

- 1 Charged particles, each of mass m and charge Q , travel at a constant speed in a circle of radius r in a uniform magnetic field of flux density B .

Which expression gives the frequency of rotation of a particle in the beam?

A $\frac{BQ}{2\pi m}$ ☐

B $\frac{BQ}{m}$ ☐

C $\frac{BQ}{\pi m}$ ☐

D $\frac{2\pi BQ}{m}$ ☐

(Total 1 mark)

- 2 Which one of the following statements is correct?

An electron follows a circular path when it is moving at right angles to

- A a uniform magnetic field.
B a uniform electric field.
C uniform electric and magnetic fields which are perpendicular.
D uniform electric and magnetic fields which are in opposite directions.

(Total 1 mark)

- 3 Two electrons, X and Y, travel at right angles to a uniform magnetic field. X experiences a magnetic force, F_X , and Y experiences a magnetic force, F_Y .

What is the ratio $\frac{F_X}{F_Y}$ if the kinetic energy of X is half that of Y?

A $\frac{1}{4}$

B $\frac{1}{2}$

C $\frac{1}{\sqrt{2}}$

D 1

(Total 1 mark)

4

The path followed by an electron of momentum p , carrying charge $-e$, which enters a magnetic field at right angles, is a circular arc of radius r .

What would be the radius of the circular arc followed by an α particle of momentum $2p$, carrying charge $+2e$, which entered the same field at right angles?

- A $\frac{r}{2}$
- B r
- C $2r$
- D $4r$

(Total 1 mark)

5

- (a) (i) State **two** situations in which a charged particle will experience no magnetic force when placed in a magnetic field.

first situation _____

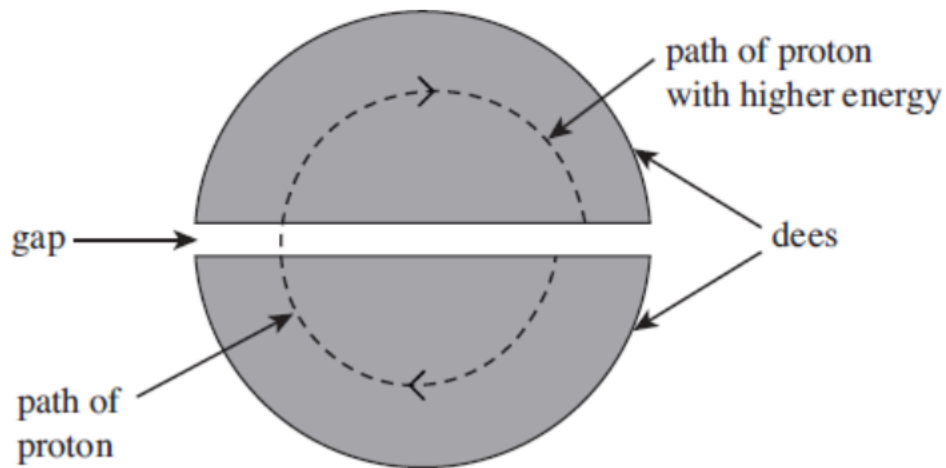
second situation _____

(2)

- (ii) A charged particle moves in a circular path when travelling perpendicular to a uniform magnetic field. By considering the force acting on the charged particle, show that the radius of the path is proportional to the momentum of the particle.

(2)

- (b) In a cyclotron designed to produce high energy protons, the protons pass repeatedly between two hollow D-shaped containers called 'dees'. The protons are acted on by a uniform magnetic field over the whole area of the dees. Each proton therefore moves in a semi-circular path at constant speed when inside a dee. Every time a proton crosses the gap between the dees it is accelerated by an alternating electric field applied between the dees. The diagram below shows a plan view of this arrangement.



- (i) State the direction in which the magnetic field should be applied in order for the protons to travel along the semicircular paths inside each of the dees as shown in the diagram above.

(1)

- (ii) In a particular cyclotron the flux density of the uniform magnetic field is 0.48 T. Calculate the speed of a proton when the radius of its path inside the dee is 190 mm.

speed _____ ms^{-1}

(2)

- (iii) Calculate the time taken for this proton to travel at constant speed in a semicircular path of radius 190 mm inside the dee.

time _____ s

(2)

- (iv) As the protons gain energy, the radius of the path they follow increases steadily, as shown in the diagram above. Show that your answer to part (b)(iii) does not depend on the radius of the proton's path.

(2)

- (c) The protons leave the cyclotron when the radius of their path is equal to the outer radius of the dees. Calculate the maximum kinetic energy, in Me V, of the protons accelerated by the cyclotron if the outer radius of the dees is 470 mm.

maximum kinetic energy _____ Me V

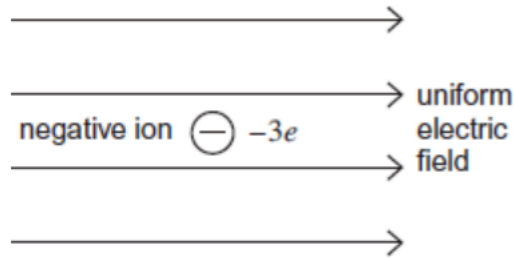
(3)

(Total 14 marks)

6

- (a) **Figure 1** shows a negative ion which has a charge of $-3e$ and is free to move in a uniform electric field. When the ion is accelerated by the field through a distance of 63 mm parallel to the field lines its kinetic energy increases by $4.0 \times 10^{-16} \text{ J}$.

