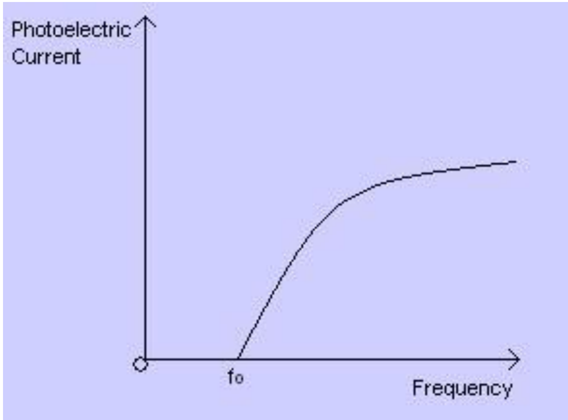
Higher Photoelectric Effect Questions

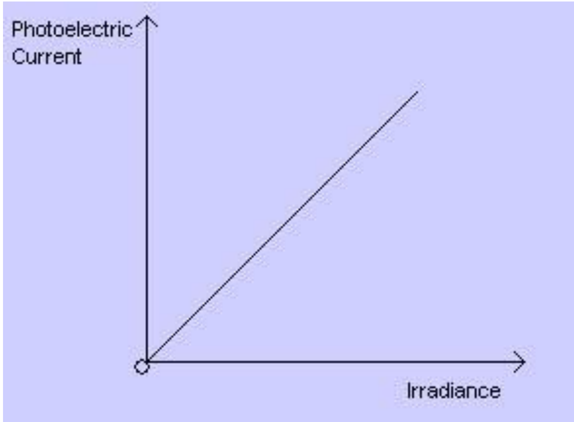
1. a) i) What does the term $\mathbf{f_o}$ stand for in the graph below?

ii) **Explain what the graph shows** in terms of photoelectric emission.



b) i) **Which important condition** must be met to produce the graph below in photoelectric emission?

ii) **Explain what the graph shows** in terms of photoelectric emission.



2. The table below shows four different metals and their corresponding work functions.

Metal	Work function ($x10^{-19}$J)
Gold	7.8
Zinc	6.9
Calcium	4.3
Potassium	3.2

a) Calculate the **threshold frequencies** for each of the **four metals** listed above.

b) When radiation of frequency **8 x 10^{14}Hz** is applied to **Calcium**, Calculate or find:
i) **Energy** of a **photon**.
ii) **Kinetic energy** of the photoelectrons leaving the Calcium.
iii) **Speed** of the photoelectrons leaving the Calcium.

3.

The minimum energy required to cause an electron to be emitted from a clean zinc surface is $6{\cdot}9 \times 10^{-19}$ 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 $4{\cdot}0 \times 10^{-7}$ m? You must justify your answer.

4.

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.

5.

The work function of a metal is $6{\cdot}4 \times 10^{-19}$ J.

(*a*) Explain what is meant by the term 'work function'.

(*b*) Light with a frequency of $1{\cdot}2 \times 10^{15}$ Hz. is shone onto the metal surface.

Find whether or not the photons of this light will cause the photoelectric effect to take place.

(*c*) The light source is now replaced with a light source which produces light with a frequency of $1{\cdot}5 \times 10^{15}$ Hz.

(i) The photons from this source contain more energy than is required to release the electrons. How much extra energy is available after the electron has been released?

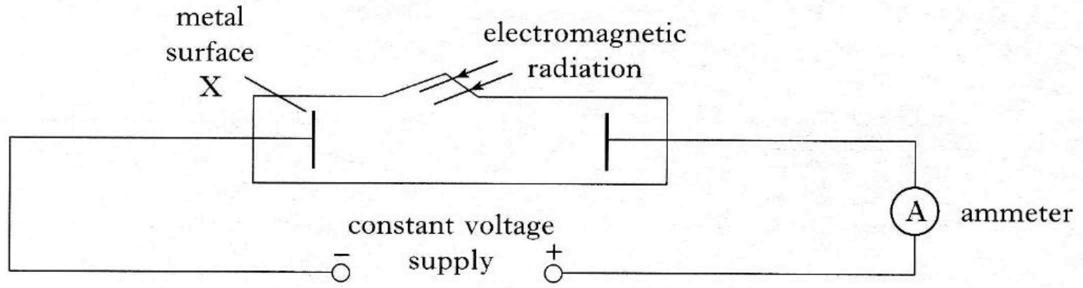
(ii) Into what energy type will this extra energy be converted?

