PapaCambridge

Cambridge International AS & A Level

PHYSICS

Paper 4

Topical Past Paper Questions
+ Answer Scheme

2016 - 2021

PapaCambridge

Chapter 12

Magnetic fields

251. 9702_w21_qp_41 Q: 8

(a) Define the *tesla*.

....

....

.... [2]

(b) A stiff metal wire is used to form a rectangular frame measuring 8.0 cm × 6.0 cm. The frame is open at the top, and is suspended from a sensitive newton meter, as shown in Fig. 8.1.

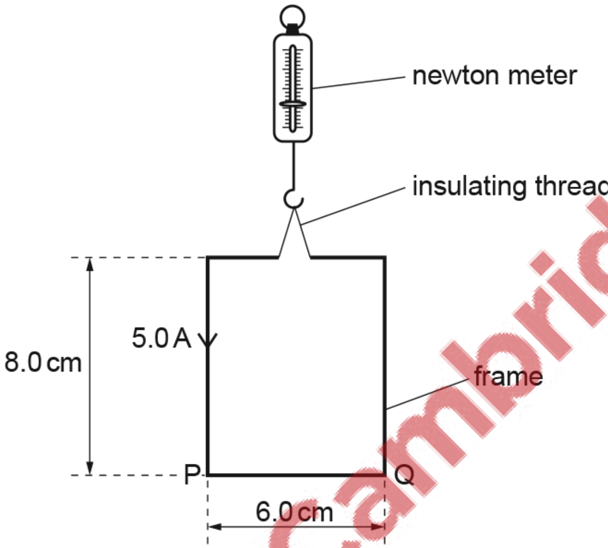

Fig. 8.1

The open ends of the frame are connected to a power supply so that there is a current of 5.0 A in the frame in the direction indicated in Fig. 8.1.

The frame is slowly lowered into a uniform magnetic field of flux density *B* so that all of side PQ is in the field. The magnetic field lines are horizontal and at an angle of 50° to PQ, as shown in Fig. 8.2.

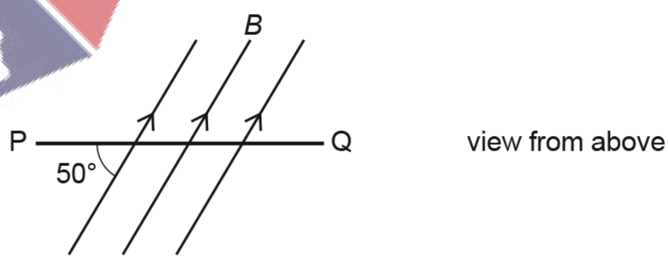

Fig. 8.2

When side PQ of the frame first enters the magnetic field, the reading on the newton meter changes by 1.0 mN.

(i) Determine the magnetic flux density B, in mT.

B = ... mT [2]

(ii) State, with a reason, whether the change in the reading on the newton meter is an increase or a decrease.

....

....

.... [1]

(iii) The frame is lowered further so that the vertical sides start to enter the magnetic field.

Suggest what effect this will have on the frame.

....

....

.... [1]

[Total: 6]

252. 9702_w21_qp_43 Q: 8

(a) Define the *tesla*.

....

....

.... [2]

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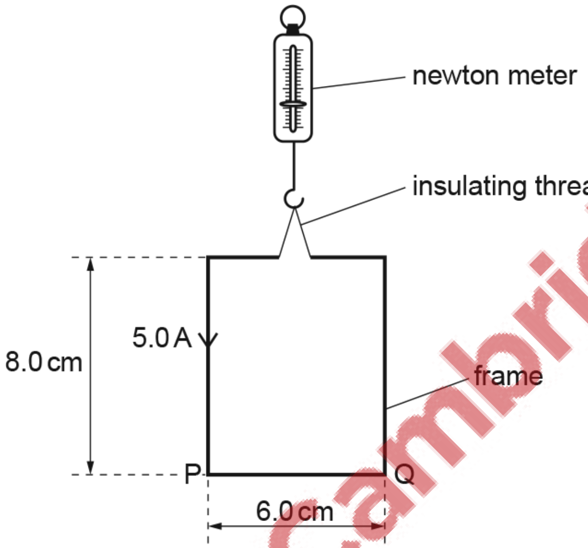

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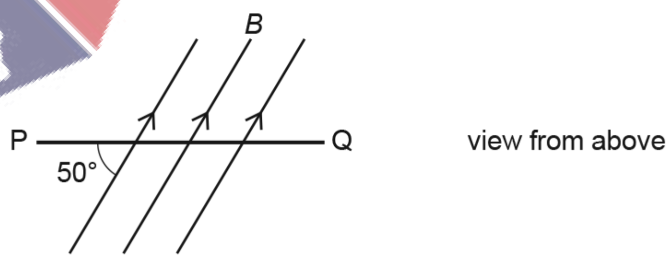
The frame is slowly lowered into a uniform magnetic field of flux density B so that all of side PQ is in the field. The magnetic field lines are horizontal and at an angle of 50° to PQ, as shown in Fig. 8.2.



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[Total: 6]

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253. 9702_s20_qp_41 Q: 8

(a) Define the *tesla*.

....

....

....

.... [3]

(b) A magnet produces a uniform magnetic field of flux density *B* in the space between its poles.

A rigid copper wire carrying a current is balanced on a pivot. Part PQLM of the wire is between the poles of the magnet, as illustrated in Fig. 8.1.

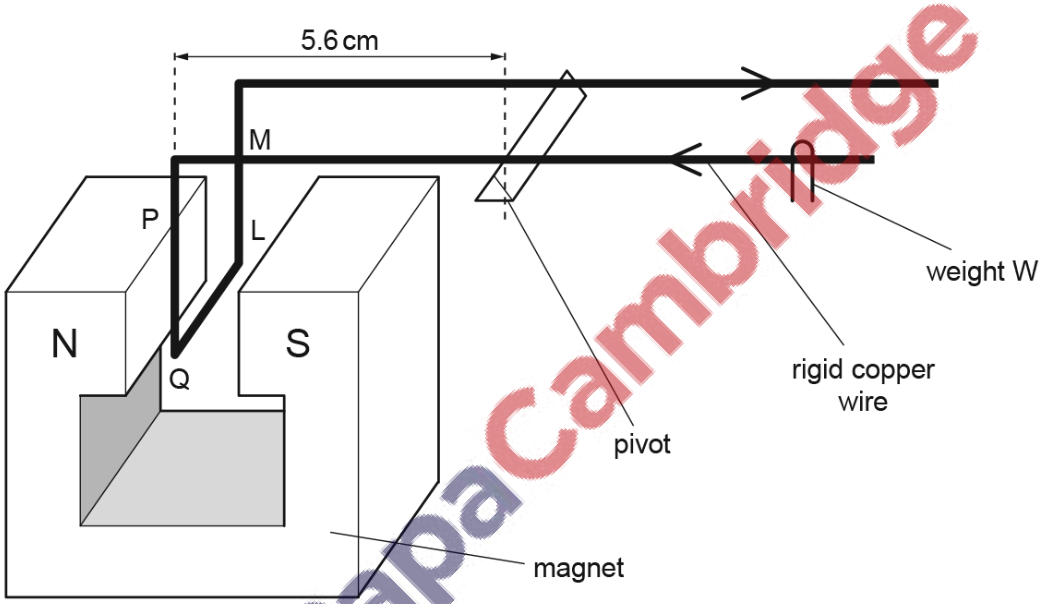

Fig. 8.1 (not to scale)

The wire is balanced horizontally by means of a small weight W.

The section of the wire between the poles of the magnet is shown in Fig. 8.2.

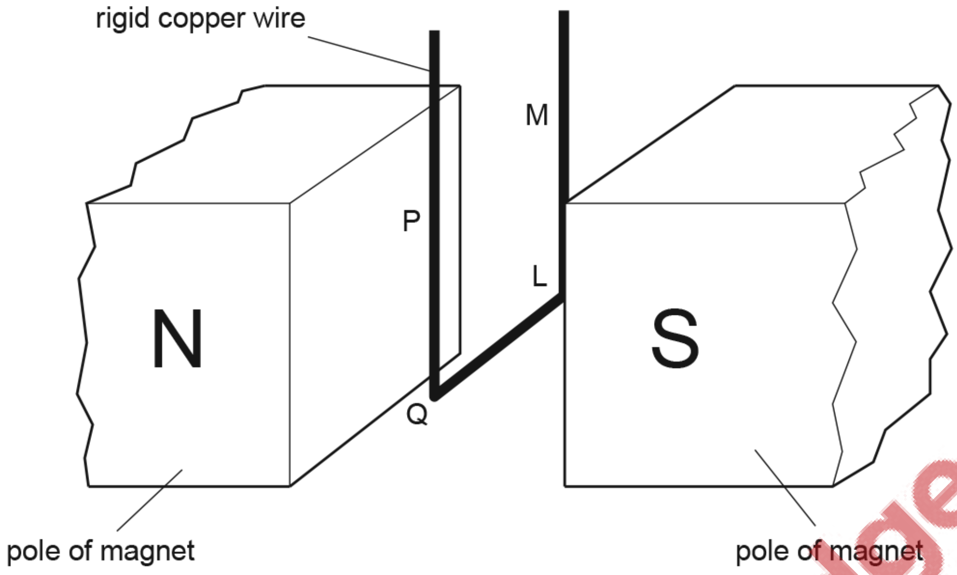

Fig. 8.2 (not to scale)

Explain why:

(i) section QL of the wire gives rise to a moment about the pivot

....

....

....

.... [3]

(ii) sections PQ and LM of the wire do not affect the equilibrium of the wire.

....

....

....

.... [2]

(c) Section QL of the wire has length 0.85 cm.

The perpendicular distance of QL from the pivot is 5.6 cm.

When the current in the wire is changed by 1.2 A, W is moved a distance of 2.6 cm along the wire in order to restore equilibrium. The mass of W is 1.3×10^{-4} kg.

(i) Show that the change in moment of W about the pivot is 3.3×10^{-5} N m.

[2]

(ii) Use the information in **(i)** to determine the magnetic flux density *B* between the poles of the magnet.

B = ... T [3]

[Total: 13]

254. 9702_s20_qp_43 Q: 8

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....

....

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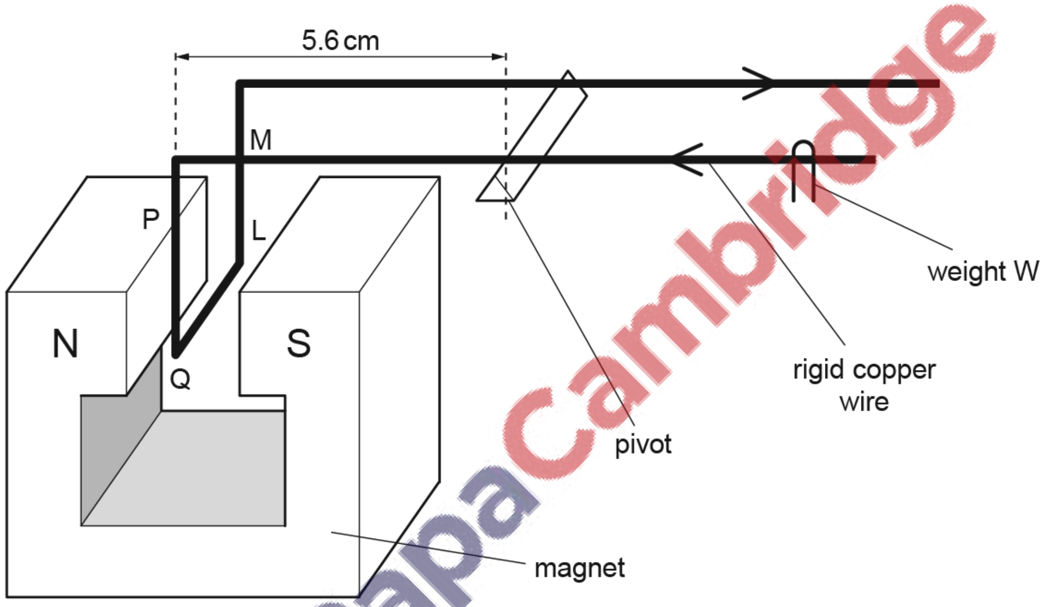

