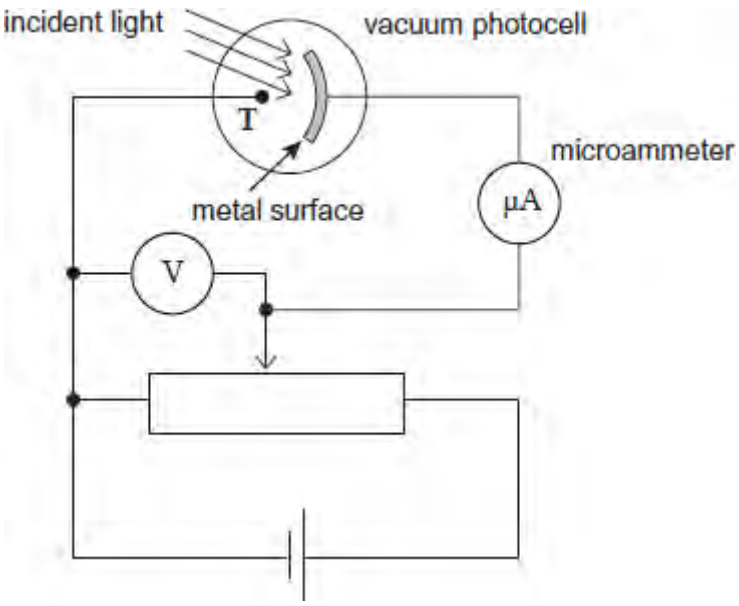
Q1. The figure below shows a metal surface in a vacuum photocell illuminated by light of a certain frequency. Electrons emitted from the metal surface are collected by terminal **T** in the photocell.



(a) The potential of the metal surface may be changed by adjusting the potential divider.
Explain why the microammeter reading decreases when the metal surface is made more positive relative to **T**.

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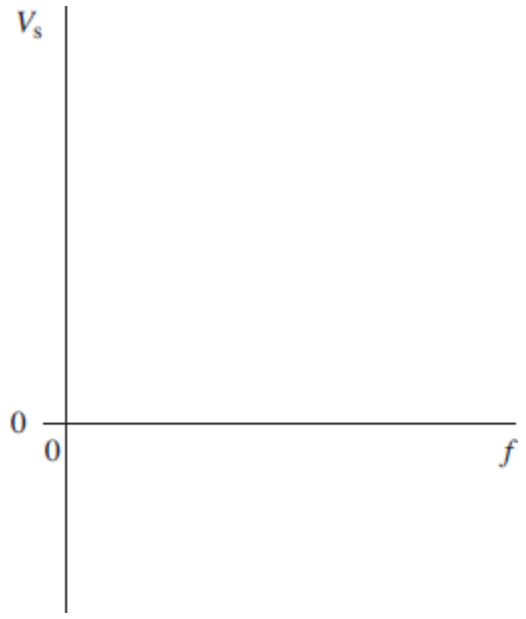
(3)

(b) The stopping potential V_s is the minimum potential that is applied to the metal surface to reduce the photoelectric current to zero when monochromatic light is incident on the surface. The circuit is used with light of different frequencies to measure the stopping potential V_s when the surface is illuminated at each frequency.

(i) Draw a graph on the axes below to show how V_s varies with the frequency f of the incident light.



(2)

(ii) Use the photoelectric equation $hf = \phi + E_k$ to explain your graph.

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(3)

(c) Using the circuit in the diagram above, the stopping potential was 1.92 V for light of wavelength 418 nm.

Use this information to calculate the work function of the metal surface.
Give an appropriate unit in your answer.

work function ..... unit .....

(4)

(Total 12 marks)

Q2. When light of wavelength 590 nm is directed at an uncharged surface of a certain metal X, electrons are emitted from the metal surface causing a photoelectric current.

(a) When the metal surface is charged positively, the photoelectric current decreases and becomes zero when the potential of the surface is +0.35 V.

(i) Calculate the maximum kinetic energy of a photoelectron emitted from the surface when the metal surface is uncharged.

answer = ... J

(2)

(ii) Calculate the work function of the metal surface, in J.

answer = ... J

(3)

(b) When the experiment was repeated using a different metal, Y, illuminated by light of the same wavelength, there was no photoelectric emission when the metal surface was uncharged.

(i) Explain this observation.

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(ii) How did this observation contribute to the failure of the wave theory of light?

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(2)
(Total 9 marks)

Q3. Photoelectric emission occurs from a certain metal plate when the plate is illuminated by blue light but not by red light.

(a) Explain why photoelectric emission occurs from this plate using blue light but not using red light.

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(b) Outline why Huygens' wave theory of light fails to explain the fact that blue light causes photoelectric emission from this plate but red light does not.

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(Total 6 marks)

Q4.(a) A certain metal has a work function of 1.2 eV.

(i) Explain what is meant by this statement.

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(ii) Calculate the threshold wavelength of light for this metal surface.

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(3)

(b) When blue light is incident on a certain metal surface, electrons are emitted from the surface. No electrons are emitted when red light, instead of blue light, is incident on the same surface at the same potential.

(i) Use Einstein's theory of light to explain these observations.

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(ii) Outline the significance of Einstein's explanation.

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(5)
(Total 8 marks)

Q5. When a clean metal surface in a vacuum is irradiated with ultraviolet radiation, electrons are emitted from the metal. The following equation relates the frequency of the incident radiation to the kinetic energy of the emitted electrons.

$$hf = \phi + E_k$$

(a) Explain what each of the following terms represents in the above equation.

(i) hf .....

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(ii) ϕ .....

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(iii) E_k .....

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(3)

(b) (i) State what would happen to the number of photoelectrons ejected per second if the ultraviolet source were replaced by a source of red light of the same intensity but of frequency less than ϕ/h.

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(ii) What would the wave theory of light predict about the effect of using the red light source instead of an ultraviolet source?

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(iii) Use the photon theory of light to explain the effect of using the red light source instead of an ultraviolet source.

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(3)

(c) Monochromatic radiation of wavelength 3.00×10^{-7} m ejects photoelectrons at kinetic energies of up to 3.26×10^{-19} J when incident on a clean metal surface. Calculate the work function of the metal, in J.

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(2)
(Total 8 marks)