8 **(a)** A beam of electrons is accelerated through a potential difference of 130 V and is then incident on a thin silicon crystal as shown in Fig. 8.1.

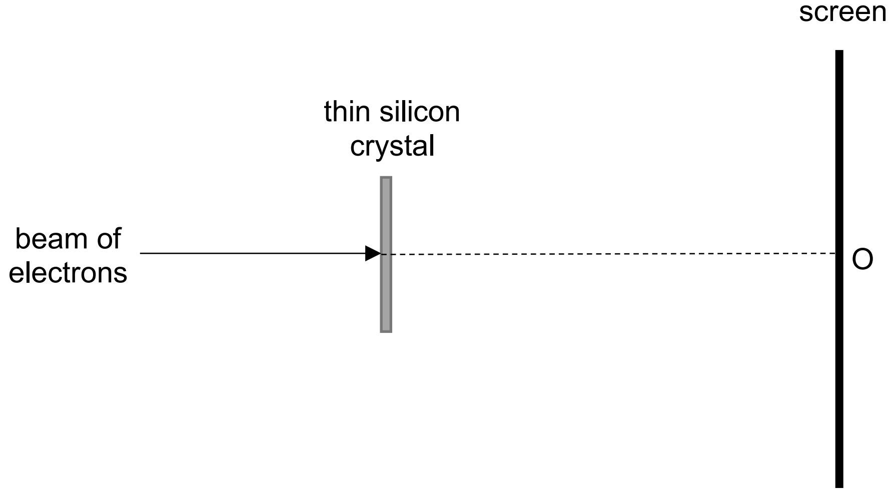


**Fig. 8.1**

**(i)** Show that the de Broglie wavelength of the electrons is $1.08 \times 10^{-10}$ m.

[3]

**(ii)** The separation of silicon atoms in a silicon crystal is 0.235 nm.

Explain why electron diffraction will be observed on the fluorescent screen.

..........................................................................................................................

..........................................................................................................................[1]

**(b)** Experiments are conducted to investigate the photoelectric effect.

**(i)** It is found that, on exposure of a metal surface to light, either electrons are emitted immediately or they are not emitted at all.

Suggest why this observation does not support a wave theory of light.

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..........................................................................................................................[3]

**(ii)** Data for the wavelength $\lambda$ of the radiation incident on the metal surface and the maximum kinetic energy $E_k$ of the emitted electrons are shown in Fig. 8.2.

| $\lambda$ / nm | $E_k$ / $10^{-19}$ J |
|---|---|
| 650 | - |
| 240 | 4.44 |

**Fig. 8.2**

**1.** Without any calculation, suggest why no value is given for $E_k$ for radiation of wavelength 650 nm.

..........................................................................................................................

..........................................................................................................................[1]

**2.** Use data from Fig. 8.2 to determine the work function energy of the metal surface.

work function energy = .............................................. J [2]

**(iii)** Radiation of wavelength 240 nm gives rise to a maximum photoelectric current $I$.

The intensity of the incident radiation is maintained constant and the wavelength is now reduced.

State and explain the effect of this change on

**1.** the maximum kinetic energy of the photoelectrons,

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..........................................................................................................................[2]

**2.** the maximum photoelectric current $I$.

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..........................................................................................................................[2]

**(c)** Some electron energy levels of the hydrogen atom are illustrated in Fig. 8.3.

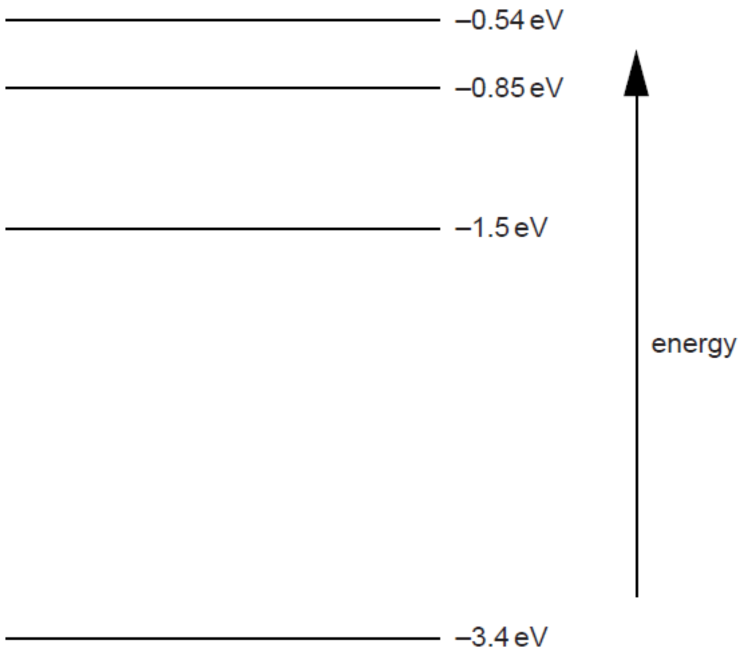


**Fig. 8.3 (not to scale)**

The longest wavelength produced as a result of electron transitions between two of the energy levels shown in Fig. 8.3 is $4.0 \times 10^{-6}$ m.

**(i)** On Fig. 8.3,

**1.** draw, and mark with the letter L, the transition giving rise to the wavelength of $4.0 \times 10^{-6}$ m, [1]

**2.** draw, and mark with the letter S, the transition giving rise to the shortest wavelength. [1]

**(ii)** Calculate the wavelength for the transition you have shown in **(c)(i) 2**.

wavelength = …………………………….m [2]

**(iii)** Photon energies in the visible spectrum vary between approximately 3.66 eV and 1.83 eV.

Determine the energies, in eV, of photons in the visible spectrum that are produced by transitions between the energy levels shown in Fig. 8.3.

photon energies = ........................................................................ eV [2]

[Total: 20]