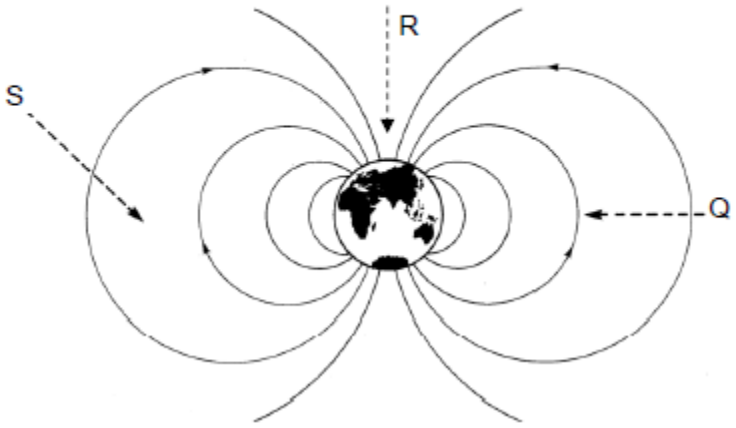
Homework exercise 2 – Particles from Space

Total = 24marks

Question 1:

The diagram shows the magnetic field lines in the region surrounding the Earth.



(a) Three positively charged particles initially approach the Earth along the paths Q, R and S.

(i) Describe the subsequent path of particle R. 1

(ii) Describe the subsequent path of particle S. 1

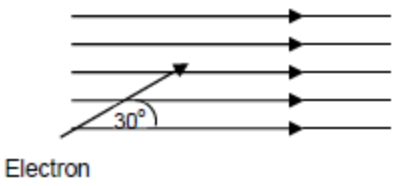
(b) A **proton** with a speed of $2{\cdot}0 \times 10^{6}$ m s^{-1} approaches the Earth along path Q at a point where the magnetic induction is 13×10^{-6} T.

Calculate the radius of curvature, in metres, of the path at a point where the magnetic induction is $1{\cdot}3 \times 10^{-5}$ T. 2

(4)

Question 2:

(a) An electron travels at a speed of $1{\cdot}0 \times 10^7$ m s^{-1} as it enters a uniform field of magnetic induction 5·0 mT. The electron travels at an angle of 30° to the field.



Show that the radius of the resultant helical path of the electron is $5{\cdot}7 \times 10^{-3}$ m. 2

(b) Explain why the electron follows a helical path. 3

(5)

Question 3:

Detailed observations of sunspots have been obtained by the Royal Greenwich Observatory since 1874. These observations include information on the sizes and positions of sunspots as well as their numbers. The number of sunspots is an indication of solar activity. A graph of the average number of sunspots since 1950 is shown in Figure 3

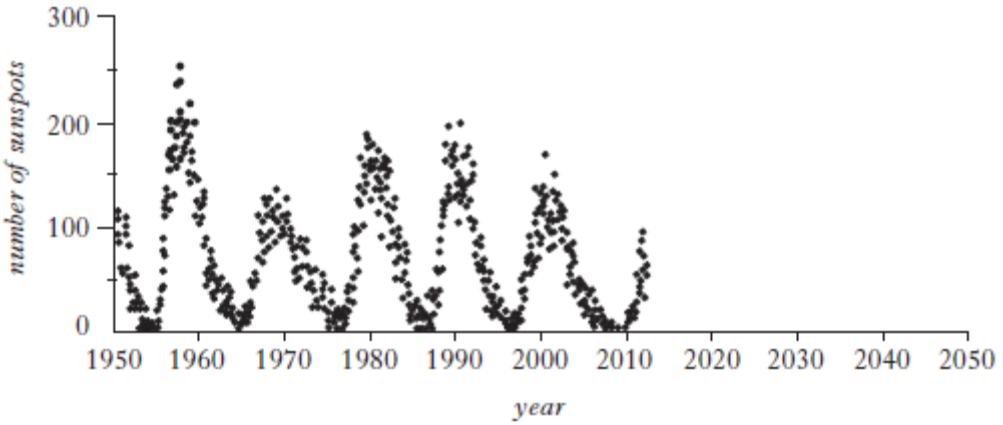


Figure 3

Coronal mass ejections (CME) are one type of solar activity. CMEs are huge magnetic bubbles of plasma that expand away from the Sun at speeds as high as 2000 km s^{-1}. A single CME can carry up to ten million tonnes (10^{10} kg) of plasma away from the Sun.

Use your knowledge of physics to discuss the potential effects that solar activity could have on Earth over the next few years.

(3)

Question 4:

The Sun is constantly losing mass through nuclear fusion. Particles also escape from the corona as shown in Figure 4A. This stream of particles radiating from the Sun is known as the Solar wind and its main constituent, by mass, is protons.

Figure 4A

(*a*) Astronomers estimate that the Sun loses mass at a rate of $1{\cdot}0 \times 10^9\,\text{kg}\,\text{s}^{-1}$. This rate has been approximately constant through the Sun's lifetime of $4{\cdot}6 \times 10^9$ years.

Estimate the mass lost by the Sun in its lifetime as a percentage of its current mass. 2

(*b*) A proton in the solar wind has energy of 3·6 MeV.

(i) Calculate the velocity of this proton. 3

(ii) The proton enters the magnetic field around the Earth at an angle of 50° as shown in Fig 4B The magnetic field strength is 58 μT.

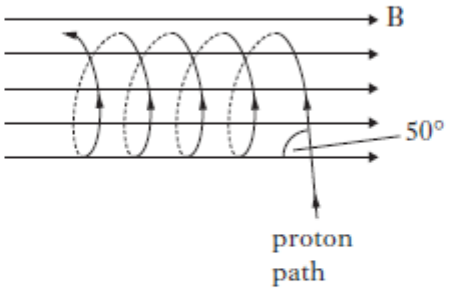


Figure 4B

(A) Explain the shape of the path followed by the proton in the magnetic field. 2

(B) Calculate the radius of curvature of this path. 3

(iii) An antiproton of energy 3·6 MeV enters the same region of the Earth's magnetic field at an angle of 30° to the field.

Describe **two** differences in the paths taken by the antiproton and the original proton. 2

(12)