Higher
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Past Paper questions
1991 - 2010
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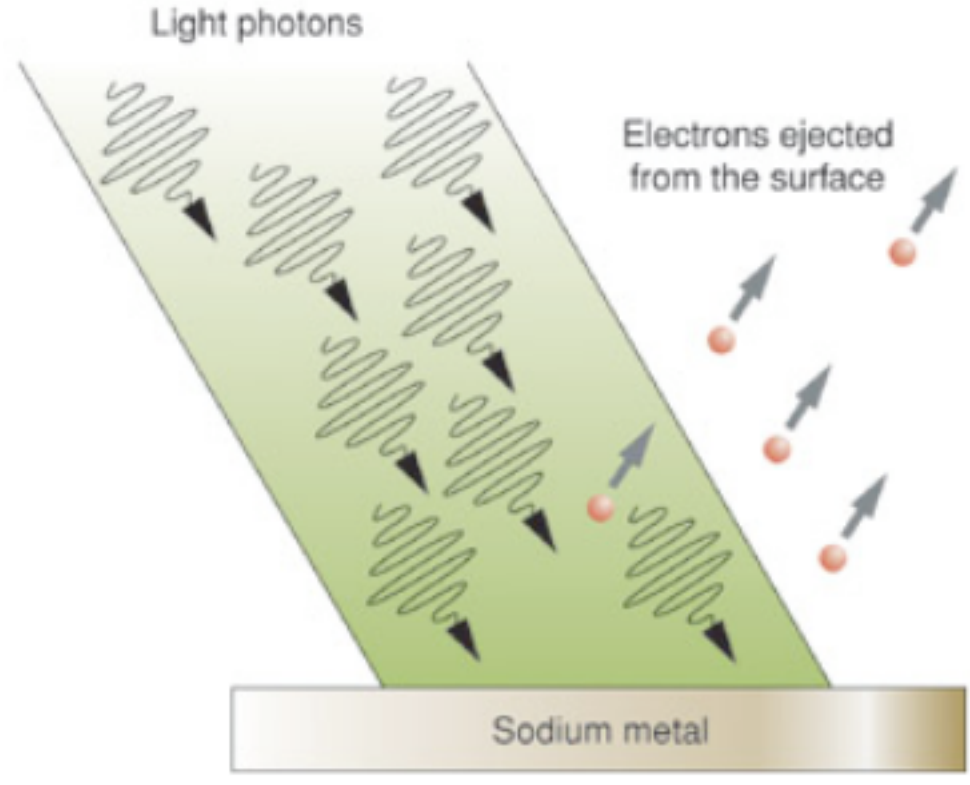
3.3 Photoelectric



1996 Q36

The work function for sodium metal is 2.9×10^{-19} J .
Light of wavelength 5.4×10^{-7} m strikes the surface of this metal.
What is the kinetic energy of the electrons emitted from the surface?
[Data:- Planck's constant = 6.63×10^{-34} Js]

1998 Q35

The minimum energy required to cause an electron to be emitted from a clean zinc surface is 6.9×10^{-19} J.

(a) Calculate the maximum wavelength of electromagnetic radiation which will cause an electron to be emitted from the clean zinc surface.

(b) What would be the effect of irradiating a clean zinc surface with radiation of wavelength 4×10^{-7} m? You must justify your answer.

1999 Q35

(a) A light meter is used to measure the intensity of light from a small lamp.

At a distance of 1.5 m from the lamp, the intensity of the light is 0.60 Wm^{-2}.
What is the intensity at a distance of 4.5 m from the lamp?

(b) At a distance of 1.5 m from a laser, the intensity of the laser light is 400 Wm^{-2}.

What is the intensity of the laser light at a distance of 4.5 m from the laser?
Justify your answer.

1999 Q37

When introducing optoelectronics to a class, a Physics teacher writes:

> "One of the important factors affecting photoelectric emission from a metal is the threshold frequency for the metal".

Explain the meaning of the terms:

(a) photoelectric emission;

(b) threshold frequency.

2000 Q36

The work function for sodium metal is 2.9×10^{-19} J .

Light of frequency 5.6×10^{14} Hz strikes the surface of this metal.

What is the maximum kinetic energy of electrons emitted from the surface?

1991 Q10

The photoelectric effect is being investigated by shining monochromatic light on a caesium metal surface.

The light source has a rating plate which indicates that its wavelength is 589 nm.

The value of this wavelength is to be checked using a diffraction grating which has 600 000 lines per metre.

(a) (i) Describe, with the aid of a diagram, how the diffraction grating can be used to find the wavelength of the light source.