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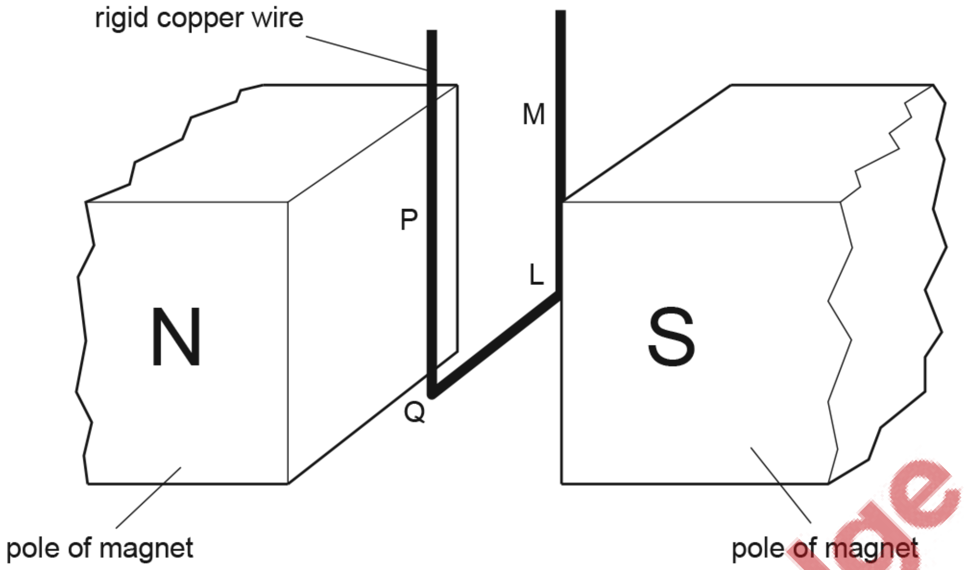

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[2]

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B = ... T [3]

[Total: 13]

255. 9702_s18_qp_41 Q: 9

A rigid copper wire is held horizontally between the pole pieces of two magnets, as shown in Fig. 9.1.

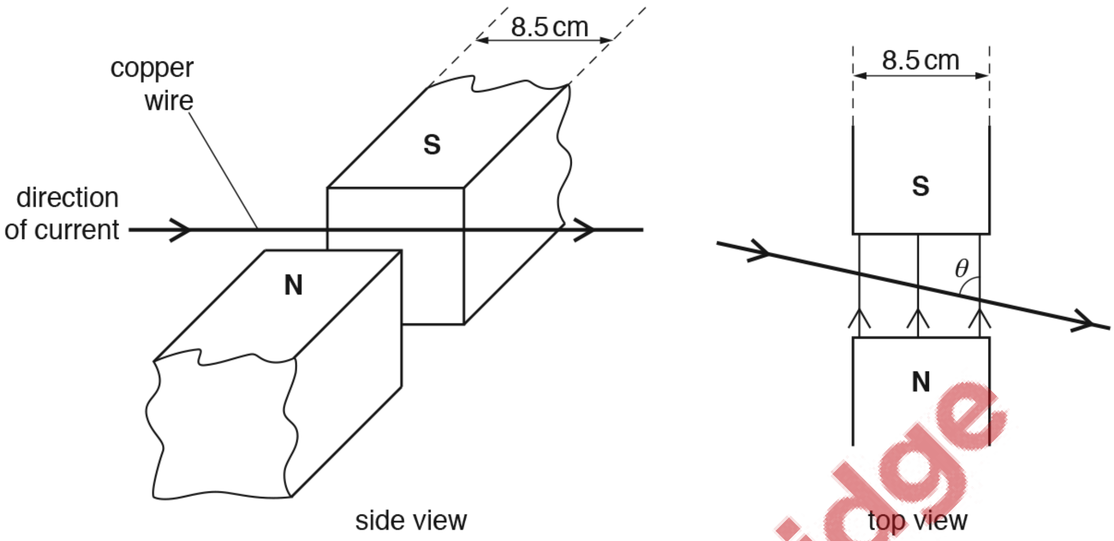


Fig. 9.1

The width of each pole piece is 8.5 cm.
The uniform magnetic flux density *B* in the region between the poles of the magnets is 3.7 mT and is zero outside this region.
The angle between the wire and the direction of the magnetic field is θ.
The current in the wire is in the direction shown on Fig. 9.1.

(a) By reference to the **side** view of Fig. 9.1, state and explain the direction of the force on the **magnets**.

....

....

....

.... [2]

(b) The constant current in the wire is 5.1 A.

(i) For angle θ equal to 90°, calculate the force on the wire.

force = ... N [2]

(ii) The angle θ is changed to 60°.

The length of wire in the magnetic field is $\left(\frac{8.5}{\sin 60°}\right)$ cm.

Calculate the force on the wire.

force = ... N [1]

(c) The constant current in the wire is now changed to an alternating current of frequency 20 Hz and root-mean-square (r.m.s.) value 5.1 A.

The angle between the wire and the direction of the magnetic field is 90°.

On Fig. 9.2, sketch a graph to show the variation with time t of the force F on the wire for two cycles of the alternating current.

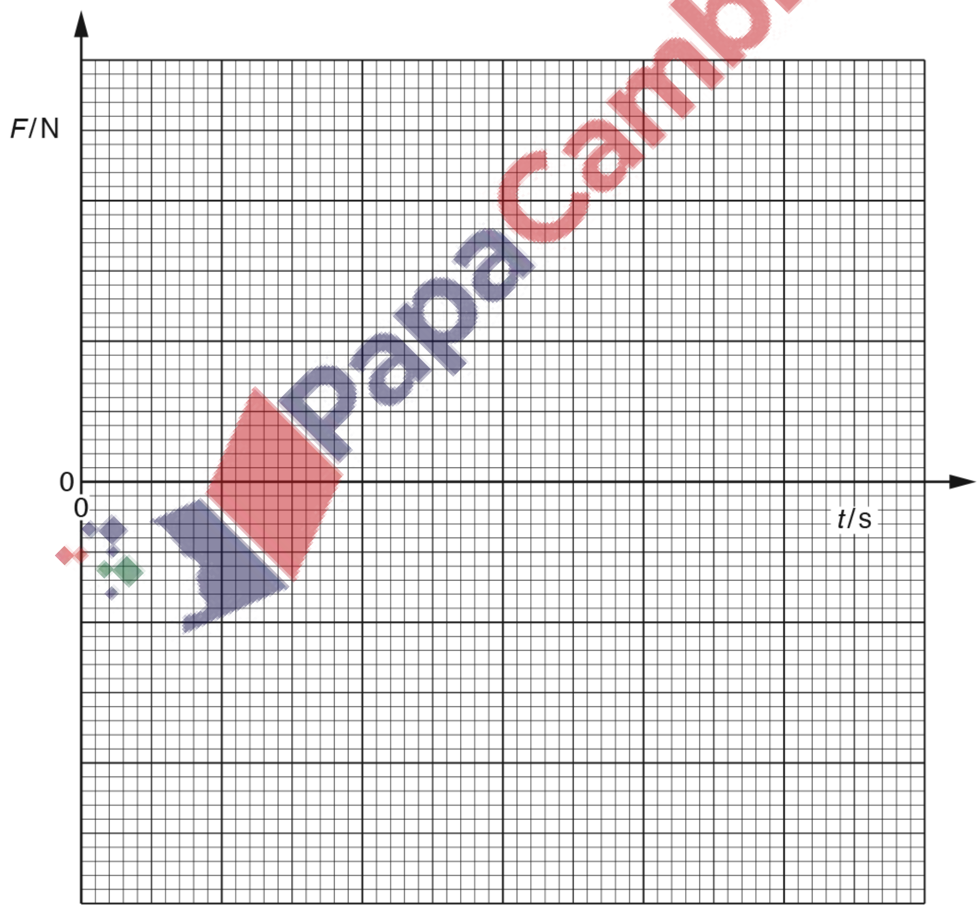


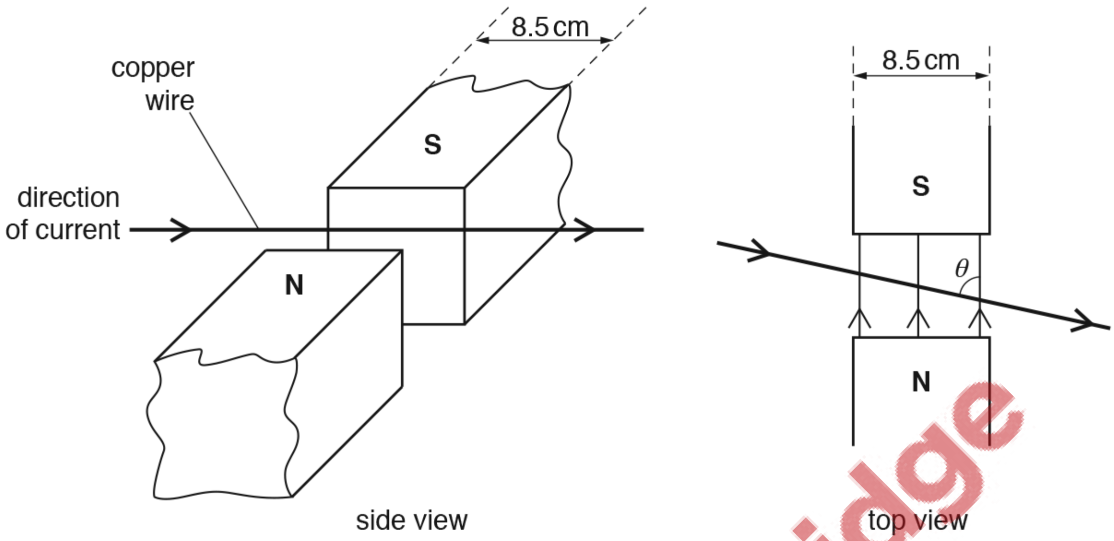
Fig. 9.2

[3]

[Total: 8]

256. 9702_s18_qp_43 Q: 9

A rigid copper wire is held horizontally between the pole pieces of two magnets, as shown in Fig. 9.1.



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....

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The length of wire in the magnetic field is $\left(\frac{8.5}{\sin 60°}\right)$ cm.

Calculate the force on the wire.

force = ... N [1]

(c) The constant current in the wire is now changed to an alternating current of frequency 20 Hz and root-mean-square (r.m.s.) value 5.1 A.

The angle between the wire and the direction of the magnetic field is 90°.

On Fig. 9.2, sketch a graph to show the variation with time t of the force F on the wire for two cycles of the alternating current.

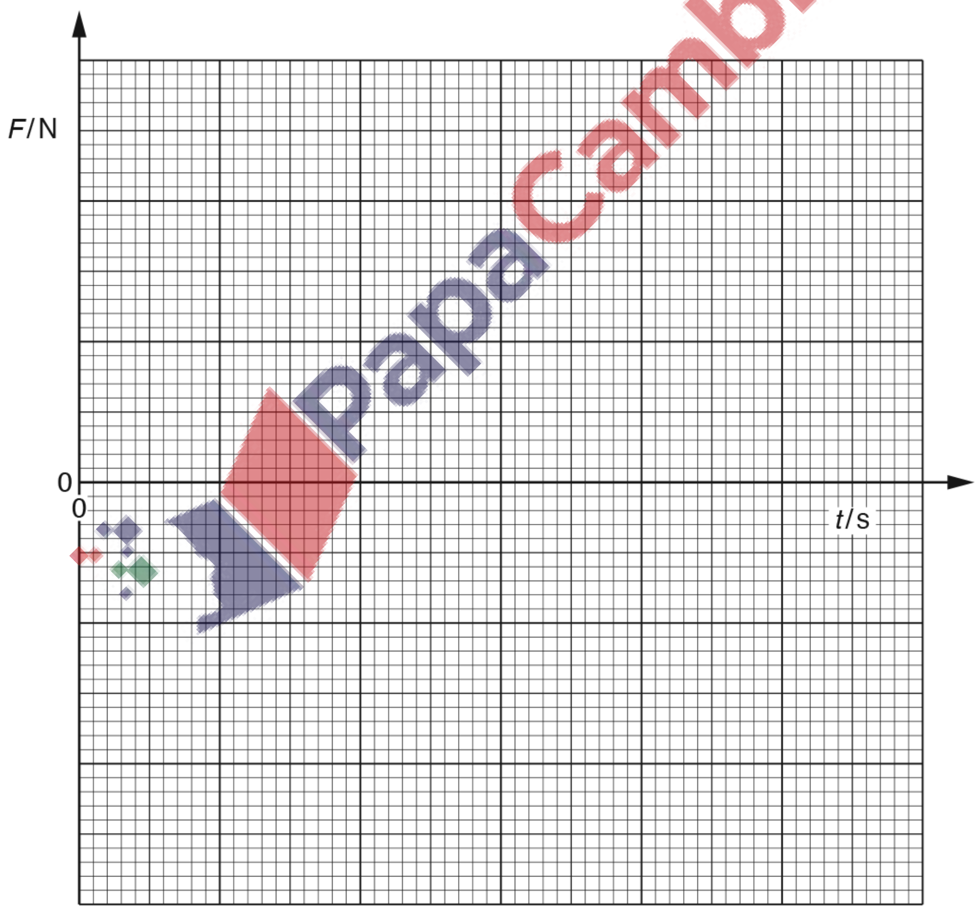

Fig. 9.2

[3]

[Total: 8]

257. 9702_w18_qp_42 Q: 8

(a) Define *magnetic flux density*.

