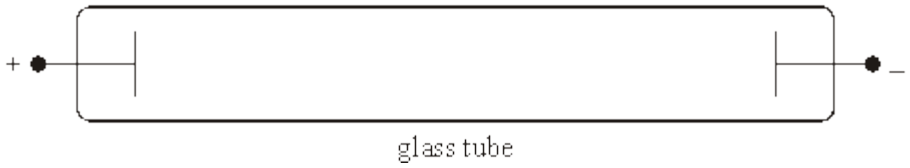
1 A potential difference was applied between two electrodes in a glass tube containing air, as shown in the diagram below. The pressure of the air in the tube was gradually reduced until a glow of light was observed between the electrodes.



(i) Explain why light was emitted.

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(ii) State why the glow was not observed until the pressure of the air in the tube was low enough.

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(Total 4 marks)

2 A narrow beam of electrons is produced in a vacuum tube using the arrangement shown in **Figure 1.**

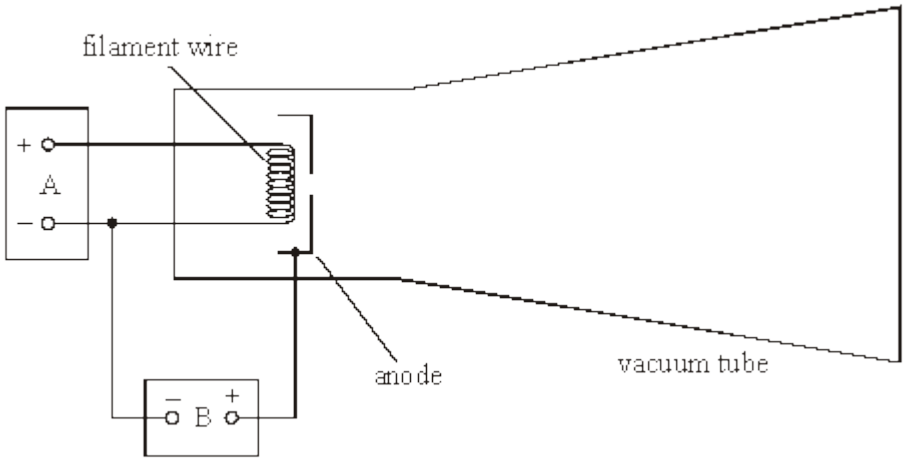

Figure 1

(a) Describe the function of each voltage supply unit and state a typical voltage for each unit.

(i) unit A

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(ii) unit B

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(3)

(b) State and explain the effect on the beam of

(i) reducing the voltage of A,

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(ii) increasing the voltage of B.

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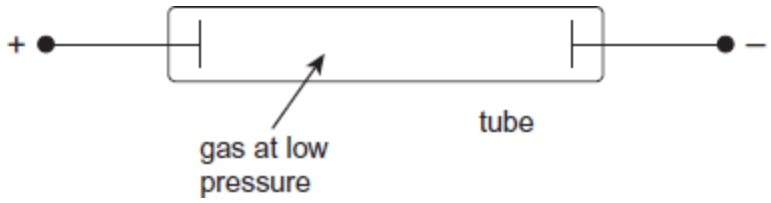
(4)
(Total 7 marks)

3 The following figure shows a discharge tube containing a gas at low pressure. When a sufficiently high potential difference is applied between the two electrodes in the tube the gas becomes conducting and emits light.



(a) (i) Describe how the charged particles responsible for conduction in the gas are produced.

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(2)

(ii) Explain why the gas emits light and why it must be at low pressure.

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(3)

(b) The charged particles moving towards the negative electrode were initially referred to as positive rays. Explain why their **specific charge** depends on the choice of gas in the tube.

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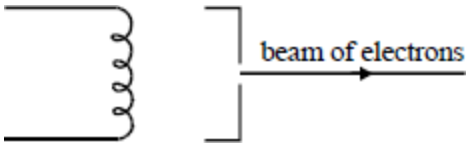
(2)
(Total 7 marks)

4 (a) The diagram shows a narrow beam of electrons produced by attracting electrons emitted from a filament wire to a metal plate which has a small hole in it.



