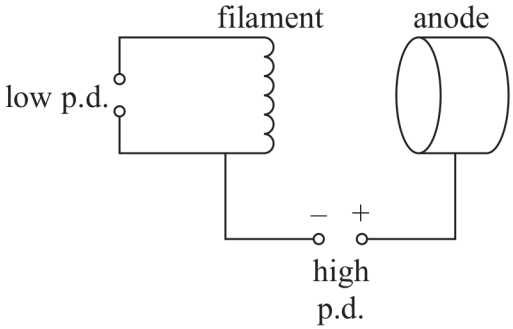
**18** The photograph shows a hospital radiotherapy machine that contains a linear accelerator (linac). The linac accelerates electrons to very high speeds for use in treating cancer.

(© Alexander Tihonov/Pearson Asset Library)

(a) The electrons used in the linac are produced by the filament in an electron gun, as shown in the diagram.




Name and describe the process in which electrons are produced by the filament.

**(2)**

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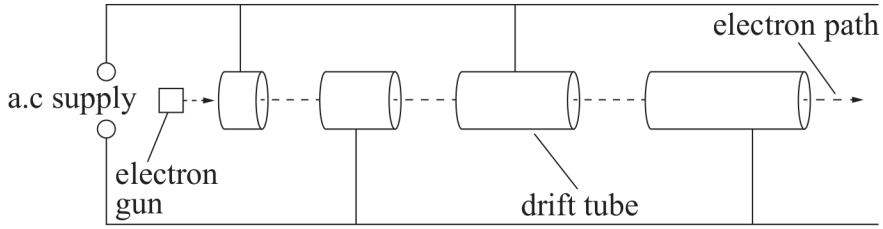
(b) The diagram shows part of a simplified linac.




An electron enters the linac from the electron gun with a speed of $2.5 \times 10^6$ m s$^{-1}$. The electron passes through 60 drift tubes before emerging from the other end.

(i) Calculate the energy of the electron as it emerges.

potential difference between adjacent drift tubes = 80 kV

**(3)**

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Energy of the electron = .....

(ii) For very high energy electrons, successive drift tubes have the same length.

Explain why.

**(2)**

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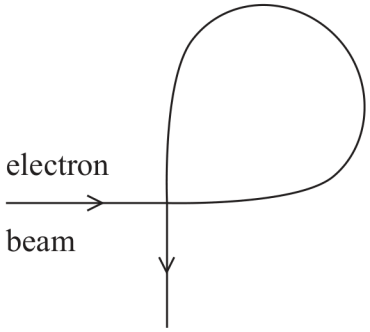
(c) Linacs used for radiotherapy operate by means of a standing wave formed within the linac.

Explain how standing waves are produced.

**(3)**

(d) Electrons emerging from a standing wave linac must be directed towards the patient. Magnets are used to rotate the path of the electron beam through 270°.




Determine the magnetic flux density required to rotate the beam through 270°.

energy of electrons = 2.5 keV

radius of curvature of path = 61 mm

**(4)**

Magnetic flux density = .....

**(Total for Question 18 = 14 marks)**