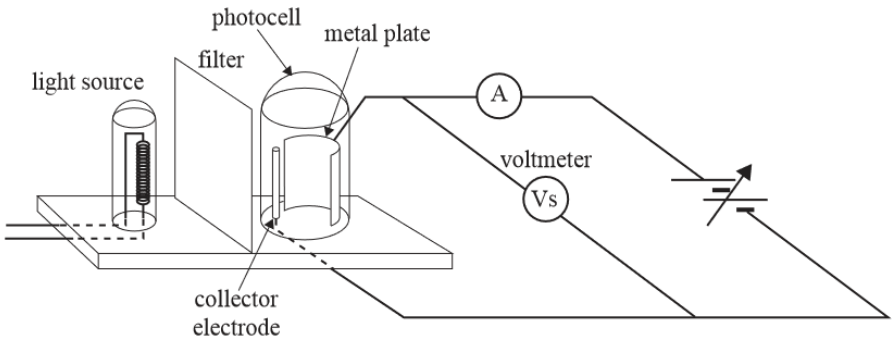
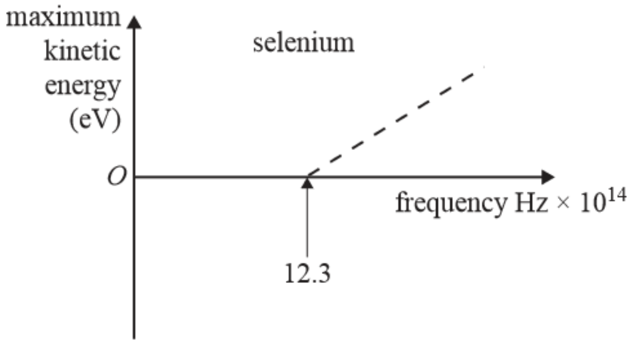
Multiple choice questions

The following information relates to Questions 5 and 6.

Students set up the following apparatus as shown below to study the photoelectric effect. They have a number of photocells with different metal plates in them.

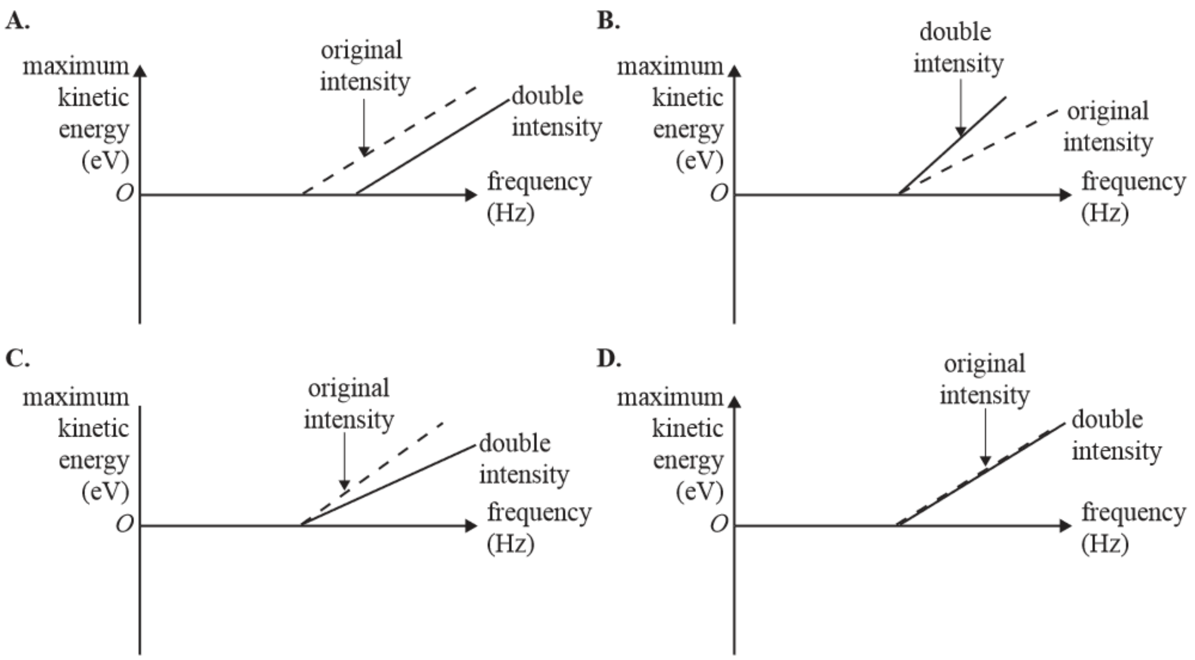


With a selenium plate in place, and using their data, the students draw the graph of maximum kinetic energy of photoelectrons versus frequency of light incident on the selenium plate. This is shown below.



Example 1 2010 Question 5, 2 marks

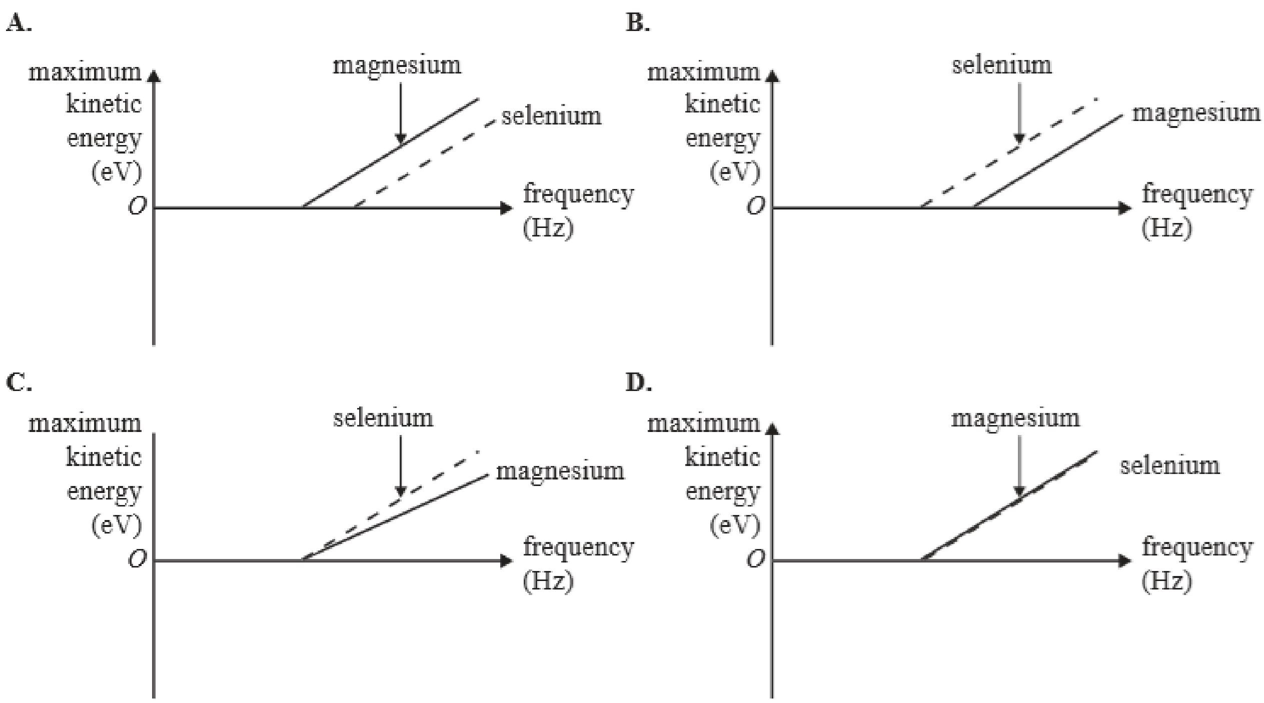
The students double the intensity of the light source and repeat the experiment. Which one of the following graphs will now show their results?



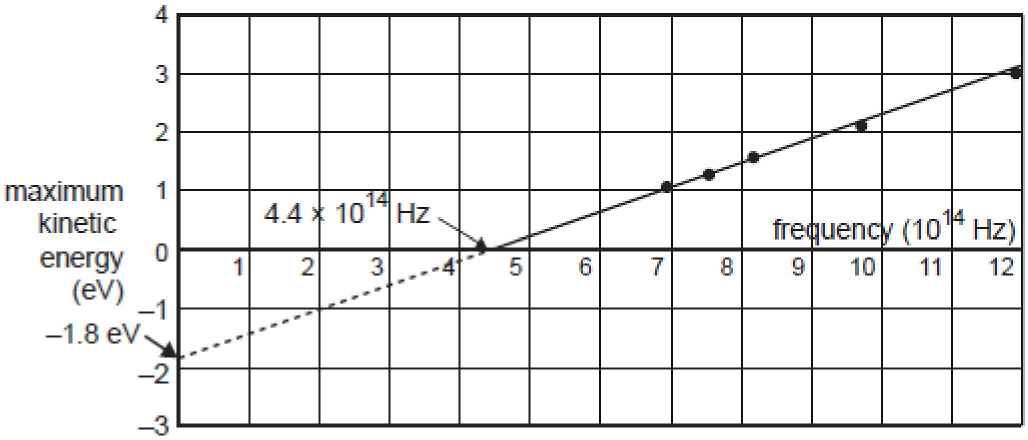
The students now use a photocell with a magnesium plate.
The work function of magnesium (3.7 eV) metal is less than that of selenium (5.1 eV).
The dotted line on each graph shows the original graph for selenium.

Example 2 2010 Question 6, 3 marks

Which one of the following graphs will now show their results? Explain your answer.



Measurements of the kinetic energy of electrons emitted from potassium metal were made at a number of frequencies. The results are shown below.

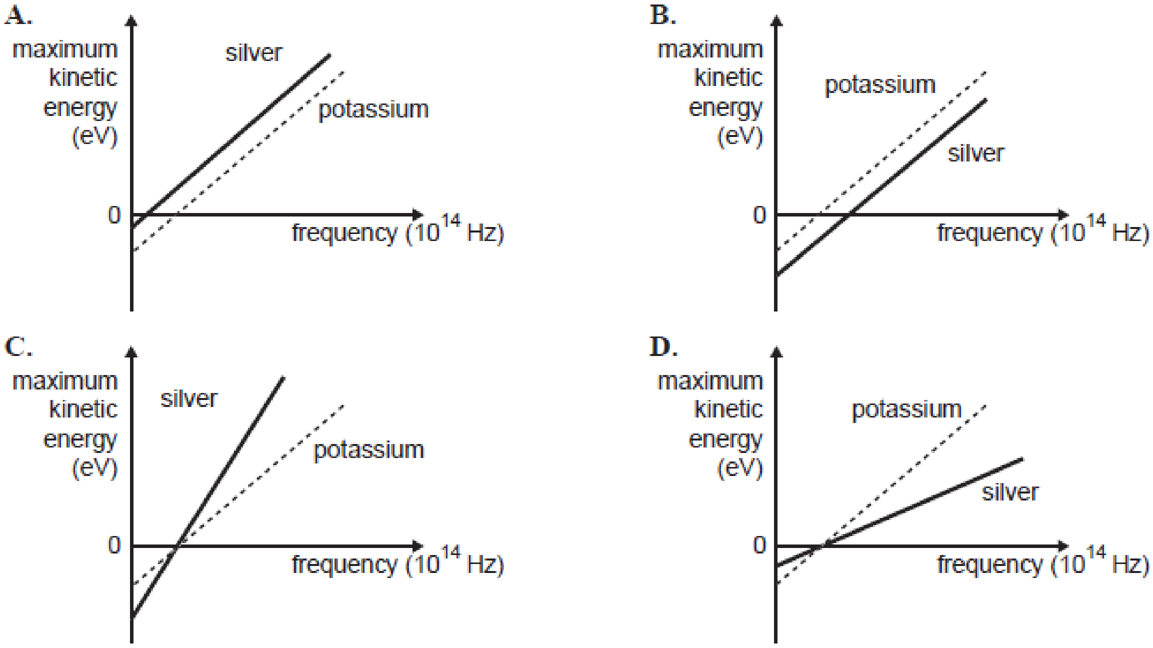


data for potassium metal

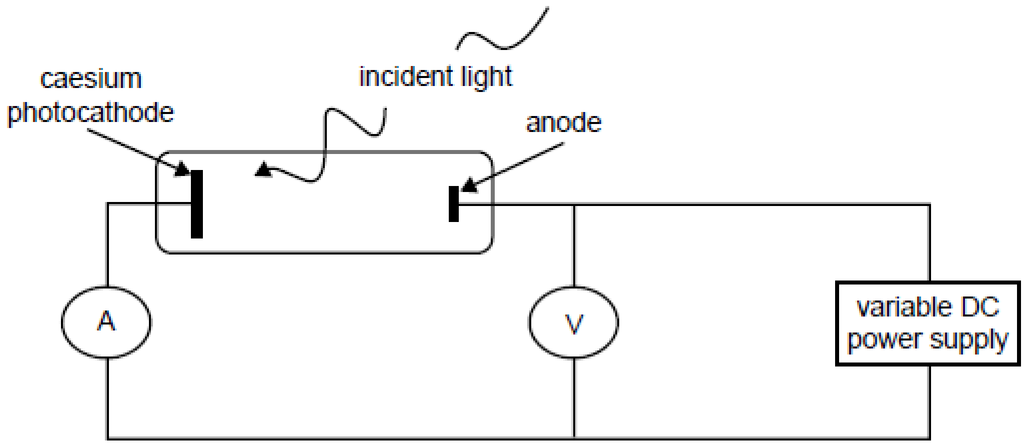
The work function for silver metal is higher than the work function for potassium metal.