....

....

....

....[3]

(b) A stiff copper wire is balanced horizontally on a pivot, as shown in Fig. 8.1.

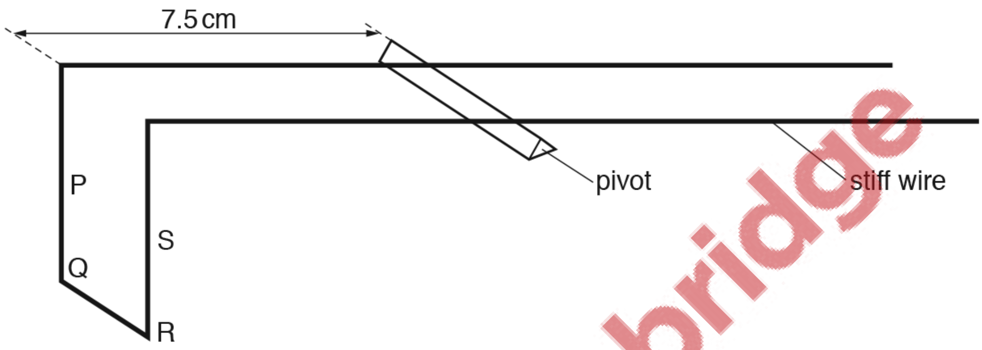

Fig. 8.1

Sections PQ, QR and RS of the wire are situated in a uniform magnetic field of flux density *B* produced between the poles of a permanent magnet.
The perpendicular distance of PQRS from the pivot is 7.5 cm.

When a current of 2.7 A is passed through the wire, a small mass of 45 mg is placed a distance 8.8 cm from the pivot in order to restore the balance of the wire, as shown in Fig. 8.2.

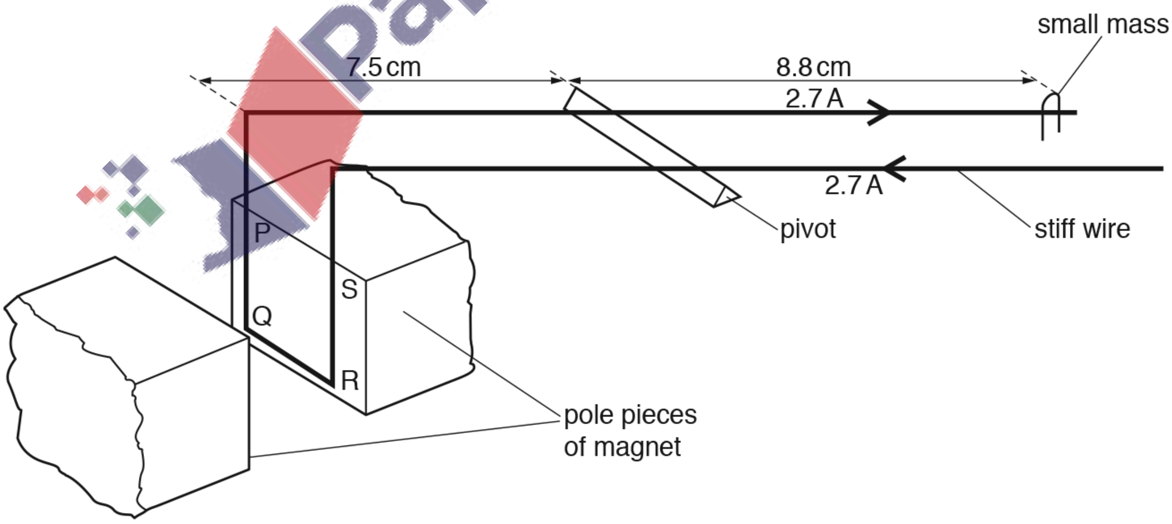

Fig. 8.2

(i) Explain why, when the current is switched on, the current in the sections PQ and RS of the wire does not affect the balance of the wire.

....

....

....[2]

(ii) The length of section QR of the wire is 1.2 cm.
Calculate the magnetic flux density *B*.

B = ... T [3]

[Total: 8]

258. 9702_w16_qp_42 Q: 9

A stiff wire is held horizontally between the poles of a magnet, as illustrated in Fig. 9.1.

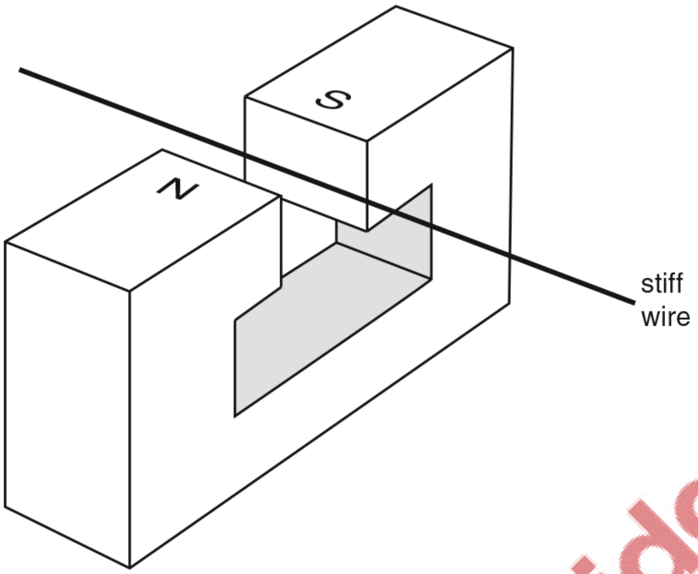

Fig. 9.1

When a constant current of 6.0 A is passed through the wire, there is an additional downwards force on the magnet of 0.080 N.

(a) On Fig. 9.1, draw an arrow on the wire to show the direction of the current in the wire. Explain your answer.

....

....

....

....[3]

(b) The constant current of 6.0 A is now replaced by a low-frequency sinusoidal current. The root-mean-square (r.m.s.) value of this current is 2.5 A.

Calculate the difference between the maximum and the minimum forces now acting on the magnet.

difference = ... N [4]

[Total: 7]

259. 9702_s21_qp_41 Q: 9

(a) State what is meant by a *magnetic field*.

....

....

.... [2]

(b) A rectangular piece of aluminium foil is situated in a uniform magnetic field of flux density B, as shown in Fig. 9.1.

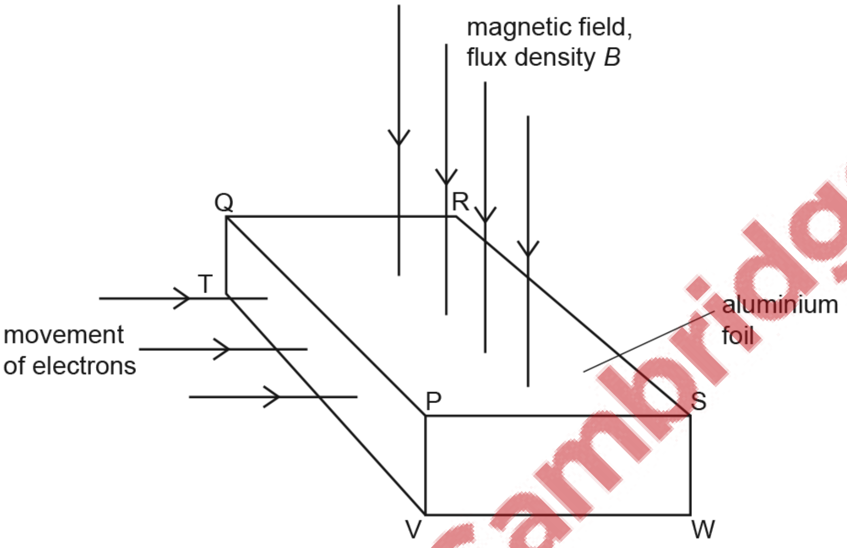

Fig. 9.1

The magnetic field is normal to the face PQRS of the foil.

Electrons, each of charge $-q$, enter the foil at right angles to the face PQTV.

(i) On Fig. 9.1, shade the face of the foil on which electrons initially accumulate. [1]

(ii) Explain why electrons do not continuously accumulate on the face you have shaded.

....

....

....

.... [3]

(c) The Hall voltage V_H developed across the foil in **(b)** is given by the expression

$$V_H = \frac{BI}{ntq}$$

where I is the current in the foil.

(i) State the meaning of the quantity n.

....

.... [1]

(ii) Using the letters on Fig. 9.1, identify the distance t.

.... [1]

(d) Suggest why, in practice, Hall probes are usually made using a semiconductor material rather than a metal.

....

.... [1]

[Total: 9]

260. 9702_s21_qp_42 Q: 8

(a) Define *magnetic flux density*.

....

....

.... [2]

(b) Electrons, each of mass m and charge q, are accelerated from rest in a vacuum through a potential difference V.

Derive an expression, in terms of m, q and V, for the final speed v of the electrons. Explain your working.

[2]

(c) The accelerated electrons in **(b)** are injected at point S into a region of uniform magnetic field of flux density B, as illustrated in Fig. 8.1.

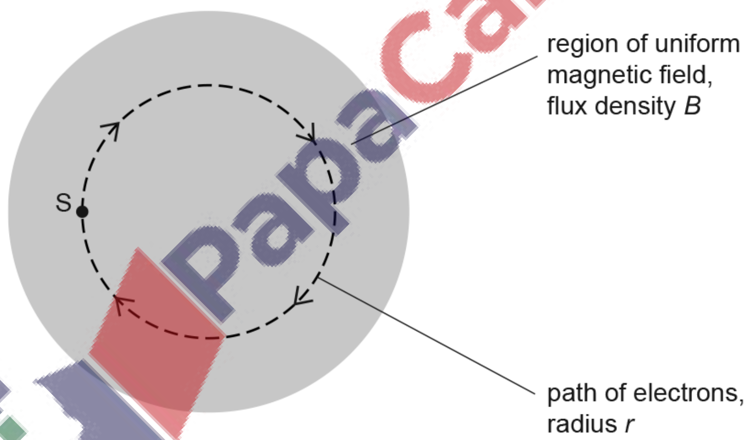

Fig. 8.1

The electrons move at right angles to the direction of the magnetic field. The path of the electrons is a circle of radius r.

(i) Show that the specific charge $\frac{q}{m}$ of the electrons is given by the expression

$$\frac{q}{m} = \frac{2V}{B^2 r^2}.$$

Explain your working.

[2]

(ii) Electrons are accelerated through a potential difference V of 230 V. The electrons are injected normally into the magnetic field of flux density 0.38 mT.
The radius r of the circular orbit of the electrons is 14 cm.

Use this information to calculate a value for the specific charge of an electron.

specific charge = ... C kg^{-1} [2]

(iii) Suggest why the arrangement outlined in **(ii)**, using the same values of B and V, is not practical for the determination of the specific charge of α-particles.

....

....

.... [2]

[Total: 10]

261. 9702_s21_qp_43 Q: 9

(a) State what is meant by a *magnetic field*.

....

....

.... [2]

(b) A rectangular piece of aluminium foil is situated in a uniform magnetic field of flux density B, as shown in Fig. 9.1.

