Neap:

PHYSICS VCE UNITS 3&4
DIAGNOSTIC TOPIC TESTS 2017

TEST 9: HOW ARE LIGHT AND MATTER SIMILAR? (I)

TOTAL 45 MARKS (45 MINUTES)

Student's Name: _____ Teacher's Name: _____

Directions to students

Write your name and your teacher's name in the spaces provided above.
Answer all questions in the spaces provided.

Use $c = 3.0 \times 10^{8}$ m s^{-1}, $h = 6.63 \times 10^{-34}$ Js, $h = 4.14 \times 10^{-15}$ eVs, $q_e = 1.6 \times 10^{-19}$ C and $m_e = 9.11 \times 10^{-31}$ kg.

Question 1 (3 marks)

Figure 1 shows two images of a radiolarian protozoa. Image A has been taken using visible light and image B has been produced using an electron microscope.

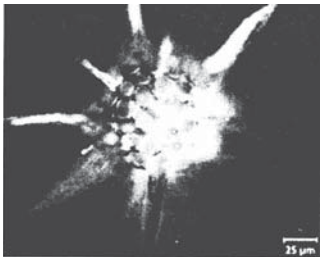

Image A
radiolarian light under microscope

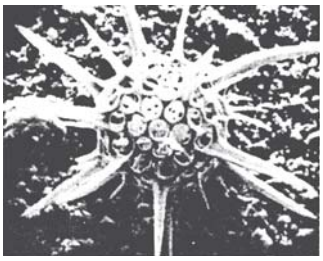

Image B
radiolarian under electron microscope

Figure 1

Image A is described as blurred and image B is described as sharp. Visible light ranges in wavelength from 0.40 μm to 0.75 μm while the de Broglie wavelength of electrons range from 1.23×10^{-3} μm to 1.90×10^{-6} μm.

Explain why the image of the radiolarian produced using visible light is blurred compared to the image produced using an electron microscope.

Question 2 (17 marks)

In a physics experiment on the photoelectric effect, students plot a graph of the maximum kinetic energy of ejected electrons (KE_{max}) versus the incident light frequency (f) for potassium. This is shown in Figure 2.

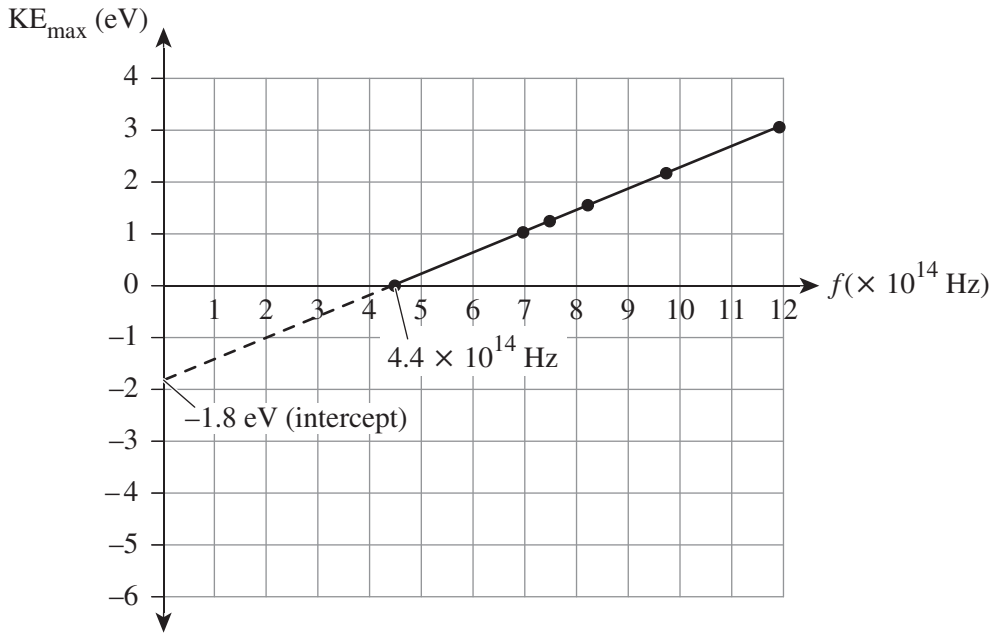

Figure 2

a. Determine the minimum amount of energy a photon of light would need to eject an electron from the potassium metal. 2 marks

J

b. 1.0 V was used to stop the electrons ejected from the metal after being irradiated by light.

What energy did the photons have that caused the irradiation of the electrons? 2 marks

eV

The physics students undertake another experiment, but this time they replace the potassium metal with silver metal that has a work function of 4.7 eV.

c. On Figure 2, accurately draw the expected graph for silver's maximum kinetic energy versus incident light frequency, labelling any intercepts. 3 marks

d. If light of frequency 2×10^{14} Hz had been used, explain whether or not electrons would be emitted from potassium metal. 3 marks

The experiment is now conducted three times using the same metal and light colour, but the light intensity is increased from the original intensity I to twice and then three times the original intensity, $2I$ and $3I$. The plotting of the photo current versus the stopping voltage for the three intensities is shown in Figure 3.