Figure 1



- (i) State and explain the direction of the electrostatic force on the ion.

(2)

- (ii) Calculate the magnitude of the electrostatic force acting on the ion.

magnitude of electrostatic force _____ N

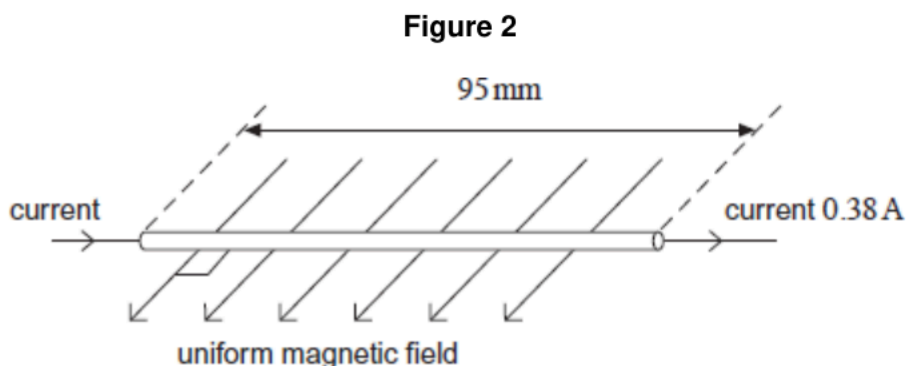
(2)

- (iii) Calculate the electric field strength.

electric field strength _____ NC^{-1}

(1)

- (b) **Figure 2** shows a section of a horizontal copper wire carrying a current of 0.38 A. A horizontal uniform magnetic field of flux density B is applied at right angles to the wire in the direction shown in the figure.



- (i) State the direction of the magnetic force that acts on the moving electrons in the wire as a consequence of the current and explain how you arrive at your answer.

(2)

- (ii) Copper contains 8.4×10^{28} free electrons per cubic metre. The section of wire in **Figure 2** is 95 mm long and its cross-sectional area is $5.1 \times 10^{-6} \text{ m}^2$. Show that there are about 4×10^{22} free electrons in this section of wire.

(1)

- (iii) With a current of 0.38 A, the average velocity of an electron in the wire is $5.5 \times 10^{-6} \text{ m s}^{-1}$ and the average magnetic force on one electron is $1.4 \times 10^{-25} \text{ N}$. Calculate the flux density B of the magnetic field.

flux density _____ T

(2)

7

Which line, **A** to **D**, in the table correctly describes the trajectory of charged particles which enter separately, at right angles, a uniform electric field, and a uniform magnetic field?

	uniform electric field	uniform magnetic field
A	parabolic	circular
B	circular	parabolic
C	circular	circular
D	parabolic	parabolic

(Total 1 mark)

8

The Large Hadron Collider (LHC) uses magnetic fields to confine fast-moving charged particles travelling repeatedly around a circular path. The LHC is installed in an underground circular tunnel of circumference 27 km.

- (a) In the presence of a suitably directed uniform magnetic field, charged particles move at constant speed in a circular path of constant radius. By reference to the force acting on the particles, explain how this is achieved and why it happens.

(4)

- (b) (i) The charged particles travelling around the LHC may be protons. Calculate the centripetal force acting on a proton when travelling in a circular path of circumference 27 km at one-tenth of the speed of light. Ignore relativistic effects.

answer = _____ N

(3)

- (ii) Calculate the flux density of the uniform magnetic field that would be required to produce this force. State an appropriate unit.

answer = _____ unit _____

(3)

- (c) The speed of the protons gradually increases as their energy is increased by the LHC. State and explain how the magnetic field in the LHC must change as the speed of the protons is increased.

(2)

(Total 12 marks)

9

When a β particle moves at right angles through a uniform magnetic field it experiences a force F . An α particle moves at right angles through a magnetic field of twice the magnetic flux density with velocity one tenth the velocity of the β particle. What is the magnitude of the force on the α particle?

- A $0.2 F$
- B $0.4 F$
- C $0.8 F$
- D $4.0 F$

(Total 1 mark)

10

Charged particles, each of mass m and charge Q , travel at a constant speed in a circle of radius r in a uniform magnetic field of flux density B . Which expression gives the frequency of rotation of a particle in the beam?

- A $\frac{BQ}{2\pi m}$
- B $\frac{BQ}{m}$
- C $\frac{BQ}{\pi m}$
- D $\frac{2\pi BQ}{m}$

(Total 1 mark)

11

Two charged particles, P and Q, move in circular orbits in a magnetic field of uniform flux density. The particles have the same charge but the mass of P is less than the mass of Q. T_P is the time taken for particle P to complete one orbit and T_Q the time for particle Q to complete one orbit. Which one of the following is correct?

- A $T_P = T_Q$
- B $T_P > T_Q$
- C $T_P < T_Q$
- D $T_P - T_Q = 1$

(Total 1 mark)

(a) The equation $F = BQv$ may be used to calculate magnetic forces.

