Photoelectric Effect Questions

1. (a) The following equation describes the release of electrons from a metal surface illuminated by electromagnetic radiation.

$$hf = k.e._{max} + \phi$$

Explain briefly what you understand by each of the terms in the equation.

hf ....

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$k.e._{max}$ ....

....

ϕ ....

....

(3)

(b) Calculate the momentum *p* of an electron travelling in a vacuum at 5% of the speed of light.

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p = ...

(3)

What is the de Broglie wavelength of electrons travelling at this speed?

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λ = ...

(2)

Why are electrons of this wavelength useful for studying the structure of molecules?

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(2)
(Total 10 marks)

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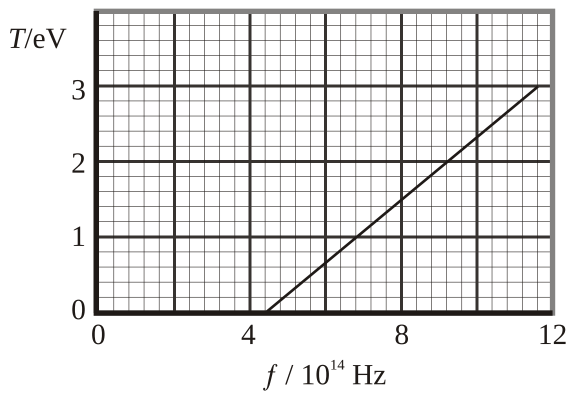
2. The graph shows how the maximum kinetic energy *T* of photoelectrons emitted from the surface of sodium metal varies with the frequency *f* of the incident radiation.



Why are no photoelectrons emitted at frequencies below 4.4×10^{14} Hz?

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(1)

Calculate the work function Ø of sodium in eV.

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Work function = ...

(3)

Explain how the graph supports the photoelectric equation $hf = T + Ø$

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(2)

How could the graph be used to find a value for the Planck constant?

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(1)

Add a line to the graph to show the maximum kinetic energy of the photoelectrons emitted from a metal which has a greater work function than sodium.

(2)
(Total 9 marks)

3. Experiments on the photoelectric effect show that

- the kinetic energy of photoelectrons released depends upon the frequency of the incident light and not on its intensity,
- light below a certain threshold frequency cannot release photoelectrons.

How do these conclusions support a particle theory but not a wave theory of light?

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(6)

Calculate the threshold wavelength for a metal surface which has a work function of 6.2 eV.

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Threshold wavelength = ...

To which part of the electromagnetic spectrum does this wavelength belong?

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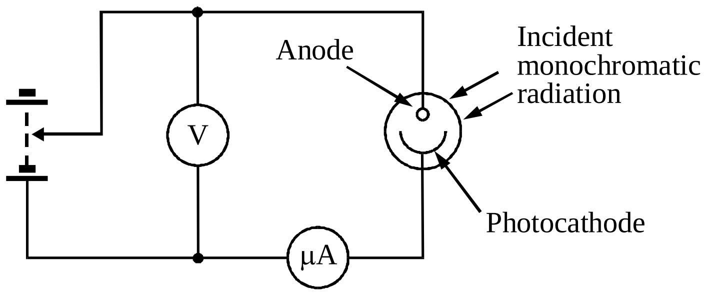
(4)
(Total 10 marks)

4. The diagram shows monochromatic light falling on a photocell.



As the reverse potential difference between the anode and cathode is increased, the current measured by the microammeter decreases. When the potential difference reaches a value V_s, called the stopping potential, the current is zero.

Explain these observations.

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(5)

What would be the effect on the stopping potential of

(i) increasing only the intensity of the incident radiation,

……..………………………………………………………………………

(ii) increasing only the frequency of the incident radiation?

……..………………………………………………………………………

(2)
(Total 7 marks)

5. Experiments on the photoelectric effect show that

- the kinetic energy of photoelectrons released depends upon the frequency of the incident light and not on its intensity.
- light below a certain threshold frequency cannot release photoelectrons.

How do these conclusions support a particle theory but not a wave theory of light? You may be awarded a mark for the clarity of your answer.

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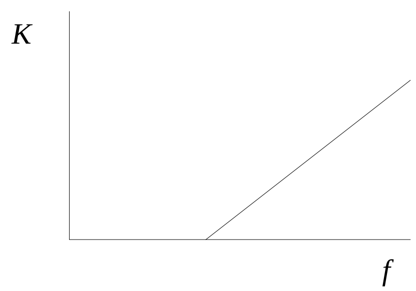
(6)

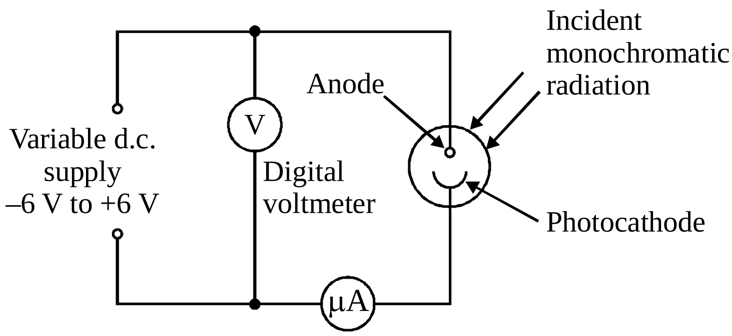
The graph shows how the kinetic energy *K* of emitted photoelectrons from one metal varies with the frequency *f* of the incident light.



Add a second line to the graph showing how *K* will vary with *f* for a second metal which has a *smaller* work function.

