Fields

Revised AH Physics 2013

11. In a nuclear power station liquid sodium is used to cool parts of the reactor. An electromagnetic pump keeps the coolant circulating. The sodium enters a perpendicular magnetic field and an electric current, I, passes through it. A force is experienced by the sodium causing it to flow in the direction shown in Figure 11.

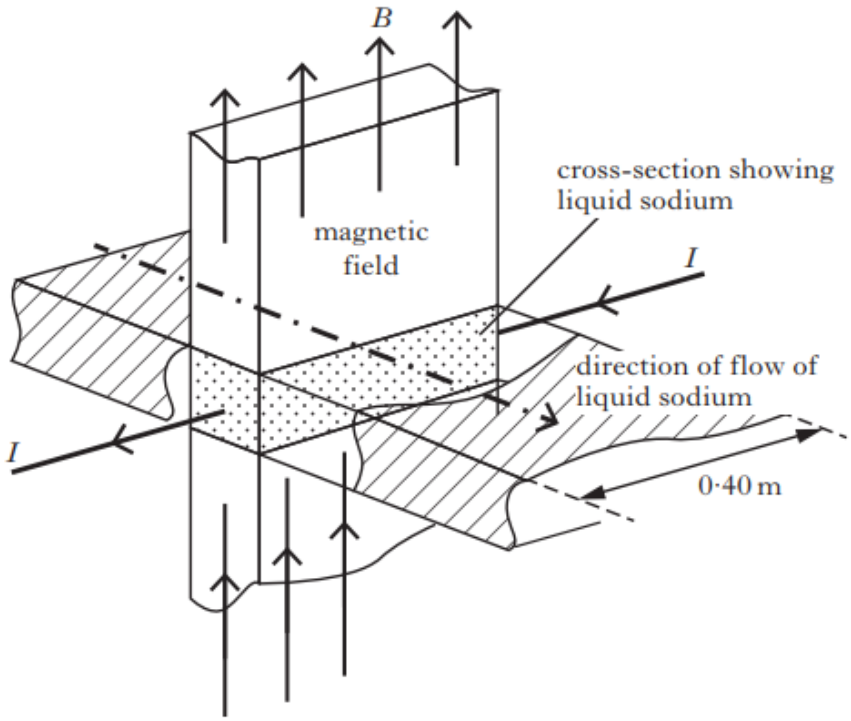

Figure 11

The magnetic induction B is 0·20 T. The current I in the sodium is 2·5 A and is perpendicular to the magnetic field.

(*a*) Calculate the force acting on the 0·40 m length of sodium within the magnetic field. **2**

(*b*) The pump is moved during maintenance and as a result the direction of the magnetic field is changed so that it is no longer perpendicular to the current. What effect does this have on the rate of flow of sodium passing through the pump?

You **must** justify your answer. **2**

(*c*) An engineer must install a long, straight, current carrying wire close to the pump and is concerned that the magnetic induction produced may interfere with the safe working of the pump.

The wire is 750 mm from the pump and carries a current of 0·60 A.

Show by calculation that the magnetic induction at this distance is negligible. **2**

(6)

Marks

12. A student is investigating the electrical potential around a point charge Q. Point P is at a distance of (0·65 ± 0·02) m from Q as shown in Figure 12. The potential at point P is (2·1 ± 0·1) V.

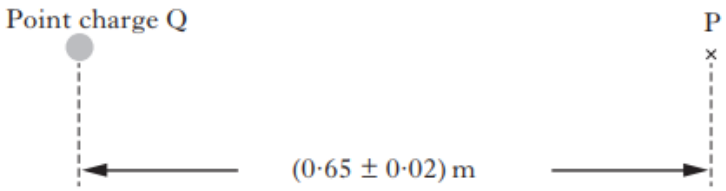

Figure 12

(*a*) Calculate the value of the point charge Q. **2**

(*b*) Calculate the absolute uncertainty in the charge. **2**

(4)

Revised AH Physics 2014

12. Two students conduct a series of experiments to investigate electric and magnetic fields.

The students measure the electric field around a positive point charge Q. They measure the electric field strength E and the electric potential V at points X and Y as shown in Figure 12A.