(i) State the condition under which this equation applies.

(1)

(ii) Identify the physical quantities that are represented by the four symbols in the equation.

F _____

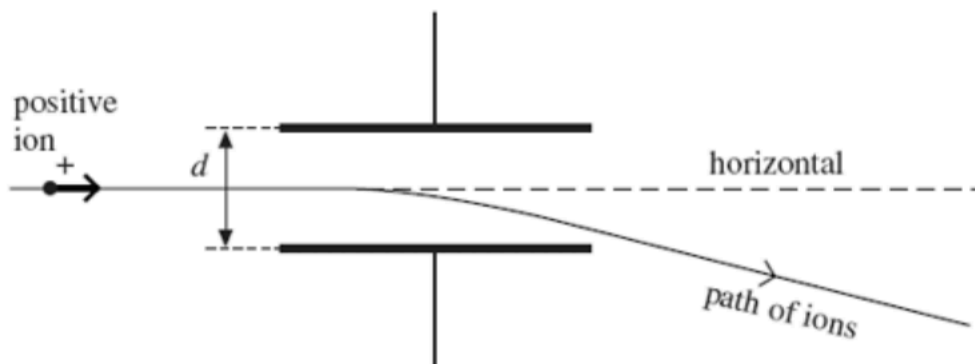
B _____

Q _____

v _____

(1)

(b) The figure below shows the path followed by a stream of identical positively charged ions, of the same kinetic energy, as they pass through the region between two charged plates. Initially the ions are travelling horizontally and they are then deflected downwards by the electric field between the plates.



While the electric field is still applied, the path of the ions may be restored to the horizontal, so that they have no overall deflection, by applying a magnetic field over the same region as the electric field. The magnetic field must be of suitable strength and has to be applied in a particular direction.

(i) State the direction in which the magnetic field should be applied.

(1)

- (ii) Explain why the ions have no overall deflection when a magnetic field of the required strength has been applied.

(2)

- (iii) A stream of ions passes between the plates at a velocity of $1.7 \times 10^5 \text{ ms}^{-1}$. The separation d of the plates is 65 mm and the pd across them is 48 V. Calculate the value of B required so that there is no overall deflection of the ions, stating an appropriate unit.

answer = _____

(4)

- (c) Explain what would happen to ions with a velocity higher than $1.7 \times 10^5 \text{ ms}^{-1}$ when they pass between the plates at a time when the conditions in part (b)(iii) have been established.

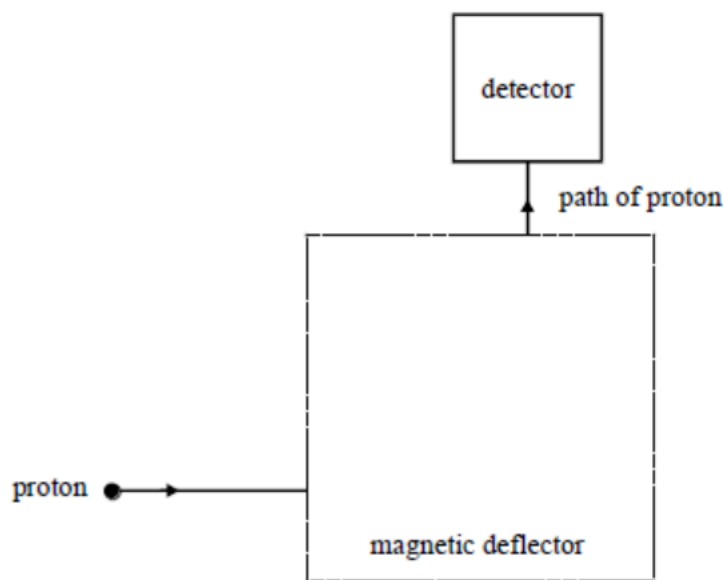
(2)

(Total 11 marks)

13

The diagram shows an arrangement in a vacuum to deflect protons into a detector using a magnetic field, which can be assumed to be uniform within the square shown and zero outside it.

The motion of the protons is in the plane of the paper.



- (a) Sketch the path of a proton through the magnetic deflector. At any point on this path draw an arrow to represent the magnetic force on the proton. Label this arrow F .

(2)

- (b) State the direction of the uniform magnetic field causing this motion.

(1)

- (c) The speed of a proton as it enters the deflector is $5.0 \times 10^6 \text{ m s}^{-1}$. If the flux density of the magnetic field is 0.50 T , calculate the magnitude of the magnetic force on the proton.

(2)

- (d) If the path were that of an electron with the same velocity, what **two** changes would need to be made to the magnetic field for the electron to enter the detector along the same path?

(2)

(Total 7 marks)

14

- (a) (i) State **two** differences between a proton and a positron.

difference 1 _____

difference 2 _____

- (ii) A narrow beam of protons and positrons travelling at the same speed enters a uniform magnetic field. The path of the positrons through the field is shown in **Figure 1**.

Sketch on **Figure 1** the path you would expect the protons to take.

