8 **(a)** Two metal electrodes are placed in an evacuated tube. The collector electrode is at a positive potential with respect to the emitter electrode. Starting from rest, electrons leave the emitter electrode and move towards the collector electrode.

(i) The potential difference between the electrodes is 140 V.

1. Determine, in electron-volts, the kinetic energy of an electron as it reaches the collector electrode.

kinetic energy = ……………………………. eV [1]

2. Determine the momentum of the electron as it reaches the collector electrode.

momentum = …………………………….kg m s^{-1} [2]

(ii) An electron diffraction pattern consisting of concentric rings is observed on a fluorescent screen after the accelerated electrons are made to pass through a graphite film.

1. Describe the energy changes of the electrons after emission from the emitter electrode to the formation of concentric rings on the fluorescent screen.

……………………………………………………………………………………..............

……………………………………………………………………………………..............

…………………………………………………………………………………….. [2]

2. State and explain what must be done to the potential difference between the electrodes in order to have the rings of the diffraction pattern closer together.

……………………………………………………………………………………..............

……………………………………………………………………………………..............

……………………………………………………………………………………..............

……………………………………………………………………………………..............

…………………………………………………………………………………….. [3]

(b) A cool gas is placed in a chamber as shown in Fig. 8.1. To excite the atoms of the gas, a beam of electrons with kinetic energy of 5.0×10^{-19} J each is directed as shown.

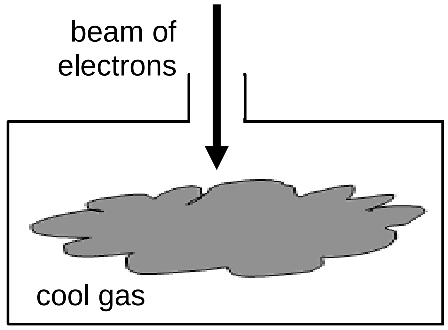

Fig. 8.1

Fig. 8.2 shows the energy states within the atoms of the gas, with level A_1 being the lowest energy state.

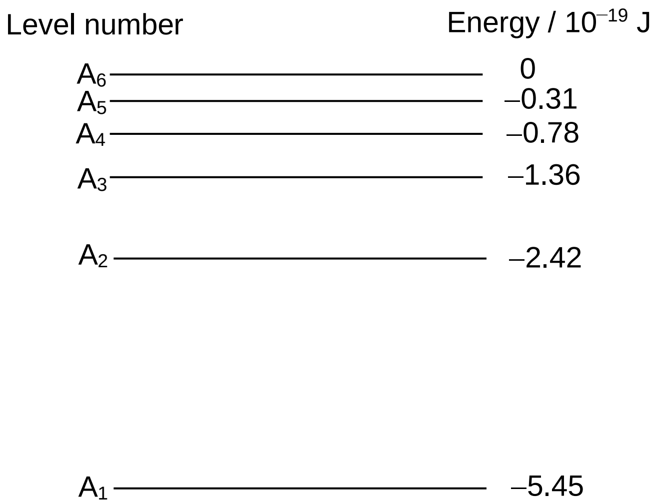

Fig 8.2

(i) State the highest energy level number in which the atoms of the gas can be excited to in this setup.

level number = …………………………… [1]

(ii) Determine the shortest wavelength of the photons emitted from the gas.

wavelength = …………….……………….m [2]

(iii) State the region of the electromagnetic spectrum which the radiation in **(b)(ii)** occurs.

region = ………….……………………………… [1]

(c) **(i)** By reference to the photoelectric effect, explain

1. what is meant by *work function energy*,

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

2. why, even when the incident light is monochromatic, the emitted electrons have a range of kinetic energies up to a maximum value.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(ii) In an experiment to investigate the photoelectric effect, a student measures the wavelength λ of the light incident on a metal surface, and the maximum kinetic energy E_{max} of the emitted electrons. The variation with E_{max} of $\frac{1}{\lambda}$ is shown in Fig. 8.3.

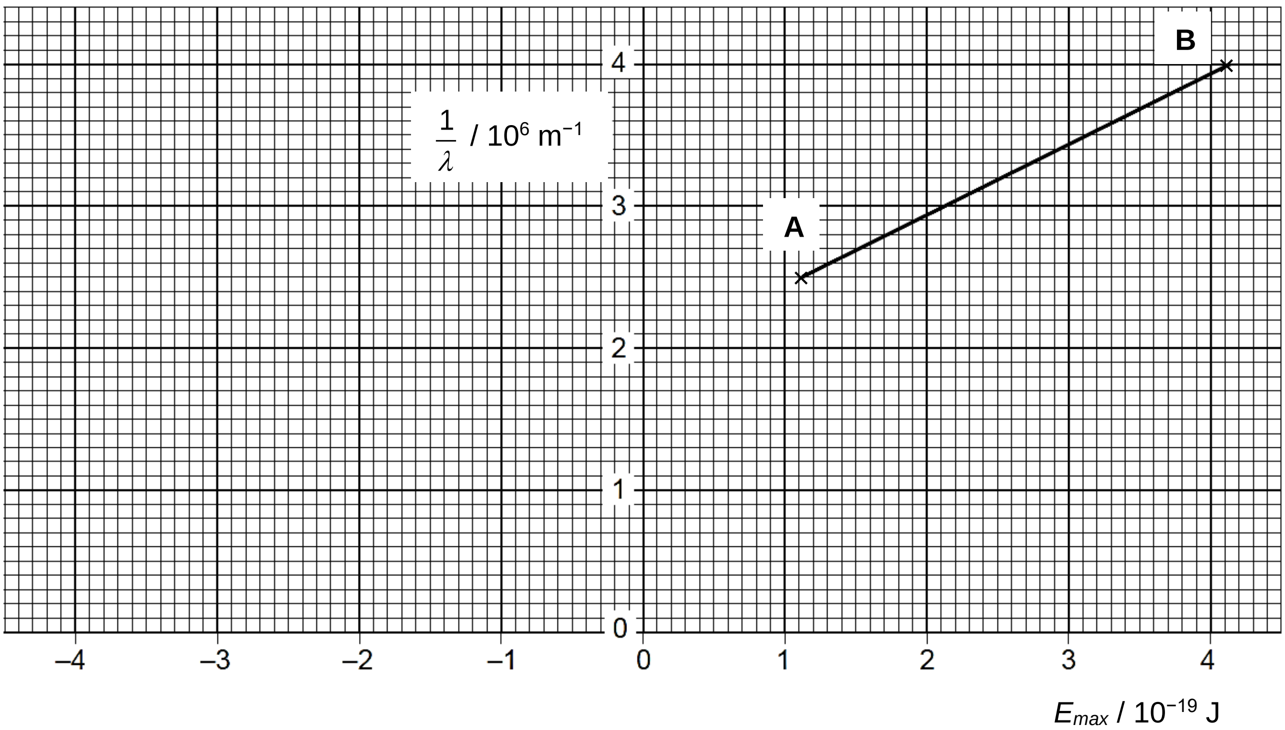

Fig. 8.3

[Turn Over

1. Without using the value of the Planck constant, use Fig. 8.3 to determine the work function energy of the metal surface.

work function energy = …………………………….. J [2]

2. Using points A and B, determine the Planck constant.

Planck constant = ……………………………. J s [3]

[Total: 20]

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