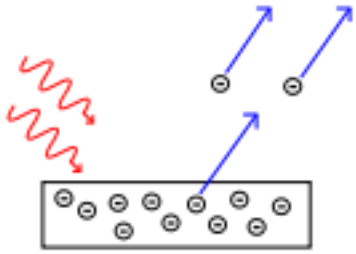
Quantum Phenomena Revision Questions

1. When electrons are incident on the surface of a metal electrons are produced.



a) What is the name of this phenomenon?

..... *(1 mark)*

The properties of the incoming photons and the emitted electrons are related by the following equation:

$$hf = \phi + E_k$$

b) For each term in the equation state what the term represents and its units.

h .....*unit*.....

f .....*unit*.....

ϕ .....*unit*.....

E_K.....*unit*.....

(4 marks)

2. Quantum mechanics includes the observations that electrons exhibit wave-like properties.

   a) Describe an observation which demonstrates this phenomenon. Details are not required.

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   .....*(1 mark)*

   b) Calculate the de Broglie wavelength of an electron travelling at 3.2×10^5 ms^{-1}.

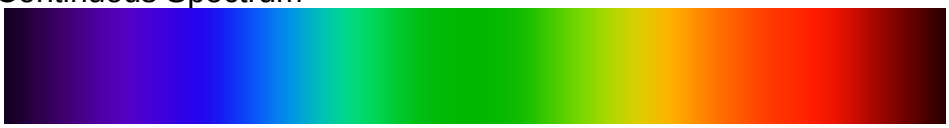
(2 marks)

   c) Calculate the kinetic energy of the above electron.

(2 marks)

3. One piece of evidence for the quantum behaviour of electrons is that of line spectra. The two images below show a continuous spectrum a light source and the spectrum of a similar light source shone through mercury vapour.

Continuous Spectrum



Mercury vapour lamp

a) Explain how the spectrum for mercury demonstrates a quantum phenomenon.

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.....*(3 marks)*

b) Mercury produces a sharp absorption line at 436 nm. Calculate the energy of this photon.

(2 marks)

4. In an experiment to measure the photoelectric effect, light of wavelength λ is incident on a metal surface and a current is produced. The current is suppressed by supplying a potential difference *V* between the metal surface and the collecting plate.

   a) Derive, with explanation, and equation relating λ, *V* and the work function, φ, of the metal.

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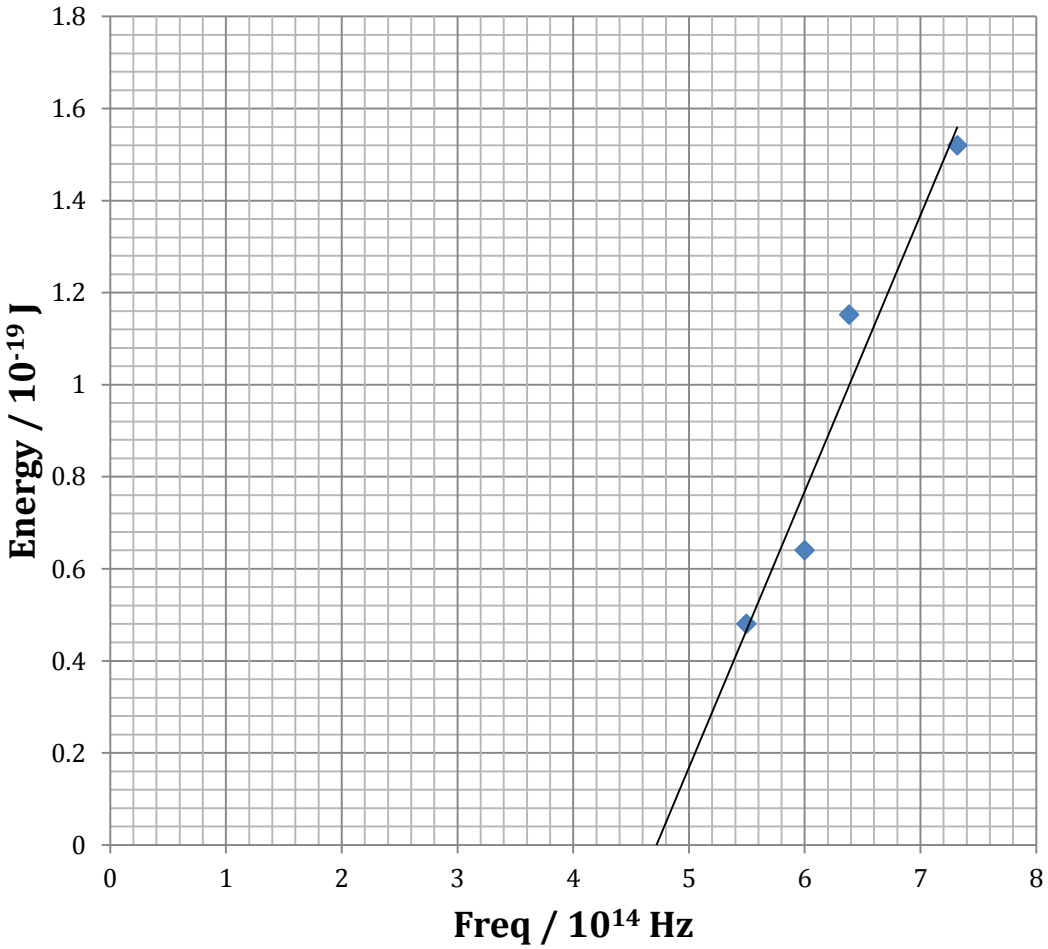
   .....*(2 marks)*

   The results of this experiment are shown below.



b) Using the graph opposite,

i. Determine *h* and the threshold frequency, f_0, from the graph. Include correct units.

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.....*(3 marks)*

ii. Calculate the work function, φ, of the metal.

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.....*(3 marks)*

c) State and explain the effect of doubling the intensity of the radiation while keeping the frequency constant.

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.....*(2 marks)*

Data

Plank's Constant	h	6.63×10^{-34}	Js
Speed of light in a vacuum	c	3.00×10^{8}	ms^{-1}
Mass of an electron	m_e	9.11×10^{-31}	kg

Equations

photon Energy	$E = hf$
photoelectricity	$hf = \phi + E_{k(max)}$
energy levels	$hf = E_1 - E_2$
de Broglie wavelength	$\lambda = \frac{h}{p} = \frac{h}{mv}$

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