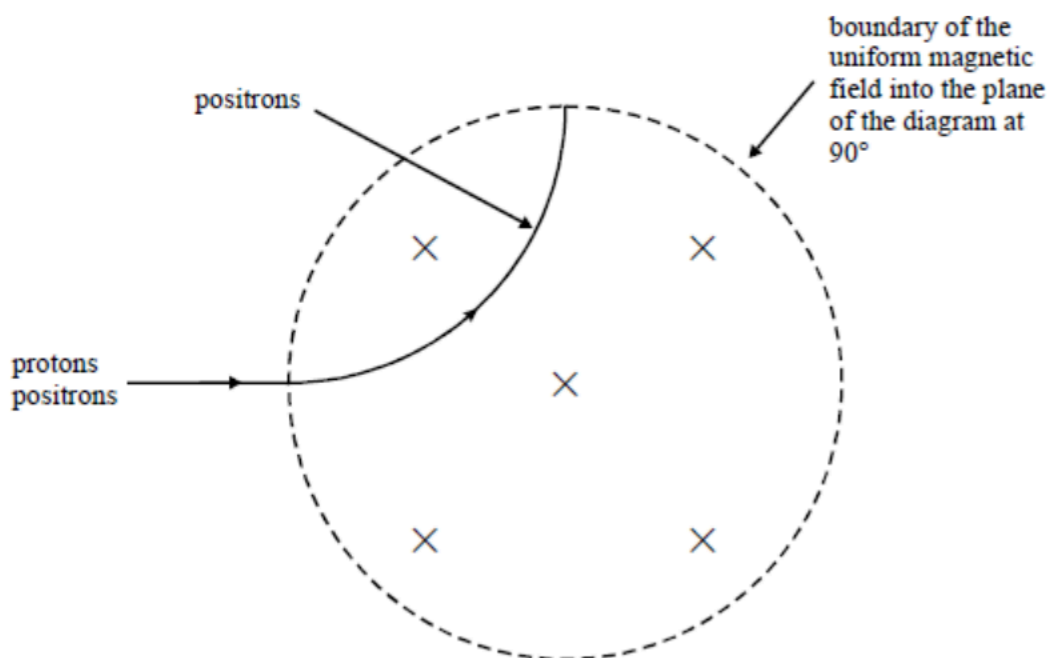


Figure 1

- (iii) Explain why protons take a different path to that of the positrons.

- (b) **Figure 2** shows five isotopes of carbon plotted on a grid in which the vertical axis represents the neutron number N and the horizontal axis represents the proton number Z . Two of the isotopes are stable, one is a beta minus emitter and two are positron emitters.

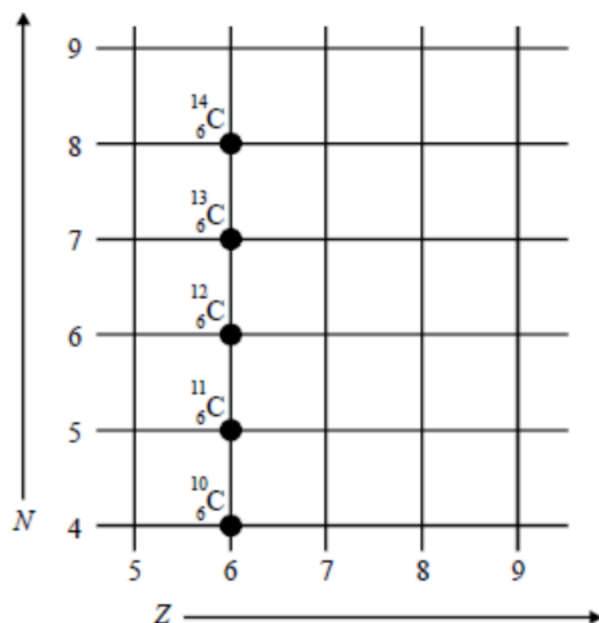


Figure 2

- (i) Which isotope is a beta minus emitter?

- (ii) Which of the two positron emitters has the shorter half-life? Give a reason for your choice.

(3)

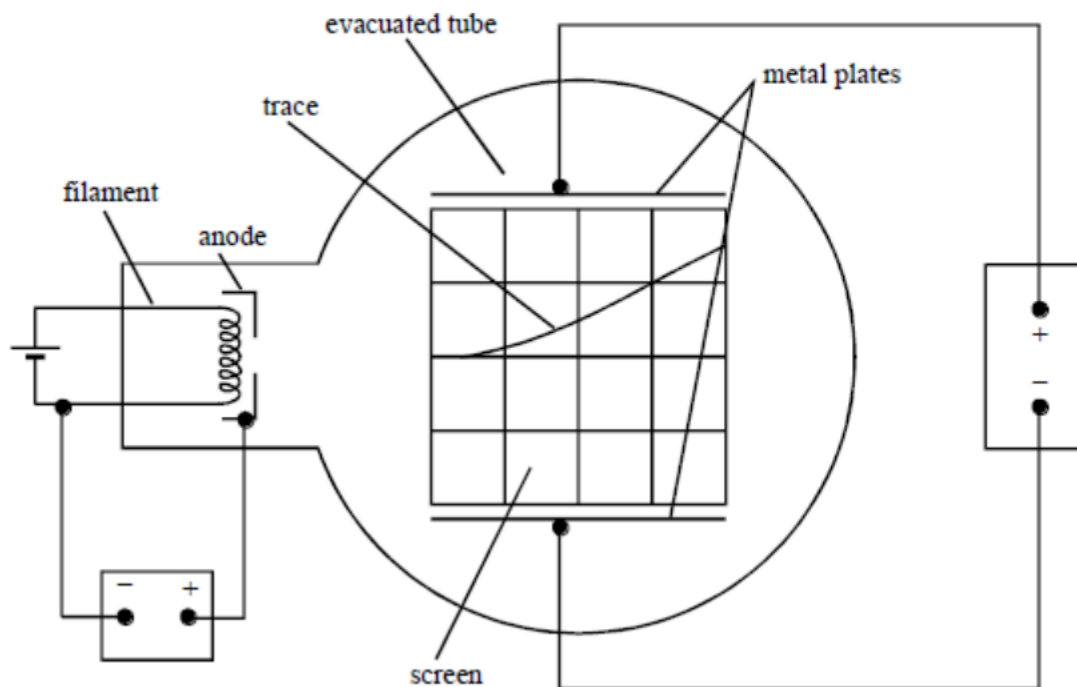
- (c) A positron with kinetic energy 2.2 MeV and an electron at rest annihilate each other. Calculate the average energy of each of the two gamma photons produced as a result of this annihilation.