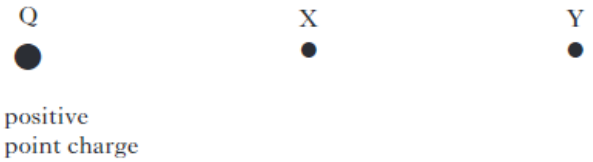

Figure 12A

The results of one set of measurements are shown in the table.

	X	Y
E / N C^{-1}	3·6	
V / V	7·2	3·6

(*a*) The first student predicts that the electric field strength at Y will be 1·8 N C^{-1}, the second predicts it will be 0·9 N C^{-1}.

Which student has made the correct prediction?

You must justify your answer. **2**

12. (continued)

(*b*) In a second experiment a magnetised iron rod is placed into a coil of wire as shown in Figure 12B.

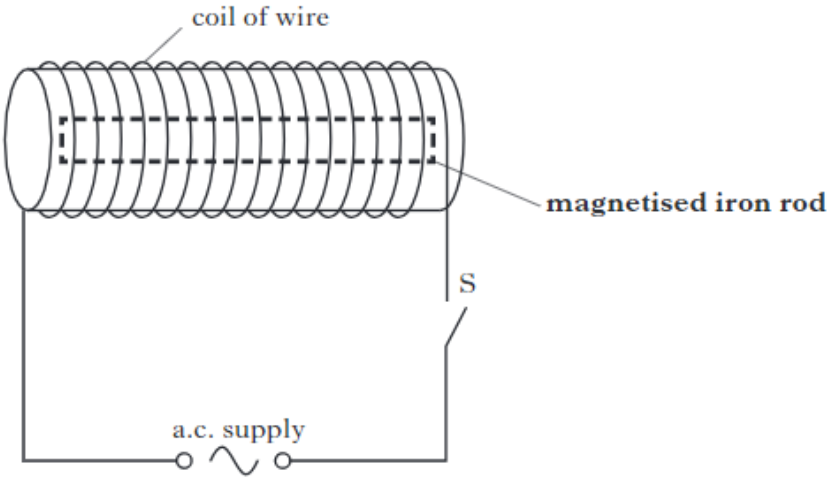

Figure 12B

Switch S is closed for a short time, passing an alternating current through the coil.

State the effect on the iron rod's magnetic field.

You must justify your answer. **3**

(5)

10. (*a*) A teacher investigates the electric field between two parallel metal plates X and Y using the apparatus shown in Figure 10A.

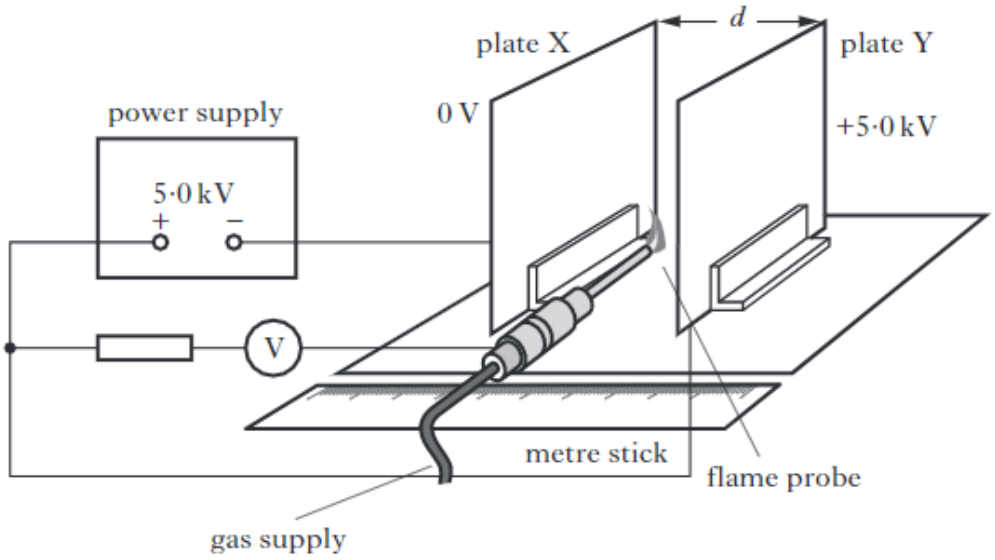

Figure 10A

The plates are connected to a 5·0 kV supply and are separated by a distance *d*.