Example 3 2006 Question 4, 2 marks

Which one of the graphs (**A - D** below) would best describe the result if the experiment was repeated with silver metal instead of potassium metal?



A group of students is investigating the photoelectric effect. The apparatus consists of a polished caesium metal plate enclosed in an evacuated clear tube. The plate is illuminated by several different light sources. A retarding potential from a variable power supply is used to stop emitted photoelectrons and hence determine their maximum kinetic energy. An ammeter is used to measure the current of the emitted photoelectrons.



Their results are summarised in Table 1 below. Note that some entries are missing from the table.

Table 1

Colour	Frequency ($\times 10^{14}$ Hz)	Energy of photon (eV)	Maximum kinetic energy (eV)	Maximum current (mA)
red	4.8	2.0		
green	5.4		0.1	0.2
blue	7.3	3.0	0.9	
UV	10.1	4.2	2.1	4.2
UV2	12.0			

The next question relates to the missing entry in the current data when the blue light source was used.

Example 4 2004 Question 3, 2 marks

Which one of the following statements is true?

The maximum current is dependent on the

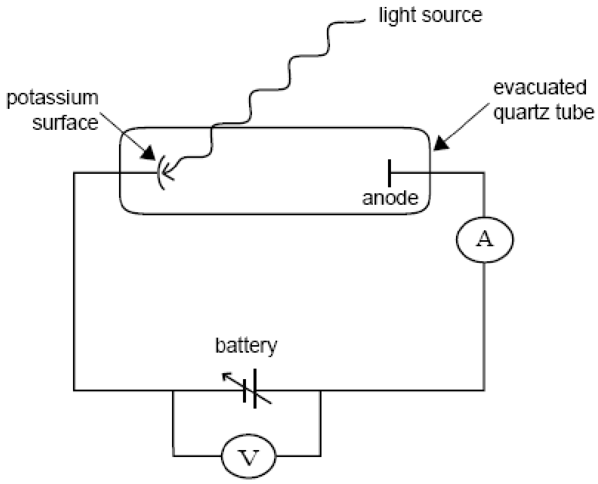
A. intensity of the incident light.

B. frequency of the incident light.

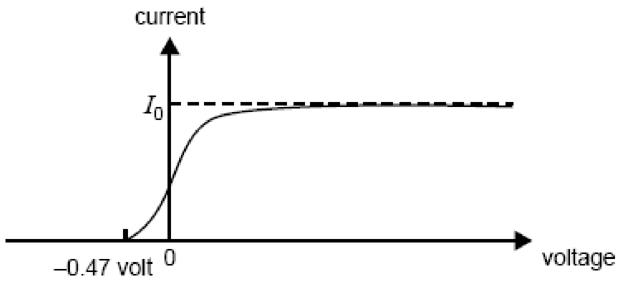
C. photon energy of the incident light.

D. wavelength of the incident light.

Light of a single wavelength is shone on a potassium surface that is enclosed in an evacuated quartz tube as shown below. The apparatus allows the voltage between the potassium surface and anode to be varied.



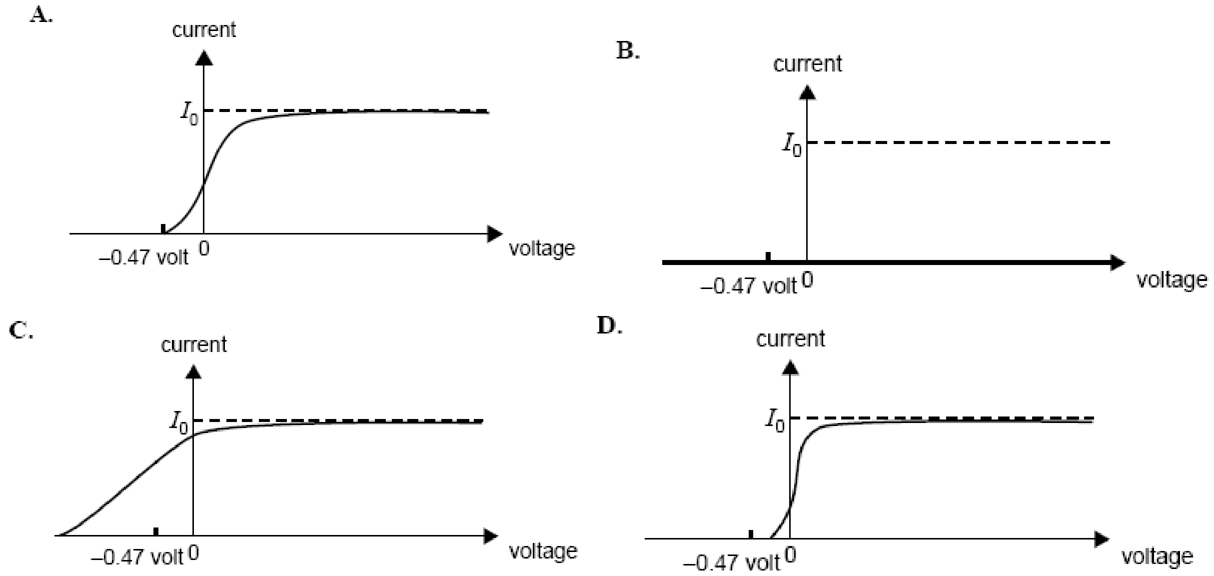
When light of wavelength 450 nm is used, the graph of current versus voltage shown below is obtained.



The wavelength from the source is now doubled to 900 nm, but its intensity is not changed.

Example 5 2000 Question 6, 2 marks

Which **one** of the graphs (**A**–**D**) best describes the results of the experiment now? (Note that I_0 is the maximum current measured in the previous experiment with 450 nm light.)



Example 6 1999 Question 1, 2 marks

Experimental work was carried out to investigate the photoelectric effect by shining light onto a particular metal surface. Measurements were made of the number and maximum kinetic energy of the emitted electrons from this particular metal surface for different frequencies and intensities of light.

Which **one** of the statements **(A – D)** was **not** one of the findings?

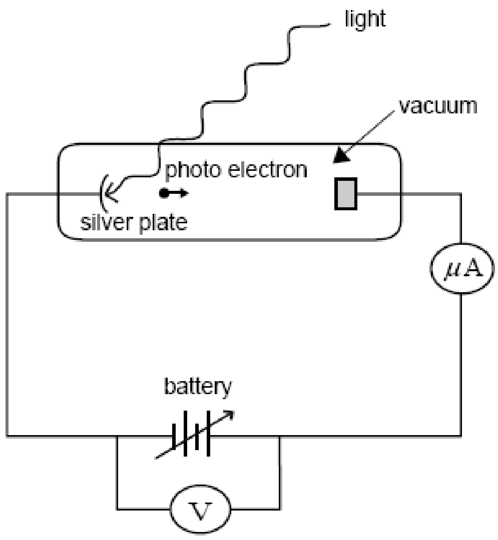
A The ability to eject electrons from this metal depended only on the frequency of light.

B At frequencies below the 'threshold frequency' no electrons were ejected from the metal no matter how high the light intensity was.

C The 'stopping potential' for the photoelectrons was independent of the light intensity.

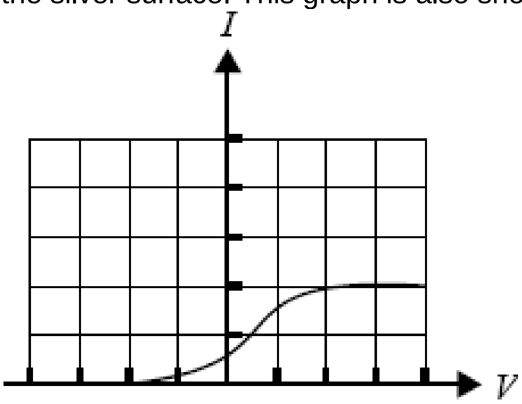
D The maximum kinetic energy of the photoelectrons depended only on the intensity of the light.

The apparatus shown was set up to investigate the photoelectric effect.



Using this apparatus it is found that light of wavelength 254 nm (2.54×10^{-7} m) ejects photoelectrons from a silver plate. The work function of the silver surface is 4.7 eV.

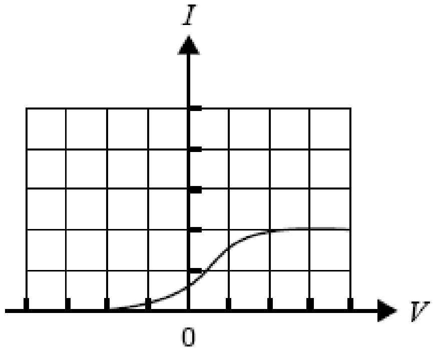
With the apparatus, a graph of current against applied voltage was obtained for a particular wavelength of light incident on the silver surface. This graph is also shown in below.



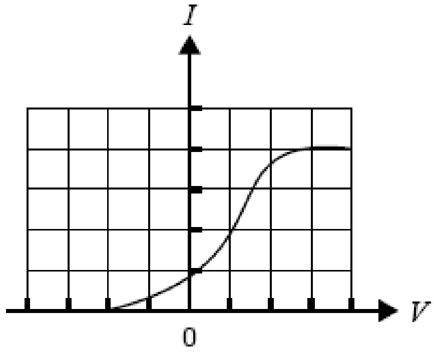
Example 7 1999 Question 4, 2 marks

Which **one** of the graphs (**A** – **D**) would be obtained for the silver surface using light of the same wavelength as above, but of greater intensity? (The vertical and horizontal scales are the same for all graphs (**A** – **D**)).

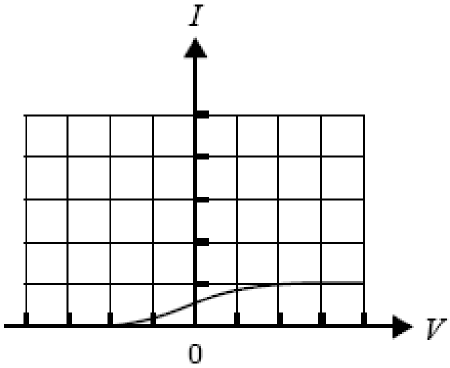
A.



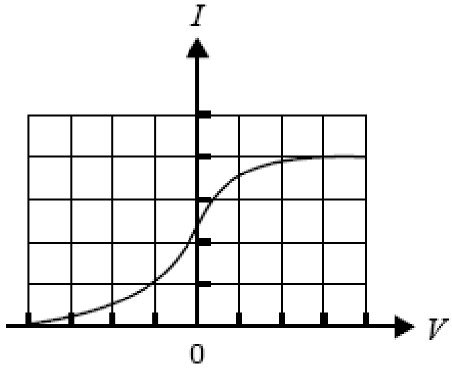
B.