(2)

(Total 10 marks)

15

A narrow beam of electrons is directed into a uniform electric field created by two oppositely-charged parallel metal plates at right angles to the field lines. A fluorescent screen is used to make the beam give a visible trace.



- (a) (i) Explain why the beam curves towards the positive plate.

- (ii) How does the trace show that, on entry to the electric field, all the electrons have the same speed?

(3)

- (b) The beam is produced as a result of accelerating electrons between the filament and a metal anode.

- (i) Explain why the wire filament must be hot.

- (ii) Write down an equation relating the speed of the electrons, v , to the potential difference, V_A , between the anode and the filament.

(2)

- (c) The deflection of the beam due to the electric field can be cancelled by applying a suitable uniform magnetic field *in* the same region as the electric field.

- (i) What direction should the magnetic field be in to do this?

- (ii) Write down an equation relating the speed of the electrons v to the plate voltage V_p , the plate separation d , and the magnetic flux density B necessary to make the beam pass undeflected between the plates.

(iii) The following measurements were made when the beam was undeflected.

$$V_A = 3700 \text{ V} \quad V_p = 4500 \text{ V} \quad d = 50 \text{ mm} \quad B = 2.5 \text{ mT}$$

Use the two equations you have written down and the given data to calculate the specific charge, e/m , of the electron.

(5)

(Total 10 marks)

16

- (a) Explain why a particle is accelerating even when it is moving with a uniform speed in a circular path.

(2)

- (b) **Figure 1** shows a schematic diagram of a proton synchrotron. This is a device for accelerating protons to high speeds in a horizontal circular path.

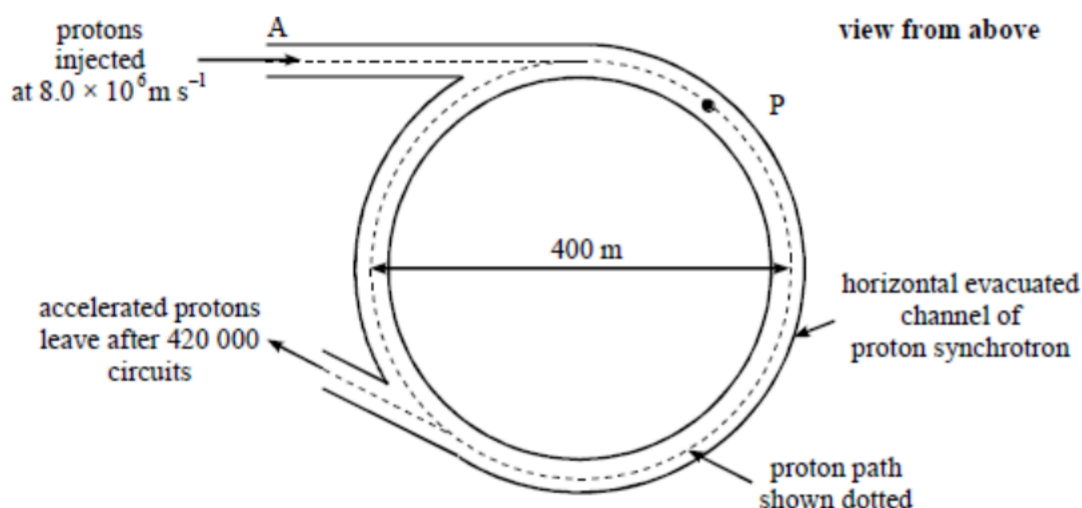
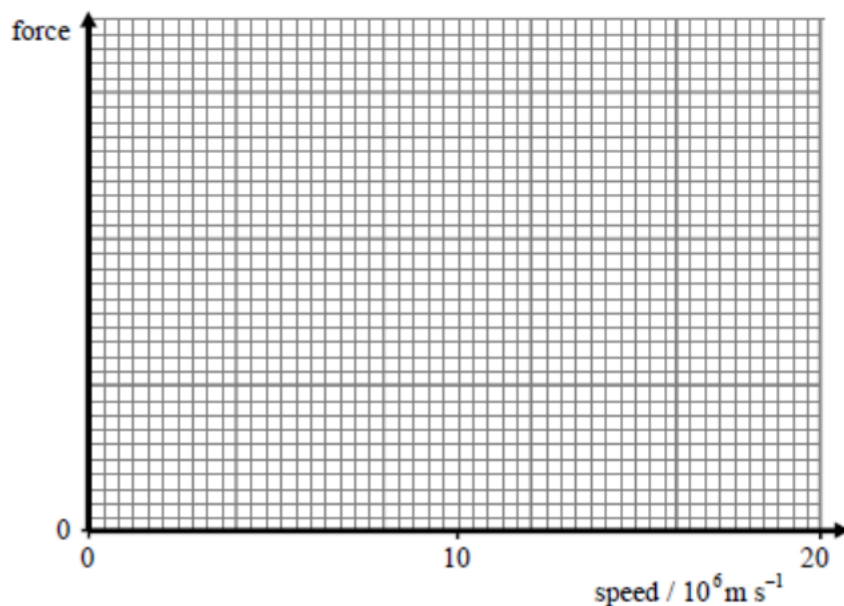


