1. An isolated metal plate is given a negative charge. Electromagnetic radiation is incident on the plate. The plate loses its charge due to the photoelectric effect.

(a) Discuss how the rate of loss of charge from the plate depends on the frequency and intensity of the incident radiation.

In your answer you should explain why:

- the plate loses its charge
- the photoelectric effect occurs only for frequencies greater than a particular value
- the rate of loss of charge increases with intensity for radiation above that particular value of frequency.

(6)

(b) Charged particles are emitted from the metal plate with a maximum kinetic energy of $1.1\ \text{eV}$ when radiation of frequency $1.2 \times 10^{15}\ \text{Hz}$ is incident on the plate.

Calculate, in eV, the work function of the metal.

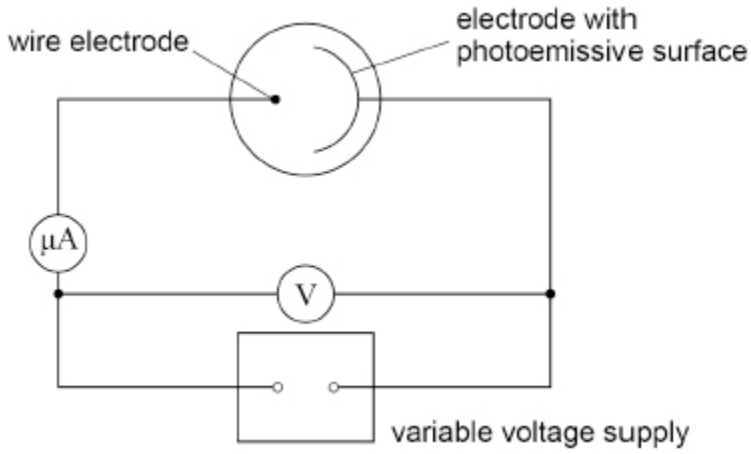
work function = _____ eV

(3)

(Total 9 marks)

2. **Figure 1** shows an arrangement used to investigate the photoelectric effect.

Figure 1



A current is measured on the microammeter only when electromagnetic radiation with a frequency greater than a certain value is incident on the photoemissive surface.

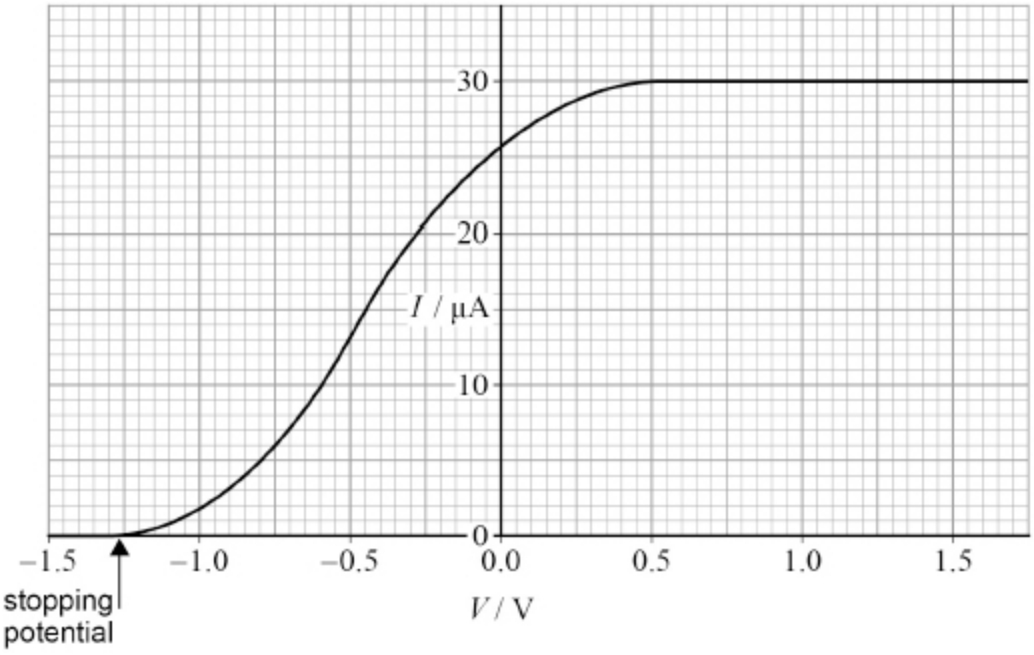
(a) Explain why the frequency of the electromagnetic radiation must be greater than a certain value.

