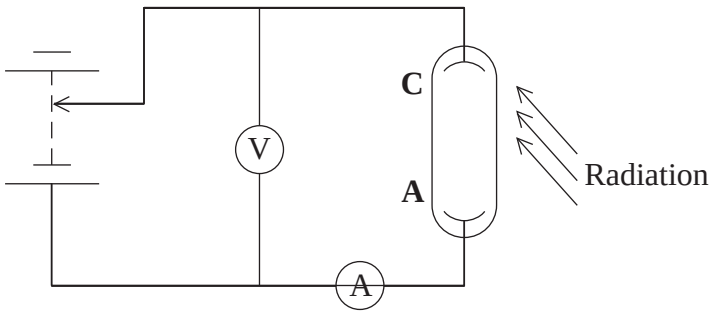
# Photoelectric Effect QP1

**1** The diagram shows the apparatus for an experiment on the photoelectric effect.




(a) A light is shone onto the cathode **C** and a potential difference is applied between the cathode and the anode **A** of the photocell. A sensitive ammeter is used to detect any current that flows.

The light is replaced by one of the same intensity, but a different photon energy. The results are shown in the table below.

| | **Photon energy/eV** | **Intensity of light/W m$^{-2}$** | **Work function/eV** | **Ammeter reading/A** |
|---|---|---|---|---|
| First light | 1.8 | 1.0 | 2.3 | 0.0 |
| Second light | 3.8 | 1.0 | 2.3 | $5.0 \times 10^{-12}$ |

Explain why the first ammeter reading is zero.

**(2)**

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(b) The experiment is repeated using the same two photon energies but the intensities of the sources are increased. Add the new ammeter readings to the table below.

**(2)**

| | **Photon energy/eV** | **Intensity of light/W m$^{-2}$** | **Work function/eV** | **Ammeter reading/A** |
|---|---|---|---|---|
| First light | 1.8 | 4.0 | 2.3 | |
| Second light | 3.8 | 4.0 | 2.3 | |

(c) (i) The cathode metal is lithium.

Express the work function of lithium in joules.

Work function of lithium = 2.3 eV

**(2)**

Work function = ..... J

(ii) Ultraviolet radiation with photon energy of $4.8 \times 10^{-18}$ J is shone onto the lithium cathode.

Calculate the maximum speed of the photoelectrons that are emitted.

**(4)**

Maximum speed = .....

***2** In 1921, Albert Einstein won the Nobel Prize for his work on the photoelectric effect.

The results of experiments on the photoelectric effect show that:

- photoelectrons are not released when the incident radiation is below a certain threshold frequency;
- the kinetic energy of the photoelectrons released depends on the frequency of the incident light and not its intensity.

Explain how these results support a particle theory, but not a wave theory of light.



**(Total for Question = 6 marks)**

**3** Ultraviolet radiation incident on a zinc plate releases electrons from the zinc's surface. The energy of each incident photon is 5.4 eV. Zinc has a work function of 4.3 eV.

(a) (i) State the name given to this effect.

**(1)**

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(ii) State the speed of the photons.

**(1)**

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(iii) What is meant by the work function of a metal?

**(1)**

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(b) An electron is emitted from the surface of the zinc.

(i) Calculate the maximum kinetic energy of the electron in joules.

**(3)**

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Maximum kinetic energy = .....

(ii) Calculate the maximum speed of the electron.

**(2)**

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Maximum speed = .....

(c) The intensity of the ultraviolet radiation is doubled.

State what happens to the maximum speed of an electron emitted from the zinc.