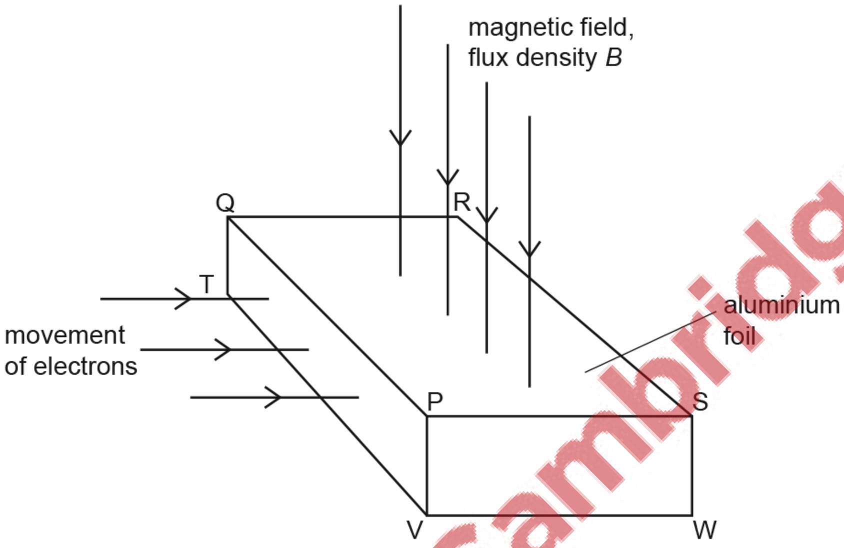

Fig. 9.1

The magnetic field is normal to the face PQRS of the foil.

Electrons, each of charge $-q$, enter the foil at right angles to the face PQTV.

(i) On Fig. 9.1, shade the face of the foil on which electrons initially accumulate. [1]

(ii) Explain why electrons do not continuously accumulate on the face you have shaded.

....

....

....

.... [3]

(c) The Hall voltage V_H developed across the foil in **(b)** is given by the expression

$$V_H = \frac{BI}{ntq}$$

where I is the current in the foil.

(i) State the meaning of the quantity *n*.

....

.... [1]

(ii) Using the letters on Fig. 9.1, identify the distance *t*.

.... [1]

(d) Suggest why, in practice, Hall probes are usually made using a semiconductor material rather than a metal.

....

.... [1]

[Total: 9]

262. 9702_m20_qp_42 Q: 8

(a) Explain what is meant by a *magnetic field*.

....

....

....

.... [1]

(b) The apparatus shown in Fig. 8.1 is used in an experiment to find the magnetic flux density *B* between the poles of a horseshoe magnet. Assume the magnetic field is uniform between the poles of the magnet and zero elsewhere.

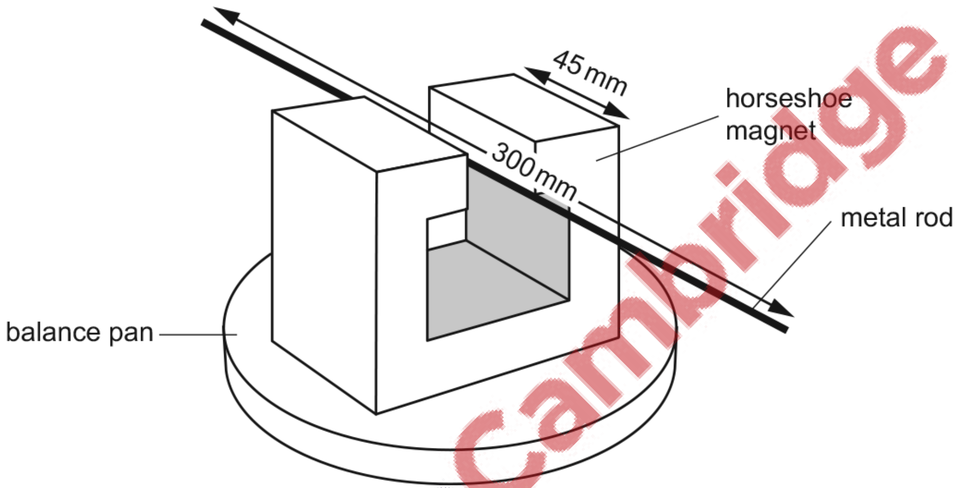

Fig. 8.1

The rigid metal rod of length 300 mm is fixed in position perpendicular to the direction of the magnetic field. The poles of the magnet are both 45 mm long. There is a current in the rod that causes a force on the rod. The balance is used to determine the magnitude of the force.

The variation with current *I* of the force *F* on the rod is shown in Fig. 8.2.

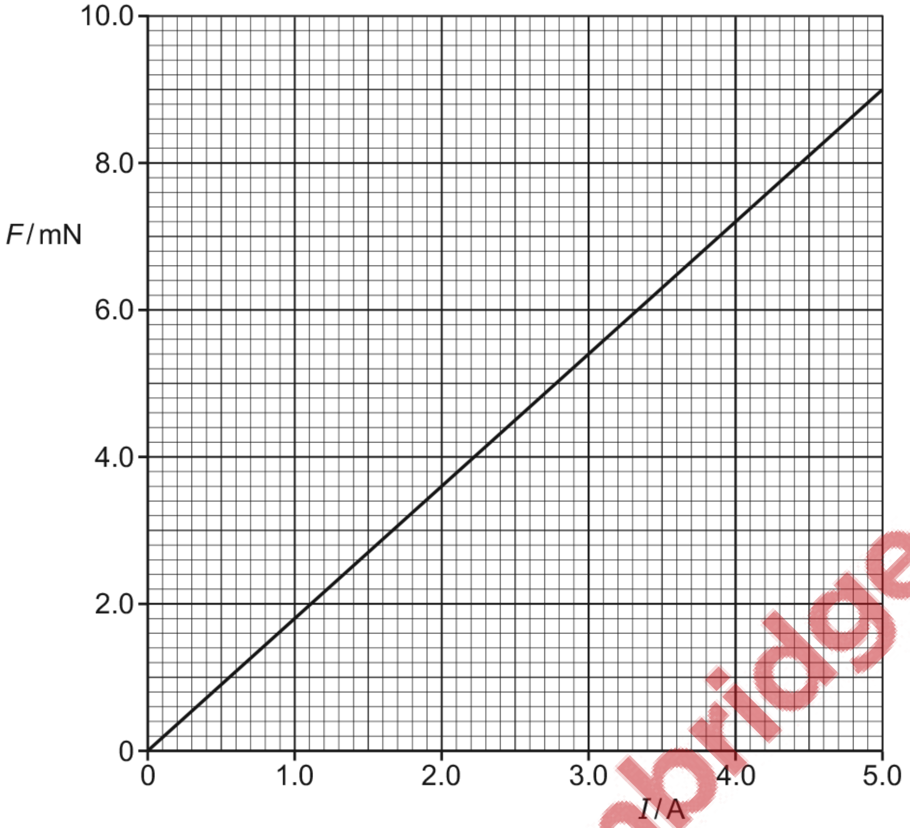

Fig. 8.2

Calculate the magnetic flux density B.

B = ... T [2]

(c) In a different experiment, electrons are accelerated through a potential difference and then enter a region of magnetic field. The magnetic field is into the plane of the paper and is perpendicular to the direction of travel of the electrons, as illustrated in Fig. 8.3.

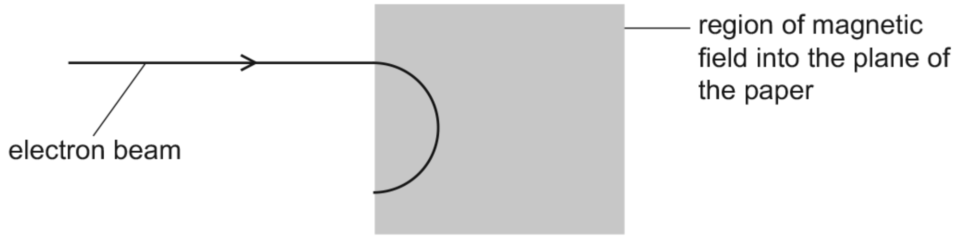

Fig. 8.3

(i) Explain why the electrons follow a circular path when inside the region of the magnetic field.

....

....

....

.... [3]

(ii) State the measurements needed in order to determine the charge to mass ratio, e/m_e, of an electron.

....

....

.... [2]

[Total: 8]

263. 9702_s20_qp_42 Q: 9

(a) An electron is travelling at speed *v* in a straight line in a vacuum. It enters a uniform magnetic field of flux density 8.0×10^{-4} T. Initially, the electron is travelling at right angles to the magnetic field, as illustrated in Fig. 9.1.

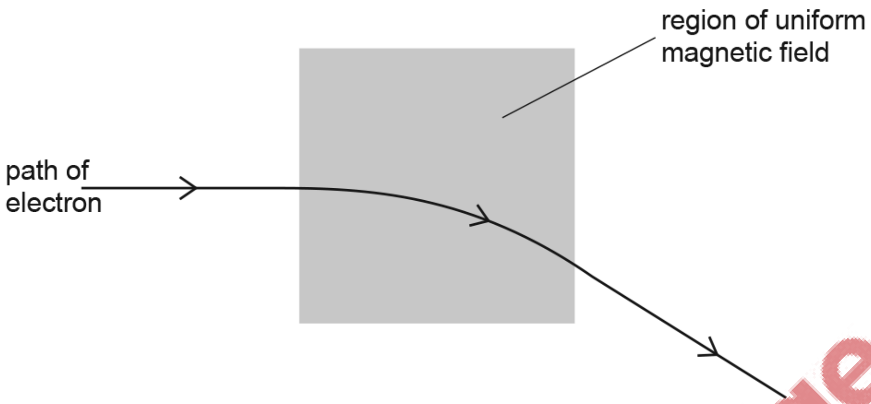

Fig. 9.1

The path of the electron in the magnetic field is an arc of a circle of radius 6.4 cm.

(i) State and explain the direction of the magnetic field.

....

....

.... [2]

(ii) Show that the speed *v* of the electron is $9.0 \times 10^{6}\,\text{m s}^{-1}$.

[3]

(b) A uniform electric field is now applied in the same region as the magnetic field.

The electron passes undeviated through the region of the two fields, as illustrated in Fig. 9.2.

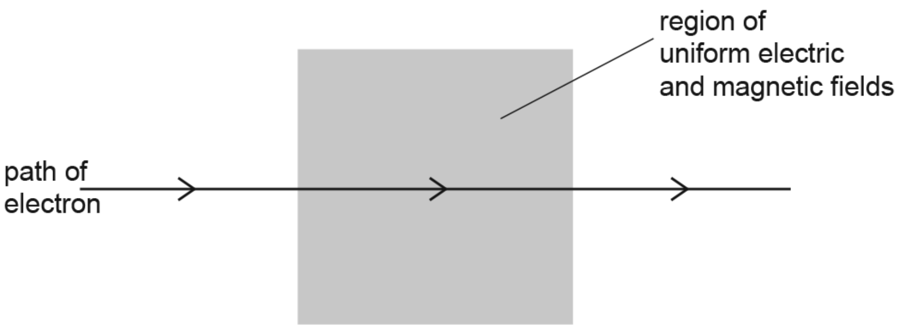

Fig. 9.2

(i) On Fig. 9.2, mark with an arrow the direction of the uniform electric field. [1]

(ii) Use data from **(a)** to calculate the magnitude of the electric field strength.

field strength = ... NC^{-1} [2]

(c) The electron in **(b)** is now replaced by an α-particle travelling at the same speed *v* along the same initial path as the electron.

Describe and explain the shape of the path in the region of the magnetic and electric fields.

....

....

.... [2]

[Total: 10]

264. 9702_s19_qp_42 Q: 8

An electron is travelling in a vacuum at a speed of $3.4 \times 10^7\,\text{m s}^{-1}$. The electron enters a region of uniform magnetic field of flux density 3.2 mT, as illustrated in Fig. 8.1.

