c. For her third experiment, April changes the metal plate from the zinc plate used in the second experiment to a plate made of platinum. Platinum has a threshold frequency of 1.53×10^{15} Hz. April uses light of frequency 7.13×10^{14} Hz but does not make any other changes. Photoelectrons are not emitted.

April observes for a longer time and then increases the intensity of the light beam but still finds that photoelectrons are not emitted.

Explain how April's observations support the particle model of light but do not support the wave model of light in explaining the photoelectric effect. 3 marks

According to particle model if frequency of the light is below threshold frequency no electrons will be emitted as photons will not have enough energy and increasing intensity increases number of photons but not their energy. According to wave model, electrons can accumulate energy and if intensity is low emission will start with delay, while according to particle theory if frequency is above threshold electrons will get out immidiately.

Question 15 40 %

Electrons pass through a fine metal grid, forming a diffraction pattern.

If the speed of the electrons was doubled using the same metal grid, what would be the effect on the fringe spacing?

A. The fringe spacing would increase.

(B.) The fringe spacing would decrease.

C. The fringe spacing would not change.

D. The fringe spacing cannot be determined from the information given.

$v \uparrow \rightarrow p \uparrow \rightarrow \lambda = \frac{h}{p} \downarrow \rightarrow \Delta x = \frac{\lambda L}{w} \downarrow$

Question 11 (3 marks) See relativity revision

What is the second postulate of Einstein's theory of special relativity regarding the speed of light? Explain how the second postulate differs from the concept of the speed of light in classical physics.

Question 12 (3 marks) 41%

A sinusoidal wave of wavelength 1.40 m is travelling along a stretched string with constant speed v, as shown in Figure 11. The time taken for point P on the string to move from maximum displacement to zero is 0.120 s.

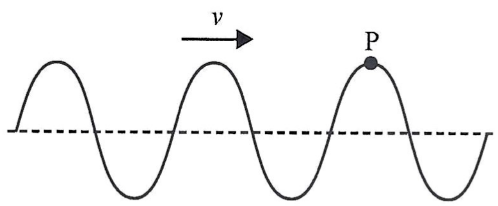


Figure 11

Calculate the speed of the wave, v. Give your answer correct to three significant figures. Show your working.

$T = 0.120 \times 4 = 0.480$ s

$v = \frac{\lambda}{T} = \frac{1.40}{0.48} = 2.92$

2.92 m s^{-1}

Question 13 (3 marks)

In an experimental set-up used to investigate standing waves, a 6.0 m length of string is fixed at both ends, as shown in Figure 12. The string is under constant tension, ensuring that the speed of the wave pulses created is a constant 40 m s^{-1}.

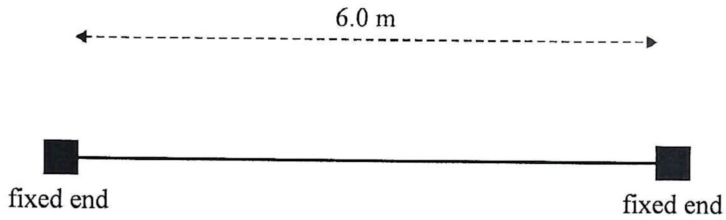


Figure 12

In an initial experiment, a continuous transverse wave of frequency 7.5 Hz is generated along the string.

a. Determine the wavelength of the transverse wave travelling along the string. 1 mark

81 %

$\lambda = \frac{v}{f} = \frac{40}{7.5} = 5.3$ m

5.3 m

b. Will a standing wave form? Give a reason for your answer. 2 marks

17 %

No

For standing wave to form $\lambda = \frac{2L}{n}$, where n is a natural number (1, 2, 3...)

$\frac{2 \times 6}{5.3} \neq$ whole number

Question 14 (6 marks)

Students have set up a double-slit experiment using microwaves. The beam of microwaves passes through a metal barrier with two slits, shown as S_1 and S_2 in Figure 13. The students measure the intensity of the resulting beam at points along the line shown. They determine the positions of maximum intensity to be at the points labelled P_0, P_1, P_2 and P_3. Take the speed of electromagnetic radiation to be 3.00×10^8 m s^{-1}.

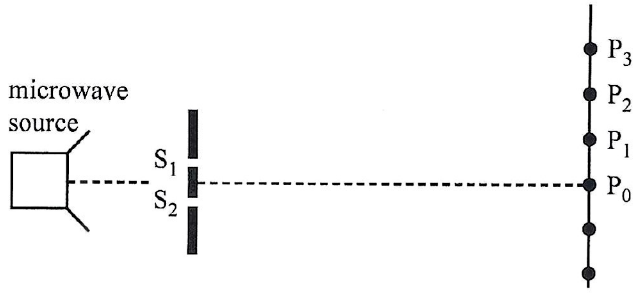


Figure 13

The distance from S_1 to P_3 is 72.3 cm and the distance from S_2 to P_3 is 80.6 cm.

a. What is the frequency of the microwaves transmitted through the slits? Show your working. 2 marks

Path difference $S_2P_3 - S_1P_3 = 0.806 - 0.723 = 0.083$ m 26%

$0.083 = 3\lambda$ $\lambda = \frac{0.083}{3} = 2.77 \times 10^{-2}$ m

$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{2.77 \times 10^{-2}} = 1.08 \times 10^{10}$

1.08×10^{10} Hz

b. The signal strength is at a minimum approximately midway between points P_0 and P_1.