**(1)**

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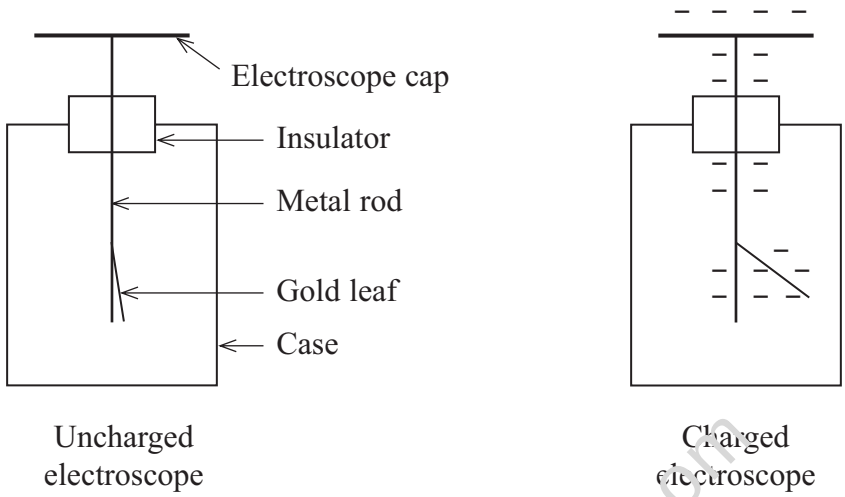
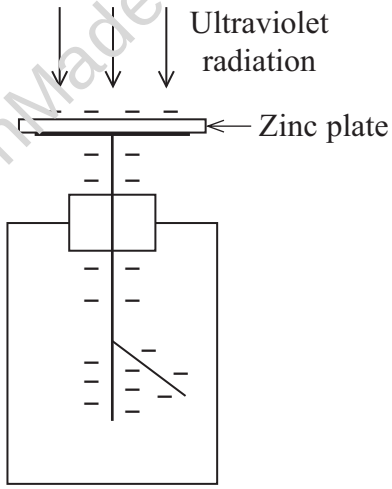
**4** A gold leaf electroscope is used to detect very small amounts of charge. When the electroscope cap is negatively charged, electrons spread along the metal rod and the gold leaf so they both become negatively charged. The rod and leaf repel each other, so the gold leaf rises up.




A gold leaf electroscope can be used to demonstrate the photoelectric effect. A clean zinc plate is placed onto the cap of the electroscope and the plate and electroscope are charged negatively. Ultraviolet radiation is shone onto the zinc plate.



*(a) The gold leaf slowly falls.

Explain, with reference to the work function of zinc, why this happens.

**(4)**

(b) Why is the effect not observed if the ultraviolet radiation is replaced by visible light?

**(1)**

(c) Ultraviolet radiation of wavelength $2.00 \times 10^{-7}$ m is shone onto the zinc plate. Calculate the maximum speed of the electrons emitted from the plate.

work function of zinc = $6.88 \times 10^{-19}$ J

**(4)**

Maximum speed of electrons = .....

(d) The source of ultraviolet radiation is moved further away from the zinc plate.

State what will happen to the maximum speed of the electrons emitted from the plate. Justify your answer.

**(2)**

**5** The following passage describes some important aspects of the photoelectric effect. Insert the missing words.

In the photoelectric effect, a single ..... interacts with a single electron at the surface of a .....…. In this interaction ..... is conserved. This was summarised by Albert Einstein in the following equation

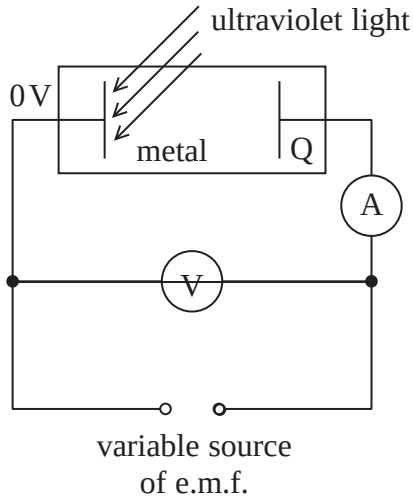
$$hf = \Phi + \tfrac{1}{2}mv^2$$

where $\tfrac{1}{2}mv^2$ is the maximum kinetic energy of the .....

and $\Phi$ is the .....….