(ii) At what angle will the second order maximum be seen if the wavelength of the light used is 589 nm?

(b) The work function of the caesium surface is 2.16×10^{-19} J.

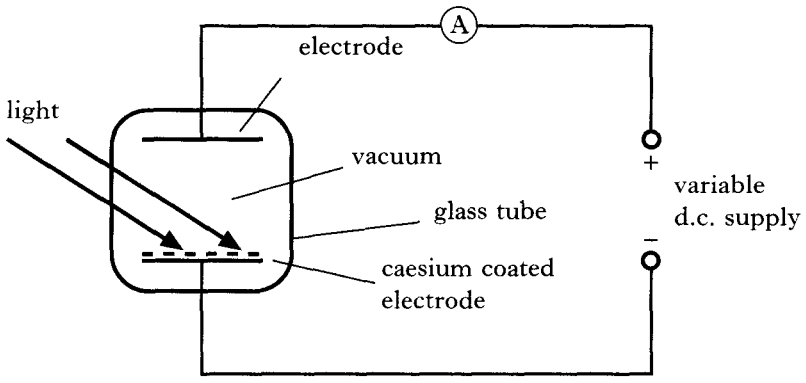
What is the maximum velocity with which electrons will be emitted from the surface, when light of wavelength 589 nm is incident on the surface?

[Data:- Planck's constant = 6.63×10^{-34} Js, Mass of an electron = 9.11×10^{-31} kg]

1995 Q8

(a) It is quoted in a text book that the work function of caesium is 3.04×10^{-19} J.
Explain what is meant by the above statement.

(b) In an experiment to investigate the photoelectric effect, a glass vacuum tube is arranged as shown below.



The tube has two electrodes, one of which is coated with caesium.
Light of frequency 6.1×10^{14} Hz is shone on to the caesium coated electrode.

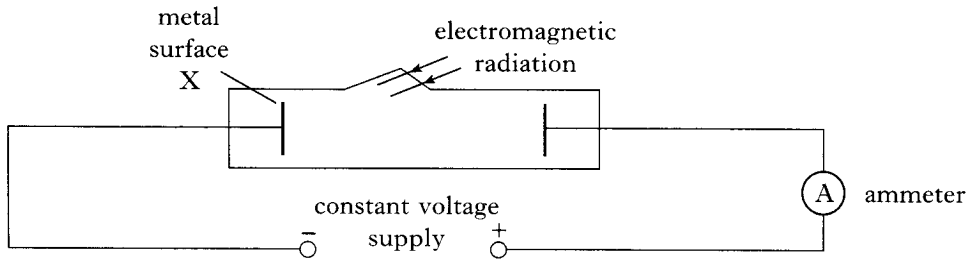
(i) Calculate the maximum kinetic energy of a photoelectron leaving the caesium coated electrode.

(ii) An electron leaves the caesium coated electrode with this maximum kinetic energy. Calculate its kinetic energy as it reaches the upper electrode when the p.d. across the electrodes is 0.8 V.

(c) The polarity of the supply voltage is now reversed.
Calculate the minimum voltage which should be supplied across the electrodes to stop photoelectrons from reaching the upper electrode.

1997 Q10

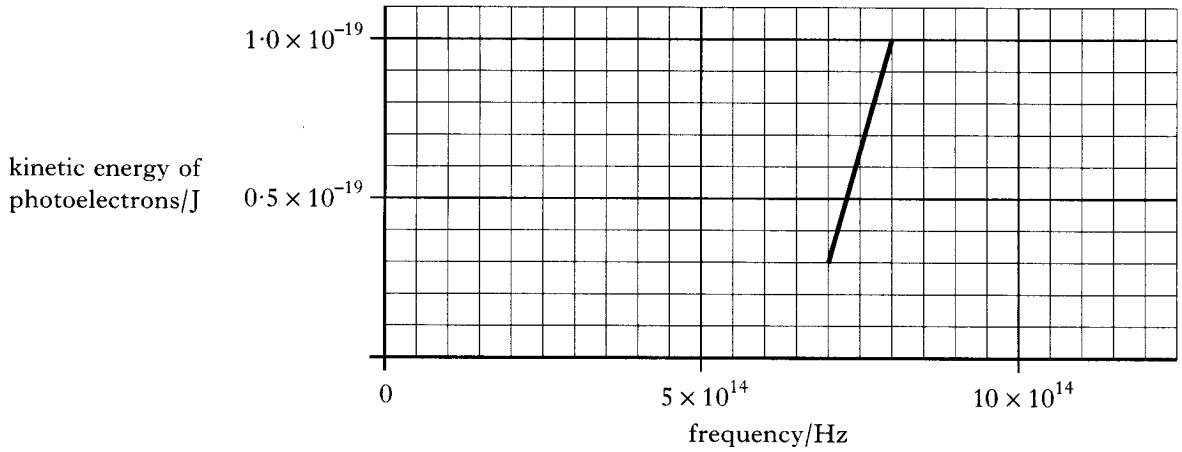
(a) The apparatus shown below is used to investigate photoelectric emission from the metal surface X when electromagnetic radiation is shone on the surface.
The frequency of the electromagnetic radiation can be varied.