Explain the reason why the signal strength would be a minimum at this location. 2 marks

Path difference will be $\frac{\lambda}{2}$ so there will be destructive interference. 17%

c. The microwaves from the source are polarised.

Explain what is meant by the term 'polarised'. You may use a diagram in your answer. 2 marks

Light is transverse wave. Polarised light is light where electric (and so magnetic field which is ⊥ to electric) is oscillating only in one plate (one direction).

41%

Question 15 (4 marks)

A student sets up an experiment involving a source of white light, a glass prism and a screen. The path of a single ray of white light when it travels through the prism and onto the screen is shown in Figure 14.

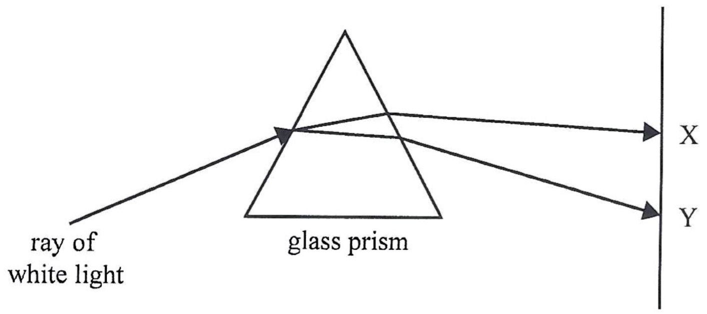


Figure 14

A spectrum of colours is observed by the student on the screen, which is positioned to the right of the prism.

a. Name and explain the effect observed by the student. 3 marks

Dispersion. Refractive index of the glass is different for different wavelength so they refract differently so different colours exit the prism at different angles. 27%

b. Points X and Y on Figure 14 represent either end of the visible spectrum observed by the student.

Identify the two visible colours observed at point X and at point Y. 1 mark

Point X red Point Y violet 68%

Question 16 (6 marks)

Students are studying the photoelectric effect using the apparatus shown in Figure 15.

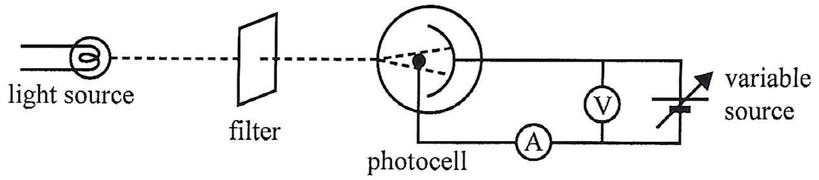


Figure 15

Figure 16 shows the results the students obtained for the maximum kinetic energy ($E_{k\ max}$) of the emitted photoelectrons versus the frequency of the incoming light.

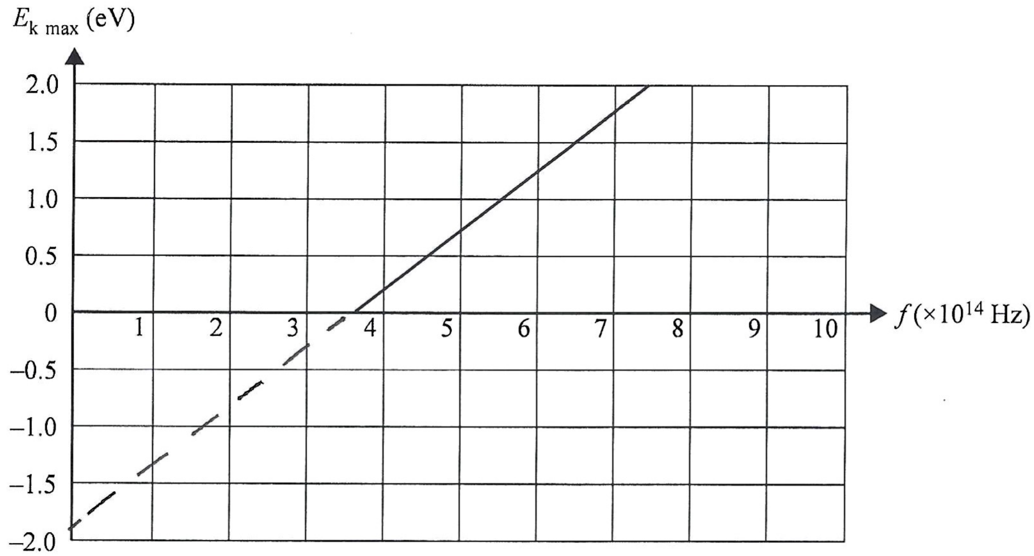


Figure 16

a. Using only data from the graph, determine the values the students would have obtained for

i. Planck's constant, h. Include a unit in your answer — 2 marks

h = gradient = $\frac{2-0}{(7.5-3.7)\times 10^{14}}$ = $= 5.3 \times 10^{-15}$ — 38 %