Figure 1

In the synchrotron the protons of mass $1.7 \times 10^{-27} \text{ kg}$ are injected at point **A** at a speed of $8.0 \times 10^6 \text{ m s}^{-1}$. The diameter of the path taken by the protons is 400 m.

- Show on **Figure 1** the direction of the force required to make a proton move in the circular path when the proton is at the position marked **P**. (1)
- Calculate the force that has to be provided to produce the circular path when the speed of a proton is $8.0 \times 10^6 \text{ m s}^{-1}$. (2)
- Sketch on **Figure 2** a graph to show how this force will have to change as the speed of the proton increases over the range shown on the x -axis. Insert an appropriate scale on the force axis.



- (c) Before reaching their final energy the protons in the synchrotron in part (b) travel around the accelerator 420 000 times in 2.0 s.

acceleration of free fall, $g = 9.8 \text{ m s}^{-2}$

- (i) Calculate the total distance travelled by a proton in the 2.0 s time interval. (2)
- (ii) Unless a vertical force is applied the protons would fall as they move through the horizontal channel.

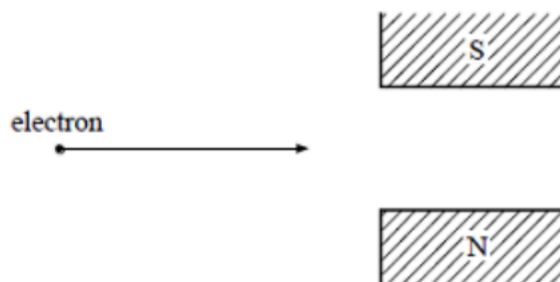
Calculate the distance a proton would fall in two seconds.

- (iii) Determine the force necessary to prevent the vertical movement. (1)

(Total 12 marks)

17

An electron moves into a region of uniform magnetic flux density between the poles of a magnet as shown in the diagram.



The deflection of the electron will be

- A** towards the pole marked **S**
- B** towards the pole marked **N**
- C** perpendicular to the plane of the paper towards you
- D** perpendicular to the plane of the paper away from you

(Total 1 mark)

18

An alpha particle moves at one-tenth the velocity of a beta particle. They both move through the same uniform magnetic field at right angles to their motion.

The magnitude of the ratio $\frac{\text{force on the alpha particle}}{\text{force on the beta particle}}$ is

A $\frac{1}{4}$

B $\frac{1}{5}$

C $\frac{1}{10}$

D $\frac{1}{20}$

(Total 1 mark)

1	A	[1]
2	A	[1]
3	C	[1]
4	B	[1]

- 2

2

- 1

2

- Max 1 if path length is taken to be $2\pi r$ (gives 1.27×10^{-7} s)

(iv) $v \propto r$ (and path length $\propto r$) ✓

$$t = (\text{path length} / v) \text{ or } (\pi r / v)$$

so r cancels ($\therefore$ time doesn't depend on r) ✓

$$[\text{or } t = \frac{\pi r}{v} = \frac{\pi r m}{B Q r} \quad \checkmark \quad = \frac{\pi m}{B Q} \text{ (because } r \text{ cancels) } \quad \checkmark \quad]$$

$$[\text{or } B Q v = m \omega^2 r \text{ gives } B Q \omega r = m \omega^2 r \text{ and } B Q = m \omega = 2 \pi f m \quad \checkmark]$$

$\therefore$ frequency is independent of r ✓]

2

$$(c) \quad v_{\max} = 8.74 \times 10^6 \times \left(\frac{0.47}{0.19} \right) = 2.16 \times 10^7 \text{ (m s}^{-1}\text{)} \quad \checkmark$$

1st mark can be achieved by full substitution, as in (b)(ii), or by use of data from (b)(i) and / or (b)(iii).

$$E_k (= \frac{1}{2} m v_{\max}^2) = \frac{1}{2} \times 1.67 \times 10^{-27} \times (2.16 \times 10^7)^2 \quad \checkmark$$

$$(\quad = 3.90 \times 10^{-13} \text{ J})$$

$$= \frac{3.90 \times 10^{-13}}{1.60 \times 10^{-13}} = 2.4(4) \text{ (Me V)} \quad \checkmark$$

Allow ECF from incorrect v from (b)(ii), or from incorrect t from (b)(iii).