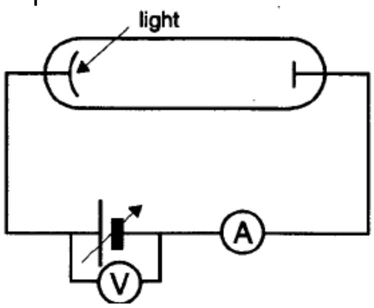
C.



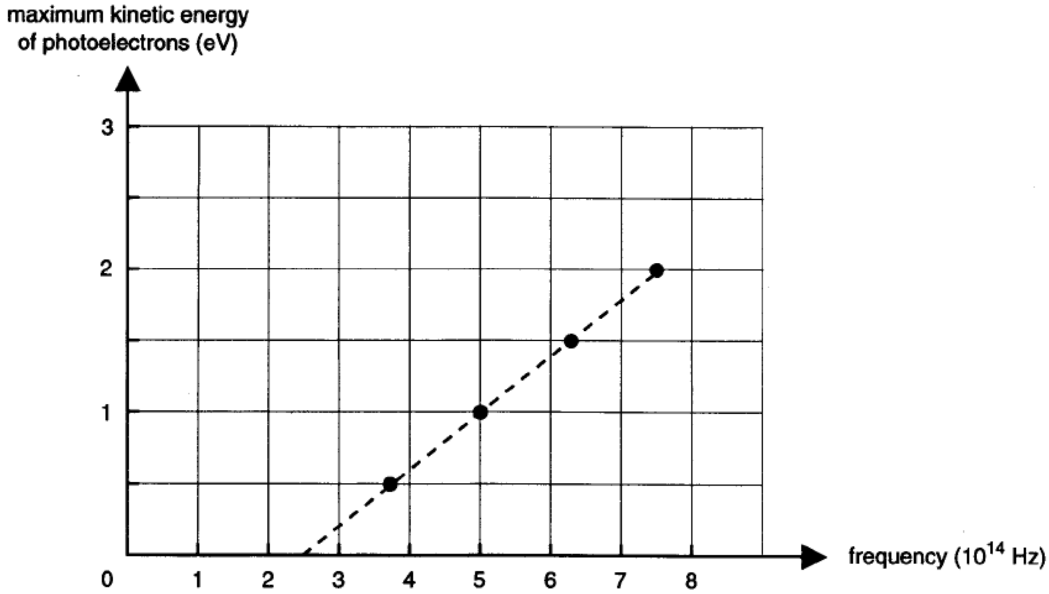
D.



An experiment is carried out to investigate the photoelectric effect. Light of various single frequencies shines onto a clean metal plate inside an evacuated glass tube as shown below.

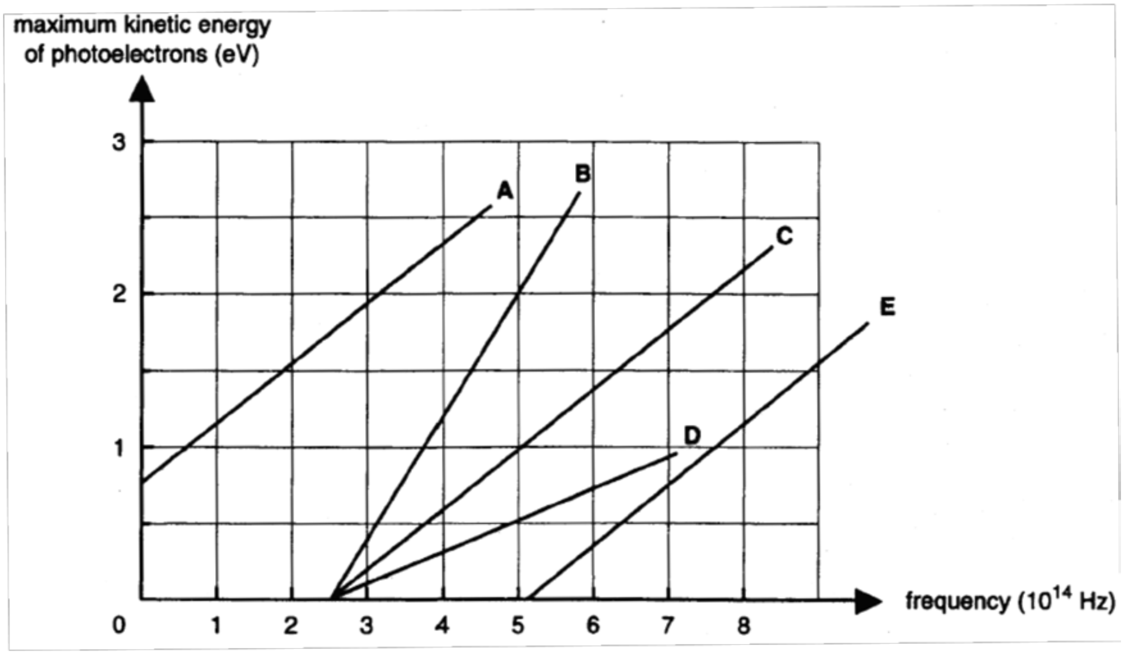


The maximum kinetic energy of the photoelectrons is measured for the different frequencies, giving the results shown below

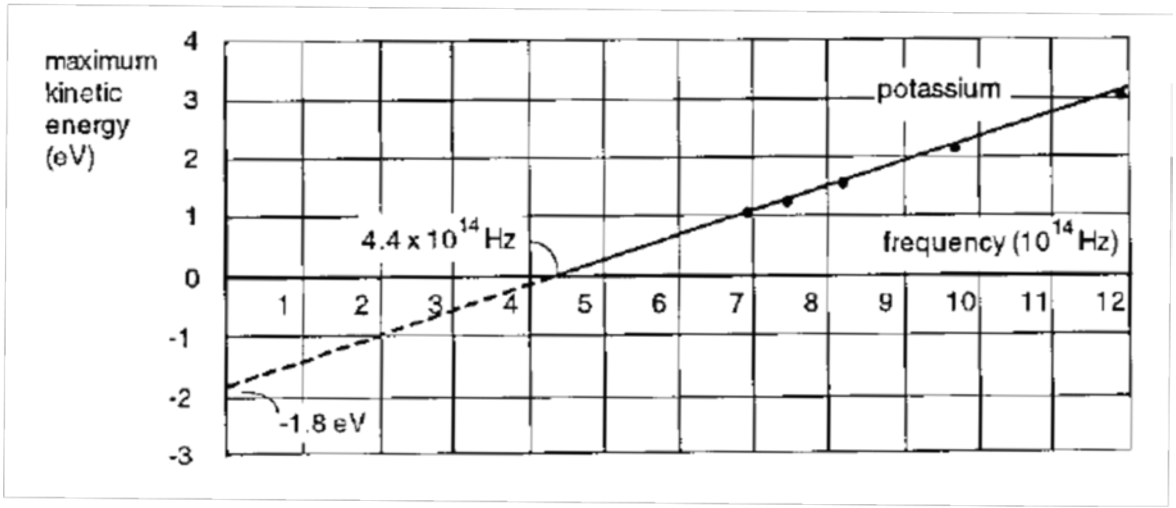


Example 8 1996 Question 3, 1 mark

Which one of the plotted lines **(A - E)**, below would be obtained for the same metal plate for light of double the intensity?



In early experiments to investigate the photoelectric effect, a beam of light of a single frequency was directed at a clean surface of potassium metal. The maximum kinetic energy of electrons which were ejected from the metal was measured.
When the experiment was repeated with different frequencies of light the maximum kinetic energy of electrons depended on the frequency of the light as shown below.

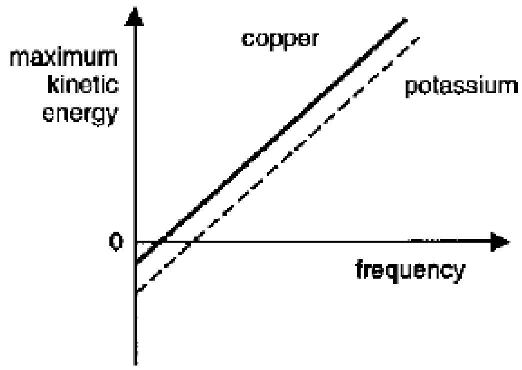


The minimum photon energy required to eject electrons from copper is approximately double the value for potassium.

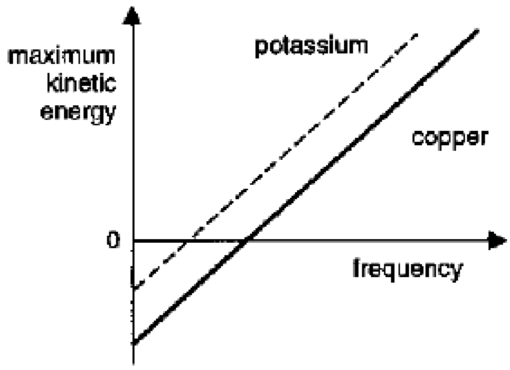
Example 9 1995 Question 3, 2 marks

Which one of the graphs below would best describe the results if the experiment were repeated with copper instead of potassium? Explain your choice, commenting on the slopes of the lines for potassium and copper and the points where the lines cross the frequency axis.
(The potassium results have been included for comparison.)

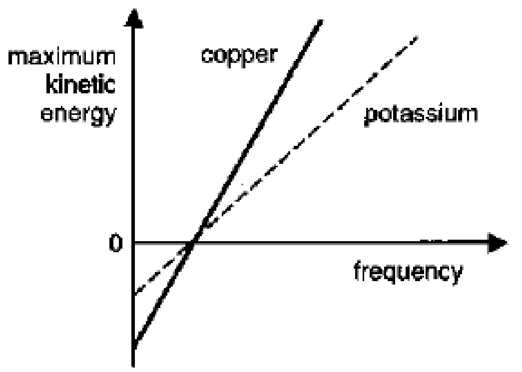
A.



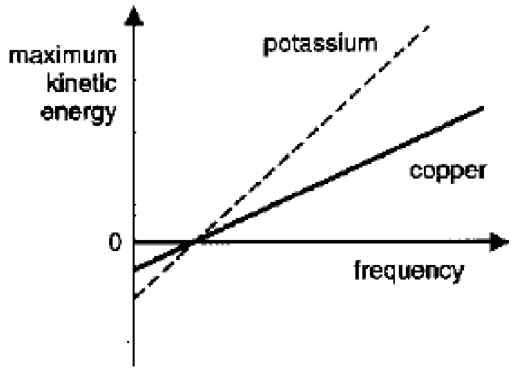
B.



C.



D.



Example 10   1984 Question 48, 1 mark

The emission of electrons from a metal surface when light falls on it is called the photo-electric effect. Which of the following statements gives the best explanation of the effect?

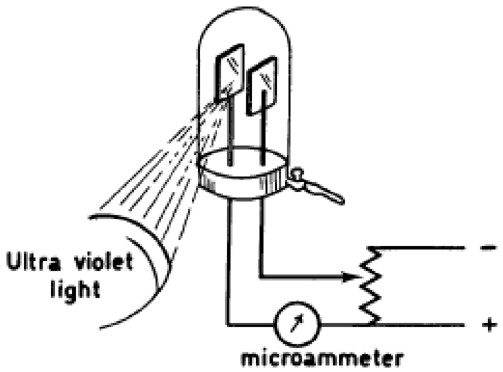
A. Because light cannot penetrate far into the metal, the light energy heats up the surface so that electrons are boiled off.

B. The metal expands because of the light energy absorbed, leaving insufficient room for all of the electrons, so that some of them are forced out of the surface.

