AQA, Edexcel

A Level

A Level Physics

Quantum Physics

Name:

M M E

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Total Marks: /30

1. Numerous models have now been developed to explain electromagnetic radiation and its interaction with matter and space. For example, the photon model accurately explains what happens when electromagnetic radiation reaches the surface of a solid but to explain its propagation through a vacuum the wave model is used.

Total for Question 1: 7

(a) State three key observations from the photoelectric effect. [3]

(b) Reconcile these observations in the context of the photon model and explain why the wave model is insufficient. [4]

2. In 1905 Einstein provided an explanation for the photoelectric effect first observed by Hertz in 1887. This question uses his equations to explore how electromagnetic radiation interacts with different metals.

Total for Question 2: 11

(a) This is Einstein's photoelectric equation: [3]

$$hf = \phi + \frac{1}{2}mv_{max}^2$$

Define each of the terms and explain why this is a statement of energy conservation.

(b) The work function of a metal is 2.36 eV and the fastest electrons that Becky measures travel at a speed of 1.1×10^6 ms^{-1}. Calculate the maximum possible wavelength of the incident radiation. Why is this an upper bound? [4]

(c) Becky doesn't know which metal she is using. The threshold frequencies of caesium, sodium and zinc are 5.16×10^{14} Hz, 5.70×10^{14} Hz and 1.04×10^{15} Hz, respectively. Which is it likely to be? [2]

(d) Next, she irradiates two samples of caesium with different radiation. Both sources have a radiant power of 10 mW. The frequencies of the radiation they emit are 5.00×10^{14} Hz and 5.50×10^{14} Hz. She then doubles the power of both lasers. Describe qualitatively the change she should expect to see in the number of electrons emitted in each case. [2]

3. Experiments such as those of Young and Hertz show electromagnetic radiation to have characteristics of both waves and particles. In a similar way, electrons are now thought to exhibit wave-like and particle-like behaviour, depending on the circumstances.

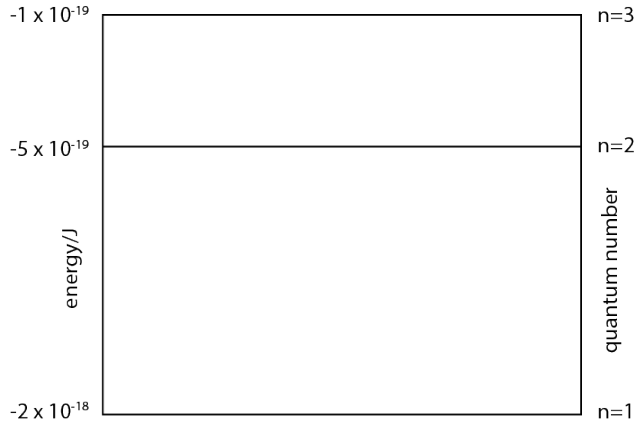
Total for Question 3: 7

(a) How might an electron gun irradiating a polycrystalline graphite crystal demonstrate wave-particle duality? [3]

(b) Electrons are accelerated through a potential difference of 300 V. What is their final de Broglie wavelength? [4]

4. The sketch below shows the first three electron energy levels in a gas. These have been annotated with their energies and their quantum numbers.

Total for Question 4: 5



(a) An electron is excited to the n=3 energy level. What was the frequency of the photon it absorbed? [2]

(b) The excited electron later de-excites. Rather than falling down to the ground state, it comes to an intermediate halt in the n=1 level. Explain, quantitatively where appropriate, what happens. State the frequency of any new particles created. [3]