(i) Why does an electric current through the filament wire cause the wire to emit electrons?

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(ii) Why must the filament wire and the metal plate be in an evacuated tube?

.....

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(3)

(b) The voltage between the filament wire and the plate is 3600 V. For each electron emerging through the hole in the plate, calculate

(i) the kinetic energy, in J,

.....

.....

(ii) the speed.

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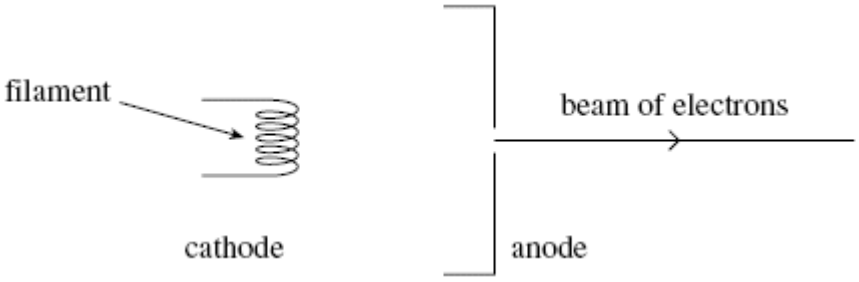
(4)
(Total 7 marks)

5 A narrow beam of electrons is produced in a vacuum tube using an electron gun, part of which is shown in **Figure 1**.

Figure 1



(a) (i) State and explain the effect on the beam of electrons of increasing the filament current.

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.....

(2)

(ii) State and explain the effect on the beam of electrons of increasing the anode potential.

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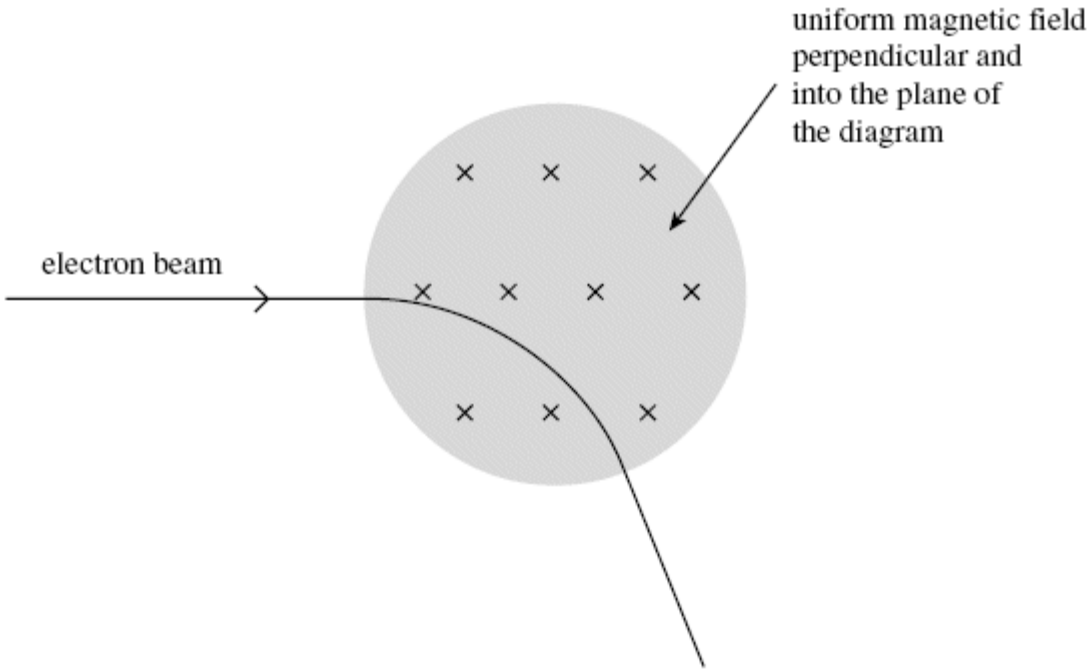
(2)

(b) The beam of electrons is directed at right angles into a uniform magnetic field as shown in **Figure 2**.

