7. Beta decay occurs when a neutron in an unstable nucleus decays into a proton and releases an electron and an antineutrino.

The following statement represents an example of beta decay.

$$^{131}_{\mathrm{P}}Z \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e + \overline{\nu}_e$$

(a) (i) (A) Determine the number represented by P. **1**

Space for working and answer

(B) Identify element Z. **1**

(ii) (A) In the Standard Model, state the type of fermion that includes electrons. **1**

(B) W-bosons and Z-bosons are the force-mediating particles associated with beta decay.

Name the fundamental force associated with beta decay. **1**

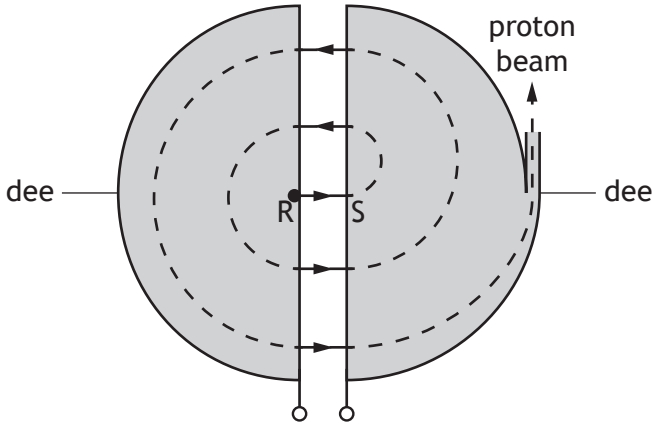
[Turn over

7. (continued)

(b) Positron Emission Tomography (PET) is a medical imaging technique, which uses isotopes that emit positrons.

Suitable isotopes are produced by bombarding a target with protons that have been accelerated in a cyclotron. A cyclotron consists of two D-shaped, hollow metal structures called 'dees', placed in a vacuum.

The diagram shows the cyclotron viewed from above.



Protons are released from rest at R and are accelerated across the gap between the 'dees' by a voltage of 32.0 kV.

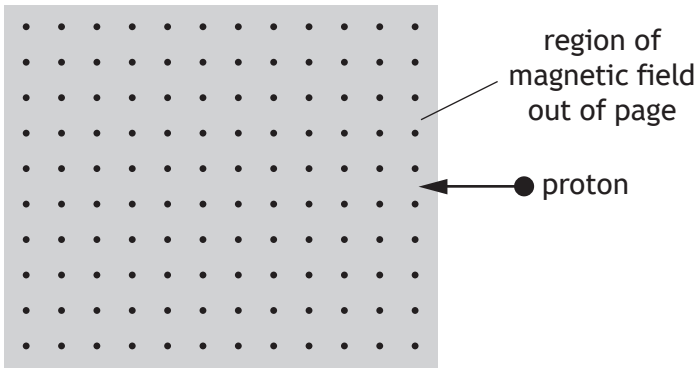
(i) Determine the speed of a proton as it reaches S. **5**

Space for working and answer

7. (b) (continued)

(ii) Explain why an alternating voltage is used in the cyclotron. **1**

(c) A proton enters a region of magnetic field as shown.



Determine the direction of the force exerted by the magnetic field on the proton immediately after entering the magnetic field. **1**

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