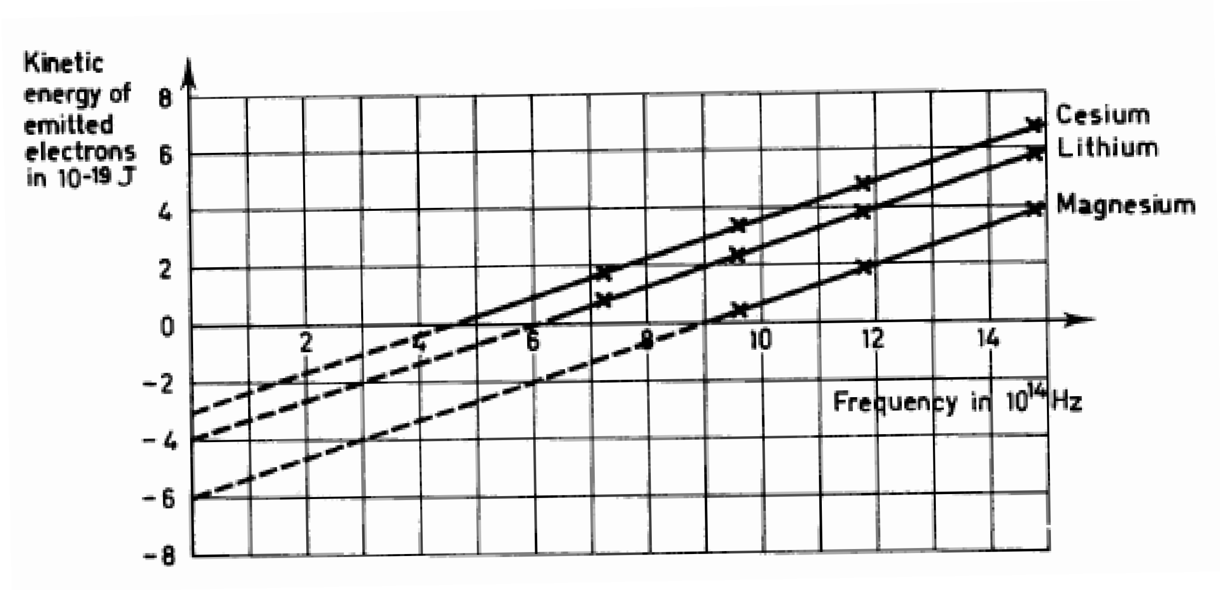
C. Photons excite the metal atoms near the surface to higher energy states; the atoms then drop back to the ground state by emitting electrons.

D When a photon strikes the metal it may lose some of its energy to electrons near the surface. If enough photons collide with an electron it may eventually gain sufficient energy to be freed from the metal.

E When a photon collides with an electron near the surface of the metal, its energy is acquired by the electron which may then escape from the metal.



The circuit shows a means of measuring the energy of electrons emitted from a metal when ultra-violet radiation falls on it. The collector is maintained at a potential that is negative relative to the emitter and which can be adjusted until no current is registered on the micro-ammeter. The glass envelope containing the collector and emitter plates is evacuated.



Each of the graphs above shows the measured kinetic energies of electrons emitted by a particular metal irradiated with ultra-violet radiation of different frequencies.

Example 11 1978 Question 70, 1 mark

For regions where the graphs indicate negative kinetic energies, which of the following is true?

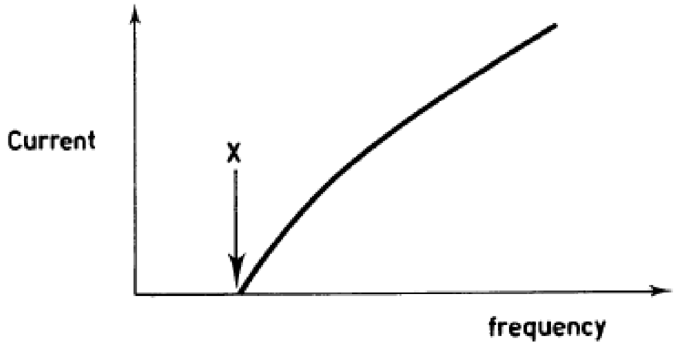
A. Electrons move from the collector to the emitter.

B. Electrons move from the surface to the inside of the emitter.

C. No electrons are emitted.

D. Radiations of such low frequencies are not available.

The graph below shows the current through the micro-ammeter as a function of the frequency of the radiation incident on a particular metal.



Example 12 1978 Question 73, 1 mark

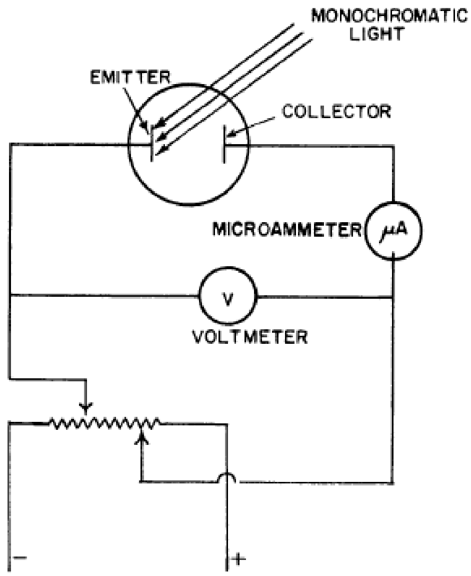
No current flows for frequencies less than X. How may a current be made to flow for frequencies less than X?

A. By increasing the intensity of the radiation.

B. By making the potential of the collector less negative'

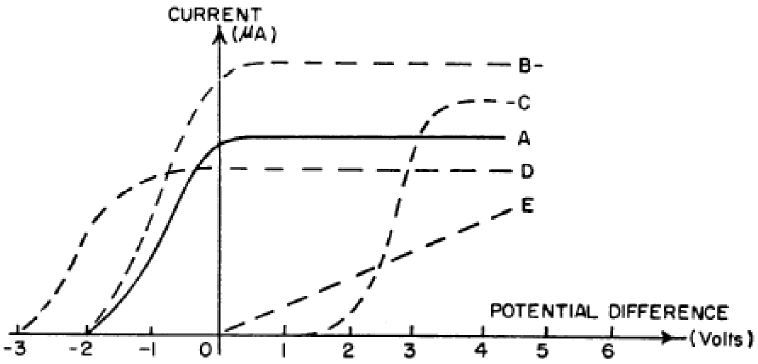
C. By increasing the gas pressure inside the glass envelope containing the plates.

D. There is no way to get current for frequencies less than X using this particular metal.



A photo-electric cell is connected into a circuit as shown. Varying the potential difference across the cell gives the results shown in graph A below. Electronic charge: 1.6 x 10^{-19}C

Which of the graphs **A** - **E** could result from the changes described in Questions 96 and 97?

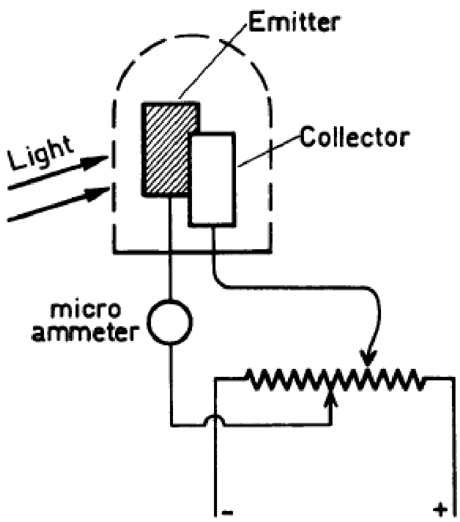


Example 13 1974 Question 96, 1 mark

The intensity of the incident light was increased.

Example 14 1974 Question 97, 1 mark

Light of higher frequency, but lower intensity was used.



A photoelectric cell is set up as shown, so that the potential of the collector can be made positive or negative relative to the emitter.

Example 15 1973 Question 92, 1 mark

With the collector at +2 volt relative to the emitter, light of a particular wavelength is shone onto the emitter. No current is observed. Which of the following changes might cause a current to flow?

A. Make the collector more positive.

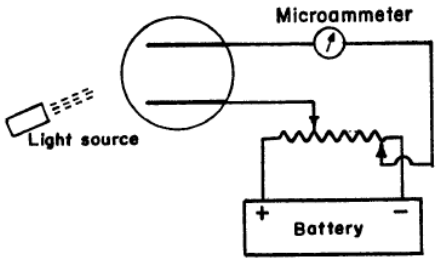
B. Make the collector negative.

C. Increase the intensity of the light.

D. Decrease the wavelength of the light.

E. Move the emitter and collector closer together.

Two identical polished metal plates are placed in an evacuated sphere as shown. Light of a single wavelength can be shone on either plate. The potential difference between the plates can be varied and reversed.



Example 16 1970 Question 91, 1 mark

With the apparatus adjusted so that the lower plate is positive, the light is directed at the upper plate and no current is observed in the circuit. What is a possible reason for this observation?

A. The light is shining on the wrong plate.

B. The light is not shining with equal intensity on both plates.

C. The wavelength of the light is too long.

D. The potential difference between the plates is not large enough.

E. The light intensity is too weak.

Example 17 1970 Question 93, 1 mark

No current is observed when the lower plate is more negative than 2 volt relative to the other because

A. electrons are no longer being emitted.

B. equal numbers of positive and negative charges are emitted.

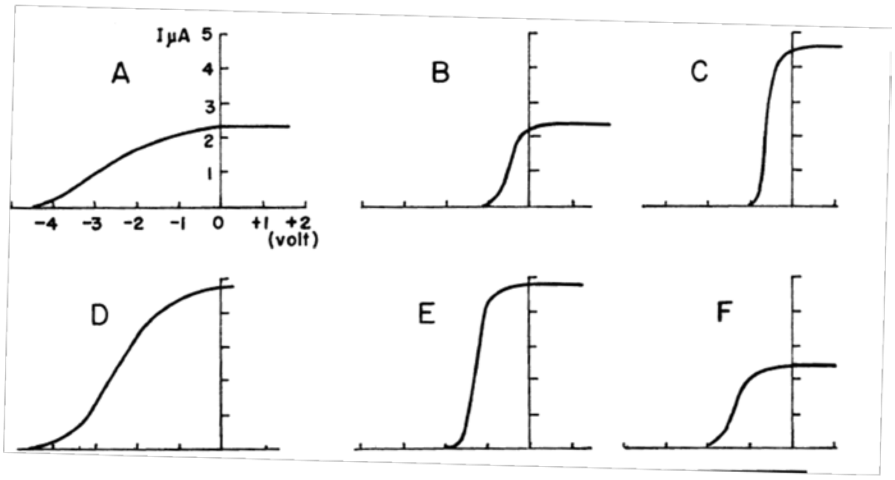
C. electrons that are emitted have no kinetic energy.

D. electrons that are emitted have insufficient kinetic energy to reach the collector electrode.

E. half the electrons that are emitted reach the collector electrode and half return to the emitting electrode.

Example 18 1970 Question 94, 1 mark

The light intensity falling on the upper plate in the two preceding questions is doubled. Which of the graphs below best represents the variation of the current (*I*) as a function of voltage across the plates? The scale on the horizontal axis is the lower plate potential relative to the upper plate.



Short answer questions

The photoelectric effect experiment supports the particle model of light rather than the wave model of light. The following are observed in a photoelectric effect experiment.

Observation 1:
The number of emitted electrons (the photocurrent) depends on the intensity of the incident light.

Observation 2:
The energy of emitted electrons depends only on the frequency of the incident light and is independent of the intensity.

Observation 3:
The energy of the emitted electrons depends on the metal surface involved.

The particle model can account for all the above three observations. The wave model can explain two of these observations but not a third.

Example 19 2010 Question 2, 3 marks

Select the observation that the wave model **cannot** explain. Explain how the particle model satisfactorily explains this observation.

Example 20 2009 Question 2, 3 marks

Einstein's explanation of the photoelectric effect reopened the question about the nature of light. Explain briefly how the results of the photoelectric effect experiment supported a competing model to the one supported by Young's double-slit experiment.

The following information relates to Questions 5 – 7.