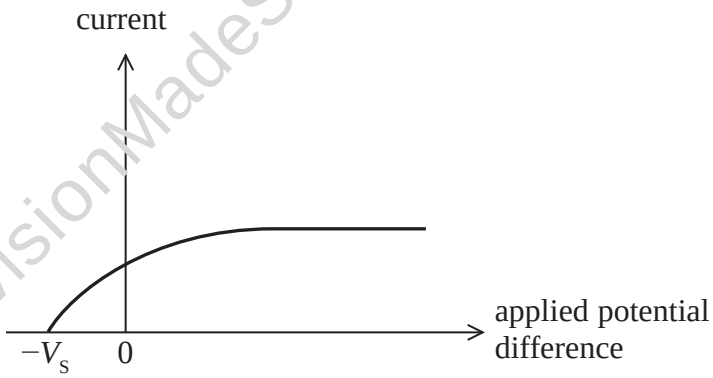
**(Total for Question 18 = 5 marks)**

**6** The diagram shows apparatus used to investigate the photoelectric effect.




When ultraviolet light of a particular frequency is shone on the metal a current is produced.
Current is produced for all values of potential difference when Q is positive.
If Q is negative there is a p.d. beyond which there is no current. The magnitude of this p.d. is called the stopping potential $V_S$.

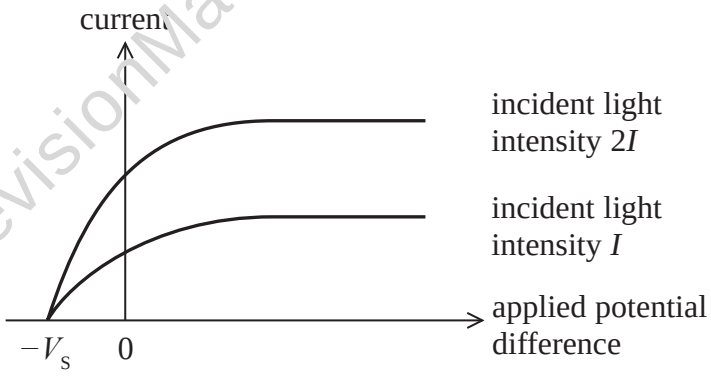
The graph shows the results for a particular investigation with light intensity $I$.



*(a) (i) Explain why there is a current for positive p.d.s, but none for reverse p.d.s greater than the stopping potential.

**(5)**

(ii) The investigation is repeated with light intensity 2*I*. The results are as shown below.




Explain the difference between the results for incident light intensity *I* and incident light intensity 2*I* for positive values of the applied potential difference.

**(2)**

(b) Calculate the value of $V_S$.

frequency of ultraviolet light = $1.20 \times 10^{15}$ Hz
work function of metal = 4.26 eV

**(3)**

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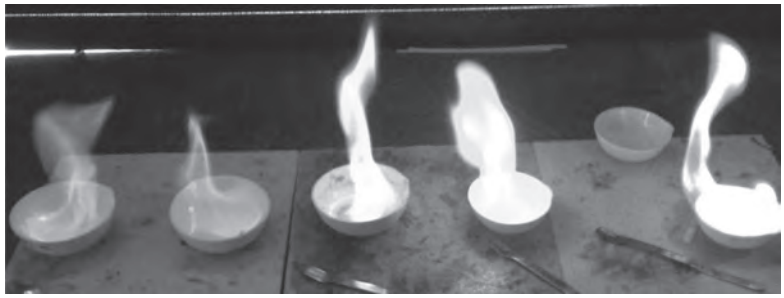
$V_S$ = .....

**7** The photograph shows flame tests being carried out on some chemical compounds.



Flame tests are used to identify the elements present in some chemical compounds. The compounds produce different coloured flames when vaporised. This is because different elements produce spectra containing light with different wavelengths.

Sodium compounds produce a yellow flame because the spectrum of sodium includes light with frequency $5.1 \times 10^{14}$ Hz.

Before the sodium compound is vaporised the electrons involved in producing the yellow light are in the energy level −5.14 eV.

(a) State what is meant by an energy level.

**(1)**

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(b) (i) Explain why light is emitted when the sodium compound is vaporised.

**(2)**

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(ii) The diagram represents the −5.14 eV energy level in a sodium atom.


Calculate the energy of the other energy level involved in the emission of the yellow light.
Add this energy level to the diagram and label it with the correct value.

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(c) Explain why different elements produce different spectra.

**(2)**

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