Examzone 5 Nature of Light

1 a The following equation describes the release of electrons from a metal surface illuminated by electromagnetic radiation.

$hf = k.e._{max} + \phi$

Explain briefly what you understand by each of the terms in the equation.

hf Energy of a photon **(1)**

$k.e._{max}$ Kinetic energy of emitted electron/equivalent **(1)**

ϕ Energy to release electron from surface / equivalent **(1)**

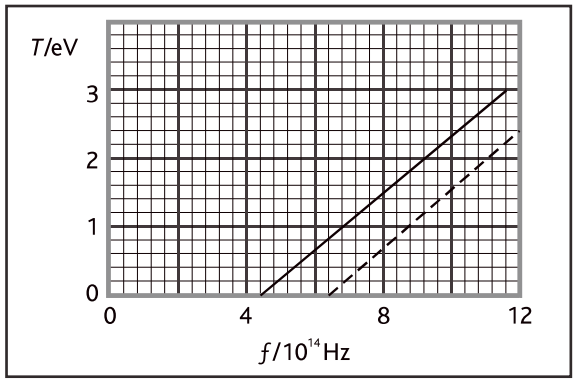
Why are electrons of this wavelength useful for studying the structure of molecules?

$\lambda <$ / similar to size / spacing atoms / molecules **(1)**

Diffraction occurs **(1)**

(Total 5 marks)

2 The graph shows how the maximum kinetic energy T of photoelectrons emitted from the surface of sodium metal varies with the frequency f of the incident radiation.



A parallel line **(1)**

starting at a higher frequency **(1)**

Why are no photoelectrons emitted at frequencies below 4.4×10^{14} Hz?

Photon energy too small/less than ϕ **(1)**

Calculate the work function ϕ of sodium in eV.

If using $\phi = hf - T$

then a valid pair of points **(1)**

with both points in the same units **(1)**

OR

If using $hf_o = \phi$

with $f_o = 4.4 \times 10^{14}$ Hz **(1)**

Work function = 1.8 eV **(1)**

Examzone 5 Nature of Light (cont.)

Explain how the graph supports the photoelectric equation $hf = T + \phi$

$T = hf - \phi$ is similar to $y = mx + c$ **(1)**

Straight line shows $\frac{T}{f}$ relationship **(1)**

Negative intercept T axis shows ϕ **(1)**

Any two

How could the graph be used to find a value for the Planck constant?

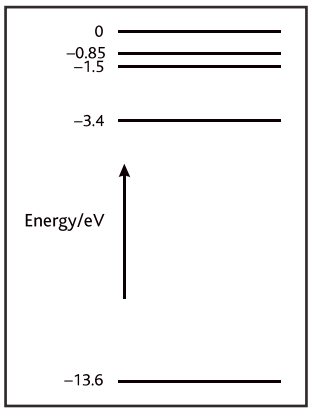
From the gradient **(1)**

(not necessary to mention conversion factor)

Add a line to the graph to show the maximum kinetic energy of the photoelectrons emitted from a metal which has a greater work function than sodium. (See graph.)

(Total 9 marks)

3 The diagram shows some of the energy levels for atomic hydrogen.



For each of the statements below, write down whether they are true or false.

a The single electron of a hydrogen atom normally occupies the –13.6 eV energy level **(true 1)**

b An electron of energy 10 eV colliding with a hydrogen atom in its ground state could have an energy of 0.2 eV after collision. **(false 1)**

c An electron moving from the –3.4 eV to the –0.85 eV level gives out a photon of energy 2.55 eV. **(false 1)**

d Light of wavelength 650 nm has sufficient energy to excite an electron from the –3.4 eV to the –1.5 eV energy level. **(true 1)**

(Total 4 marks)

Examzone 5 Nature of Light (cont.)

4 Particle theory:
One photon releases one electron giving it kinetic energy **(1)**
Increase $f \rightarrow$ greater k.e. electrons **(1)**
Lower f finally k.e. = 0 i.e. no electrons released **(1)**

Waves:
More intense light should give greater k.e. **(1)**

More intense light gives more electrons but no change in maximum kinetic energy **(1)**

Waves continuous / when enough are absorbed electrons should be released **(1)**

Quality of written communication

Line parallel to existing line **(1)**
to left of existing line **(1)**

(Total 8 marks)