(2)
(Total 8 marks)

6. The diagram shows monochromatic radiation falling on a photocell connected to a circuit.



The incident radiation has a wavelength of 215 mm. The metal surface of the photocathode has a work function of 2.26eV.

Calculate the energy in eV of a photon of the incident radiation.

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Energy = ... eV

(4)

What is the maximum kinetic energy in eV of the emitted electrons?

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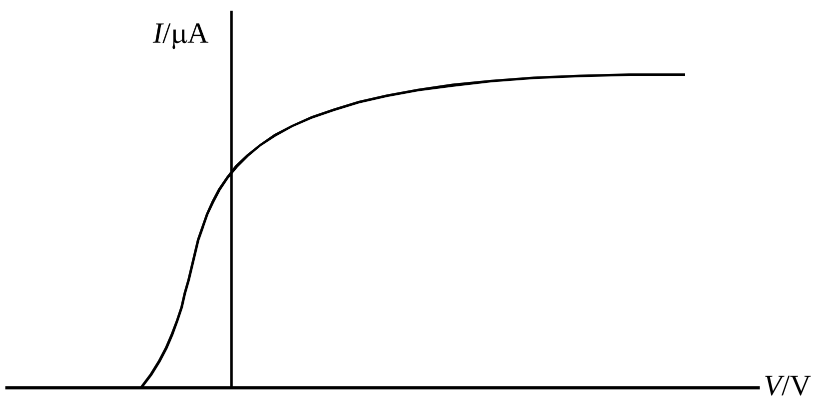
Maximum k.e. = ... eV

Write down the value of the stopping potential.

Stopping potential = ...

(2)

If the wavelength and intensity of the incident radiation is kept constant, a graph of the current I through the photocell against applied p.d. V is as shown.



Mark a letter S on the graph to show the stopping potential.

The photocathode is replaced with one whose metal surface has a greater work function. On the graph above, sketch how I would vary with V given that the wavelength and intensity of the incident radiation remain unchanged.

(3)
(Total 9 marks)

7. The photoelectric effect supports a particle theory of light but not a wave theory of light.

Below are two features of the photoelectric effect. For each feature explain why it supports the particle theory and not the wave theory.

(a) Feature 1: The emission of photoelectrons from a metal surface can take place instantaneously.

Explanation ....

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(2)

(b) Feature 2: Incident light with a frequency below a certain threshold frequency cannot release electrons from a metal surface.

Explanation ....

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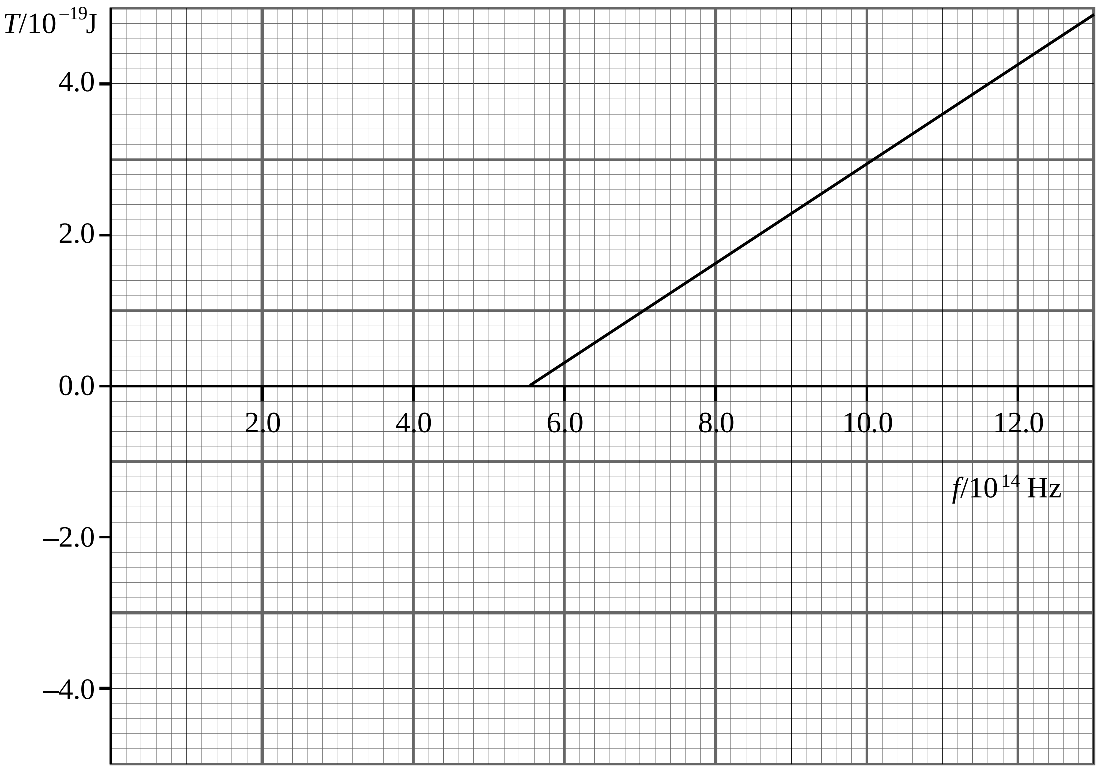
(2)
(Total 4 marks)

8. The graph shows how the maximum kinetic energy T of photoelectrons emitted from the surface of sodium metal varies with the frequency f of the incident electromagnetic radiation.



Use the graph to find a value for the Planck constant.

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Planck constant = ...

(3)

Use the graph to find the work function ϕ of sodium metal.

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Work function = ...

(2)

Calculate the stopping potential when the frequency of the incident radiation is 9.0×10^{14} Hz.

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Stopping potential = ...

(3)

(Total 8 marks)