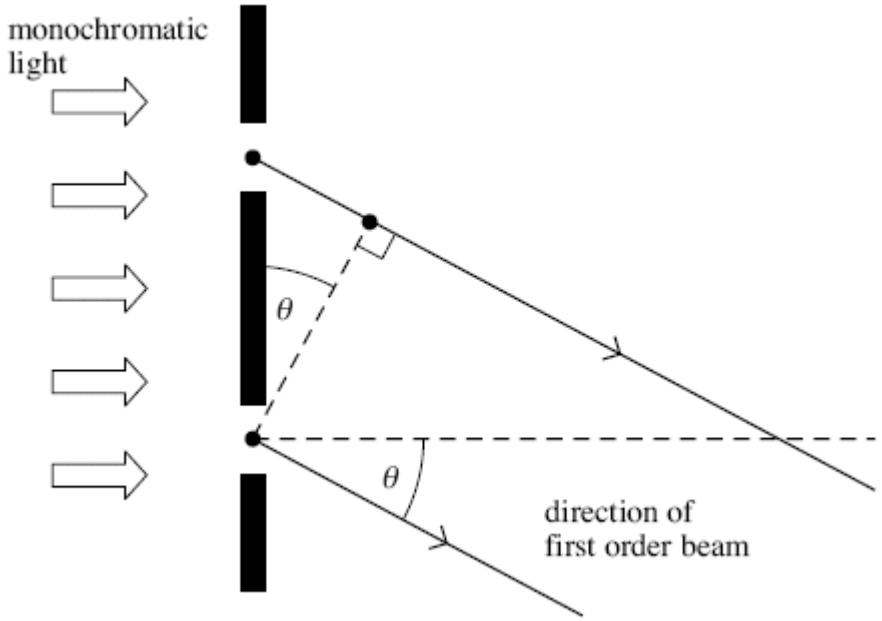
17 For a plane transmission diffraction grating, the diffraction grating equation for the first order beam is:

$$\lambda = d \sin \theta$$

(a) The figure below shows two of the slits in the grating. Label the figure below with the distances d and λ.



(2)

(b) State and explain what happens to the value of angle θ for the first order beam if the wavelength of the monochromatic light decreases.

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(2)

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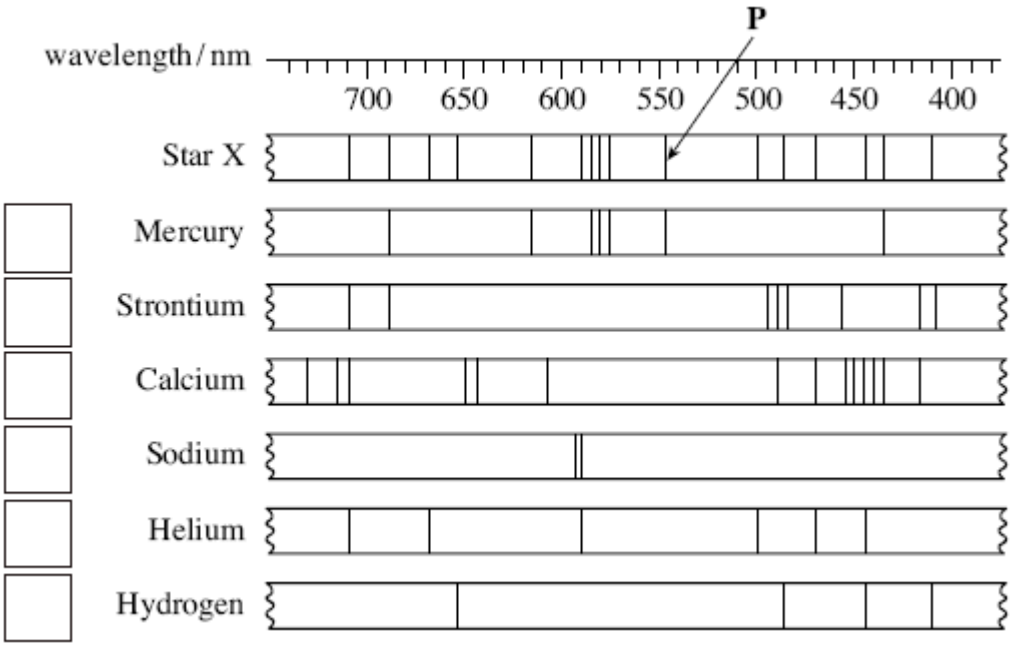
(c) A diffraction grating was used with a spectrometer to obtain the line spectrum of star **X** shown in the figure below. Shown are some line spectra for six elements that have been obtained in the laboratory.

Place ticks in the boxes next to the **three** elements that are present in the atmosphere of star X.



(2)

(d) The diffraction grating used to obtain the spectrum of star X had 300 slits per mm.

(i) Calculate the distance between the centres of two adjacent slits on this grating.

answer = ... m

(1)

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(ii) Calculate the first order angle of diffraction of line **P** in the figure above.

answer = ... degrees

(2)

(Total 9 marks)