Qunatum
May 02

7 Electrons are emitted from a metal surface when it is illuminated with suitable electromagnetic radiation.

(a) Name the effect described above.

....[1]

(b) The variation with frequency *f* of the maximum kinetic energy E_k of the emitted electrons is shown in Fig. 7.1.

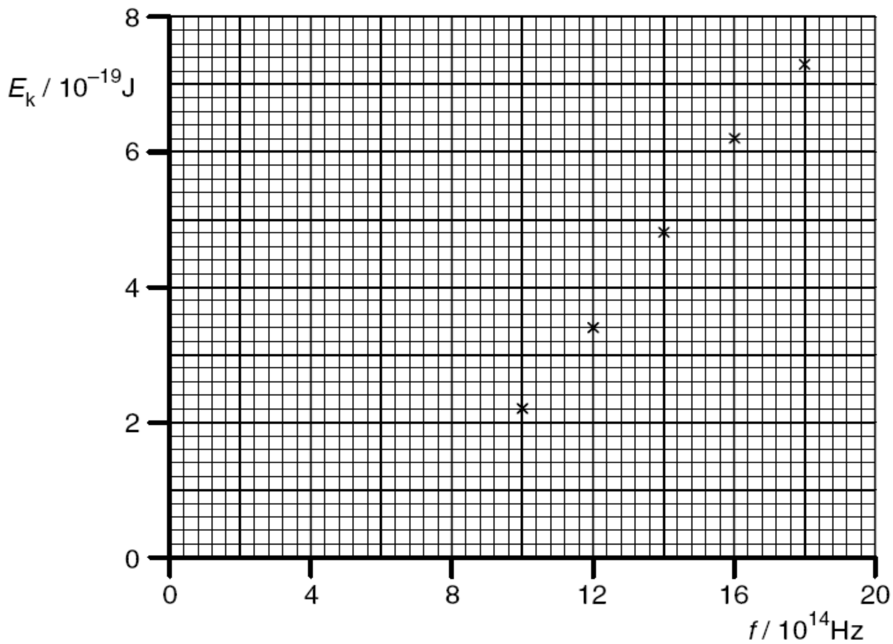

Fig. 7.1

Use Fig. 7.1 to determine

(i) the threshold frequency of the radiation,

threshold frequency = ... Hz

(ii) a value for the Planck constant.

Planck constant = ... J s
[4]

(c) On Fig. 7.1, draw a line to show the variation with frequency f of the maximum kinetic energy E_k of the emitted electrons for a second metal which has a lower work function than that in **(b)**. [2]

(d) The kinetic energy of the electrons is described as the maximum. Suggest why emitted electrons are likely to have a range of values of kinetic energy for any one frequency of the electromagnetic radiation.

....

....

....[2]

Nov 02

2 Fig. 2.1 gives information on three lines observed in the emission spectrum of hydrogen atoms.

wavelength / nm	photon energy / 10^{-19} J
656	3.03
486	....
1880	1.06

Fig. 2.1

(a) Complete Fig. 2.1 by calculating the photon energy for the wavelength of 486 nm.

[2]

(b) Fig. 2.2 is a partially completed diagram to show energy levels of a hydrogen atom.

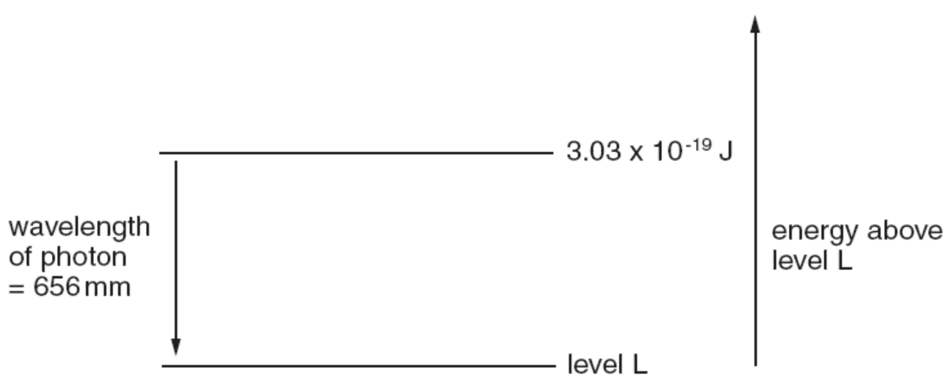

Fig. 2.2

On Fig. 2.2 draw one further labelled energy level, and complete the diagram with arrows to show the energy changes for the other two wavelengths. [3]

Nov 03

6 **(a)** Explain what is meant by a *photon* of electromagnetic radiation.

....

....