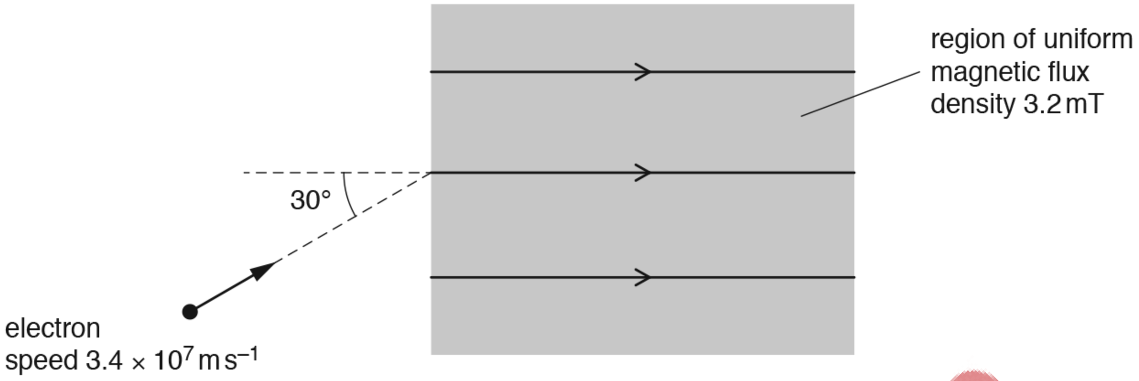

Fig. 8.1

The initial direction of the electron is at an angle of 30° to the direction of the magnetic field.

(a) When the electron enters the magnetic field, the component of its velocity v_N normal to the direction of the magnetic field causes the electron to begin to follow a circular path.

Calculate:

(i) v_N

v_N = ... m s^{-1} [1]

(ii) the radius of this circular path.

radius = ... m [3]

(b) State the magnitude of the force, if any, on the electron in the magnetic field due to the component of its velocity along the direction of the field.

....[1]

(c) Use information from **(a)** and **(b)** to describe the resultant path of the electron in the magnetic field.

....

....[1]

[Total: 6]

265. 9702_w19_qp_42 Q: 8

Electrons enter a rectangular slice PQRSEFGH of a semiconductor material at right-angles to face PQFE, as shown in Fig. 8.1.

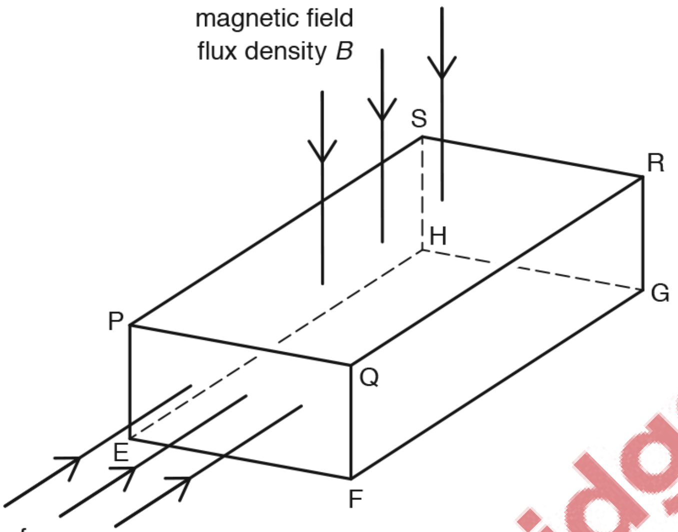

Fig. 8.1

A uniform magnetic field of flux density B is directed into the slice, at right-angles to face PQRS.

(a) The electrons each have charge $-q$ and drift speed v in the slice.

State the magnitude and the direction of the force due to the magnetic field on each electron as it enters the slice.

....

....

.... [2]

(b) The force on the electrons causes a voltage V_H to be established across the semiconductor slice given by the expression

$$V_H = \frac{BI}{ntq}$$

where I is the current in the slice.

(i) State the two faces between which the voltage V_H is established.

face .... and face .... [1]

(ii) Use letters from Fig. 8.1 to identify the distance t.

.... [1]

(c) Aluminium ($^{27}_{13}\text{A}l$) has a density of 2.7 g cm^{-3}. Assume that there is one free electron available to carry charge per atom of aluminium.

(i) Show that the number of charge carriers per unit volume in aluminium is 6.0×10^{28} m^{-3}.

[2]

(ii) A sample of aluminium foil has a thickness of 0.090 mm. The current in the foil is 4.6 A.

A uniform magnetic field of flux density 0.15 T acts at right-angles to the foil.

Use the value in **(i)** to calculate the voltage V_H that is generated.

V_H = ... V [2]

[Total: 8]

266. 9702_m18_qp_42 Q: 9

A thin slice of conducting material has its faces PQRS and VWXY normal to a uniform magnetic field of flux density B, as shown in Fig. 9.1.

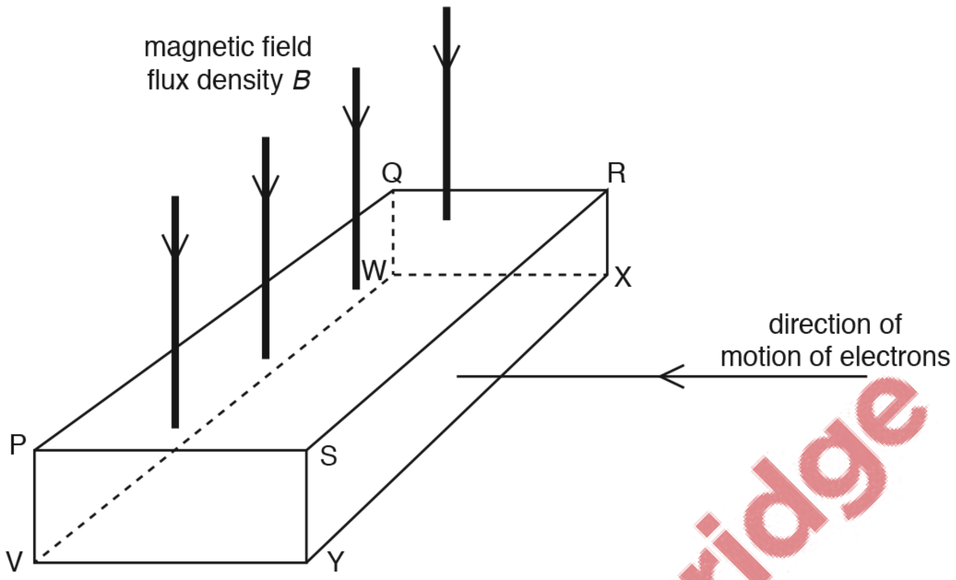

Fig. 9.1

Electrons enter the slice at right-angles to face SRXY.

A potential difference, the Hall voltage V_H, is developed between two faces of the slice.

(a) **(i)** Use letters from Fig. 9.1 to name the two faces between which the Hall voltage is developed.

.... and ....[1]

(ii) State and explain which of the two faces named in **(a)(i)** is the more positive.

....

....[2]

(b) The Hall voltage V_H is given by the expression

$$V_H = \frac{BI}{ntq}.$$

(i) Use the letters in Fig. 9.1 to identify the distance *t*.

....[1]

(ii) State the meaning of the symbol *n*.

....

....[1]

(iii) State and explain the effect, if any, on the polarity of the Hall voltage when negative charge carriers (electrons) are replaced with positive charge carriers, moving in the same direction towards the slice.

....

....

....[2]

[Total: 7]

---

267. 9702_s18_qp_42 Q: 8

(a) Explain how a uniform magnetic field and a uniform electric field may be used as a velocity selector for charged particles.

....

....

....

....[3]

(b) Particles having mass *m* and charge +1.6 × 10^{-19} C pass through a velocity selector. They then enter a region of uniform magnetic field of magnetic flux density 94 mT with speed 3.4 × 10^4 m s^{-1}, as shown in Fig. 8.1.

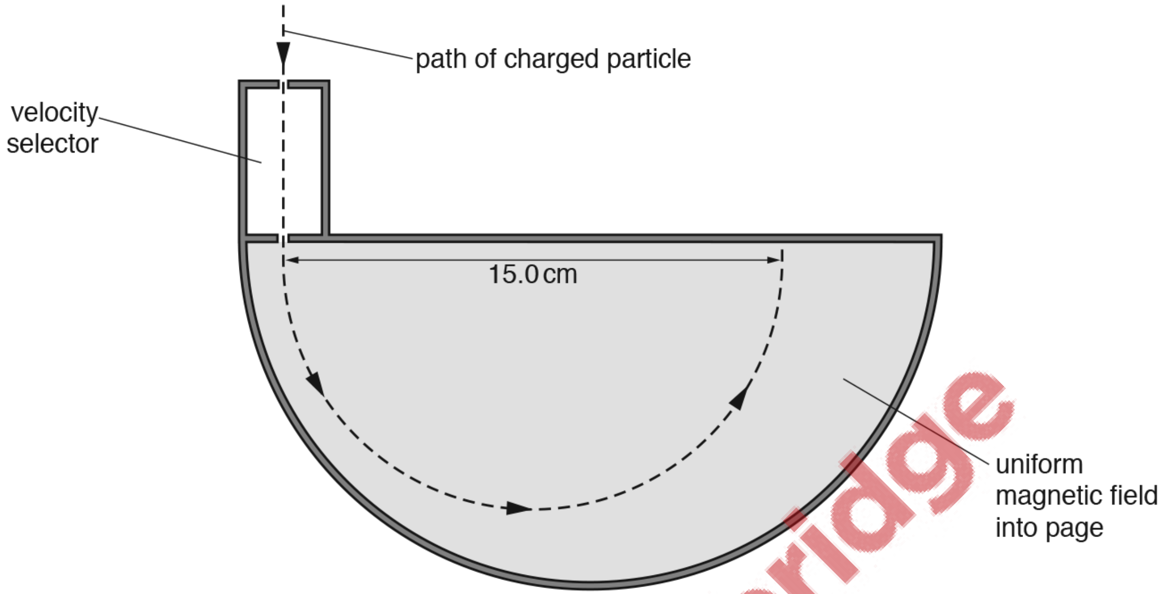

Fig. 8.1

The direction of the uniform magnetic field is into the page and normal to the direction in which the particles are moving.

The particles are moving in a vacuum in a circular arc of diameter 15.0 cm.

Show that the mass of one of the particles is 20 u.

[4]

(c) On Fig. 8.1, sketch the path in the uniform magnetic field of a particle of mass 22 u having the same charge and speed as the particle in **(b)**. [2]

[Total: 9]

268. 9702_w18_qp_41 Q: 8

(a) Explain what is meant by a *magnetic field*.

....

....

....[2]

(b) A particle has mass m, charge $+q$ and speed v.

The particle enters a uniform magnetic field of flux density B such that, on entry, it is moving normal to the magnetic field, as shown in Fig. 8.1.

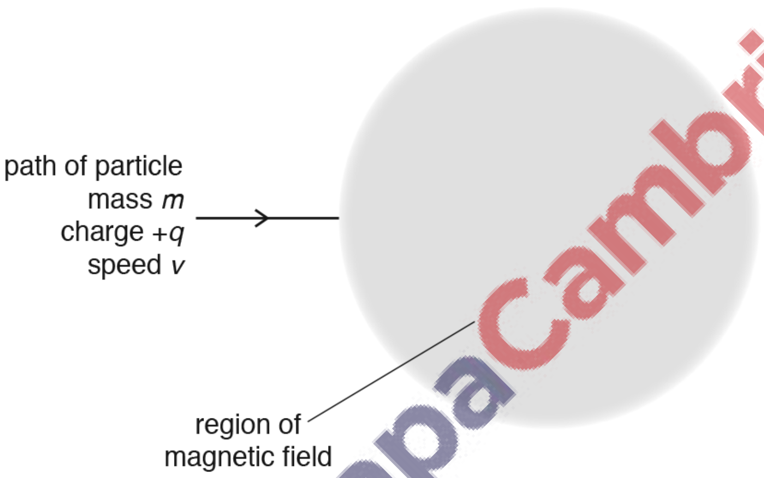

Fig. 8.1

The direction of the magnetic field is perpendicular to, and into, the plane of the paper.

(i) On Fig. 8.1, draw the path of the particle through, and beyond, the region of the magnetic field. [3]

(ii) There is a force acting on the particle, causing it to accelerate.
Explain why the speed of the particle on leaving the magnetic field is v.

....

....

....[1]

(c) The particle in **(b)** loses an electron so that its charge becomes $+2q$. Its change in mass is negligible.