(i) When radiation of a certain frequency is shone on the metal surface X, a reading is obtained on the ammeter.
Sketch a graph to show how the current in the circuit varies with the intensity of the radiation.

(ii) Explain why there is no reading on the ammeter when the frequency of the radiation is decreased below a particular value.

(b) The maximum kinetic energy of the photoelectrons emitted from metal X is measured for a number of different frequencies of the radiation.
The graph shows how this kinetic energy varies with frequency.



(i) Use the graph to find the threshold frequency for metal X.

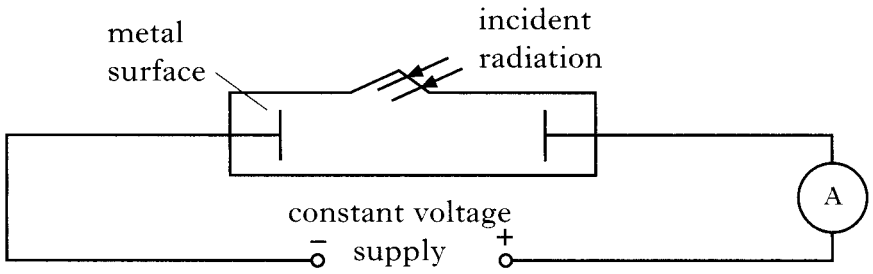
(ii) The table below gives the work function of different metals.

Metal	*Work function*/J
Potassium	$3{\cdot}2 \times 10^{-19}$
Calcium	$4{\cdot}3 \times 10^{-19}$
Zinc	$6{\cdot}9 \times 10^{-19}$
Gold	$7{\cdot}8 \times 10^{-19}$

Which one of these metals was used in the investigation?
You must justify your answer using the information given in the table.

2000 Q28

(a) The apparatus shown below is used to investigate photoelectric emission from a metal surface when electromagnetic radiation is shone on the surface.
The intensity and frequency of the incident radiation can be varied as required.



(i) Explain what is meant by photoelectric emission from a metal.
(ii) What is the name given to the minimum frequency of the radiation that produces a current in the circuit?
(iii) A particular source of radiation produces a current in the circuit.
Explain why the current in the circuit increases as the intensity of the incident radiation increases.

(b) A semiconductor chip is used to store information.
The information can only be erased by exposing the chip to ultraviolet radiation for a period of time.
The following data is provided.

Frequency of ultraviolet radiation used	$= 9.0 \times 10^{14}$ Hz
Minimum intensity of ultraviolet radiation required at the chip	$= 25$ Wm^{-2}
Area of the chip exposed to radiation	$= 1.8 \times 10^{-9}$ m^2
Time taken to erase the information	= 15 minutes
Energy of radiation needed to erase the information	= 40.5 μJ

(i) Calculate the energy of a photon of the ultraviolet radiation used.
(ii) Calculate the number of photons of the ultraviolet radiation required to erase the information.
(iii) Sunlight of intensity 25 Wm^{-2} , at the chip, can also be used to erase the information.
State whether the time taken to erase the information is greater than, equal to or less than 15 minutes.
You must justify your answer.

2001 Q25 (b)

(b) A capacitor is used to provide the energy for an electronic flash in a camera.
When the flash is fired, 6.35×10^{-3} J of the stored energy is emitted as light.
The mean value of the frequency of photons of light from the flash is 5.80×10^{14} Hz.
Calculate the number of photons emitted in each flash of light.