(iii) Photons come from three lamps that emit red, green and blue light. Which of these lamps produces photons with the highest energy?

6.

(*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.



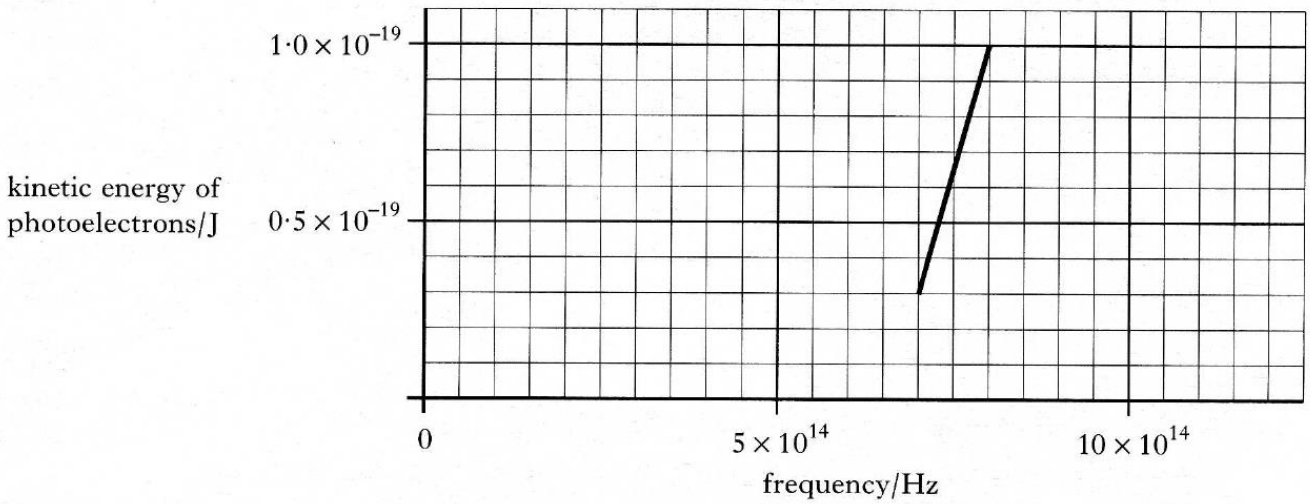
(i) When radiation of a certain frequency is shone on the metal surface X, a reading is obtained on the ammeter.

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	$7{\cdot}8 \times 10^{-19}$

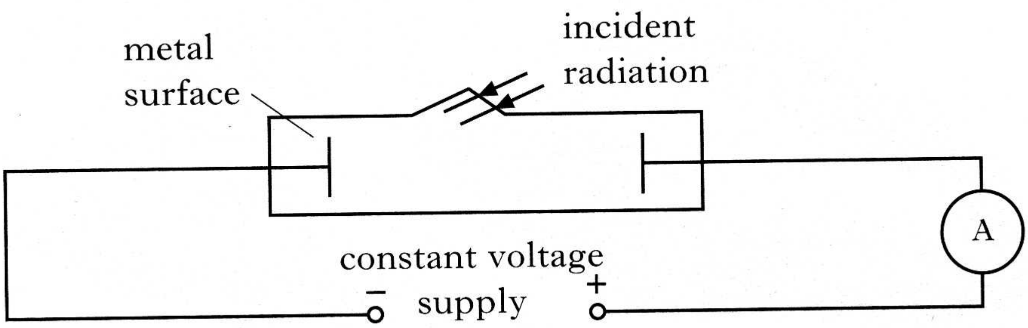
Which one of these metals was used in the investigation?

You must justify your answer using the information given in the table.

7.

(*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	$= 9{\cdot}0 \times 10^{14}$ Hz
Minimum intensity of ultraviolet radiation required at the chip	$= 25$ W m^{-2}
Area of the chip exposed to radiation	$= 1{\cdot}8 \times 10^{-9}$ m^2
Time taken to erase the information	= 15 minutes
Energy of radiation needed to erase the information	$= 40{\cdot}5$ 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.