5.3×10^{-15} eV s

5.0 – 5.6 was accepted

ii. the maximum wavelength of light that would cause the emission of photoelectrons — 1 mark

44%

$f_0 = 3.7 \times 10^{14}$

$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{3.7 \times 10^{14}} = 8.1 \times 10^{-7}$

810 nm

790 – 833 was accepted

iii. the work function of the metal of the photocell. — 1 mark

56%

From the graph

1.9 eV

1.8 – 2.0 was accepted

b. The work function for the original metal used in the photocell is ϕ.

On Figure 17, draw the line that would be obtained if a different metal, with a work function of $\frac{1}{2}\phi$, were used in the photocell. The original graph is shown as a dashed line. — 2 marks

69%

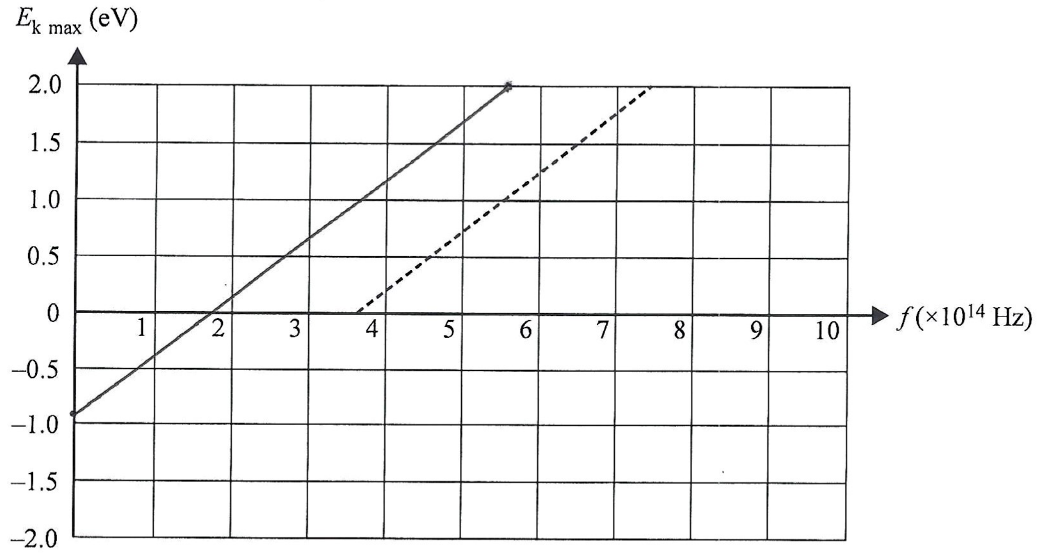
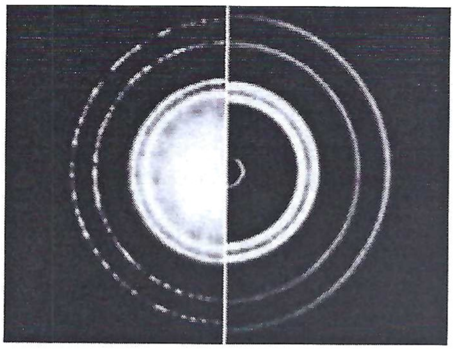


Figure 17

Question 17 (7 marks)

Students are comparing the diffraction patterns produced by electrons and X-rays, in which the same spacing of bands is observed in the patterns, as shown schematically in Figure 18. Note that both patterns shown are to the same scale.



electrons X-rays

Figure 18

The electron diffraction pattern is produced by 3.0×10^3 eV electrons.

a. Explain why electrons can produce the same spacing of bands in a diffraction pattern as X-rays. 3 marks

Electrons can behave as waves 22%

Diffraction pattern depends on wavelength.

Electrons and X-Rays have same wavelength

b. Calculate the frequency of X-rays that would produce the same spacing of bands in a diffraction pattern as for the electrons. Show your working. 4 marks

$p_{el} = \sqrt{2mE} = \sqrt{2 \times 9.1 \times 10^{-31} \times 3 \times 10^{3} \times 1.6 \times 10^{-19}}$ 23%

$= 2.96 \times 10^{-23}$ kg m s^{-1}

$p_{ph} = p_{el}$ $\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{2.96 \times 10^{-23}} = 2.24 \times 10^{-11}$ m

$f = \frac{c}{\lambda} = \frac{3 \times 10^{8}}{2.24 \times 10^{-11}} = 1.34 \times 10^{19}$

1.34×10^{19} Hz