4 **(a)** **(i)** Incident radiation of wavelength 444 nm is shone on a metal with a work function of 2.2 eV. Calculate the maximum kinetic energy of an ejected photoelectron.

maximum kinetic energy = ...J [2]

(ii) Calculate the stopping potential.

stopping potential = ...V [1]

(iii) The intensity of the incident radiation is doubled but the wavelength is kept constant. State and explain how this will affect your answers in **(a)(i)** and **(a)(ii).**

----- [2]

(b) A beam of electrons traveling the positive x-direction with speed 3.75×10^6 m s^{-1} passes through a slit that is parallel to the y-axis and 5.0 μm wide. The diffraction pattern is recorded on a screen 2.5 m from the slit.

(i) State Heisenberg's Uncertainty Principle.

----- [1]

(ii) In single-slit diffraction, the first minima of the central diffraction pattern occurs at $\sin\theta = \dfrac{\lambda}{D}$, where D is the width of the slit. Based on the angle of diffraction of the first minima of the central diffraction pattern, show that the maximum y-component of the momentum of an electron just after it has passed through the slit is 1.32×10^{-28} N s.

[3]

(iii) Hence, estimate the minimum uncertainty in the y-coordinate of an electron's position just after it has passed through the slit.

uncertainty in the y-coordinate of position= ....m [2]

4 (c) A CD-ROM is used in an electron diffraction experiment as shown in Fig. 4.1. The surface of the CD-ROM has tracks of tiny pits with a uniform spacing of 1.60 μm. Assume that you can use the same equation as for optical diffraction, $n\lambda = d \sin\theta$.

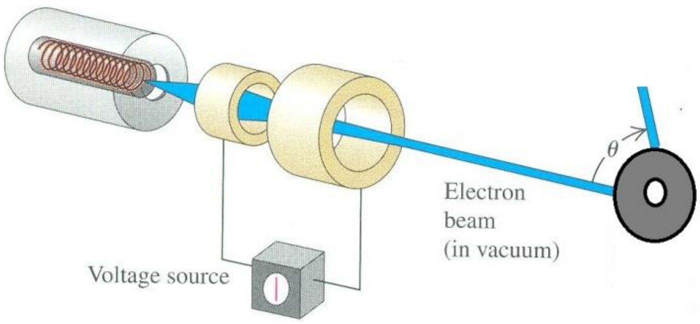

Fig. 4.1

If the speed of the electrons is 1.26×10^4 m s^{-1}, calculate the angle θ, in radians, of the 2nd order maxima.

θ = ...rad [2]

(d) Fig. 4.2 (not drawn to scale) represents part of the emission spectrum of atomic hydrogen.

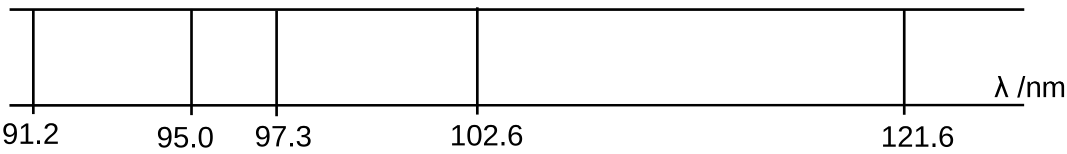

Fig. 4.2

The ionization energy of hydrogen atom is 13.6 eV. The electron transition giving rise to the emission line with wavelength 91.2 nm is indicated in Fig. 4.3.

(i) Calculate the photon energies, in eV, equivalent to all the emission lines marked in Fig. 4.2.

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

(ii) Using your answers in **(d)(ii)**, map a partial energy level diagram for hydrogen in Fig.4.3. Show, and label clearly, the electron transitions responsible for the emission lines labelled in Fig. 4.2.

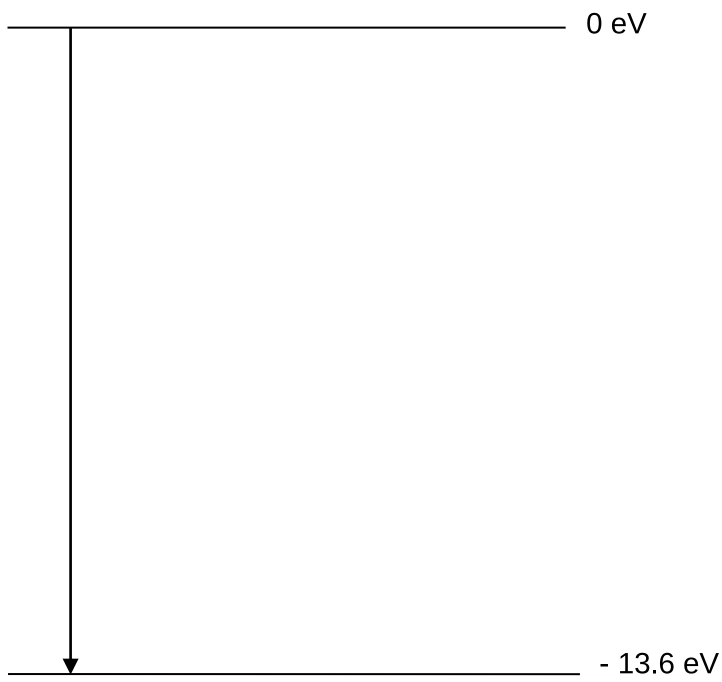

Fig. 4.3 [2]

[Total: 17]