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

……..……

……..……

…….. [2]

(b) A laser produces light of wavelength 656 nm in an ultrashort pulse with a duration of 9.00×10^{-15} s.

For a single photon in the pulse,

(i) calculate the momentum,

momentum = …… kg m s^{-1} [1]

(ii) determine a value for the minimum uncertainty in momentum.

minimum uncertainty in momentum = …… kg m s^{-1} [2]

(c) Explain how an emission line spectrum provides evidence for discrete energy levels in isolated atoms.

……

……

……

……

……

…….. [3]

(d) When an electron transits from a higher energy level to the energy level –13.6 eV in a hydrogen atom, a photon of frequency 3.19×10^{15} Hz is emitted.

Determine the energy, in eV, of the higher energy level.

energy = …… eV [2]

(e) The radiation emitted from transitions between electron energy levels of the hydrogen atom is incident on the surface of a sheet of metal of work function ϕ in a photoelectric effect experiment.

In order to investigate the relationship between the stopping potential V_s and the wavelength of incident light λ, a line of best fit was drawn from the data collected in the experiment.

Fig. 5.1 shows the variation with $\frac{1}{\lambda}$ of V_s.

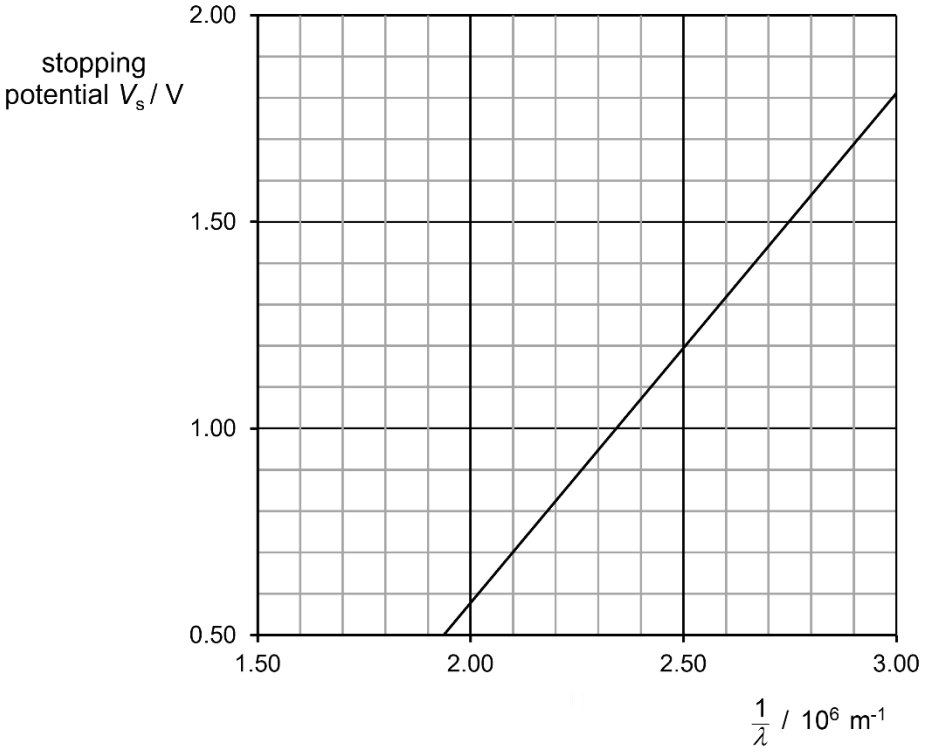

Fig. 5.1

(i) State an equation that shows the relationship between V_s, λ and ϕ in a photoelectric effect experiment.

…….. [1]

(ii) Using Fig. 5.1, determine a value for the Planck's constant.

Planck’s constant = …… J s [3]

[Total: 14]

Section B

Answer **one** question from this Section in the spaces provided.