A calibrated flame probe and voltmeter measure the potential relative to plate X. The probe is placed at different points between the plates. The distance from plate X and the potential at each point are measured.

The results are used to plot the graph shown in Figure 10B.

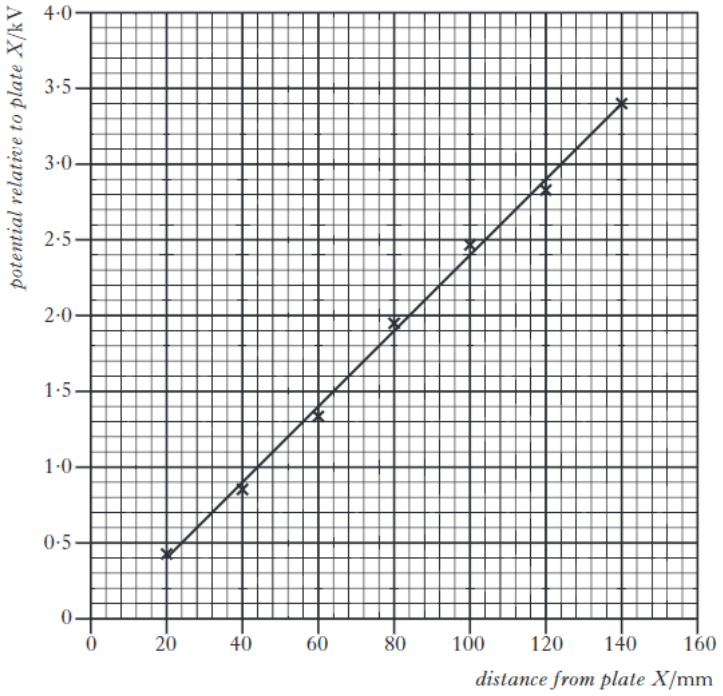

Figure 10B

(i) The electric field strength in the region between the plates is considered to be uniform. Explain the meaning of the term *uniform electric field*. **1**

(ii) Using information from the graph, determine the electric field strength between the plates. **2**

(iii) Calculate the separation *d* of the plates. **2**

(iv) In theory the best fit line for this graph should pass through the origin. Suggest why the line on the graph in Figure 10B does not pass through the origin. **1**

(*b*) In an experiment to investigate the deflection of alpha particles in an electric field a potential difference is applied across two parallel metal plates.

An alpha particle moving horizontally enters the region between the plates.

The alpha particle is deflected vertically by a distance *s* as shown in Figure 10C.

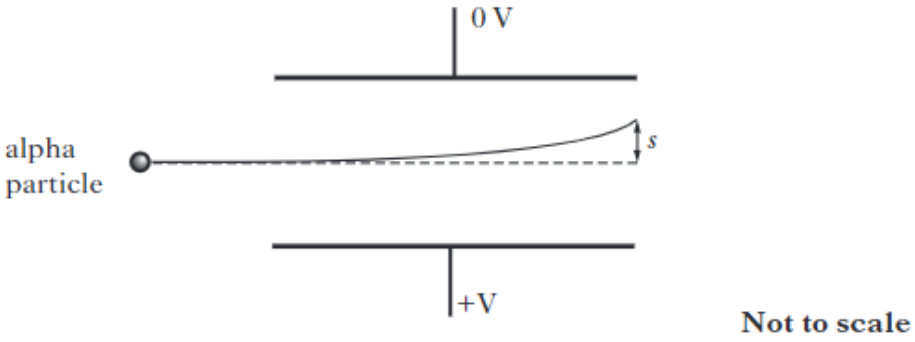

Figure 10C

The separation of the parallel plates is now increased. An alpha particle enters the electric field at the same point and with the same velocity as before.

What effect does this have on the magnitude of the deflection *s*?

You must justify your answer. **2**

(8)

Marks

11. A geomagnetic reversal is a change in polarity of the Earth's magnetic field. On average this happens every 300 000 years. Reversals can take in excess of 1000 years to complete. During a previous reversal, the strength of the Earth's magnetic field dropped to 5% of its present value.

Figure 11 shows a computer simulation of the Earth's magnetic field during a reversal.

