

- 8 (a)** The photoelectric effect may be represented by the equation

$$\text{photon energy} = \text{work function energy} + \text{maximum kinetic energy of electron.}$$

State what is meant by

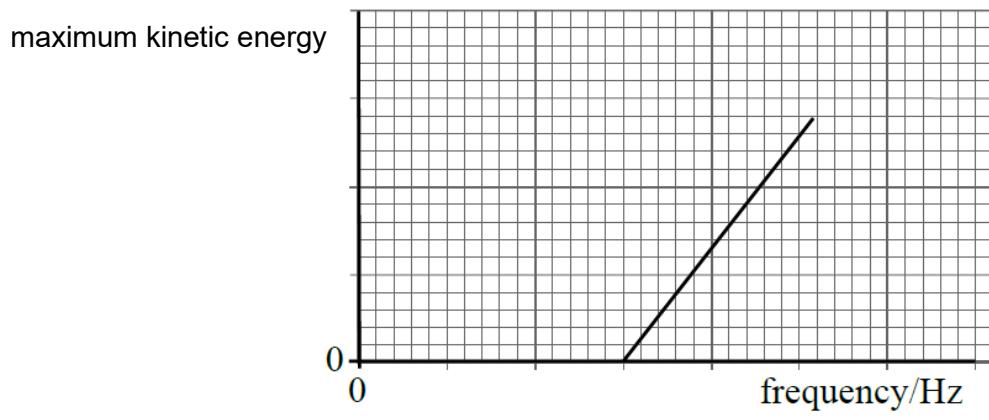
- (i) *a photon,*

..... [1]

- (ii) *the work function energy.*

..... [1]

- (b)** Fig. 8.1 shows how the maximum kinetic energy of the electrons varies with the frequency of the light shining on a metal surface.



frequency

**Fig. 8.1**

(i) On Fig. 8.1,

1. mark the threshold frequency and label it  $f_0$ ,  
[1]
2. draw a line for a metal which has a higher work function energy.  
[1]

(ii) State what information is provided by the gradient of the graph.

..... [1]

(iii) Explain why the kinetic energy of the emitted electrons varies up to a maximum value.

..... [1]

- (iv) Explain why the graphs on Fig. 8.1 do not depend on the intensity of the incident radiation.

..... [2s]

- (c) Fig. 8.2 shows part of an energy level diagram for a hydrogen atom.

|       |       |            |
|-------|-------|------------|
| n = 4 | ..... | - 0.85 eV  |
| n = 3 | ..... | - 1.50 eV  |
| n = 3 | ..... | - 1.50 eV  |
| "     | ..... |            |
| n = 2 | ..... | - 3.40 eV  |
| n = 1 | ..... | - 13.60 eV |
| n = 1 | ..... | - 13.60 eV |

**Fig. 8.2** (not to scale)

- (i) State the ionisation energy of the atom.

ionisation energy = ..... eV [1]

(ii) When an electron of energy 12.1 eV collides with the atom (initially at the ground state),

photons of three different energies are emitted.

1. On Fig. 8.2, draw arrows to show the transitions responsible for these photons. [2]

2. Calculate the wavelength of the photon with the smallest energy and state the region of the electromagnetic spectrum this wavelength corresponds to.

wavelength = ..... m

region of the electromagnetic spectrum = ..... [3]

(d) Electrons having a *de Broglie* wavelength  $1.2 \times 10^{-10}$  m are required to investigate the crystal structure of a certain solid.

(i) State what is meant by the *de Broglie wavelength*.

.....

..... [1]

(ii) Calculate the speed of the electron.

speed = ..... m s<sup>-1</sup> [3]

(iii) Suggest how such electrons may assist with an understanding of the crystal structure.

.....

.....

[2]