Determine, in terms of v, the initial speed of the particle such that its path through the magnetic field is unchanged. Explain your working.

speed = ... [3]

[Total: 9]

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269. 9702_w18_qp_43 Q: 8

(a) Explain what is meant by a *magnetic field*.

....

....

....[2]

(b) A particle has mass *m*, charge +*q* and speed *v*.

The particle enters a uniform magnetic field of flux density *B* such that, on entry, it is moving normal to the magnetic field, as shown in Fig. 8.1.

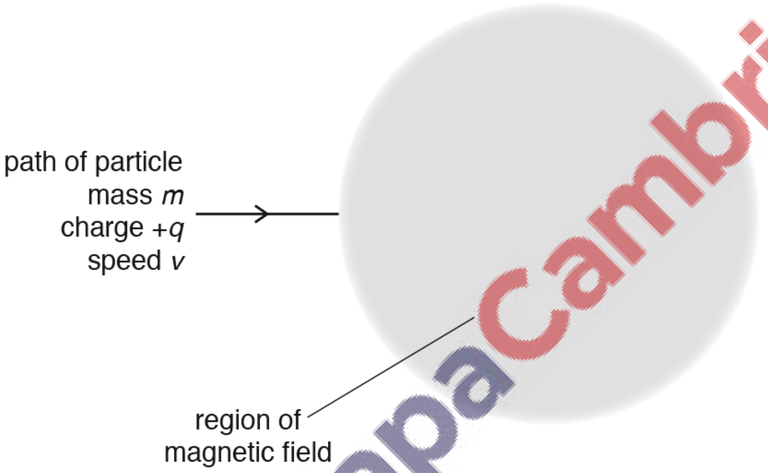

Fig. 8.1

The direction of the magnetic field is perpendicular to, and into, the plane of the paper.

(i) On Fig. 8.1, draw the path of the particle through, and beyond, the region of the magnetic field. [3]

(ii) There is a force acting on the particle, causing it to accelerate.
Explain why the speed of the particle on leaving the magnetic field is *v*.

....

....

....[1]

(c) The particle in **(b)** loses an electron so that its charge becomes +2*q*. Its change in mass is negligible.

Determine, in terms of *v*, the initial speed of the particle such that its path through the magnetic field is unchanged. Explain your working.

speed = ... [3]

[Total: 9]

270. 9702_m17_qp_42 Q: 8

(a) State what is meant by a *magnetic field*.

....

....

....[2]

(b) A particle of charge $+q$ and mass m is travelling in a vacuum with speed v. The particle enters, at a right angle, a uniform magnetic field of flux density B, as shown in Fig. 8.1.

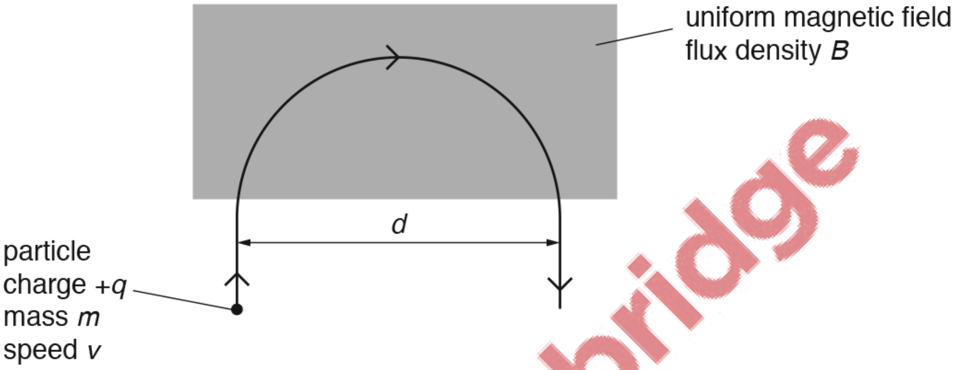

Fig. 8.1

The particle leaves the field after following a semi-circular path of diameter d.

(i) State the direction of the magnetic field.

....[1]

(ii) Explain why the speed of the particle is not affected by the magnetic field.

....

....

....[2]

(iii) Show that the diameter d of the semi-circular path is given by the expression

$$d = \frac{2mv}{Bq}.$$

[2]

(iv) Use the expression in **(b)(iii)** to show that the time T_F spent in the field by the particle is independent of its speed v.

[2]

[Total: 9]

---

271. 9702_s17_qp_41 Q: 7

An electron having charge $-q$ and mass m is accelerated from rest in a vacuum through a potential difference V.
The electron then enters a region of uniform magnetic field of magnetic flux density B, as shown in Fig. 7.1.

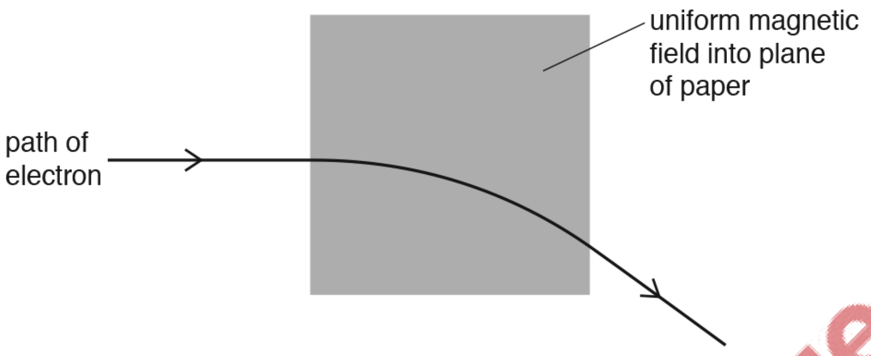

Fig. 7.1

The direction of the uniform magnetic field is into the plane of the paper.
The velocity of the electron as it enters the magnetic field is normal to the magnetic field.
The radius of the circular path of the electron in the magnetic field is r.

(a) Explain why the path of the electron in the magnetic field is the arc of a circle.

....

....

....

....[3]

(b) Show that the magnitude p of the momentum of the electron as it enters the magnetic field is given by

$$p = \sqrt{(2mqV)}.$$

[2]

(c) The potential difference *V* is 120 V. The radius *r* of the circular arc is 7.4 cm.

Determine the magnitude *B* of the magnetic flux density.

B = ... T [3]

(d) The potential difference *V* in **(c)** is increased. The magnetic flux density *B* remains unchanged.

By reference to the momentum of the electron, explain the effect of this increase on the radius *r* of the path of the electron in the magnetic field.

....

....

....[2]

[Total: 10]

272. 9702_s17_qp_42 Q: 9

A Hall probe is placed near to one end of a current-carrying solenoid, as shown in Fig. 9.1.

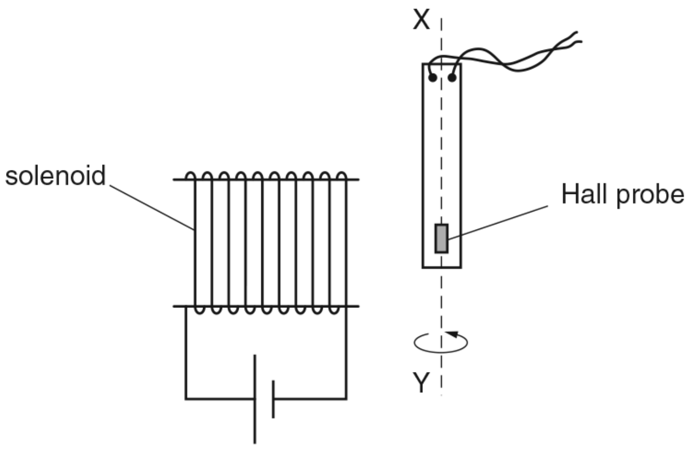

Fig. 9.1

The probe is rotated about the axis XY and is then held in a position so that the Hall voltage is maximum.

(a) Explain why

(i) a Hall probe is made from a *thin slice* of material,

....

....

.... [2]

(ii) in order for consistent measurements of magnetic flux density to be made, the current in the probe must be constant.

....

.... [1]

(b) The probe is now rotated through an angle of 360° about the axis XY.
At angle $\theta = 0$, the Hall voltage V_H has maximum value V_{MAX}.

On Fig. 9.2, sketch the variation with angle θ of the Hall voltage V_H for one complete revolution of the probe about axis XY.

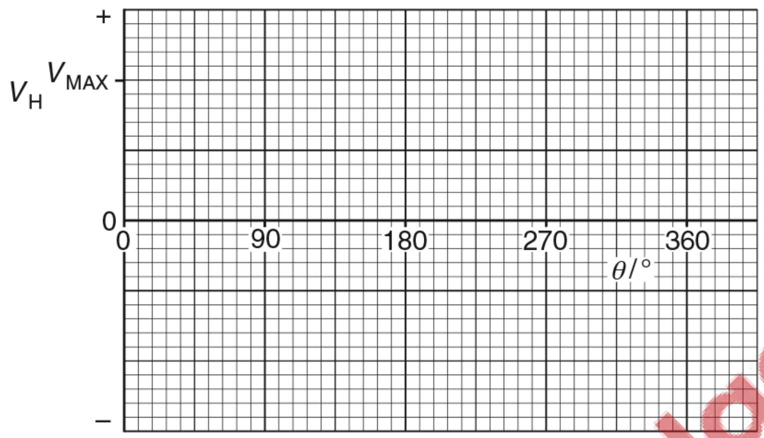

Fig. 9.2

[3]

[Total: 6]

273. 9702_s17_qp_43 Q: 7

An electron having charge $-q$ and mass m is accelerated from rest in a vacuum through a potential difference V.
The electron then enters a region of uniform magnetic field of magnetic flux density B, as shown in Fig. 7.1.

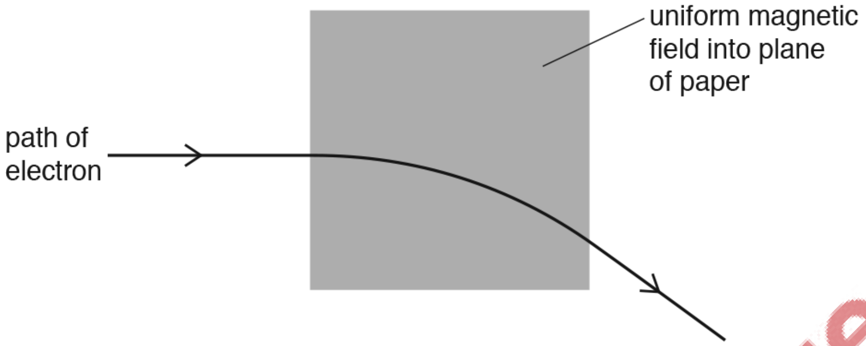

Fig. 7.1

The direction of the uniform magnetic field is into the plane of the paper.
The velocity of the electron as it enters the magnetic field is normal to the magnetic field.
The radius of the circular path of the electron in the magnetic field is r.

(a) Explain why the path of the electron in the magnetic field is the arc of a circle.

....

....

....

....[3]

(b) Show that the magnitude p of the momentum of the electron as it enters the magnetic field is given by

$$p = \sqrt{(2mqV)}.$$

[2]

(c) The potential difference *V* is 120 V. The radius *r* of the circular arc is 7.4 cm.

Determine the magnitude *B* of the magnetic flux density.

B = ... T [3]

(d) The potential difference *V* in **(c)** is increased. The magnetic flux density *B* remains unchanged.

By reference to the momentum of the electron, explain the effect of this increase on the radius *r* of the path of the electron in the magnetic field.

....

....

....[2]

[Total: 10]

274. 9702_w17_qp_41 Q: 8

A thin slice of conducting material is placed normal to a uniform magnetic field of flux density B, as shown in Fig. 8.1.