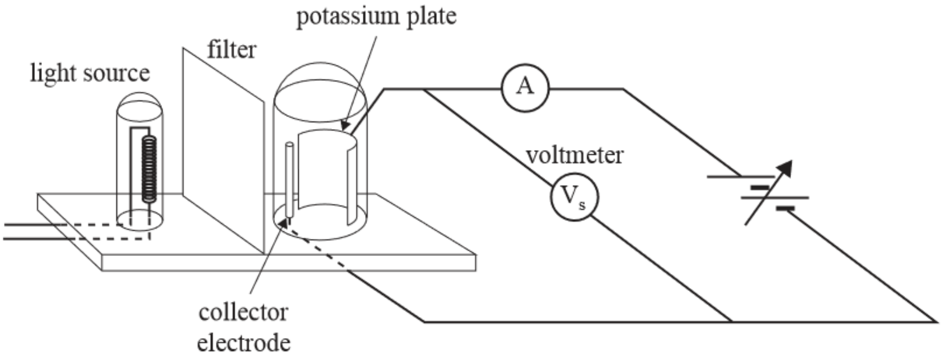
The photoelectric effect occurs when photons falling on a metal surface cause the emission of electrons. Einstein's equation for the photoelectric effect can be written as follows.

$E_{K\ max} = hf - W$

Kristy and Adrian have set up an experiment to study the energy of photoelectrons emitted from a potassium plate. Their apparatus consists of

• a light source
• a set of filters, each of which allows through only one wavelength
• an evacuated tube containing a potassium plate onto which the light falls, and a collector electrode.

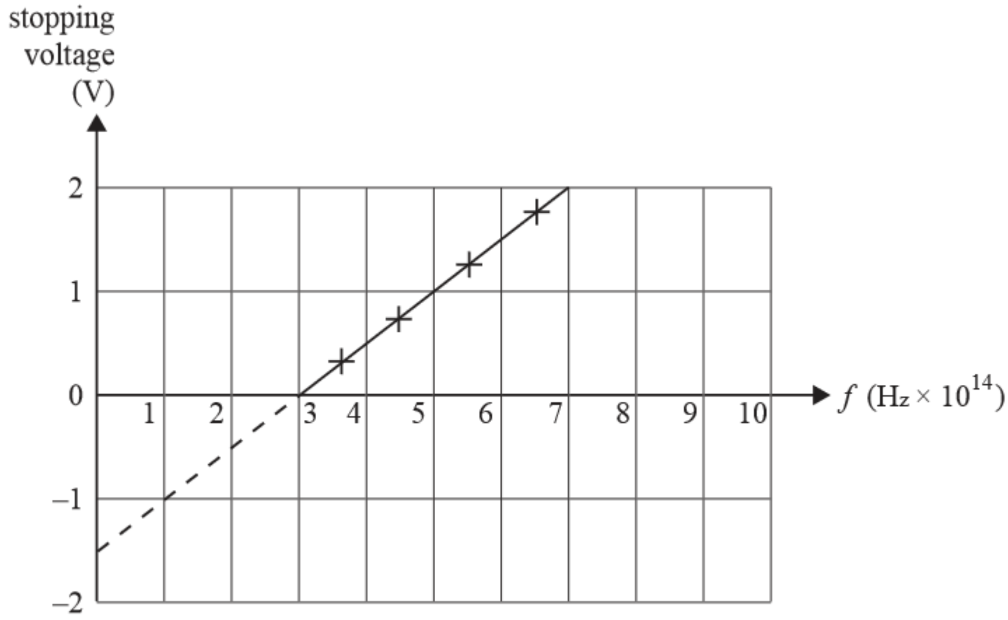
A variable DC source allows a voltage (stopping voltage) to be applied between the potassium plate and the collector electrode. A voltmeter (Vs) measures this voltage, and a microammeter (A) reads the current. Their apparatus is shown below.



Example 21 2009 Question 5, 3 marks

Explain in words the physical meaning of the terms $\mathbf{E_{K\ max}}$**, f,** and **W** in the equation above. Your explanation must show how each term relates to the experiment in the figure above.

The graph below shows the stopping voltage as a function of the frequency.



Example 22 2009 Question 6, 3 marks

From the data on the graph, determine the values Kristy and Adrian would obtain for Planck's constant, h, and the work function of the metal. Show your working.

Example 23 2009 Question 7, 2 marks

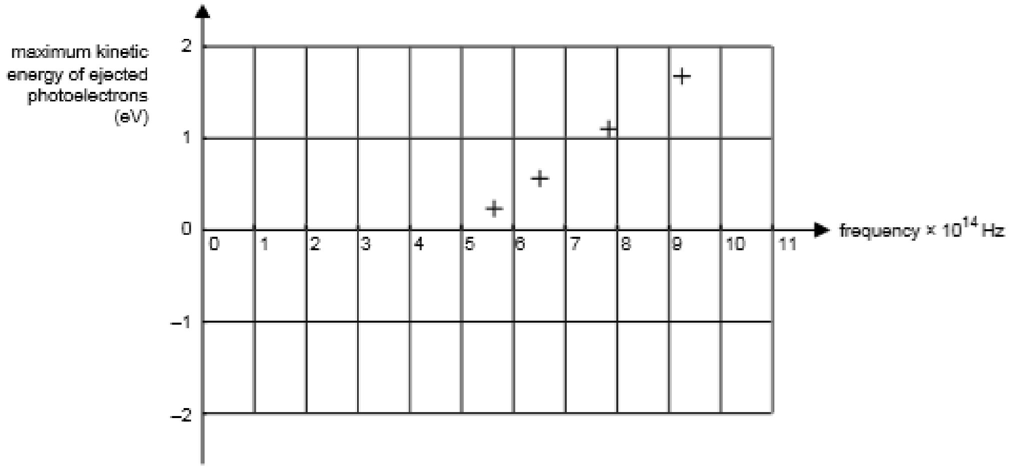
With the filter for a particular frequency (8.0×10^{14} Hz), Kristy and Adrian now double the intensity of the light from the light source. State what effect this will have on

i. the maximum kinetic energy of the emitted electrons

ii. the number of electrons emitted per second as indicated by the microammeter.

Use the following information to answer Questions 1 - 3.

Some students are investigating the photoelectric effect. They shine light of different wavelengths onto a rubidium plate. They measure the maximum kinetic energy of photoelectrons emitted from the plate. Their data of maximum kinetic energy of ejected photoelectrons as a function of the frequency of incident light is shown below. In answering the following questions, you must use the data from the graph. Take the speed of light to be 3.0×10^8 m s^{-1}.



Example 24 2007 Question 1, 2 marks

From the data on the graph, what is the minimum energy, W, required to remove photoelectrons from the rubidium plate?

The students shine light of wavelength λ = 400 nm onto the rubidium plate.

Example 25 2007 Question 2, 2 marks

From the graph, with what maximum kinetic energy would the photoelectrons be emitted?

Example 26 2007 Question 3, 3 marks

The students use a light source that emits a large range of frequencies. They use filters which allow only certain frequencies from the source to shine onto the plate. Most of the students filters produce frequencies below the cut-off frequency. Alice says that if they increase the intensity of light, these frequencies below the cut-off frequency will be able to produce emitted photoelectrons.

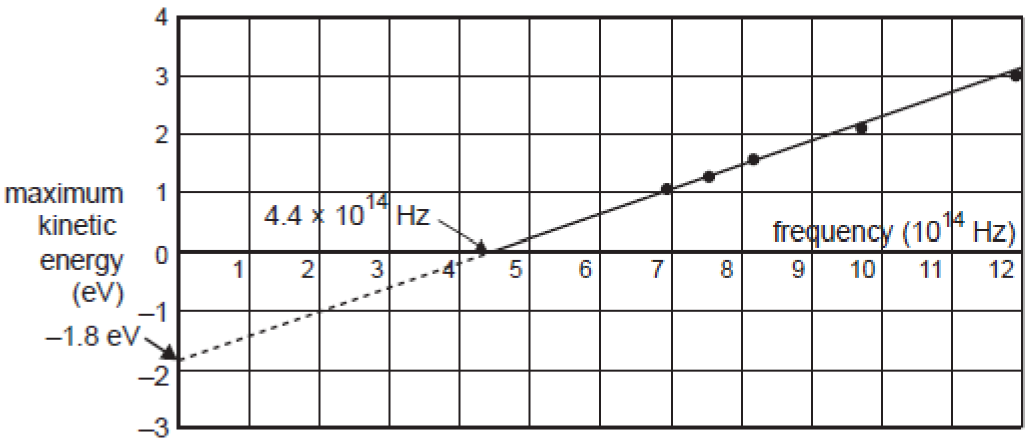
They experiment and find Alice is incorrect. Comment whether this experimental evidence supports the wavelike or the particle-like theory of light.

The table below contains some predictions for the behaviour of light incident on a shiny metal sheet. Complete the table by placing a 'Y' (Yes) or 'N' (No) in the appropriate boxes if the prediction is supported by the wave **and/or** particle model of light. Some answers have already been provided. It is possible for predictions to be supported by both models.

Example 27 2006 Question 2, 4 marks

Prediction	Wave model	Particle model
The number of photoelectrons produced is proportional to the intensity of the incident beam.	Y	
Light of low intensity will give rise to the emission of photoelectrons later than light of high intensity.		N
Light of high intensity will produce photoelectrons with a greater maximum kinetic energy than light of low intensity.	Y	
Light of sufficient intensity of any frequency should produce the photoelectric effect.	Y	

Measurements of the kinetic energy of electrons emitted from potassium metal were made at a number of frequencies. The results are shown below.

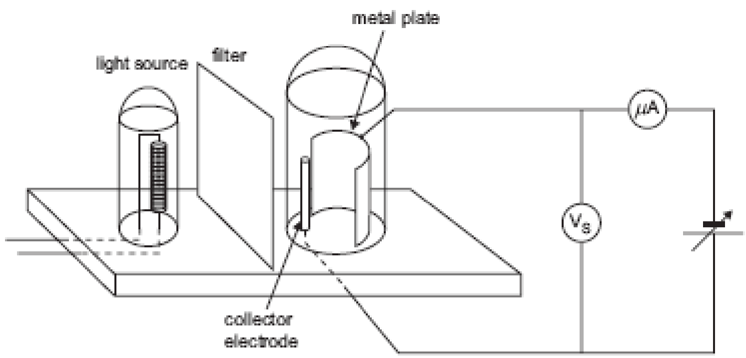


data for potassium metal

Example 28 2006 Question 3, 2 marks

What is the minimum energy of a light photon that can eject an electron from potassium metal?

Susan and Peter conducted a photo-electric experiment in which they used a light source and various filters to allow light of different frequencies to fall on the metal plate of a photo-electric cell. The maximum kinetic energy of any emitted photo-electrons was determined by measuring the voltage required, V_S (stopping voltage), to just stop them reaching the collector electrode. The apparatus is shown below.



The figure below shows the stopping voltage, V_S, as a function of the frequency (f) of the light falling on the plate.

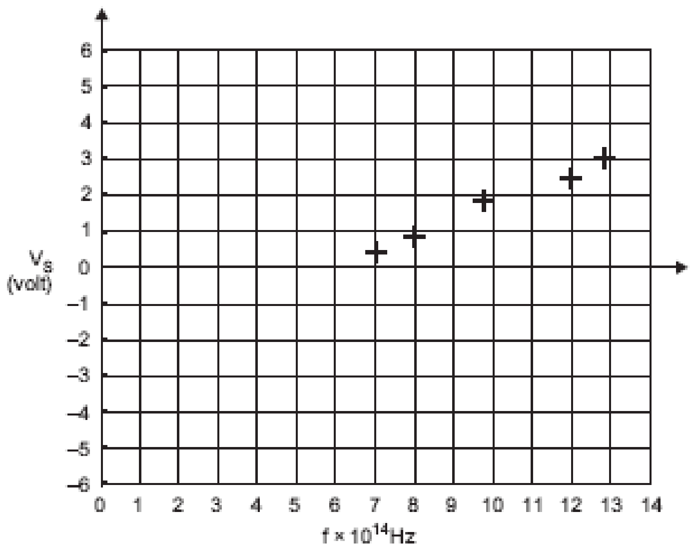


Table 1 shows the work functions for a series of metals.

Table 1

Metal	Work function
selenium	1.90 eV
sodium	2.75 eV
copper	4.70 eV
gold	5.30 eV

Example 29 2005 Question 3, 2 marks

Use the information above to identify the metal surface used in Susan and Peter's experiment.