(2)

The apparatus in **Figure 1** is used with a monochromatic light source of constant intensity. Measurements are made to investigate how the current I in the microammeter varies with positive and negative values of the potential difference V of the variable voltage supply.

The **Figure 2** shows how the results of the investigation can be used to find the stopping potential.

Figure 2



(b) Determine the number of photoelectrons per second leaving the photoemissive surface when the current is a maximum.

number of photoelectrons per second = _____

(2)

(c) Explain why I reaches a constant value for positive values of V.

_____

_____

_____

_____

_____

_____

(2)

(d) Explain why I decreases as the value of V becomes more negative.

_____

_____

_____

_____

_____

_____

_____

(3)

(e) The investigation is repeated with a different photoemissive surface that has a smaller value of the work function. The source of electromagnetic radiation is unchanged.

Discuss the effect that this change in surface has on the value of the stopping potential.

(3)

(Total 12 marks)

3. The photoelectric effect can be demonstrated by illuminating a negatively charged plate, made from certain metals, with ultraviolet (UV) light and showing that the plate loses its charge.

(a) Explain why, when ultraviolet light is shone on a **positively** charged plate, no charge is lost by the plate.

(2)

(b) Threshold frequency and work function are important ideas in the study of the photoelectric effect.

Tables 1 and **2** summarise the work functions of three metals and photon energies of three UV light sources.

Table 1

Metal	Work function / eV
Zinc	4.3
Iron	4.5
Copper	4.7

Table 2

Light source	Photon energy / eV
1	4.0
2	4.4
3	5.0

Discuss the combinations of metal and UV light source that could best be used to demonstrate the idea of threshold frequency and the idea of work function.

(6)

(c) Calculate the maximum kinetic energy, in J, of the electrons emitted from a zinc plate when illuminated with ultraviolet light.

work function of zinc = 4.3 eV

frequency of ultraviolet light = 1.2×10^{15} Hz

maximum kinetic energy _____ J

(3)

(d) Explain why your answer is a maximum.

_____

_____

_____

(1)

(Total 12 marks)

4. Photoelectrons are released when monochromatic light with a photon energy of 4.2×10^{-19} J is incident on a metal surface.
The work function of the surface is 2.4 eV.

What is the maximum speed of the photoelectrons as they leave the surface?

A 1.3×10^{6} m s^{-1} ⬭

B 6.3×10^{5} m s^{-1} ⬭

C 2.8×10^{5} m s^{-1} ⬭

D 2.0×10^{5} m s^{-1} ⬭

(Total 1 mark)

5. Monochromatic light of frequency f is incident on a metal surface in a vacuum. Photoelectrons are emitted from the surface.

The photoelectric current I is measured.

The magnitude of the stopping potential V_s is then measured.

f is increased without changing the rate at which photons arrive at the metal surface.

What are the new measurements of the photoelectric current and the magnitude of the stopping potential?

	Photoelectric current	**Magnitude of the stopping potential**	
A	I	V_s	⬭
B	I	$> V_s$	⬭
C	$> I$	V_s	⬭
D	$> I$	$> V_s$	⬭

(Total 1 mark)

6. In photoelectricity, V_s is the stopping potential.

What quantity is eV_s?

A energy of an incident photon ⬭

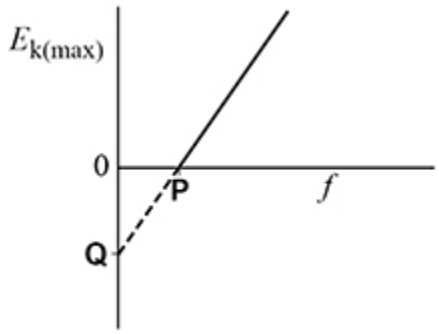
B maximum kinetic energy of a photoelectron ⬭