.... [2]

(b) The photoelectric effect provides evidence for the particulate nature of electromagnetic radiation. State three experimental observations that support this conclusion.

1. ....

....

2. ....

....

3. ....

.... [3]

(c) Electromagnetic radiation of wavelength λ and intensity I, when incident on a metal surface, causes n electrons to be ejected per unit time. The maximum kinetic energy of the electrons is E_{max}.

State and explain the effect, if any, on n and E_{max} when

(i) the intensity is reduced to $\frac{1}{2}I$ but the wavelength λ is unchanged,

....

....

....

(ii) the wavelength λ is reduced but the intensity I is not changed.

....

....

....

[4]

May 04

1 (a) State the significance of the Millikan experiment.

....

.... [1]

(b) In the Millikan experiment, oil droplets were found to have the following charges.

1.56×10^{-19} C
4.88×10^{-19} C
1.64×10^{-19} C
3.14×10^{-19} C
4.76×10^{-19} C

Use these data to determine a value for the elementary charge. Explain your working.

....

....

elementary charge = ... C [2]

May 04

7 (a) State the de Broglie relation, explaining any symbols you use.

....

....

.... [2]

(b) An electron of mass m has kinetic energy E. Show that the de Broglie wavelength λ of this electron is given by

$$\lambda = \frac{h}{\sqrt{2mE}}.$$

[2]

(c) Calculate the potential difference through which an electron, initially at rest, must be accelerated so that its de Broglie wavelength is equal to 0.40 nm (the diameter of an atom).

potential difference = ... V [3]

May 06

7 A parallel beam of electrons, all travelling at the same speed, is incident normally on a carbon film. The scattering of the electrons by the film is observed on a fluorescent screen, as illustrated in Fig. 7.1.

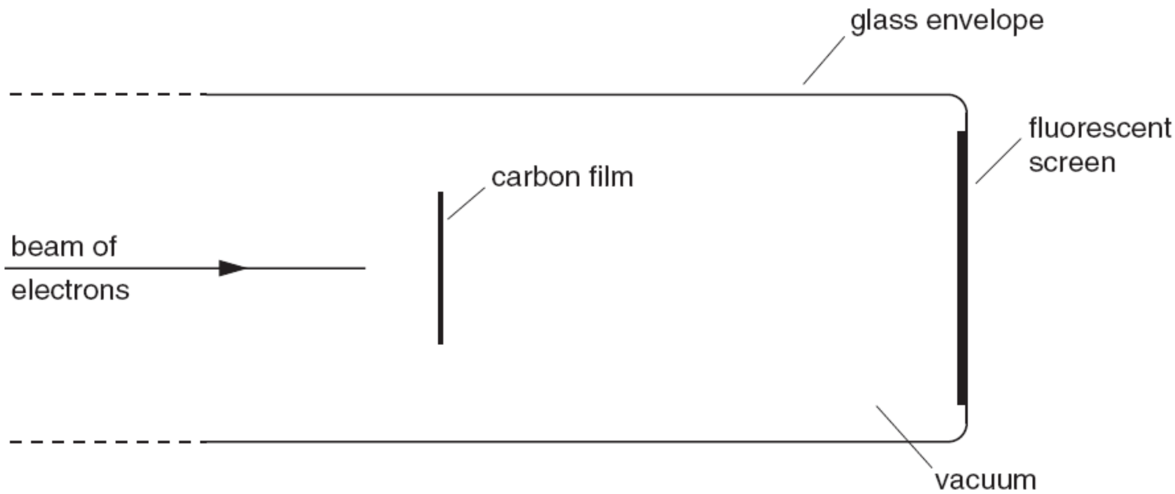

Fig. 7.1

(a) Assuming that the electrons behave as **particles**, predict what would be seen on the screen.

....

.... [1]

(b) In this experiment, the electrons do **not** behave as particles.

Describe briefly the pattern that is actually observed on the screen. You may draw a sketch if you wish.

....

.... [1]

(c) The speed of the electrons is gradually increased.

State and explain what change, if any, is observed in the pattern on the screen.

....

....

....

.... [3]

Nov 06

7 The photoelectric effect may be summarised in terms of the word equation

photon energy = work function energy + maximum kinetic energy of emitted electrons.

(a) Explain

(i) what is meant by a *photon*,

....

....

.... [2]

(ii) why most electrons are emitted with kinetic energy less than the maximum.

....

....

.... [2]

(b) Light of constant intensity is incident on a metal surface, causing electrons to be emitted.

State and explain why the rate of emission of electrons changes as the frequency of the incident light is increased.

....

....

.... [2]

May 07

5 **(a)** **(i)** Explain what is meant by a *photon*.