Figure 2



(i) Explain why the electrons move in a circular path at a constant speed in the magnetic field.

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(3)

(ii) When the speed of the electrons in the beam is 7.4×10^6 m s^{-1} and the magnetic flux density is 0.60 m T, the radius of curvature of the beam is 68 mm.

Use these data to calculate the specific charge of the electron, stating an appropriate unit. Give your answer to an appropriate number of significant figures.

answer = ...

(4)

(iii) Discuss the historical relevance of the value of the specific charge of the electron compared with the specific charge of the H^+ ion.

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(2)

(Total 13 marks)

6 (a) In a cathode ray tube, electrons emitted from a cathode are attracted towards an anode by means of a large potential difference. If the anode-cathode potential difference is 2200 V, calculate the kinetic energy, in J, and speed of each electron just before impact at the anode.

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(2)

(b) (i) If an electron of this energy was to impinge on a fluorescent screen, calculate the shortest wavelength of the electromagnetic radiation subsequently emitted and explain why this is a minimum value.

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(ii) Calculate the de Broglie wavelength of an electron with the same energy as that hitting the screen previously.

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(7)
(Total 9 marks)

7 **Figure 1** shows an electron gun that produces electrons with a kinetic energy of 6.0×10^{-16} J.

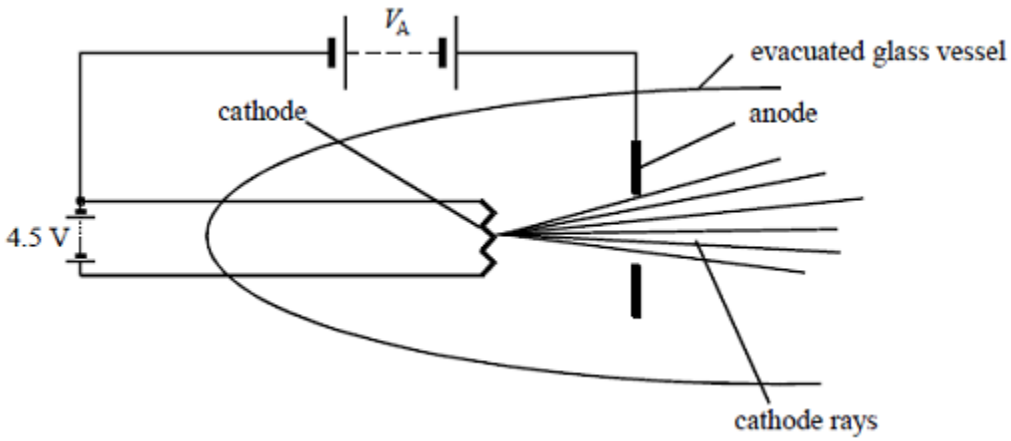

Figure 1

(a) (i) Calculate the cathode-anode potential, V_A.

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(ii) What part does the 4.5 V power supply play in producing electrons?

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(4)

(b) After leaving an electron gun, a narrow beam of electrons of speed 3.6×10^7 m s^{-1} enters a uniform electric field at right angles to the field. The electric field is due to two oppositely charged parallel plates of length 60 mm, separated by a distance of 25 mm as shown in **Figure 2**. The potential difference between the plates is adjusted to 1250 V so that the beam just emerges from the field at P without touching the positive plate.

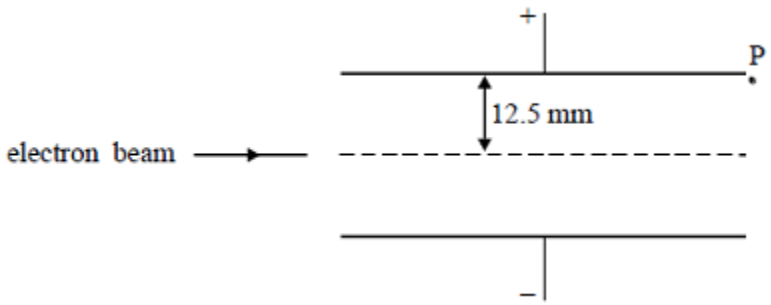

Figure 2

(i) On **Figure 2**, sketch the path of the beam in the field and beyond.