Example 30 2005 Question 4, 3 marks

Use the results to calculate the value for Planck's constant that Susan and Peter would have obtained from the data. You must show your working.

Caesium metal is illuminated by green light with a wavelength of 550 nm.

Example 31 2004 Question 1, 2 marks

Calculate the energy of a photon of green light.

($h = 4.14 \times 10^{-15}$ eV s, $c = 3.00 \times 10^{8}$ m s^{-1})

The work function of caesium is 2.10 eV.

Example 32 2004 Question 2, 2 marks

Calculate the maximum kinetic energy of the electrons ejected from the metal surface when green light illuminates caesium metal.

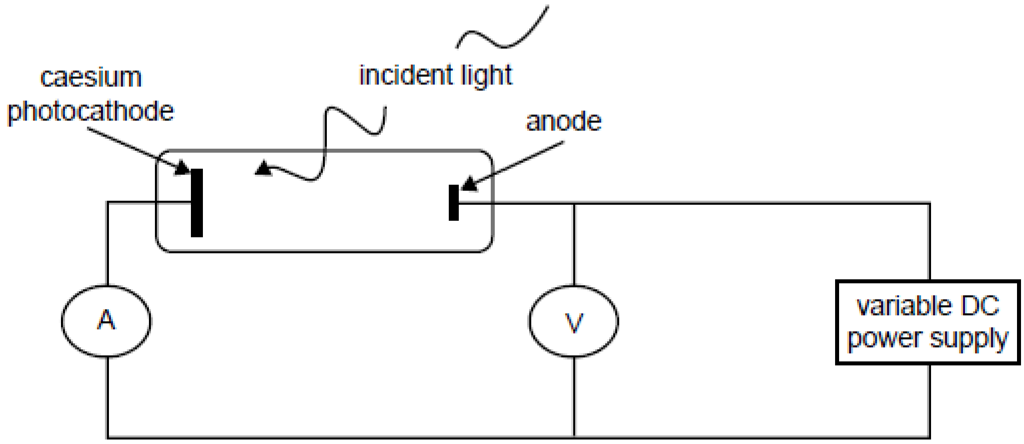
Violet light now illuminates the caesium metal and the maximum kinetic energy of the photoelectrons is 2.80 eV.

Example 33 2004 Question 3, 3 marks

Show that the maximum speed of the electrons ejected from the metal surface is 9.9×10^5 m s^{-1}.

($e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg)

A group of students is investigating the photoelectric effect. The apparatus consists of a polished caesium metal plate enclosed in an evacuated clear tube. The plate is illuminated by several different light sources. A retarding potential from a variable power supply is used to stop emitted photoelectrons and hence determine their maximum kinetic energy. An ammeter is used to measure the current of the emitted photoelectrons.



Their results are summarised in Table 1 below. Note that some entries are missing from the table.

Table 1

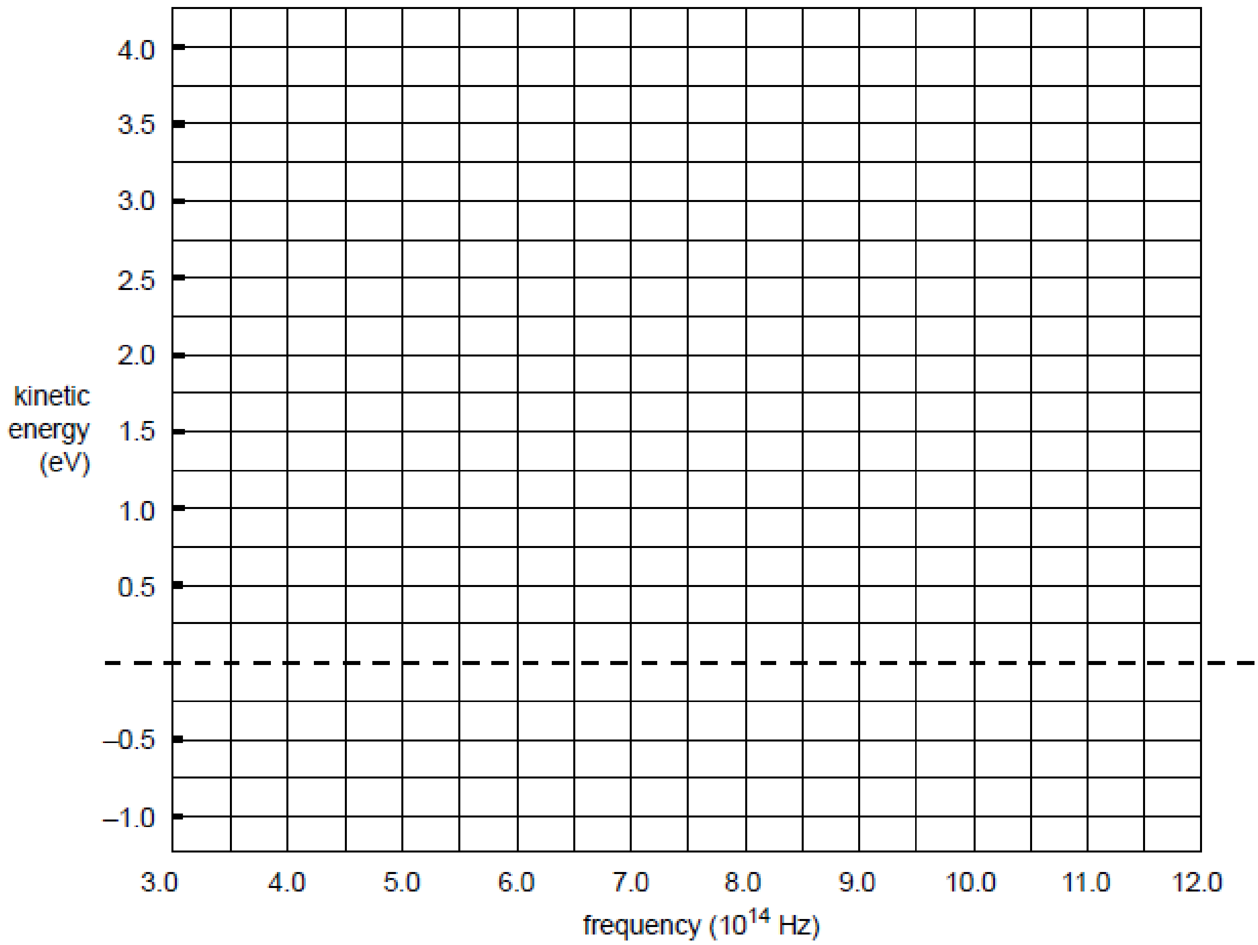
Colour	Frequency ($\times 10^{14}$ Hz)	Energy of photon (eV)	Maximum kinetic energy (eV)	Maximum current (mA)
red	4.8	2.0		
green	5.4		0.1	0.2
blue	7.3	3.0	0.9	
UV	10.1	4.2	2.1	4.2
UV2	12.0			

Example 34 2004 Question 1, 2 marks

Use the results above to estimate the work function for caesium metal.

Example 35 2004 Question 4a, 4b, 1 + 2 marks

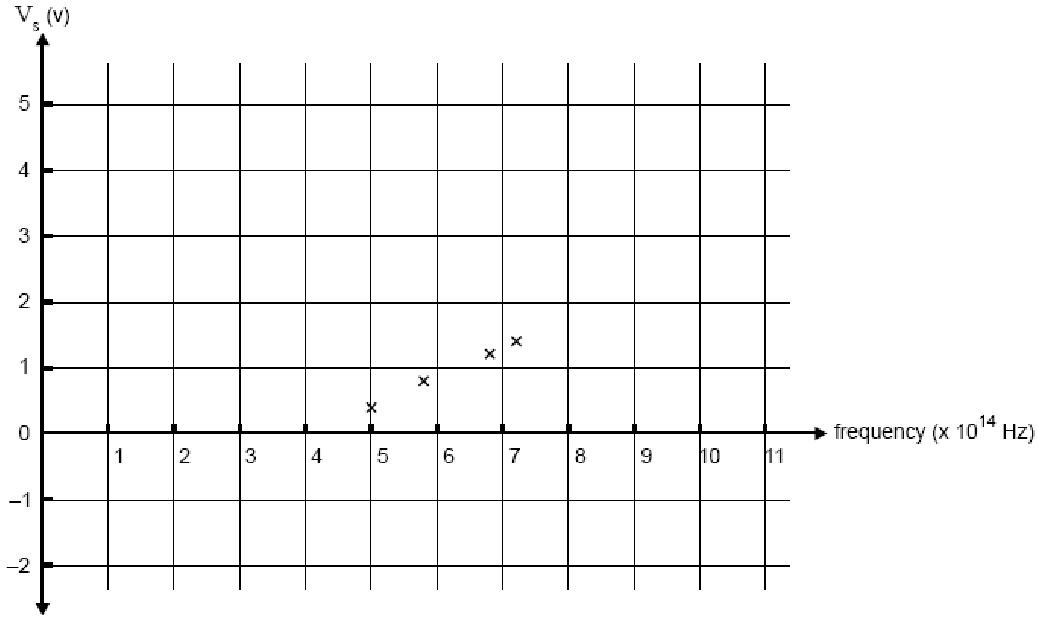
a) Use the data from Table 1 in Question 1 to graph the maximum kinetic energy of the photoelectrons as a function of frequency in the range 3.0×10^{14} Hz to 12.0×10^{14} Hz.



b) Use your graph to estimate the maximum kinetic energy of the photoelectrons for the red and UV2 sources by extrapolating the experimental results in Table 1. If no electrons are emitted, write N/A.

Example 36 2003 Question 5, 2 marks

In an experiment to demonstrate the photoelectric effect, physics students allow light of various frequencies to fall on a metal surface in a photocell. The photoelectrons are decelerated across a retarding voltage, and the stopping potential, Vs, is measured for each frequency. The data they obtained is graphed below.



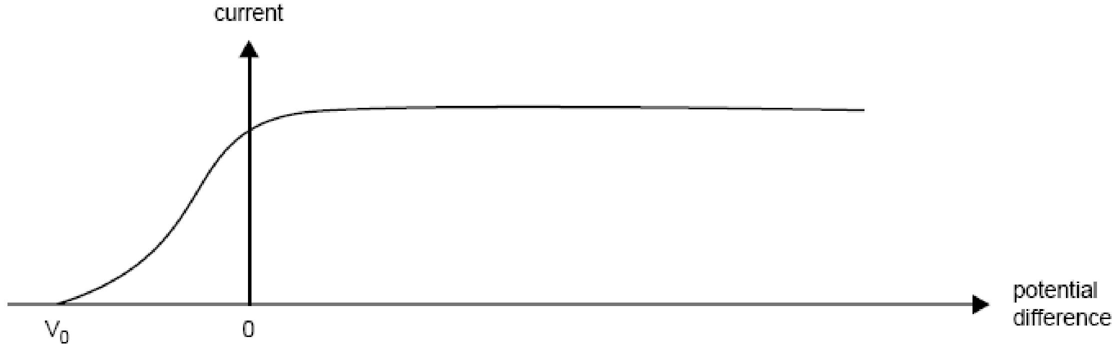
The students use the data points on the graph to determine a value for the work function of the metal. Determine the magnitude and unit of the work function for this metal surface.

Example 37 2003 Question 6, 3 marks

What is the maximum kinetic energy (in eV) of the photoelectrons produced when ultraviolet light of frequency 1.93×10^{16} Hz is incident on the metal surface? ($h = 4.14 \times 10^{-15}$ eV s)

Example 38 2002 Question 6, 3 marks

Blue light of frequency 6.25×10^{14} Hz is shone onto the sodium photocathode of a photocell. The graph of the photoelectric current versus potential difference is shown below.