....

.... [1]

(ii) Show that the photon energy of light of wavelength 350 nm is 5.68×10^{-19} J. [1]

(iii) State the value of the ratio

$$\frac{\text{energy of photon of light of wavelength 700 nm}}{\text{energy of photon of light of wavelength 350 nm}}.$$

ratio = …………….. [1]

(b) Two beams of monochromatic light have similar intensities. The light in one beam has wavelength 350 nm and the light in the other beam has wavelength 700 nm.

The two beams are incident separately on three different metal surfaces. The work function of each of these surfaces is shown in Fig. 5.1.

metal	work function / eV
tungsten	4.49
magnesium	3.68
potassium	2.26

Fig. 5.1

(i) Explain what is meant by the *work function* of the surface.

....

....

.... [2]

(ii) State which combination, if any, of monochromatic light and metal surface could give rise to photo-electric emission. Give a quantitative explanation of your answer.

....

....

....

....

....

.... [3]

May 08

7 The Millikan oil-drop experiment enabled the charge on the electron to be determined.

(a) State a fundamental property of charge that was suggested by this experiment.

....

....[1]

(b) Two parallel metal plates P and Q are situated in a vacuum. The plates are horizontal and separated by a distance of 5.4 mm, as illustrated in Fig. 7.1.

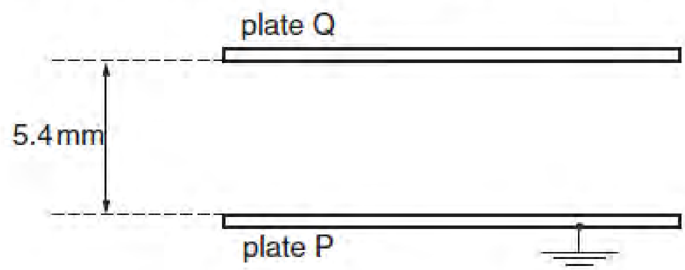

Fig. 7.1

The lower plate P is earthed. The potential difference between the plates can be varied. An oil droplet of mass 7.7×10^{-15} kg is observed to remain stationary between the plates when plate Q is at a potential of +850 V.

(i) Suggest why plates P and Q must be parallel and horizontal.

....

....

....[2]

(ii) Calculate the charge, with its sign, on the oil droplet.

charge = ... C [3]

(c) The procedure in **(b)** was repeated for three further oil droplets. The magnitude of the charge on each of the droplets was found to be 3.2×10^{-19} C, 6.4×10^{-19} C and 3.2×10^{-19} C.
Explain what value these data and your answer in **(b)(ii)** would suggest for the charge on the electron.

....

....

....[1]

Nov 08

7 **(a)** State three pieces of evidence provided by the photoelectric effect for a particulate nature of electromagnetic radiation.

1. ....

....

2. ....

....

3. ....

....
[3]

(b) **(i)** Briefly describe the concept of a photon.

....

....

....[2]

(ii) Explain how lines in the emission spectrum of gases at low pressure provide evidence for discrete electron energy levels in atoms.

....

....

....[2]

(c) Three electron energy levels in atomic hydrogen are represented in Fig. 7.1.

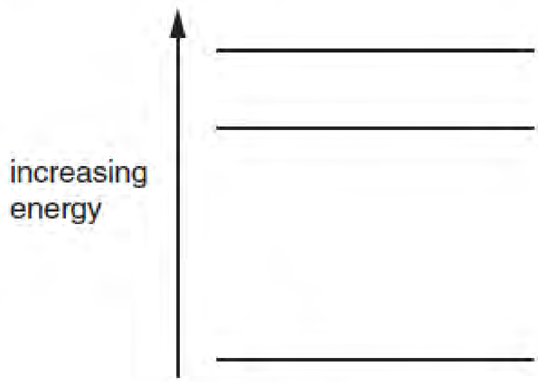

Fig. 7.1

The wavelengths of the spectral lines produced by electron transitions between these three energy levels are 486 nm, 656 nm and 1880 nm.

(i) On Fig. 7.1, draw arrows to show the electron transitions between the energy levels that would give rise to these wavelengths.
Label each arrow with the wavelength of the emitted photon. [3]

(ii) Calculate the maximum change in energy of an electron when making transitions between these levels.

energy = ... J [3]

May 09

8 **(a)** Explain why, for the photoelectric effect, the existence of a threshold frequency and a very short emission time provide evidence for the particulate nature of electromagnetic radiation, as opposed to a wave theory.

....

....

....

....

....

.... [4]

(b) State and explain two relations in which the Planck constant *h* is the constant of proportionality.

1. ....

....

....

....

2. ....

....

....

....

[6]