(ii) Calculate the time for which each electron is between the plates.

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(iii) Use the data above to calculate the specific charge of the electron, e/m.

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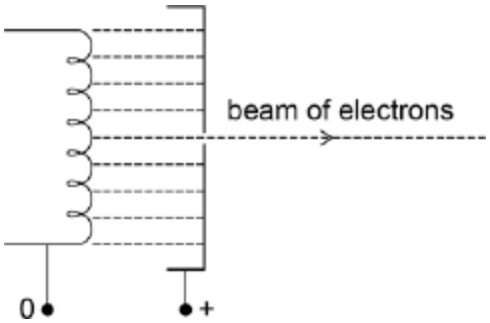
(8)
(Total 12 marks)

8 **Figure 1** shows a narrow beam of electrons produced by attracting the electrons emitted from a filament wire, to a positively charged metal plate which has a small hole in it.

Figure 1



(a) Explain why an electric current through the filament wire causes the wire to emit electrons.

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(2)

(b) Explain why the filament wire and the metal plates must be in an evacuated tube.

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(1)

(c) The potential difference between the filament wire and the metal plate is 4800 V.

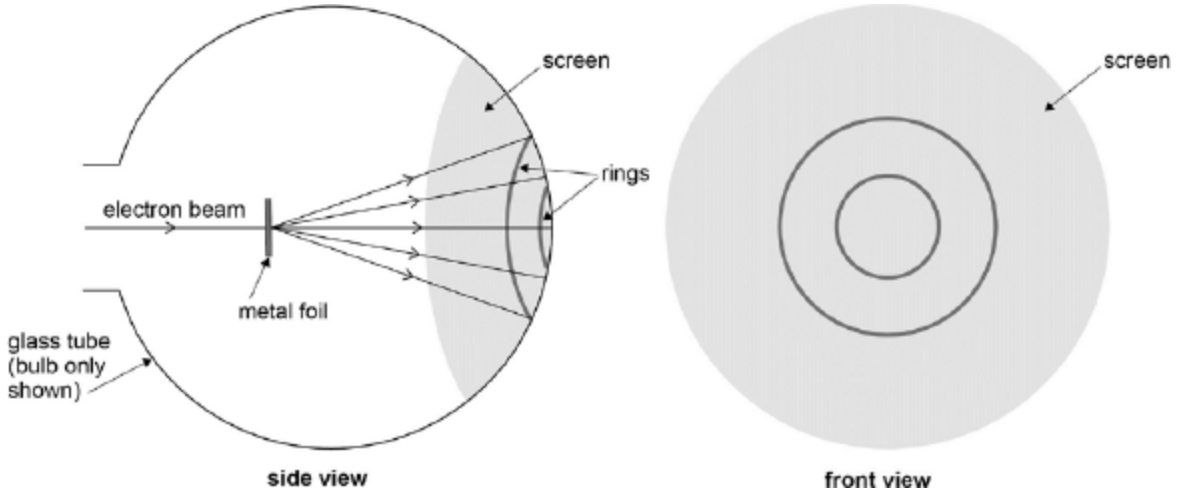
Calculate the de Broglie wavelength of the electrons in the beam.

wavelength = ... m

(4)

The beam is directed at a thin metal foil between the metal plate and a fluorescent screen at the end of the tube, as shown in **Figure 2**.
The electrons that pass through the metal foil cause a pattern of concentric rings on the screen.

Figure 2



(d) The potential difference between the filament and the metal plate is increased. State and explain the effect this has on the diameter of the rings.

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(3)
(Total 10 marks)