3

(Total 14 marks)

6

(a) (i) force acts towards left or in opposite direction to field lines ✓
because ion (or electron) has negative charge

($\therefore$ experiences force in opposite direction to field) ✓

Mark sequentially.

Essential to refer to negative charge (or force on + charge is to right) for 2nd mark.

2

$$(ii) \quad (\text{use of } W = F s \text{ gives) force } F = \frac{4.0 \times 10^{-16}}{63 \times 10^{-3}} \quad \checkmark$$

$$= 6.3(5) \times 10^{-15} \text{ (N)} \quad \checkmark$$

*If mass of ion m is used correctly **using algebra** with $F = ma$, allow both marks (since m will cancel). If numerical value for m is used, max 1.*

2

(iii) electric field strength $E\left(=\frac{F}{Q}\right)=\frac{6.35\times10^{-15}}{3\times1.6\times10^{-19}}=1.3(2)\checkmark10^4\text{ (N C}^{-1}\text{)}\checkmark$

[or $\Delta V\left(=\frac{\Delta W}{Q}\right)=\frac{4.0\times10^{-16}}{3\times1.60\times10^{-19}}\quad(833\text{ V})$

$E\left(=\frac{\Delta V}{d}\right)=\frac{833}{63\times10^{-3}}=1.3(2)\checkmark10^4\text{ (V m}^{-1}\text{)}\checkmark]$

Allow ECF from wrong F value in (ii).

1

- (b) (i) (vertically) downwards on diagram $\checkmark$
reference to Fleming's LH rule **or** equivalent statement $\checkmark$

Mark sequentially.

1st point: allow "into the page".

2

- (ii) number of free electrons in wire = $A \times l \times$ number density
 $= 5.1 \times 10^{-6} \times 95 \times 10^{-3} \times 8.4 \times 10^{28} = 4.1\text{ (4.07)} \times 10^{22} \checkmark$

Provided it is shown correctly to at least 2SF, final answer alone is sufficient for the mark. (Otherwise working is mandatory).

1

(iii) $B\left(=\frac{F}{Qv}\right)=\frac{1.4\times10^{-25}}{1.60\times10^{-19}\times5.5\times10^{-6}}\checkmark=0.16\text{ (0.159) (T)}\checkmark$

[or $B\left(=\frac{F}{Il}\right)=\frac{1.4\times10^{-25}\times4.07\times10^{22}}{0.38\times95\times10^{-3}}\checkmark=0.16\text{ (0.158) (T)}\checkmark]$

In 2nd method allow ECF from wrong number value in (ii).

2

[10]

8

- (a) (magnetic) field is applied perpendicular to path

or direction or velocity of charged particles ✓

(magnetic) force acts perpendicular to path

or direction or velocity of charged particles ✓

force depends on speed of particle or on B [or $F \propto v$ or $F = BQv$ explained] ✓

force provides (centripetal) acceleration towards centre of circle

[or (magnetic) force is a centripetal force] ✓

$$BQv = \frac{mv^2}{r} \text{ or } r = \frac{mv}{BQ} \text{ shows that } r \text{ is constant when } B \text{ and } v \text{ are constant } \checkmark$$

4

- (b) (i) radius r of path = $\frac{\text{circumference}}{2\pi} = \frac{27 \times 10^3}{2\pi} = 4.30 \times 10^3 \text{ (m)}$
(allow 4.3km) ✓

$$\text{centripetal force } \left(= \frac{mv^2}{r} \right) = \frac{1.67 \times 10^{-27} \times (3.00 \times 10^7)^2}{4.30 \times 10^3} \checkmark = 3.50 \times 10^{-16} \text{ (N)} \checkmark$$

3

$$\begin{aligned} \text{(ii) magnetic flux density } B \left(= \frac{F}{Qv} \right) &= \frac{3.50 \times 10^{-16}}{1.60 \times 10^{-19} \times 3.00 \times 10^7} \checkmark \\ &= 7.29 \times 10^{-5} \checkmark \text{ T } \checkmark \end{aligned}$$

3

- (c) magnetic field must be increased ✓

to increase (centripetal) force or in order to keep r constant ✓

[or otherwise protons would attempt to travel in a path of larger radius]

[or, referring to $r = \frac{mv}{BQ}$, B must increase when v increases to keep r constant]

2

[12]

9

B

[1]

10

A

[1]

11

C

[1]

12

- (a) (i) magnetic field (or B) must be at right angles to velocity (or v) ✓

1

- (ii) $F =$ (magnetic) force (on a charged particle or ion)

$B =$ **flux density** (of a magnetic field)

$Q =$ charge (of particle or ion)

$v =$ velocity [**or** speed] (of particle or ion)

all four correct ✓

1

- (b) (i) into plane of diagram ✓

1

- (ii) magnetic **force** = electric **force** [or $BQv = EQ$] ✓

these forces act in opposite directions [**or** are balanced
or resultant vertical force is zero] ✓