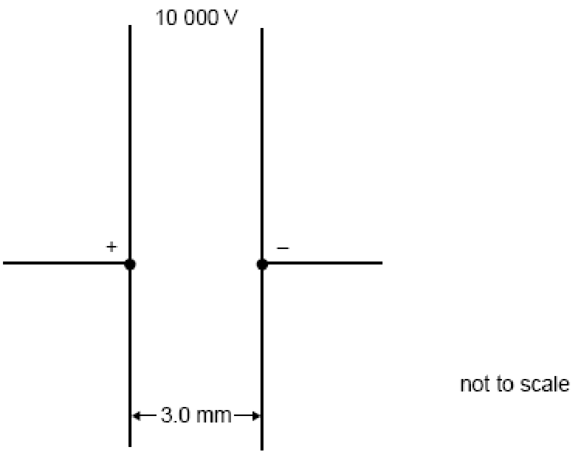
The threshold frequency for sodium is 5.50×10^{14} Hz.
What is the cut-off potential, Vo, when blue light of frequency 6.25×10^{14} Hz is shone onto the sodium photocathode of this photocell.

($h = 4.14 \times 10^{-15}$ eV s)

Example 39 2002 Question 7, 2 marks

On **the figure above** sketch the curve expected if the light is changed to **ultraviolet** with a **lower intensity** than the original.

A pair of charged parallel plates have a potential difference of 10 000 volt between them, and are 3.0 mm apart, as shown below.



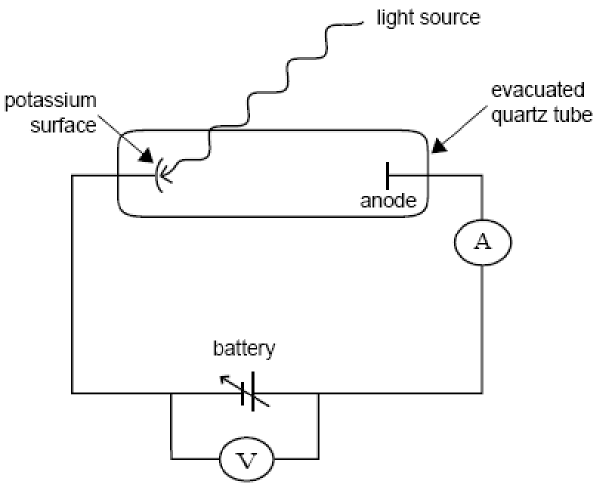
Example 40 2000 Question 1, 2 marks

Calculate the magnitude of the electric field between the plates. (Give your answer in V m^{-1})

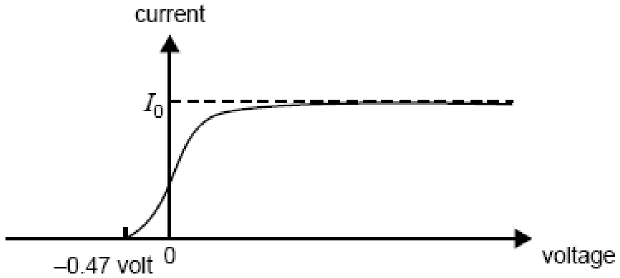
Example 41 2000 Question 2, 2 marks

Calculate the work done on an electron crossing from the negative plate to the positive plate. Give your answer in joule. Use ($e = 1.6 \times 10^{-19}$ C).

Light of a single wavelength is shone on a potassium surface that is enclosed in an evacuated quartz tube as shown below. The apparatus allows the voltage between the potassium surface and anode to be varied.



When light of wavelength 450 nm is used, the graph of current versus voltage shown below is obtained.



Example 42 2000 Question 3, 3 marks

What is the energy of a photon of 450 nm light? Give your answer in electron volt.

($h = 4.14 \times 10^{-15}$ eV s, $c = 3.0 \times 10^{8}$ m s^{-1})

The following equation can be used to explain the results of this experiment. $Ek_{max} = hf - W$
In this equation W is called the **work function**.

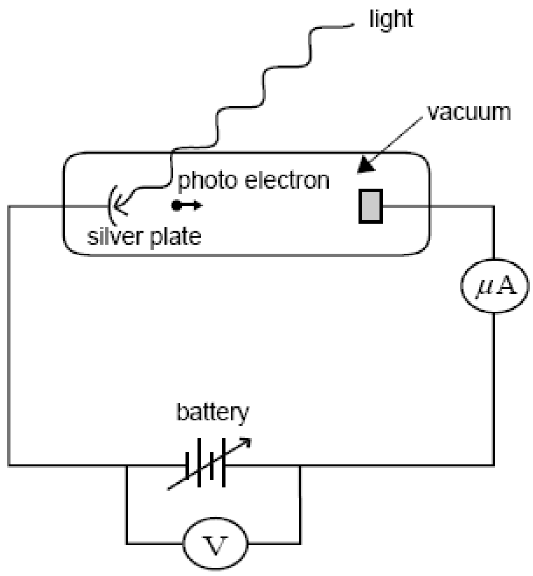
Example 43 2000 Question 4, 2 marks

Explain the meaning of the term **work function**.

Example 44 2000 Question 5, 3 marks

Calculate the value of the work function of potassium, in electron volt. Show your working.

Experimental work was carried out to investigate the photoelectric effect by shining light onto a particular metal surface. Measurements were made of the number and maximum kinetic energy of the emitted electrons from this particular metal surface for different frequencies and intensities of light.
The apparatus shown was set up to investigate the photoelectric effect.



Using this apparatus it is found that light of wavelength 254 nm (2.54×10^{-7} m) ejects photoelectrons from a silver plate. The work function of the silver surface is 4.7 eV.

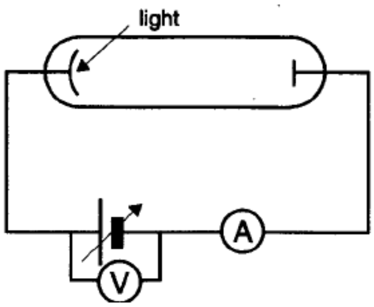
Example 45 1999 Question 2, 2 marks

Calculate the energy, in eV, of a single photon of light of wavelength 254 nm.
($h = 4.14 \times 10^{-15}$ eV s, $c = 3.0 \times 10^{8}$ m s^{-1})

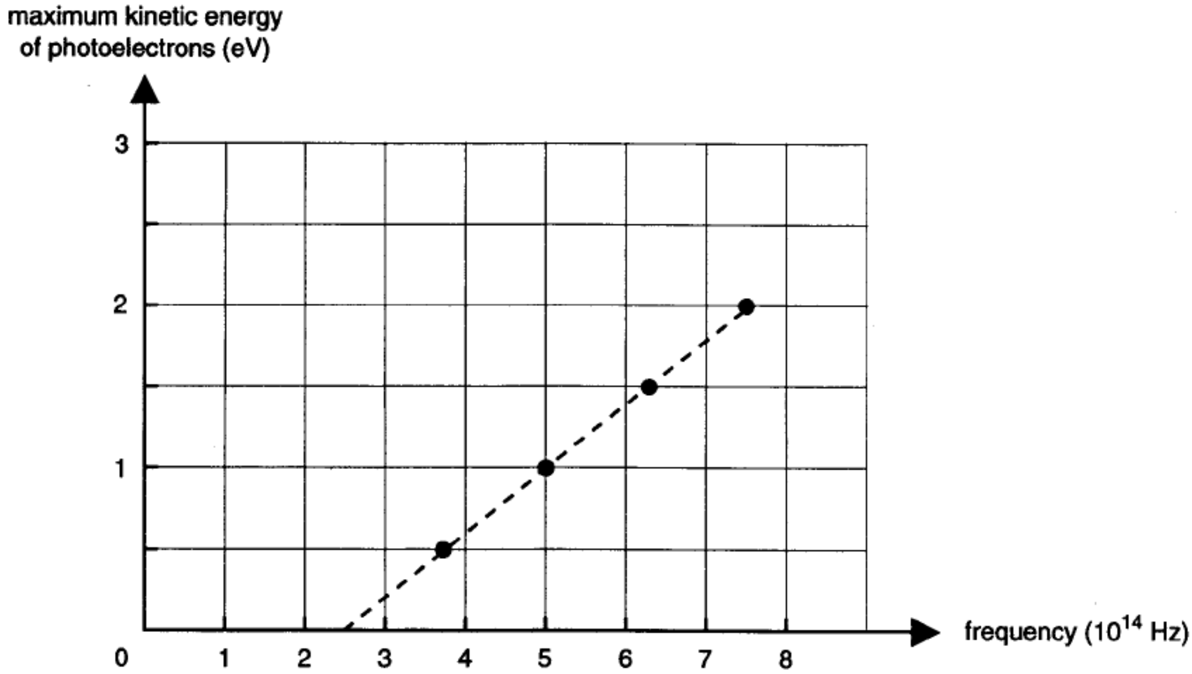
Example 46 1999 Question 3, 2 marks

What is the kinetic energy, in eV, of the fastest moving photoelectrons ejected by light of wavelength 254 nm?

An experiment is carried out to investigate the photoelectric effect. Light of various single frequencies shines onto a clean metal plate inside an evacuated glass tube as shown below.



The maximum kinetic energy of the photoelectrons is measured for the different frequencies, giving the results shown below



Example 47 1996 Question 1, 1 mark

From this graph, calculate the value of Planck's constant, h, in the units eV s. You must show your working.

Example 48 1996 Question 2, 1 mark

Calculate the minimum retarding voltage needed to prevent an electron of kinetic energy 4.8×10^{-19} J from crossing the evacuated glass tube. ($e = 1.6 \times 10^{-19}$ C)

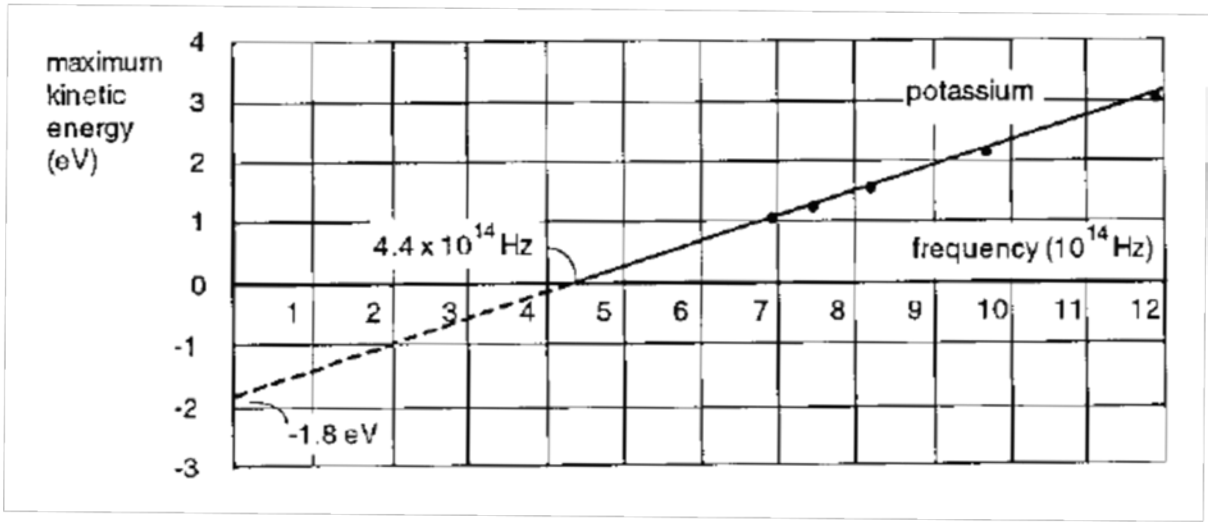
Example 49 1996 Question 4, 2 marks

Newton proposed a particle model for light and Huygens proposed a wave model for light. Explain, giving reasons, how Einstein's interpretation of the photoelectric effect supported a wave or a particle model.

Example 50 1996 Question 7, 1 mark

In a famous double slit interference experiment, G. I. Taylor used light of very low intensity. Explain why Taylor used light of such low intensity.

In early experiments to investigate the photoelectric effect, a beam of light of a single frequency was directed at a clean surface of potassium metal. The maximum kinetic energy of electrons which were ejected from the metal was measured.
When the experiment was repeated with different frequencies of light the maximum kinetic energy of electrons depended on the frequency of the light as shown below.