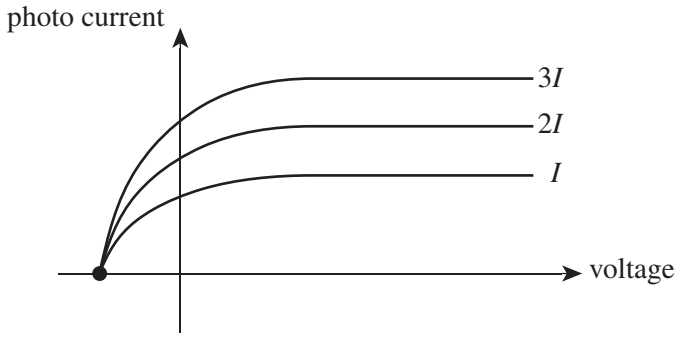

Figure 3

e. Explain why the particle model accounts for the results shown in Figure 3. 3 marks

The experiment is now again conducted three times where the same metal and light intensity are used but the light colours used are red in the first experiment, green in the second experiment and violet in the third experiment. The plotting of the photo current versus the stopping voltage for the three colours is shown in Figure 4.

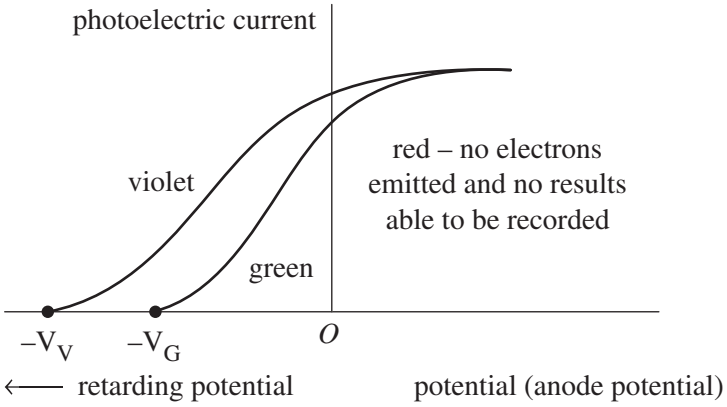

Figure 4

f. Explain what the wave model predicts about the results when the only variable is the colour of light and provide the correct explanation of the results of Figure 4. 4 marks

Question 3 (7 marks)

An electron is accelerated from rest by a potential difference 1000 V.

a. Determine the final kinetic energy of the electron in eV. 2 marks

eV

b. Determine the final momentum of the electron. 3 marks

Ns

c. Determine the de Broglie wavelength of the electron. 2 marks

m

Question 4 (7 marks)

An electron beam of energy 30 eV bombards a thin wafer of zinc whose spacing between the zinc atoms is 0.135 nm.

a. Determine the de Broglie wavelength of an electron in this beam. 3 marks

m

b. Explain whether the electrons in the beam behave as waves or particles as they approach the spacing between the zinc atoms of the wafer. Provide a calculation to support your explanation. 4 marks

Question 5 (6 marks)

A photon and an electron both have the same wavelength of 600 nm.

a. Determine the momentum of the photon. 2 marks

Ns

b. Determine the momentum of the electron and provide an explanation for this. 2 marks

Ns

A different photon has a momentum of 3.0×10^{-27} Ns.

c. Determine the energy of the photon in eV. 2 marks

eV

Question 6 (5 marks)

Figure 5 shows the pattern of bright and dark bands produced when a beam of X-rays (left image) and then a beam of electrons (right image) strike the surface of a metal (both images are of the same scale).

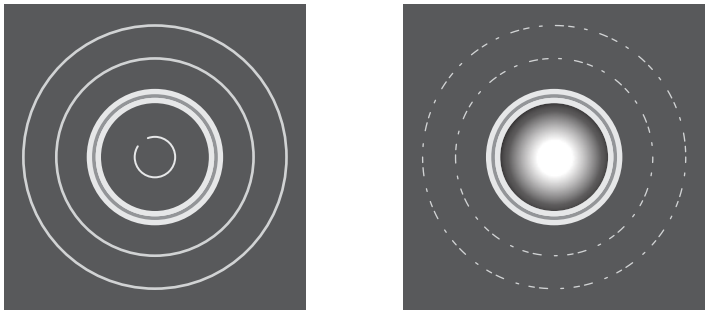

Figure 5

a. State the conclusion that can be drawn about the behaviour of the electrons and explain the evidence that leads to the conclusion. 2 marks

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b. Explain the quantities that were the same regarding the electrons and the X-rays. 3 marks

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