C threshold frequency × the Planck constant ⬭

D work function ⬭

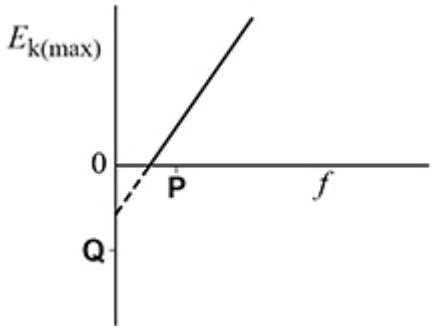
(Total 1 mark)

7. The graph shows how the maximum kinetic energy $Ek_{(max)}$ of photoelectrons emitted from a metal surface varies with the frequency f of the incident radiation.
P is the intercept on the f axis. **Q** is the intercept on the $Ek_{(max)}$ axis.

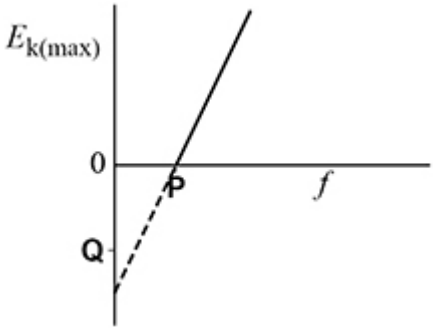


Which graph shows the variation of $Ek_{(max)}$ with f for a metal with a greater work function?

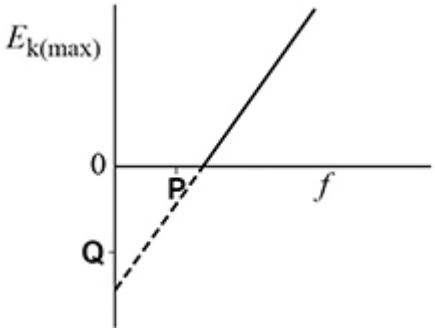
A



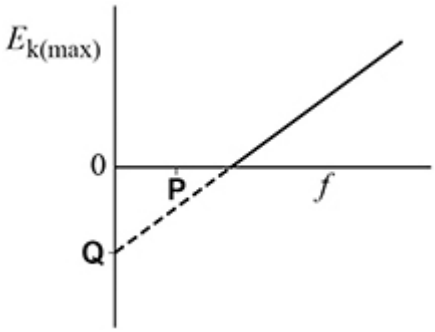
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

8. Monochromatic light with a photon energy of 4.1×10^{-19} J is incident on a metal surface. The maximum speed of the photoelectrons released is 4.2×10^{5} m s^{-1}.

What is the work function of the metal?

A 2.5×10^{-19} J ⬭

B 3.3×10^{-19} J ⬭

C 4.1×10^{-19} J ⬭

D 4.9×10^{-19} J ⬭

(Total 1 mark)

9. A photon has energy of 1×10^{18} eV.
An object of mass 0.03 kg has kinetic energy equal to the energy of the photon.

What is the speed of the object?

A 1 m s^{-1} ⬭

B 3 m s^{-1} ⬭

C 10 m s^{-1} ⬭

D 30 m s^{-1} ⬭

(Total 1 mark)

10. Photons of energy 1.0×10^{-18} J are incident on a metal surface and cause the emission of electrons from the metal surface.

Which statement about the emitted electrons is correct?

A They each have a kinetic energy of 1.0×10^{-18} J. ⬭

B They each have a kinetic energy that is a multiple of 1.0×10^{-18} J. ⬭

C Their mean kinetic energy is 1.0×10^{-18} J. ⬭

D The kinetic energy of each must be less than 1.0×10^{-18} J. ⬭

(Total 1 mark)

11. Light of frequency 2.0×10^{15} Hz is incident on a metal surface. The work function of the metal is 4.6×10^{-19} J.

Which statement is correct?

A No photoelectrons are released. ⬭

B Photoelectrons are released with a maximum kinetic energy of 3.1×10^{-19} J. ⬭

C Photoelectrons are released with a maximum kinetic energy of 8.7×10^{-19} J. ⬭

D Photoelectrons are released with a maximum kinetic energy of 18×10^{-19} J. ⬭

(Total 1 mark)