

# HW Two Solar Cells

38 min  
38 marks

1. Define electrical potential difference.

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(1)

State an appropriate unit for potential difference.

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(1)

Express this unit in terms of base units.

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(2)

**(Total 4 marks)**

2. (a) Magnesium has a work function of  $5.89 \times 10^{-19}$  J. Explain the meaning of this statement.

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(2)

(b) Ultraviolet radiation from an extremely faint source is incident normally on a magnesium plate. The intensity of the radiation is  $0.035 \text{ W m}^{-2}$ . A single magnesium atom occupies an area of about  $8 \times 10^{-20} \text{ m}^2$  on the surface of the plate.

(i) Show that, if the radiation is regarded as a wave motion, it should take at least 200 s for a magnesium atom to absorb  $5.89 \times 10^{-19} \text{ J}$  of energy.

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(3)

(ii) In practice, it is found that photoemission from the plate begins as soon as the radiation source is switched on. Explain how the photon model of electromagnetic radiation accounts for this. You may be awarded a mark for the clarity of your answer.

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(4)

(Total 9 marks)

3. 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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(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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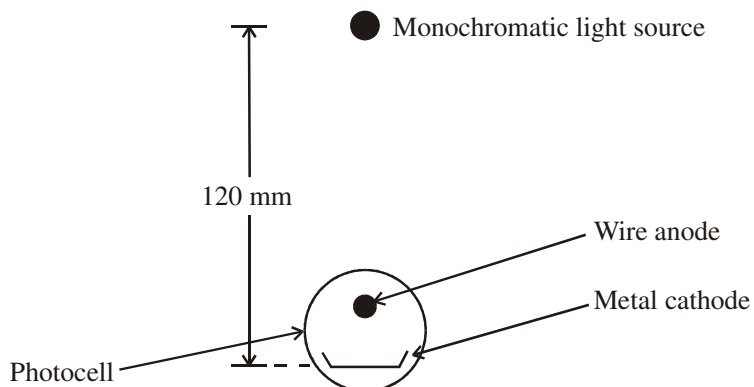
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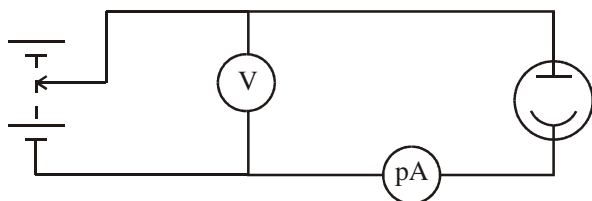
(2)

(Total 4 marks)

4. A monochromatic light source is placed 120 mm above the cathode of a photocell.



A potential difference is applied between the cathode and the anode of the photocell and the sensitive ammeter detects the current.



The table below shows the currents which are obtained with this apparatus for two different intensities and two different wavelengths of light, using two different cathode materials. Work function energies are given.

Wavelength of incident radiation /nm	Cathode material	Work function /eV	Photocurrent /A when intensity of incident radiation is	
			1 W m <sup>-2</sup>	5 W m <sup>-2</sup>
320	Aluminium	4.1	0	0
640	Aluminium	4.1	0	0
320	Lithium	2.3	$0.2 \times 10^{-12}$	$1.0 \times 10^{-12}$
640	Lithium	2.3	0	0

Show that the incident photons of  $\lambda = 320 \text{ nm}$  and  $\lambda = 640 \text{ nm}$  have energies of approximately 4 eV and 2 eV respectively.

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Account for the photocurrent readings shown in the table.

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Calculate the stopping potential for the photoelectrons released by lithium when irradiated by light of wavelength 320 nm.

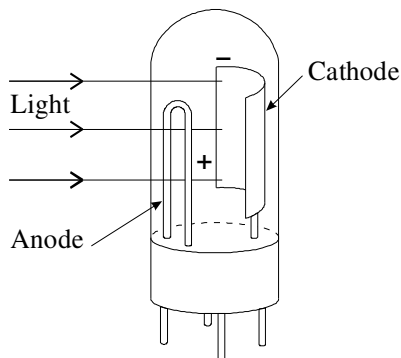
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Stopping potential = .....

(2)

(Total 9 marks)

5. The intensity of the light falling on the photocell shown in the diagram below controls the electric current flowing in a circuit.



An electron is sometimes released when a photon hits a metal surface. This is known as the photoelectric effect and can be expressed mathematically by the Einstein equation.

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

Show that the energy of a photon of light of frequency  $6.0 \times 10^{14}$  Hz is about  $4 \times 10^{-19}$ J.

