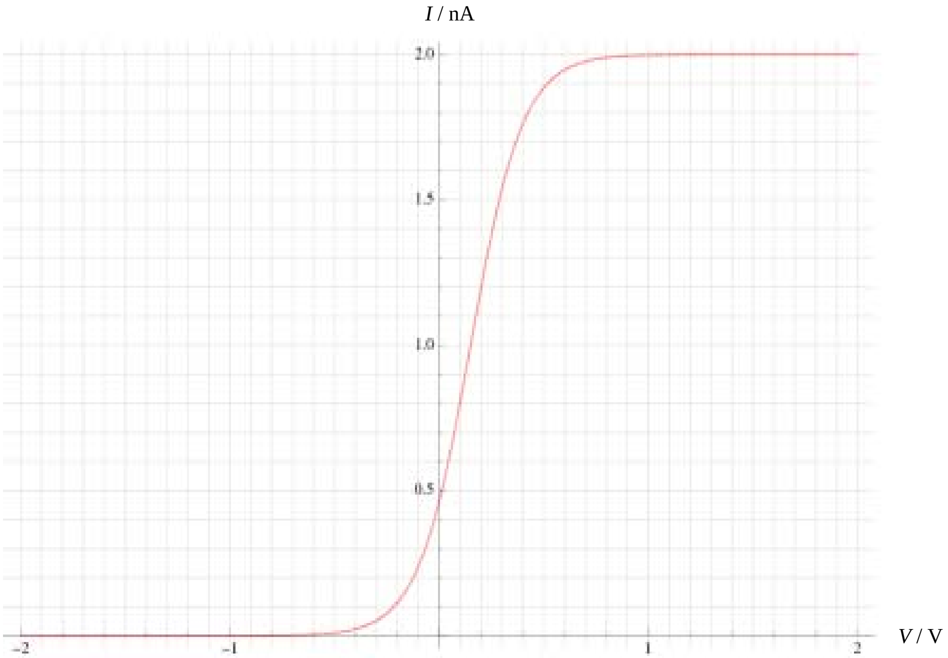
Extension Worksheet – Topic 6, Worksheet 2

1 The following graph, showing the variation with applied voltage of the photocurrent from a photosurface when monochromatic light is incident on it, was obtained in a standard photoelectric effect experiment.



a Draw a diagram of the apparatus used in an experiment from which this graph could have been obtained. [3]

b Describe one observation in the photoelectric effect that **cannot** be explained by the classical wave theory of light. [2]

c Explain how the photon theory of light provides a satisfactory explanation for the observation you described in **b**. [2]

d Define the term **work function**. [1]

e Explain the significance of the voltage at which the current becomes zero. [1]

f Determine the speed of the electrons as they leave the metal. [3]

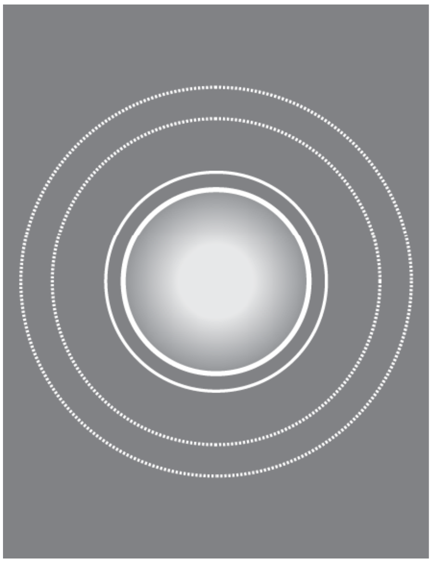
g Using the graph, calculate the wavelength λ of the light incident on this photosurface. The work function of this photosurface is 1.2 eV. [2]

h Explain why, as the voltage increases, the current approaches a constant value. [1]

i State whether or not the saturation current will increase when the wavelength of the light is decreased. [1]

j On the axes above draw the graph of photocurrent versus voltage for this photosurface when light of wavelength 4.0×10^{-7} m is incident on the surface. (Assume that the number of photons incident on the surface per unit area per unit time does not change.) [3]

2 The diagram shows an image obtained when electrons were transmitted through aluminium foil. White areas indicate large concentrations of electrons.



a Explain how this image is evidence for matter waves. [3]

b Describe an experiment from which this image could have been obtained. [3]

3 A ball of mass 0.20 kg is thrown with speed 12 m s^{-1} through a square window of side 0.50 m.

a Calculate the de Broglie wavelength of this ball. [2]

b Determine whether the ball would suffer appreciable diffraction as it goes through the window. [2]

4 Show that the kinetic energy of an electron in the hydrogen atom is given by the expression $E_K = \frac{1}{2}\frac{ke^2}{r}$ where k is the Coulomb law constant, e the charge of the electron and r the radius of the electron's orbit and hence deduce that the total energy of the electron is given by $E_T = -\frac{1}{2}\frac{ke^2}{r}$. [4]

5 The **total** energy of an electron in a hydrogen atom is given by the formula $E_T = -\frac{C}{n^2}$ where C is a constant.

a Explain the significance of the minus sign in the formula for the electron total energy. [2]

b Use the result of the previous problem to show that the radius of the electron's orbit is given by $r = \frac{ke^2 n^2}{2C}$. [1]

c Explain whether or not the Heisenberg uncertainty principle is consistent with the result in **b**. [2]

6 Describe two differences between the structure of the energy levels of an electron in a box and an electron in the hydrogen atom. [4]

7 Explain, using the particle in the box model, why an electron confined within a region of linear size L cannot be at rest. [2]

8 Explain how the result of the previous problem is consistent with the Heisenberg uncertainty principle. [2]

