5 **(a)** Heinrich Hertz discovered that electrodes illuminated with ultraviolet light created electric sparks more easily. Einstein carried on the research and his interpretation of the photoelectric effect led him to formulate the photoelectric equation given by $hf = \Phi + E_K$.

Explain the meaning of the following symbols.

(i) Φ

.....

..... [1]

(ii) E_K

.....

..... [1]

(b) In a typical set-up of the photoelectric experiment, a metal surface is illuminated with monochromatic radiation of wavelength 300 nm and intensity 0.500 W m^{-2}, over an area of 4.5×10^{-5} m^2. The value of Φ of the metal is 2.03 eV.

(i) Calculate the stopping potential.

stopping potential = ... V [2]

(ii) The photoelectric quantum yield is defined as the ratio

$$\frac{\text{rate of emission of photoelectrons}}{\text{rate of incidence of photons}}.$$

By assuming a quantum yield of 0.5, determine the maximum photoelectric current measured.

maximum photoelectric current = ... A [3]

(c) According to experiments conducted, a student claimed that it is impossible to achieve a quantum yield of 1. Provide a reason to support the student's claim.

……

.....[1]

(d) Fig. 5.1 shows the essential structure of an X-ray tube. The electrons emitted from the filament are accelerated by a high voltage *V*. X-rays are produced when the target in the anode is bombarded by the fast electrons. The heat generated is removed by the cooling liquid. The spectrum of the X-rays emitted is shown in Fig. 5.2.

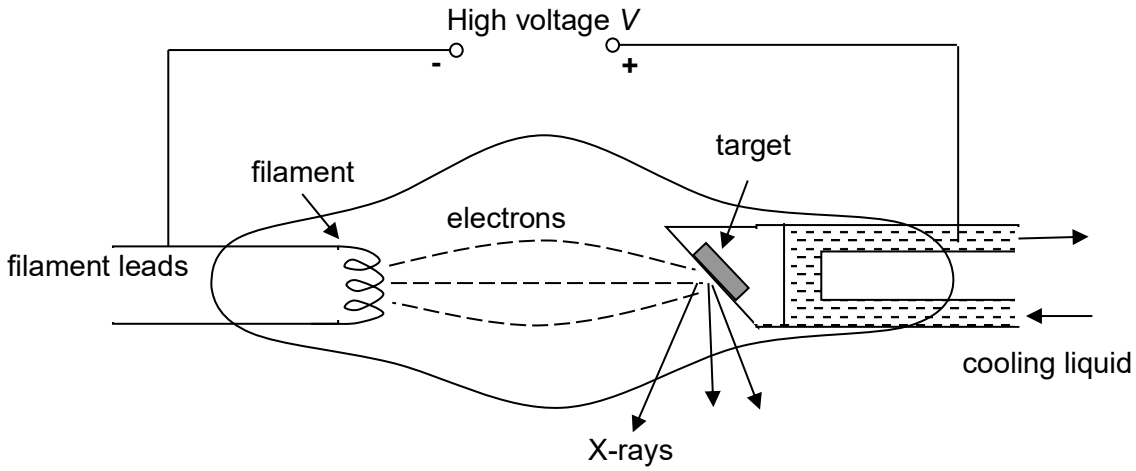

Fig. 5.1

Fig 5.2

(i) Determine the maximum energy of the X–ray photons emitted.

maximum energy =…… J [2]

(ii) Calculate the accelerating potential difference *V*.

V =..... V [2]

(iii) On Fig. 5.2 , sketch a graph to show how the intensity of the X–rays emitted varies with wavelength if the current in the filament is increased. [1]

(iv) Assuming the efficiency of the X-ray tube is 0.5%, calculate the number of electrons bombarding the target per second if heat is generated in the target at a rate of 600 W.

number of electrons per second =…… [2]

[Total: 15]

Section B

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