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(1)

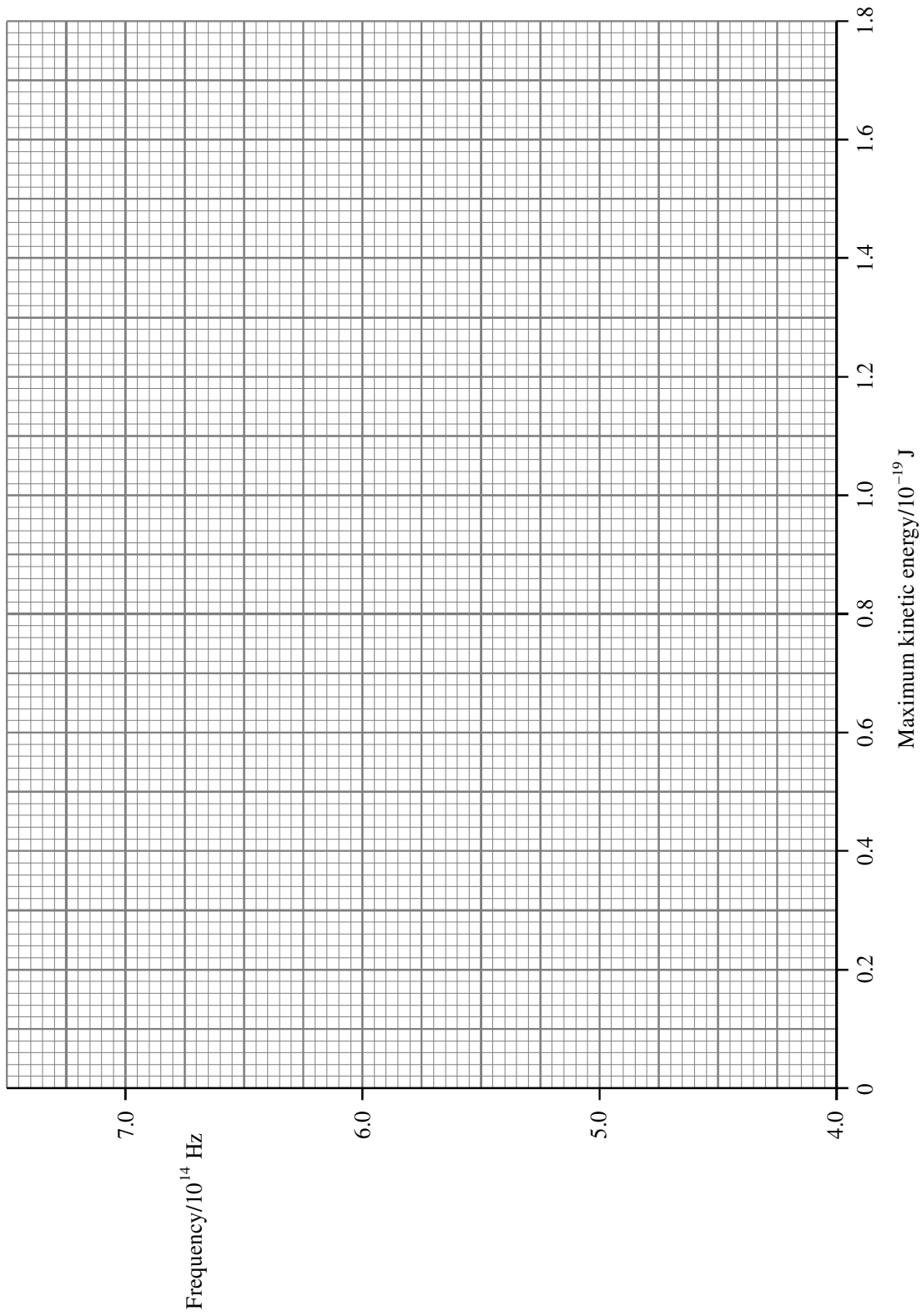
A student is investigating the photoelectric effect and selects light of various frequencies to shine on to a metal surface. Using his experimental data, he calculates the maximum kinetic energy of the electrons emitted from the surface. The results are given below.

Frequency/ $10^{14}$ Hz	Maximum kinetic energy/ $10^{-19}$ J
7.0	1.65
6.5	1.29
6.0	0.96
5.5	0.65
5.0	0.30

Plot the points on the grid below. Add the line of best fit.

The Einstein equation can be rearranged to give

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



(4)

Use the graph you have plotted to find a value for  $h$ .

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Hence show that  $\phi$  is about  $3 \times 10^{-19}$  J.

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The student continues the experiment and shines light with a frequency of  $4.5 \times 10^{14}$  Hz on to the surface but finds that he cannot detect any photoelectrons. Explain why photoelectrons are not being emitted from the surface.

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**(Total 12 marks)**