2000 Q28

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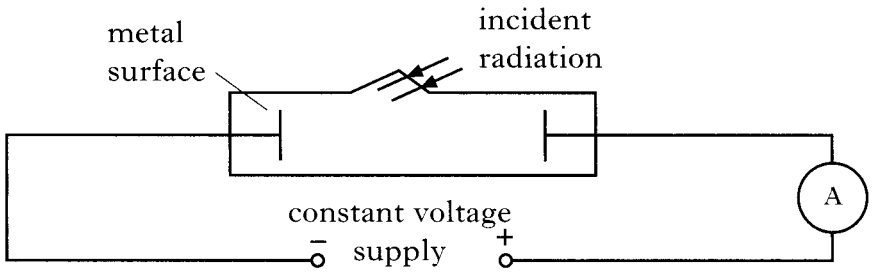

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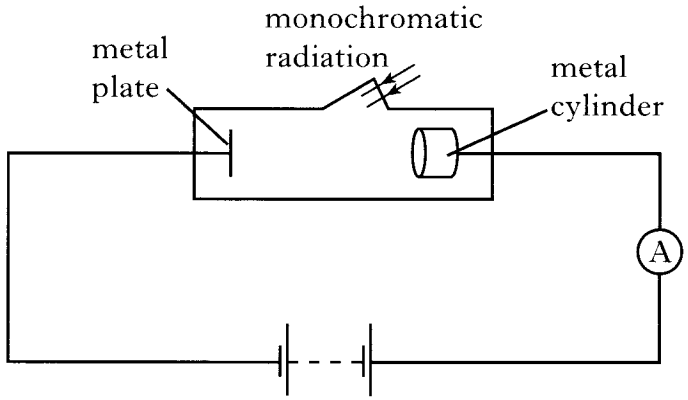
2005 Q29.

In 1902, P. Lenard set up an experiment similar to the one shown below.



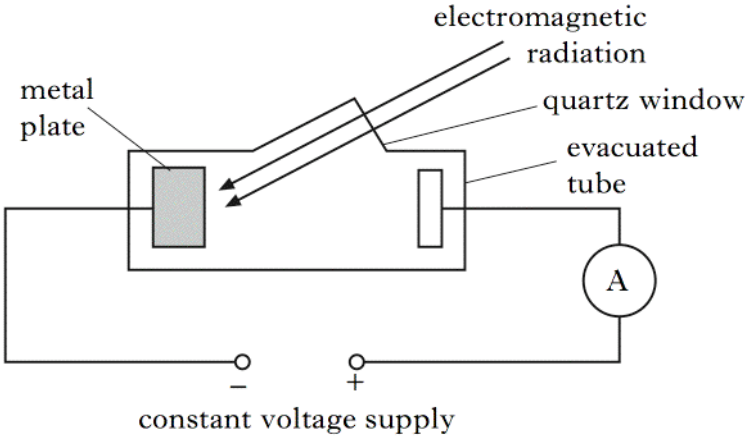
There is a constant potential difference between the metal plate and the metal cylinder.
Monochromatic radiation is directed onto the plate. Photoelectrons produced at the plate are collected by the cylinder. The frequency and the intensity of the radiation can be altered independently. The frequency of the radiation is set at a value above the threshold frequency.

(a) The intensity of the radiation is slowly increased.
Sketch a graph of the current against intensity of radiation.

(b) The metal of the plate has a work function of 3.11×10^{-19} J.
The wavelength of the radiation is 400 nm.
(i) Calculate the maximum kinetic energy of a photoelectron.
(ii) The battery connections are now reversed.
Explain why there could still be a reading on the ammeter.

2007 Q30.

A metal plate emits electrons when certain wavelengths of electromagnetic radiation are incident on it.



When light of wavelength 605 nm is incident on the metal plate, electrons are released with zero kinetic energy.

(a) Show that the work function of this metal is 3.29×10^{-19} J.

(b) The wavelength of the incident radiation is now altered. Photons of energy 5.12×10^{-19} J are incident on the metal plate.

(i) Calculate the maximum kinetic energy of the electrons just as they leave the metal plate.

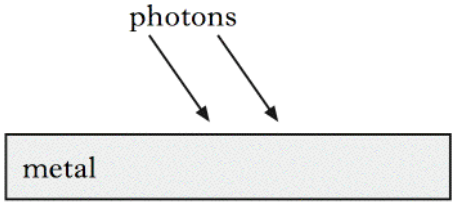
(ii) The irradiance of this radiation on the metal plate is now decreased.
State the effect this has on the ammeter reading.
Justify your answer.

2008 Q29.

To explain the photoelectric effect, light can be considered as consisting of tiny bundles of energy. These bundles of energy are called photons.

(a) Sketch a graph to show the relationship between photon energy and frequency.

(b) Photons of frequency 6.1×10^{14} Hz are incident on the surface of a metal.



This releases photoelectrons from the surface of the metal.

The maximum kinetic energy of any of these photoelectrons is 6.0×10^{-20} J.

Calculate the work function of the metal.

(c) The irradiance due to these photons on the surface of the metal is now reduced.

Explain why the maximum kinetic energy of each photoelectron is unchanged.