Example 51 1995 Question 1, 1 mark

What is the minimum energy of a light photon that can eject an electron from potassium metal? (Answer in units of eV.)

The figure above shows that electrons ejected by light of frequency 6.0 x 10^{14} Hz have a maximum kinetic energy of 0.7 eV.
The maximum kinetic energy of electrons ejected by light of frequency 1.2 x 10^{15} Hz is 3.2 eV.

Example 52 1995 Question 2, 1 mark

Explain why the maximum kinetic energy of electrons ejected by light of a higher frequency is greater than the maximum kinetic energy of electrons ejected by light of a lower frequency.

A teacher, performing a demonstration of the photoelectric effect, used two different sources of radiation. One emitted red light and the other emitted ultraviolet radiation.
The power of the two sources was the same and each source emitted radiation of a single wavelength. The wavelength of the red light was 600 nm (1nm = 10^{-9} m). The wavelength of radiation from the ultraviolet source was 200 nm.

Example 53 1994 Question 1, 1 mark

What is the value of the ratio

$$\frac{\text{number of photons of red light emitted per second}}{\text{number of photons of ultraviolet radiation emitted per second}}?$$

Example 54 1994 Question 2, 1 mark

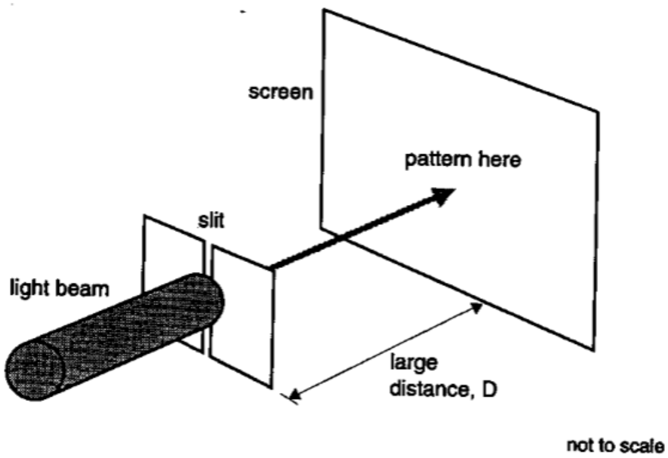
Calculate the energy of each photon emitted by the ultraviolet radiation source.

To demonstrate the photoelectric effect, the teacher exposed a clean zinc block to radiation from each source first from the red-light source and then from the ultraviolet source. It was observed that when the zinc block was exposed to red light, electrons were never ejected, but when it was exposed to ultraviolet radiation, electrons were immediately ejected from the zinc block.
A student predicted that increasing the intensity of the red light would enable the light to eject electrons. To test this prediction, the teacher exposed the block to light of the same wavelength as before, but from a much more intense red-light source

Example 55 1994 Question 4, 1 mark

Will the high-intensity red light eject electrons from the zinc block? Justify your prediction. Your answer should include an explanation of why, in the original experiment, the ultraviolet radiation did eject electrons while the red light did not.

When light of a single wavelength passes through a narrow slit, a pattern of bright and dark bands can be seen on a screen some distance away. The experimental arrangement is illustrated in below.

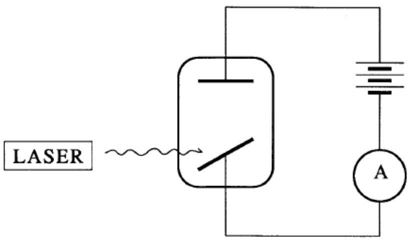


Light, with a wavelength of 500 nm, passes through the slit.

Example 56 1994 Question 5, 1 mark

What is the momentum of a photon of this radiation?

A laser emits 2.0 mW of light with wavelength 600 nm (6.0×10^{-7} m). The light falls on a metallic surface and causes one electron to be emitted for every 10^6 photons that falls on the surface.
The resulting current flowing in the circuit shown below is measured.
Take Planck's constant $h = 6.6 \times 10^{-34}$ J s, the electron charge $e = 1.6 \times 10^{-19}$ C, and the speed of light in vacuum $c = 3.0 \times 10^8$ m s^{-1}.



Example 57 1991 Question 34, 1 mark

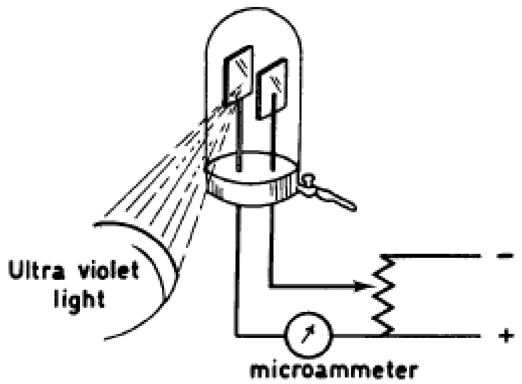
What is the energy (in joule) of each photon in the laser beam?

Example 58 1991 Question 35, 1 mark

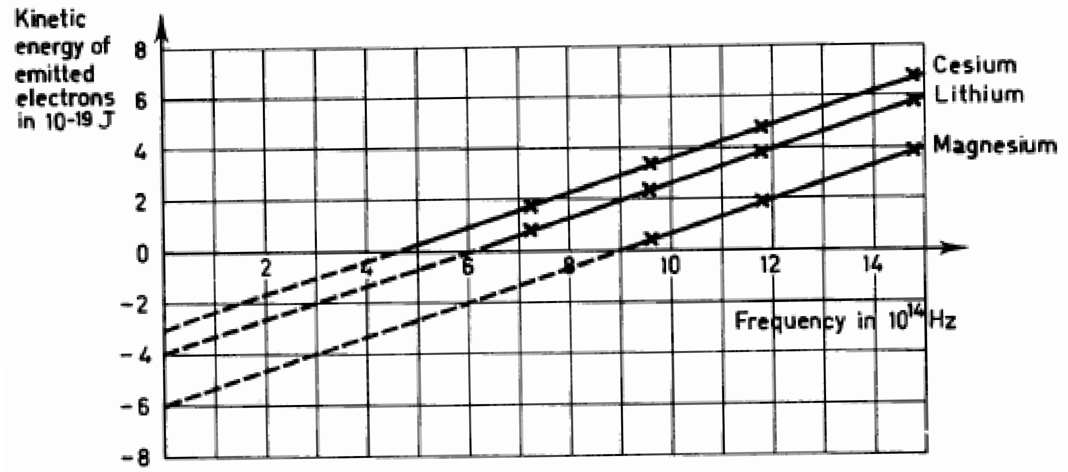
How many photons per second are emitted from the laser?

Example 59 1991 Question 36, 1 mark

Assuming that all the photo-electrons emitted from the surface contribute to the current flow, what is the current?



The circuit shows a means of measuring the energy of electrons emitted from a metal when ultra-violet radiation falls on it. The collector is maintained at a potential that is negative relative to the emitter and which can be adjusted until no current is registered on the micro-ammeter. The glass envelope containing the collector and emitter plates is evacuated.



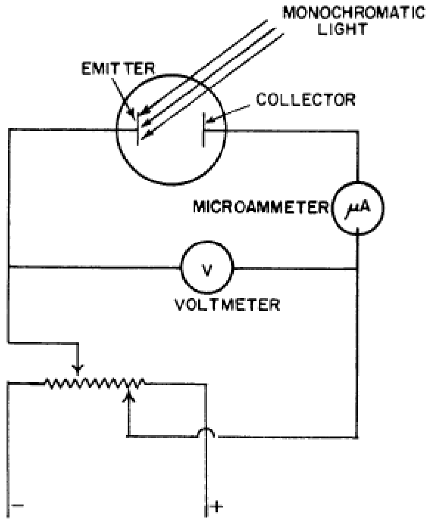
Each of the graphs above shows the measured kinetic energies of electrons emitted by a particular metal irradiated with ultra-violet radiation of different frequencies.

Example 60 1978 Question 71, 1 mark

What is the lowest frequency of radiation which can result in the emission of an electron from Lithium?

Example 61 1978 Question 72, 1 mark

What is the energy of a photon of the radiation that is just able to remove an electron from Magnesium?

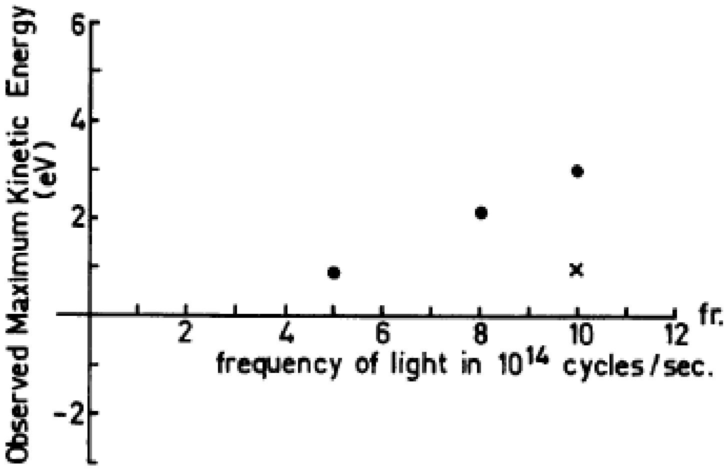


A photo-electric cell is connected into a circuit as shown. Varying the potential difference across the cell gives the results shown in graph A below. Electronic charge: 1.6×10^{-19}C

Example 62 1974 Question 98, 1 mark

For the conditions that apply to graph A, what is the maximum kinetic energy (in eV) with which electrons leave the emitter surface?

The apparatus is used to measure the kinetic energy, in electron-volt, of photoelectrons emitted when the emitter is irradiated with light of different frequencies.
The dots on the graph below represent results obtained for an emitter coated with caesium.



Example 63 1973 Question 93, 1 mark

The velocity of light is 3×10^8 m s^{-1}. What is the longest wavelength light that will cause electrons to be emitted from the caesium metal?

Example 64 1973 Question 94, 1 mark

What energy photons will be just able to cause electrons to be emitted from the caesium metal?

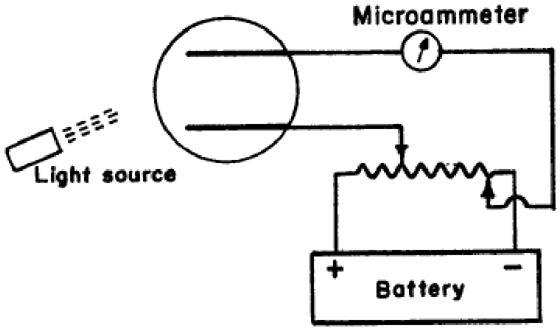
Example 65 1973 Question 95, 1 mark

From the given data, estimate Planck's constant (h) in units of eV s.

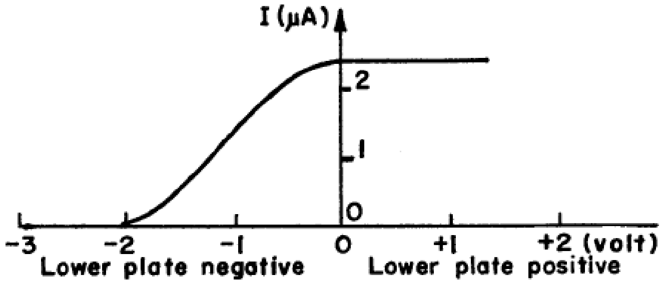
Example 66 1973 Question 96, 1 mark

The emitter is now changed from one coated with caesium to one made of copper, and one more measurement of the electron energy is made. This result is shown on the graph as a cross.
How much energy is required to be just able to remove an electron from the copper metal?

Two identical polished metal plates are placed in an evacuated sphere as shown. Light of a single wavelength can be shone on either plate. The potential difference between the plates can be varied and reversed.



In another experiment, ultra-violet light of quantum energy 5 electron volt is used. The apparatus is correctly adjusted, and the current through the micro-ammeter is plotted for different potential differences between the plates. The results are shown below.



Example 67 1970 Question 92, 1 mark

How much of the original quantum energy (in eV) is used in removing an electron from the metal?