2

- (iii) $BQv = EQ$ gives flux density $B = \frac{E}{v}$ ✓

$$E \left(= \frac{v}{d} \right) = \frac{45}{65 \times 10^{-3}} \quad \checkmark \quad (= 738 \text{ V m}^{-1})$$

$$B \left(= \frac{738}{1.7 \times 10^5} \right) = 4.3 \times 10^{-3} \quad \checkmark \quad \text{T} \quad \checkmark$$

4

- (c) ions would be deflected upwards ✓

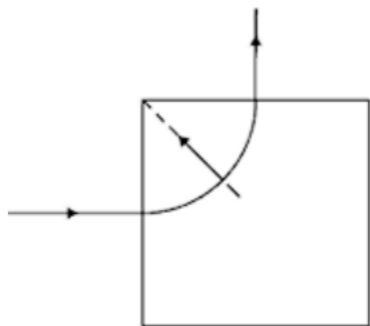
magnetic force increases but electrostatic force is
unchanged [**or** magnetic force now exceeds electrostatic force] ✓

2

[11]

13

- (a)



(uniformly) curved path continuous with linear paths at entry and exit points (1)
arrow marked F towards top left-hand corner (1)

(b) into (the plane of) the diagram (1) (not accept "downwards")

1

(c) $F(=BQv) = 0.50 \times 1.60 \times 10^{-19} \times 5.0 \times 10^6$ (1)
 $= 4.0 \times 10^{-13} \text{ N}$ (1)

2

(d) B must be in opposite direction (1)

(much) smaller magnitude ($\approx \frac{1}{2000}$) (1)

2

[7]

14

(a) (i) *including, for example:*

positron is an antimatter particle; proton is a matter particle (*)

positron is a lepton; proton is a hadron (*)

positron has a smaller rest mass than a proton (*)

positron is not composed of other particles; proton is made up of quarks (*)

(*) any two [1] [1]

(ii) proton path has greater radius of curvature than positron (1)

(iii) radius of curvature $r = \frac{mv}{Be}$ and v , B and e are constants (1)

therefore r proportional to m (1)

mass of proton is (much) greater than mass

of positron (at same speed) (1)

5

(b) (i) C - 14 (1)

(ii) C - 10 (1)

as this is furthest from stability (1)

3

(c) rest mass of electron = 0.51 MeV therefore total energy available
 $= (2.2 + 2 \times 0.51) = 3.22 \text{ (MeV)}$ (1)

gamma photons produced have average energy $= \frac{3.22}{2} = 1.6 \text{ MeV}$ (1)

2

[10]

15

(a) (i) electrons are negatively charged so beam is attracted to positive plate

[or repelled by negative plate or electron experiences force towards positive plate]

(1)

(ii) beam does not spread out (1)

if speeds varied, faster electrons would be

deflected less than slower electrons (1)

3

- (b) (i) to give conduction electrons sufficient k.e. to leave metal [or to cause thermionic emission or electrons have insufficient ke. in a cold filament to leave filament] (1)

$$(ii) \quad \frac{1}{2} mv^2 = eV_A \text{ [or } v = \sqrt{\frac{2eV_A}{m}} \text{]} (1)$$

2

- (c) (i) into the plane of the diagram (1)
perpendicular to the diagram [or the electric field] (1)

$$(ii) \quad Bev = \frac{eV_p}{d} (1)$$

- (iii) combine the two equations to give $\frac{e}{m} = \frac{V_p^2}{2V_A B^2 d^2} (1)$

$$\frac{e}{m} = \frac{4500^2}{2 \times 3700 \times (2.5 \times 10^{-3})^2 \times (50 \times 10^{-3})^2} (1)$$

$$1.75 \times 10^{11} \text{ Ckg}^{-1} (1)$$

max 5

[10]

16

- (a) acceleration is (rate of) change of velocity
or velocity is a vector
or velocity has magnitude and direction

B1

velocity is changing since direction is changing
(must be clear that it is the velocity that is changing direction)

B1

allow 1 mark for 'it would move in a straight line at constant speed if it were not accelerating'

do not allow 'because there is a force acting'
'because direction is changing'

(2)

- (b) (i) arrow toward centre of circle at **P**

B1

(1)

$$(ii) \quad F = mv^2 / r \text{ or } mr\omega^2$$

or numerical equivalent (*r* must be 200 m)

C1

$$5.4 \times 10^{-16} \text{ N}$$

A1

(iii) graph showing correct curvature with F plotted correctly (e.c.f. for F)

(should be between 5×10^{-14} and 6×10^{-16} N

B1

double v , quadruple F

(should be possible to do these tasks to $\pm 1/2$ a square)

B1

(2)

(c) (i) circumference = 1256 m or $2\pi r \times 420\,000$

(allow e.c.f. for incorrect r from (b)(ii))

C1

distance travelled = 5.3×10^8 m

A1

(2)

(ii) $s = \frac{1}{2}gt^2$ **or** $ut + \frac{1}{2}at^2$

C1

19.6m (20m)

A1

(2)

(iii) $mg = 1.7 (1.67) \times 10^{-26}$ N

B1

(1)

[12]

17

D

[1]

18

B

[1]