1

Diffraction Grating

A Physics

1\. a) What does each term in the diffraction grating equation mean? (2)

$c_{light} = 3 \times 10^8$ m/s
λ red = 700 nm.
λ blue = 400 nm.
1 nm = 1×10^{-9} m
$n\lambda = d \sin\theta$

b) A grating is marked "5500 lines/cm". What is the spacing between two adjacent slits in m? (2)

c) Sodium street light is orange, with a frequency of 5.1×10^{14} Hz.
What is the wavelength of sodium light? (2)

d) At what angles are the 1st and 2nd order diffracted rays produced? Draw a simple diagram to show this (5)

(e) Can a 3rd order diffracted ray be produced?
Explain your answer (2 : even correct guess gets 0).

$\boxed{13}$

2\. Mercury street light has 2 main colours, blue and green.
The green light has a wavelength of 546 nm.

(a) What is the spacing for a diffraction grating with 4000 lines/cm? (2

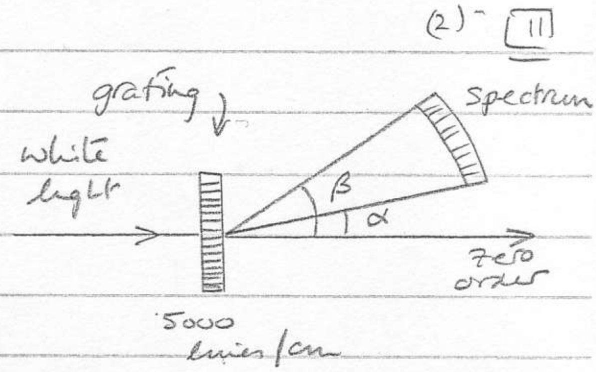
(b) Mercury light is shone through this grating. Calculate the angles of the 1st and 2nd order diffracted rays of the green light. (3)

(c) The angle for the 1st order diffracted blue light is 10.0°.
Calculate the frequency and wavelength of mercury blue light. (4)

(d) Draw a simple diagram showing the diffracted green and blue rays. (2)

$\boxed{11}$

3\. When white light is shone on to a diffraction grating a spectrum is produced.



(a) Why? (3)

(b) Draw a simple diagram to show the spectrum. (2)

(c) Calculate the diffraction angles of the red and blue ends of the spectrum (3)

$\boxed{8}$

TLH
2.99.

Q... 1.../13   2/11   3/8   Total /32

Diffraction Gratings — Answers — A Phys 1.21

1. a) $n\lambda = d\sin\theta$

order of diffracted ray; wavelength, m; grating spacing, m; angle of diffraction ($\frac{1}{2}$ each)

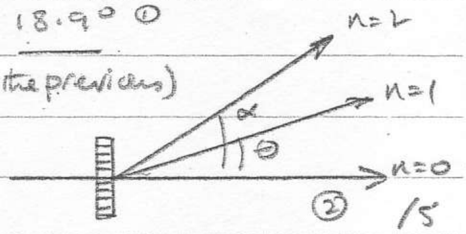
b) 5500 lines/cm = 5.5×10^{5} lines/m ① $\Rightarrow d = 1.82\times10^{-6}$ m ① (2

c) $V_{light} = f\lambda \rightarrow \lambda = V/f =$ ① $3\times10^{8}\times5.1\times10^{14} = 5.88\times10^{-9}$ m ① (2

d) 1st order... $1\times\lambda = d\sin\theta$ ① $\rightarrow \sin\theta = 0.323 \rightarrow \theta = 18.9°$ ①

2nd order... $2\times\lambda = d\sin\theta \rightarrow \sin\theta = 0.646$ (2x the previous)

so $\theta = 40.3°$ ①



② /5

e) for 3rd order... $3\lambda = d\sin\theta$ ①

so $\sin\theta = 3\lambda/d = 3\times588\times10^{-9}/1.82\times10^{-6} = 0.97 \rightarrow \theta = 75.8°$ ①

so a third order diffracted ray can be produced – yes ① (2) $\boxed{15}$

2. a) spacing $d = \frac{1}{4000\times10^{2}\text{ lines/m}}$ ① $= 2.5\times10^{-6}$ m ① (2

b) 1st order .... $n\lambda = d\sin\theta \rightarrow \sin\theta = n\lambda/d =$ ①

$n\lambda = d\sin\theta \rightarrow \sin\theta = n\lambda/d = 1\times546\times10^{-9}/2.5\times10^{-6} = 0.2184$ ($n=1$)

$\theta = 12.6°$ ①

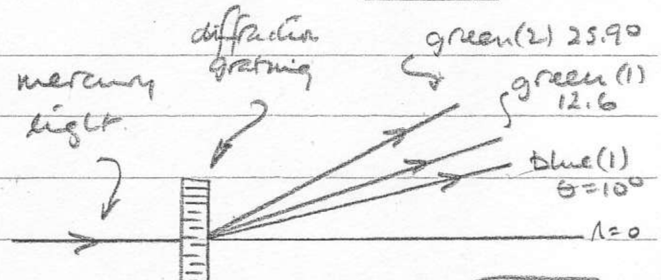
2nd order... $\sin\theta = 2\times546\times10^{-9}/2.5\times10^{-6} = 25.9°$ ① (3

c) Blue light... $n\lambda = d\sin\theta$ ① $\rightarrow 1\times\lambda = 2.5\times10^{-6}\times\sin 10 \rightarrow \lambda = 434\times10^{-9}$ m ①

since $V_{light} = f\lambda$ ①, $f_{blue} = V/\lambda = \frac{3\times10^{8}}{434\times10^{-9}} = 6.9\times10^{14}$ Hz ① (4

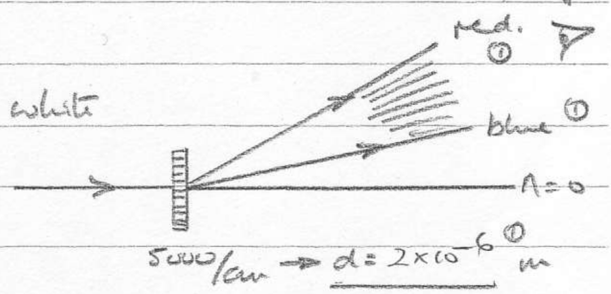
d) 4 diffracted rays ... ½ each (2

total $\boxed{11}$



3. a) "white" light is a combination of all the colours of the spectrum ① The diffraction angle depends on the wavelength. Blue, with the smallest wavelength ①, has the smallest angle, red the largest ① – the different colours are spread into a spectrum

golly!



(b) see diagram ...

5000/cm $\rightarrow d = 2\times10^{-6}$ m ①

c) red, λ_{red} = 700 nm $n\lambda = d\sin\theta \rightarrow \sin\theta_{red} = \frac{\lambda}{d} = 0.35 \rightarrow \theta = 20.5°$ ①

λ_{blue} = 400 nm $\rightarrow \sin\theta_{blue} = 0.2 \rightarrow \theta_{blue} = 11.5°$ ① $\boxed{8}$

PW 3.99

Q... 1 /13 2 /11 3 /8 total /32