(a) Briefly describe two phenomena associated with the photoelectric effect that cannot be explained using a wave theory of light.

?

1. instantaneous emmission

2.

[2]

(b) The maximum energy E_{MAX} of electrons emitted from a metal surface when illuminated by light of wavelength λ is given by the expression

$$E_{MAX} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

where h is the Planck constant and c is the speed of light.

(i) Identify the symbol λ_0.

threshold wavelength. [1]

21

(ii) The variation with $\frac{1}{\lambda}$ of E_{MAX} for the metal surface is shown in Fig. 10.1.

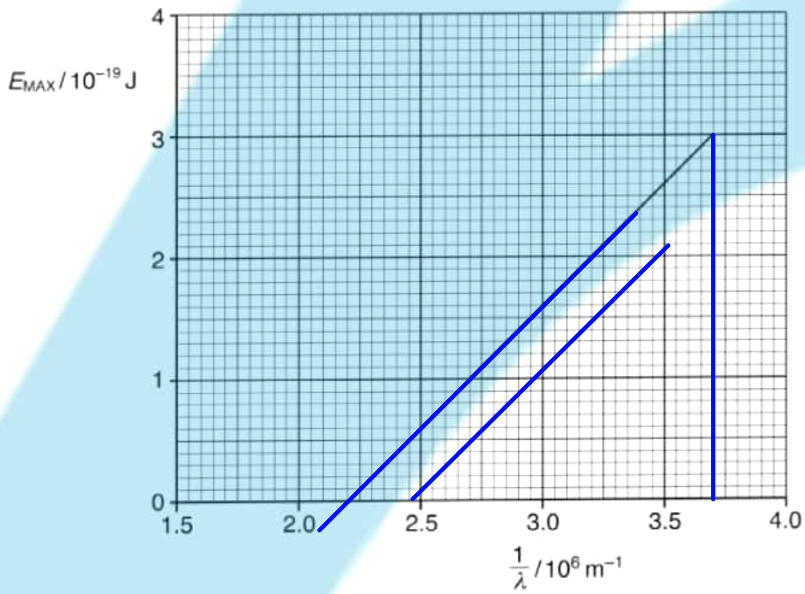

Fig. 10.1

1. Use Fig. 10.1 to determine the magnitude of λ_0.

$\frac{hc}{\lambda_0} = \frac{hc}{2.}$

$\lambda_0 =$ 2.2×10^6 m [1]

2. Use the gradient of Fig. 10.1 to determine a value for the Planck constant h.

$\frac{3 \times 10^{-19}}{(3.7 - 2.2) \times 10^6} = 2 \times 10^{-25}$

$hc = 2 \times 10^{-25}$

$h = \frac{2 \times 10^{-25}}{3 \times 10^8}$

6.66×10^{-34}

$h =$ 6.67 J s [3]

(c) The metal surface in **(b)** becomes oxidised.
Photoelectric emission is still observed but the work function energy is increased.

On Fig. 10.1, draw a line to show the variation with $\frac{1}{\lambda}$ of E_{MAX} for the oxidised surface. [2]

[Total: 9]

A stationary isolated nucleus emits a γ-ray photon of energy 0.51 MeV.

(a) State what is meant by a *photon*.

....

....

....[2]

(b) For the γ-ray photon, calculate

?

(i) its wavelength,

$$\frac{hc}{\lambda} = 0.51 \times 1.6 \times 10^{-19} \times 10^{6}$$

$$\lambda = \frac{hc}{816 \times 10^{-16}}$$

wavelength = ... m [2]

(ii) its momentum.

?

$$\lambda = \frac{h}{p}$$

momentum = ... N s [2]

(c) **(i)** For this nucleus, determine the change in mass Δm during the decay that gives rise to the energy of the γ-ray photon.

?

Δm = ... kg [2]

(ii) Explain why, after the decay, the nucleus is no longer stationary.

? unstable

....

....[1]

[Total: 9]

(a) Describe the *photoelectric effect*.

It is the emmission of e- off of a surface of metal when photons of energy greater than the work function energy hit it. [2]

(b) Data for the work function energy Φ of two metals are shown in Fig. 10.1.

	Φ / J
sodium	3.8×10^{-19}
zinc	5.8×10^{-19}

Fig. 10.1

Light of wavelength 420 nm is incident on the surface of each of the metals.

(i) State what is meant by a *photon*.

....

....

.... [2]

(ii) Calculate the energy of a photon of the incident light.

$$E = \frac{hc}{\lambda}$$

$$= \frac{hc}{420 \times 10^{-9}} = 4.73 \times 10^{-19}$$

energy = 4.73×10^{-19} J [2]

(iii) State whether photoelectric emission will occur from each of the metals.

sodium: Yes

zinc: No

[1]

[Total: 7]

(a) State what is meant by a *photon*.

....

....

....[2]

(b) A stationary cobalt-60 ($^{60}_{27}Co$) nucleus emits a γ-ray photon of energy 1.18 MeV.

(i) Calculate the wavelength of the photon.

$$\frac{hc}{\lambda} = 1.18 \times 10^{6} \times 1.6 \times 10^{-19}$$

$$\lambda = \frac{hc}{1888 \times 10^{-16}} = 1.052 \times 10^{-12}$$

wavelength = ...1.05×10^{-12}...... m [2]

(ii) Show that the momentum of the photon is 6.3×10^{-22} N s.

$$\lambda = \frac{h}{p}$$

$$p = \frac{h}{\lambda} = 6.3 \times 10^{-22}$$

[2]

(c) Use information in **(b)(ii)** to determine the recoil speed of the cobalt-60 nucleus when the γ-ray photon is emitted.

?

$$p = mv$$

$$V = \frac{p}{m} = \frac{6.3 \times 10^{-22}}{60 \times 1.66 \times 10^{-27}}$$

speed = ...6.3×10^{3}...... m s^{-1} [2]

[Total: 8]