Q1.(a) (i) Describe how Newton used the corpuscular theory to explain the refraction of light as it passes from one substance into a substance of higher optical density.

.....

.....

.....

.....

.....

.....

.....

(3)

(ii) Huygens used a wave theory to explain refraction.

Explain why the corpuscular theory was rejected in favour of a wave theory to explain refraction.

.....

.....

.....

.....

.....

.....

(2)

(iii) Describe and explain the difference in the appearance of the fringes in Young's double-slit experiment that are predicted by the corpuscular theory and by the wave theory for light.

.....

.....

.....

.....

.....

.....

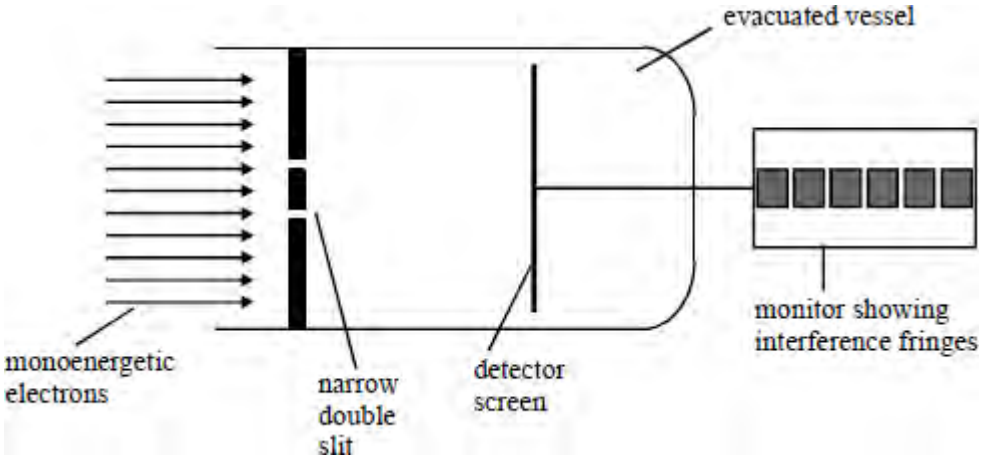
(2)

(b) Electromagnetic waves and matter are now known to exhibit both particle and wave behaviour. The photons for a particular X-ray wavelength have energy 5.0 keV.

Calculate the potential difference through which an electron has to be accelerated so that its de Broglie wavelength is the same as that of this X-ray.

(4)
(Total 11 marks)

Q2. A beam of electrons travelling at 1.2×10^3 m s^{-1} inside an evacuated container is directed normally onto a double slit arrangement, as shown in the diagram. An array of detectors forms a screen which collects the electrons that pass through the slits for a selected period of time. The number of electrons collected by the detectors is displayed as a fringe pattern on a monitor.



(a) (i) Show that the de Broglie wavelength of the incident electrons is 6.1×10^{-7} m. Ignore relativistic effects.

.....

.....

.....

.....

(ii) The monitor screen shows six bright fringes. Estimate the number of electrons that contribute to each bright fringe when the detector current is 4.8×10^{-13} A and the electrons are collected over a period of 1.0 m s.

.....

.....

.....

.....

.....

(4)

(b) (i) The intensity of the incident electron beam is reduced to a level where only one electron is travelling through the slits at a time. The collection time is increased to allow the original number of electrons to be collected. Compare the pattern observed on the monitor screen with that originally observed.

.....

.....

.....

(ii) The speed of the electrons in the beam is reduced to half by reducing the anode potential of the electron gun that produced the beam. Describe and explain how the pattern observed on the monitor screen would differ from that originally observed in part (a).

.....

.....

.....

.....

.....

(4)

(c) The electrons are replaced with a source of monochromatic light and the detector screen is replaced with a light-sensitive detecting screen. Determine the frequency of light that would produce fringes with the same fringe spacing as those originally observed using electrons.

.....

.....

.....

.....

(2)
(Total 10 marks)