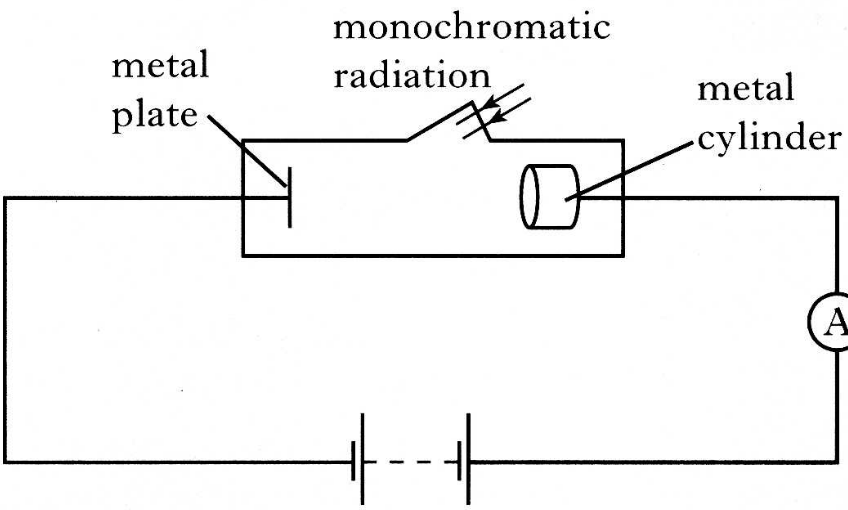
(iii) Sunlight of intensity 25 W m^{-2}, at the chip, can also be used to erase the information.

State whether the time taken to erase the information is greater than, equal to or less than 15 minutes.

You must justify your answer.

8.

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 $3 \cdot 11 \times 10^{-19}$ 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.

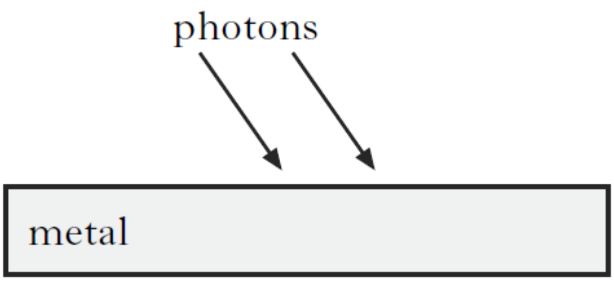
Explain why there could still be a reading on the ammeter.

9.

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 $6{\cdot}1 \times 10^{14}$ 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 $6{\cdot}0 \times 10^{-20}$ J.

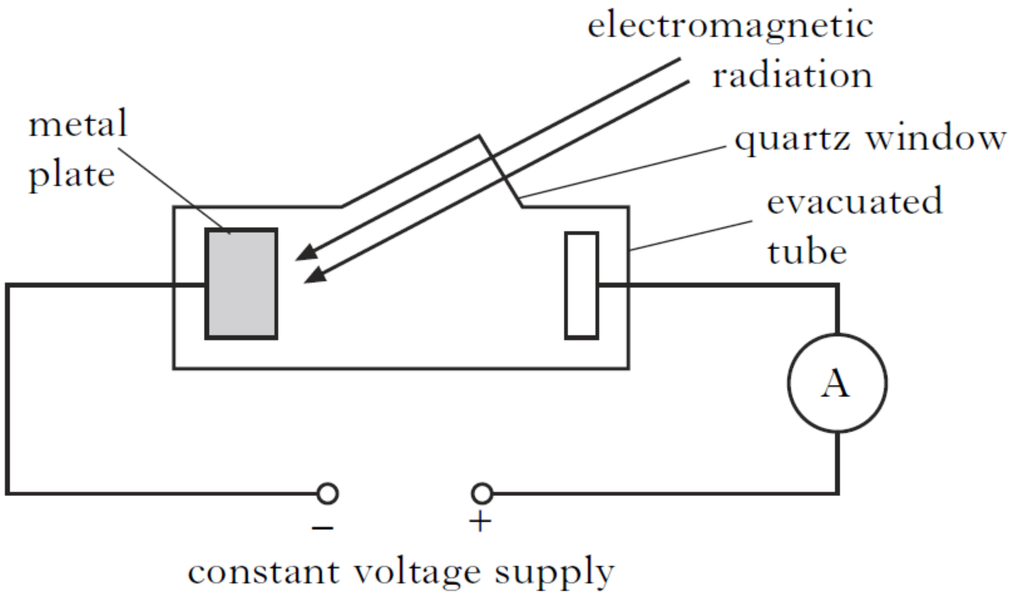
Calculate the work function of the metal.

(*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.

10.

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 $3{\cdot}29 \times 10^{-19}$ J.

(*b*) The wavelength of the incident radiation is now altered. Photons of energy $5{\cdot}12 \times 10^{-19}$ 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.