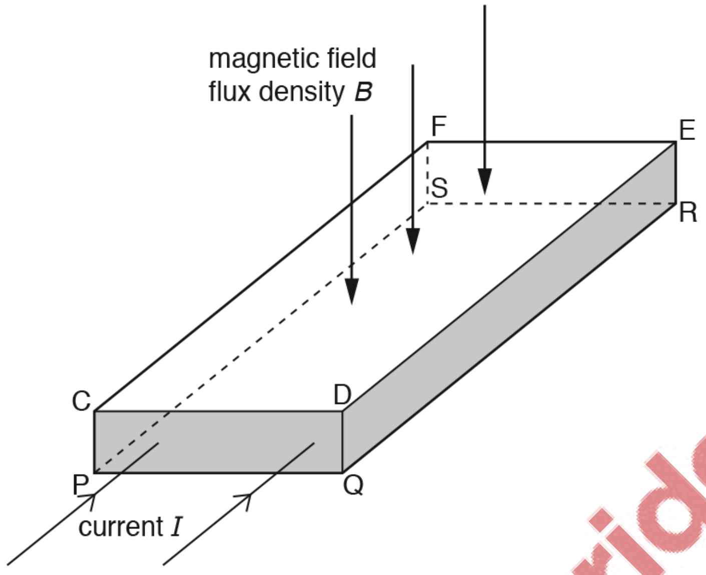

Fig. 8.1

The magnetic field is normal to face CDEF and to face PQRS.

A current I passes through the slice and is normal to the faces CDQP and FERS.

A potential difference, the Hall voltage V_H, is developed across the slice.

(a) State the faces between which the Hall voltage V_H is developed.

.... and .... [1]

(b) The current I is produced by charge carriers, each of charge $+q$ moving at speed v in the direction of the current. The number density of the charge carriers is n.

(i) Derive an expression relating the Hall voltage V_H to v, B and d, where d is one of the dimensions of the slice.

[3]

(ii) Use your answer in **(b)(i)** and an expression for the current I in the slice to derive the expression

$$V_H = \frac{BI}{ntq}.$$

Explain your working.

[2]

(c) Suggest why the Hall voltage is difficult to detect in a thin slice of copper.

....

....

.... [2]

[Total: 8]

275. 9702_w17_qp_42 Q: 8

A thin slice of conducting material is placed normal to a uniform magnetic field, as shown in Fig. 8.1.

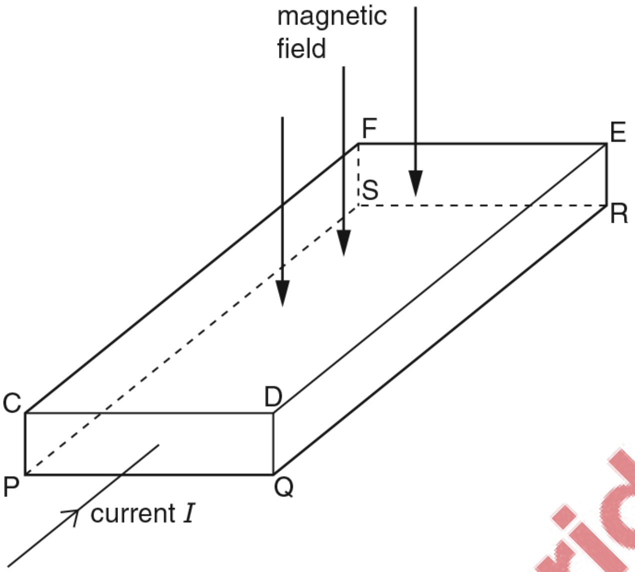

Fig. 8.1

The magnetic field is normal to face CDEF and to face PQRS.

The current I in the slice is normal to the faces CDQP and FERS.

A potential difference, the Hall voltage V_H, is developed across the slice.

(a) **(i)** State the faces between which the Hall voltage V_H is developed.

.... and .... [1]

(ii) Explain why a constant voltage V_H is developed between the faces you have named in **(i)**.

....

....

....

....

....

....

....[4]

(b) Two slices have similar dimensions. One slice is made of a metal and the other slice is made of a semiconductor material.

For the same values of magnetic flux density and current, state which slice, if either, will give rise to the larger Hall voltage. Explain your reasoning.

....

....

....

....[2]

[Total: 7]

---

276. 9702_w17_qp_42 Q: 9

(a) State what is meant by a *field of force*.

....

....

....[2]

(b) Explain the use of a uniform magnetic field and a uniform electric field for the selection of the velocity of charged particles. You may draw a diagram if you wish.

....

....

....

....

....

....[4]

(c) A beam of charged particles enters a region of uniform magnetic and electric fields, as illustrated in Fig. 9.1.

Fig. 9.1

The direction of the magnetic field is into the plane of the paper. The velocity of the charged particles is normal to the magnetic field as the particles enter the field.

A particle in the beam has mass *m*, charge +*q* and velocity *v*. The particle passes undeviated through the region of the two fields.

On Fig. 9.1, sketch the path of a particle that has

(i) mass *m*, charge +2*q* and velocity *v* (label this path Q), [1]

(ii) mass *m*, charge +*q* and velocity slightly larger than *v* (label this path V). [2]

[Total: 9]

277. 9702_w17_qp_43 Q: 8

A thin slice of conducting material is placed normal to a uniform magnetic field of flux density *B*, as shown in Fig. 8.1.

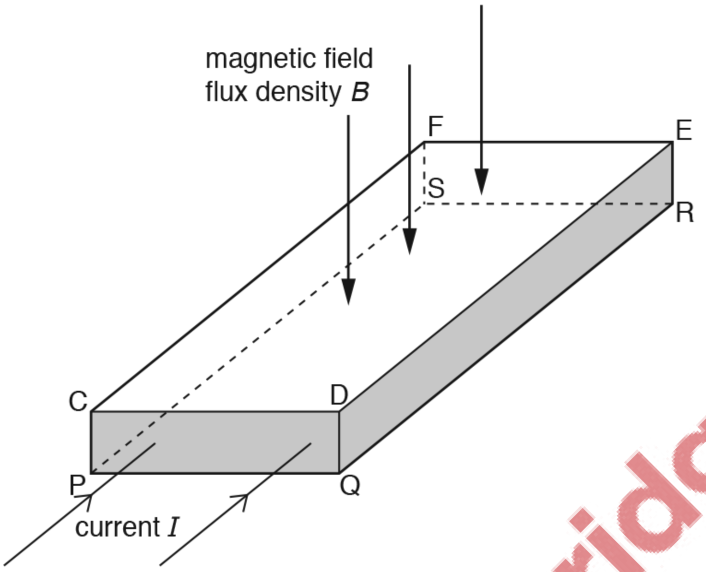

Fig. 8.1

The magnetic field is normal to face CDEF and to face PQRS.

A current I passes through the slice and is normal to the faces CDQP and FERS.

A potential difference, the Hall voltage V_H, is developed across the slice.

(a) State the faces between which the Hall voltage V_H is developed.

.... and .... [1]

(b) The current I is produced by charge carriers, each of charge $+q$ moving at speed v in the direction of the current. The number density of the charge carriers is n.

(i) Derive an expression relating the Hall voltage V_H to v, B and d, where d is one of the dimensions of the slice.

[3]

(ii) Use your answer in **(b)(i)** and an expression for the current I in the slice to derive the expression

$$V_H = \frac{BI}{ntq}.$$

Explain your working.

[2]

(c) Suggest why the Hall voltage is difficult to detect in a thin slice of copper.

....

....

.... [2]

[Total: 8]

278. 9702_w16_qp_41 Q: 7

(a) Explain what is meant by a *field of force*.

....

.... [1]

(b) State the type of field, or fields, that will give rise to a force acting on

(i) a moving uncharged particle,

.... [1]

(ii) a stationary charged particle,

.... [1]

(iii) a charged particle moving at an angle to the field or fields.

....

.... [1]

(c) An electron, mass m and charge $-q$, is moving at speed v in a vacuum. It enters a region of uniform magnetic field of flux density B, as shown in Fig. 7.1.

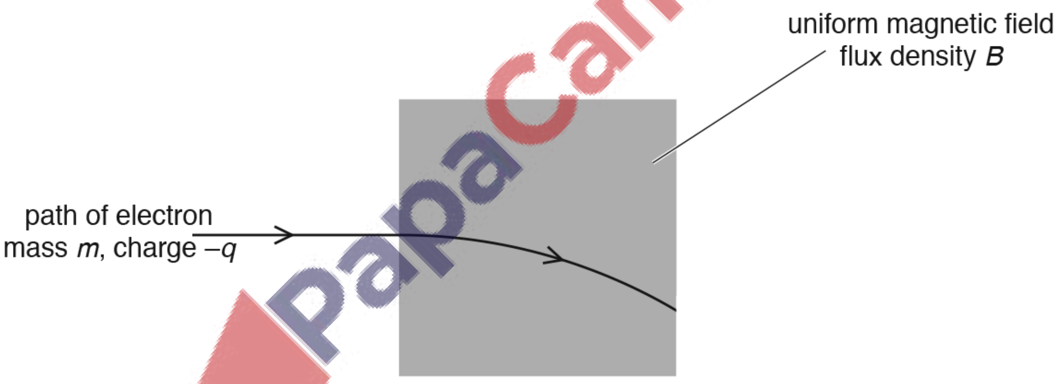

Fig. 7.1

Initially, the electron is moving at right-angles to the direction of the magnetic field.

(i) Explain why the path of the electron in the magnetic field is the arc of a circle.

....

....

....

....

.... [3]

(ii) Derive an expression, in terms of the radius *r* of the path, for the linear momentum of the electron. Show your working.

[2]

[Total: 9]

279. 9702_w16_qp_43 Q: 7

(a) Explain what is meant by a *field of force*.

....

.... [1]

(b) State the type of field, or fields, that will give rise to a force acting on

(i) a moving uncharged particle,

.... [1]

(ii) a stationary charged particle,

.... [1]

(iii) a charged particle moving at an angle to the field or fields.

....

.... [1]

(c) An electron, mass m and charge $-q$, is moving at speed v in a vacuum. It enters a region of uniform magnetic field of flux density B, as shown in Fig. 7.1.

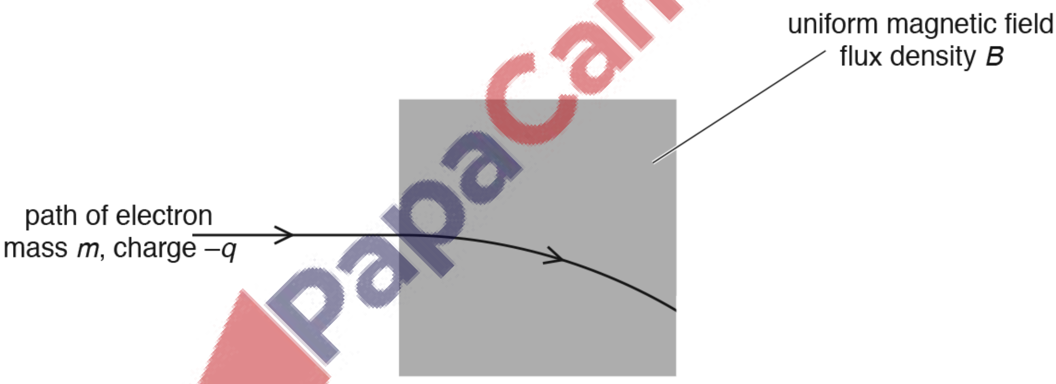

Fig. 7.1

Initially, the electron is moving at right-angles to the direction of the magnetic field.

(i) Explain why the path of the electron in the magnetic field is the arc of a circle.

....

....

....

....

.... [3]

(ii) Derive an expression, in terms of the radius *r* of the path, for the linear momentum of the electron. Show your working.

[2]

[Total: 9]

280. 9702_w21_qp_42 Q: 8

Two long straight parallel wires P and Q carry currents into the plane of the paper, as shown in Fig. 8.1.

Fig. 8.1

The current in P is I and the current in Q is $2I$.

(a) **(i)** On Fig. 8.1, draw an arrow to show the direction of the magnetic field at wire Q due to the current in wire P. Label this arrow B. [1]

(ii) On Fig. 8.1, draw another arrow to show the direction of the force acting on wire Q due to the current in wire P. Label this arrow F. [1]

(b) **(i)** State, with a reason, how the magnitude of the force acting on wire P compares with the magnitude of the force acting on wire Q.

....

....

....

.... [2]

(ii) State how the direction of the force on wire P compares with the direction of the force on wire Q.

....

.... [1]

[Total: 5]

281. 9702_w19_qp_41 Q: 8

(a) A long straight vertical wire carries a current I. The wire passes through a horizontal card EFGH, as shown in Fig. 8.1 and Fig. 8.2.

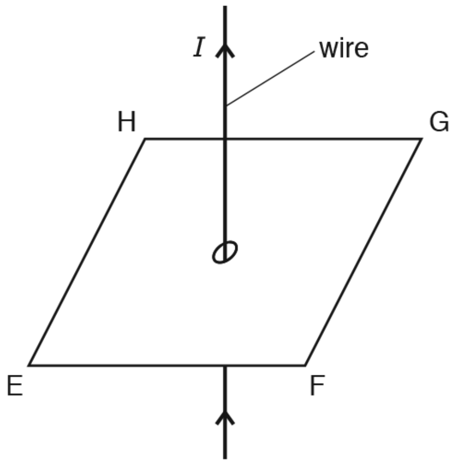

Fig. 8.1

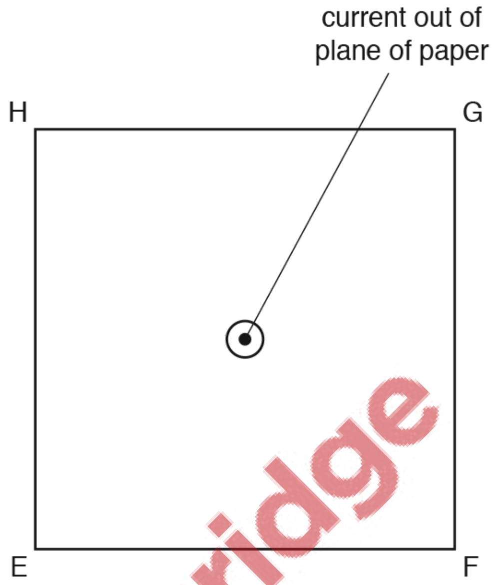

Fig. 8.2 (view from above)

On Fig. 8.2, draw the pattern of the magnetic field produced by the current-carrying wire on the plane EFGH. [3]

(b) Two long straight parallel wires P and Q are situated a distance 3.1 cm apart, as illustrated in Fig. 8.3.

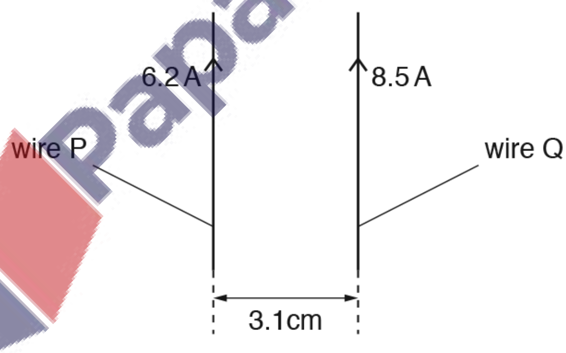

Fig. 8.3

The current in wire P is 6.2 A. The current in wire Q is 8.5 A.

The magnetic flux density B at a distance x from a long straight wire carrying current I is given by the expression

$$B = \frac{\mu_0 I}{2\pi x}$$

where μ_0 is the permeability of free space.

Calculate:

(i) the magnetic flux density at wire Q due to the current in wire P

flux density = ... T [2]

(ii) the force per unit length, in $N\,m^{-1}$, acting on wire Q due to the current in wire P.

force per unit length = ... $N\,m^{-1}$ [2]

(c) The currents in wires P and Q are different in magnitude.

State and explain whether the forces per unit length on the two wires will be different.

....

....

.... [2]

[Total: 9]

282. 9702_w19_qp_43 Q: 8

(a) A long straight vertical wire carries a current I. The wire passes through a horizontal card EFGH, as shown in Fig. 8.1 and Fig. 8.2.

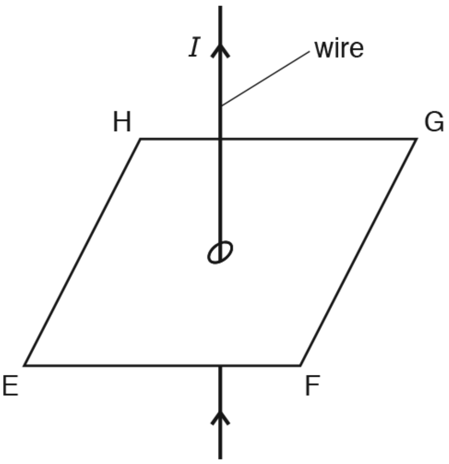

Fig. 8.1

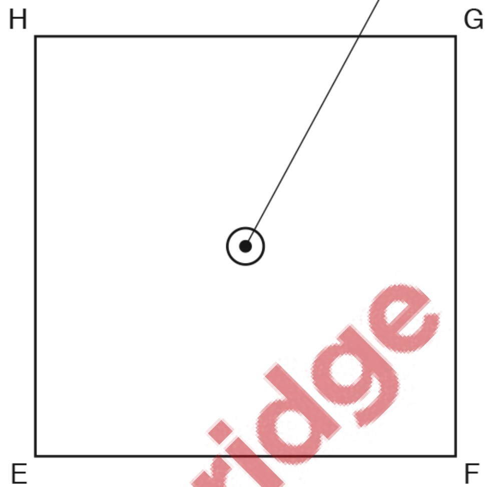

Fig. 8.2 (view from above)

On Fig. 8.2, draw the pattern of the magnetic field produced by the current-carrying wire on the plane EFGH. [3]

(b) Two long straight parallel wires P and Q are situated a distance 3.1 cm apart, as illustrated in Fig. 8.3.

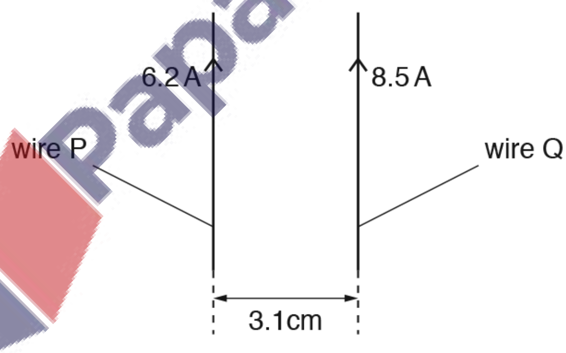

Fig. 8.3

The current in wire P is 6.2 A. The current in wire Q is 8.5 A.

The magnetic flux density B at a distance x from a long straight wire carrying current I is given by the expression

$$B = \frac{\mu_0 I}{2\pi x}$$

where μ_0 is the permeability of free space.

Calculate:

(i) the magnetic flux density at wire Q due to the current in wire P

flux density = ... T [2]

(ii) the force per unit length, in N m^{-1}, acting on wire Q due to the current in wire P.

force per unit length = ... N m^{-1} [2]

(c) The currents in wires P and Q are different in magnitude.

State and explain whether the forces per unit length on the two wires will be different.

....

....

.... [2]

[Total: 9]

283. 9702_m21_qp_42 Q: 8

Two long straight wires P and Q are parallel to each other, as shown in Fig. 8.1. There is a current in each wire in the direction shown.

The pattern of the magnetic field lines in a plane normal to wire P due to the current in the wire is also shown.

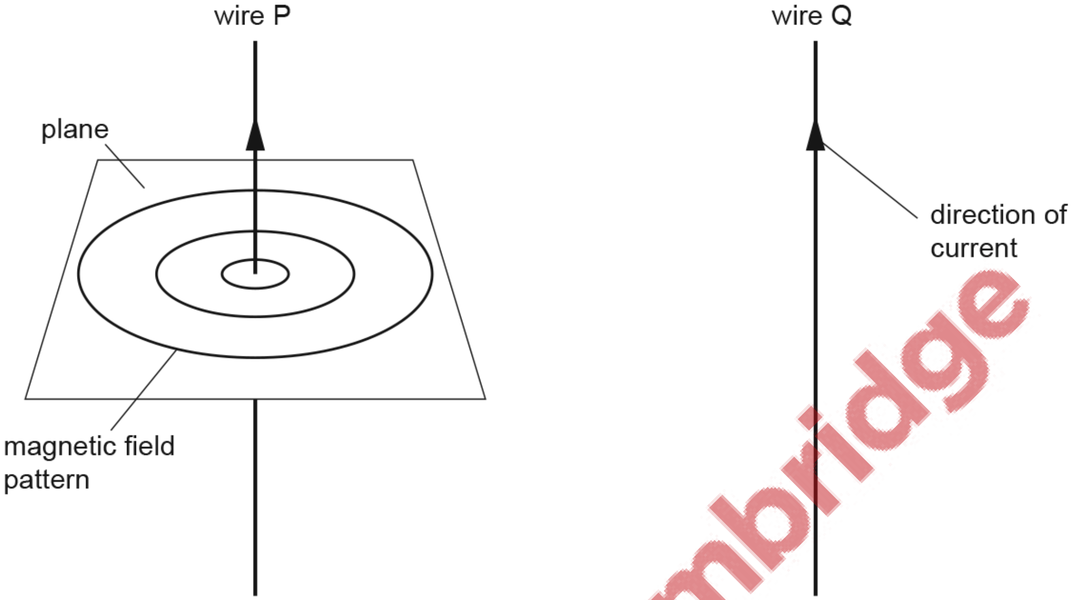

Fig. 8.1

(i) Draw arrows on the magnetic field lines in Fig. 8.1 around wire P to show the direction of the field. [1]

(ii) Determine the direction of the force on wire Q due to the magnetic field from wire P.

.... [1]

(iii) The current in wire Q is less than the current in wire P.

State and explain whether the magnitude of the force on wire P is less than, equal to, or greater than the magnitude of the force on wire Q.

....

....

.... [2]

(b) Nuclear magnetic resonance imaging (NMRI) is used to obtain diagnostic information about internal structures in the human body.

Radio waves are produced and directed towards the body. The radio waves affect the protons within the body.

(i) Explain why radio waves are used.

....

....

.... [2]

(ii) Explain why the radio waves are applied in pulses.

....

....

.... [2]

[Total: 8]

284. 9702_s19_qp_41 Q: 9

Nuclear magnetic resonance imaging (NMRI) is used to obtain diagnostic information about internal body structures.

State, during the use of NMRI, the function of:

(a) the large constant magnetic field

....

....

....

....

.... [3]

(b) the non-uniform magnetic field.

....

....

....

....

.... [2]

[Total: 5]

285. 9702_s19_qp_43 Q: 9

Nuclear magnetic resonance imaging (NMRI) is used to obtain diagnostic information about internal body structures.

State, during the use of NMRI, the function of:

(a) the large constant magnetic field

....

....

....

....

.... [3]

(b) the non-uniform magnetic field.

....

....

....

....

.... [2]

[Total: 5]

286. 9702_w19_qp_41 Q: 9

Diagnosis using nuclear magnetic resonance imaging (NMRI) requires the use of a non-uniform magnetic field superimposed on a constant magnetic field of large magnitude.

Explain the purpose of:

(a) the large constant magnetic field

....

....

....

....

.... [2]

(b) the non-uniform magnetic field.

....

....

....

....

.... [2]

[Total: 4]

287. 9702_w19_qp_43 Q: 9

Diagnosis using nuclear magnetic resonance imaging (NMRI) requires the use of a non-uniform magnetic field superimposed on a constant magnetic field of large magnitude.

Explain the purpose of:

(a) the large constant magnetic field

....

....

....

....

.... [2]

(b) the non-uniform magnetic field.

....

....

....

....

.... [2]

[Total: 4]

288. 9702_s17_qp_41 Q: 8

Explain the main principles behind the use of nuclear magnetic resonance imaging (NMRI) to obtain information about internal body structures.

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....[8]

[Total: 8]

289. 9702_s17_qp_43 Q: 8

Explain the main principles behind the use of nuclear magnetic resonance imaging (NMRI) to obtain information about internal body structures.

....

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....[8]

[Total: 8]

290. 9702_w16_qp_41 Q: 8

Explain the main principles behind the use of nuclear magnetic resonance imaging (NMRI) to obtain diagnostic information about internal body structures.

....

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....

.... [8]

[Total: 8]

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291. 9702_w16_qp_42 Q: 10

Explain the function of the non-uniform magnetic field that is superimposed on a large uniform magnetic field in diagnosis using nuclear magnetic resonance imaging (NMRI).

....

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292. 9702_w16_qp_43 Q: 8

Explain the main principles behind the use of nuclear magnetic resonance imaging (NMRI) to obtain diagnostic information about internal body structures.

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