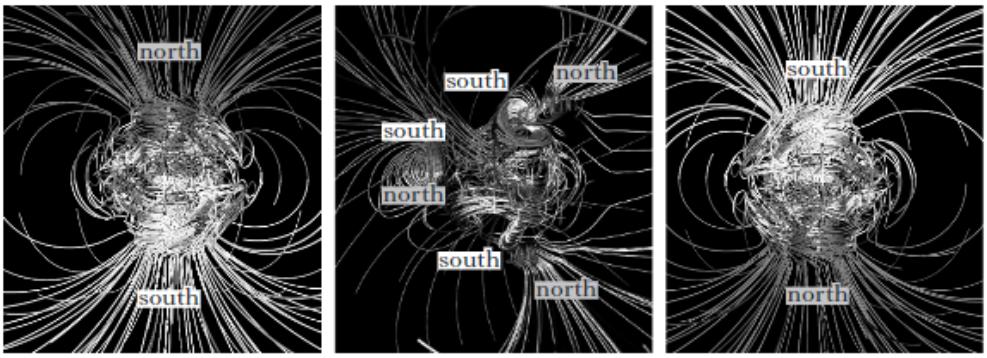

Figure 11

Use your knowledge of Physics to comment on the possible effects of such a reversal. **(3)**

CfE AH 2016

13. (a) Q_1 is a point charge of +12 nC. Point Y is 0·30 m from Q_1 as shown in Figure 13A.

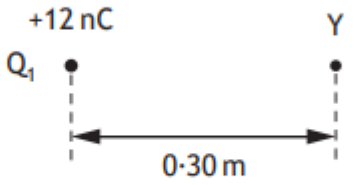

Figure 13A

Show that the electrical potential at point Y is +360 V. **2**

(b) A second point charge Q_2 is placed at a distance of 0·40 m from point Y as shown in Figure 13B . The electrical potential at point Y is now zero.

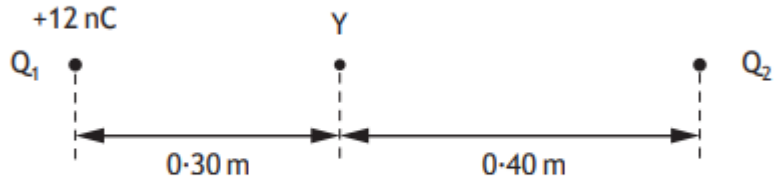

Figure 13B

(i) Determine the charge of Q_2. **3**

(ii) Determine the electric field strength at point Y. **4**

(iii) On Figure 13C, sketch the electric field pattern for this system of charges. **2**

Figure 13C

14. A student measures the magnetic induction at a distance r from a long straight current carrying wire using the apparatus shown in Figure 14.

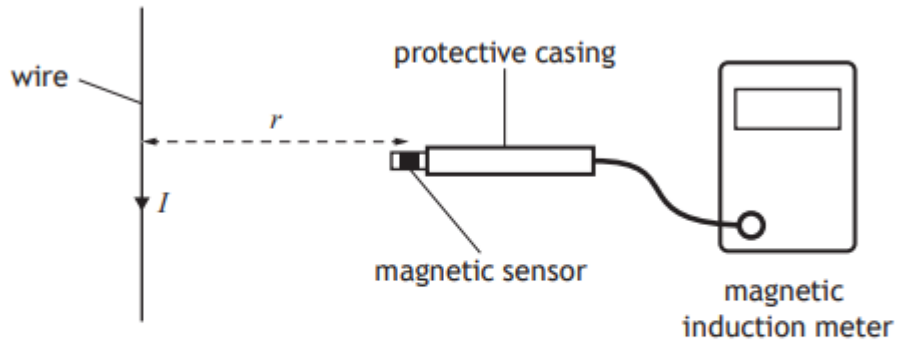

Figure 14

The following data are obtained.

Distance from wire $r = 0{\cdot}10\,\text{m}$
Magnetic induction $B = 5{\cdot}0\,\mu\text{T}$

(a) Use the data to calculate the current I in the wire. **3**

(b) The student estimates the following uncertainties in the measurements of B and r.

Uncertainties in r		Uncertainties in B	
reading	±0·002 m	reading	±0·1 μT
calibration	±0·0005 m	calibration	±1·5% of reading

(i) Calculate the percentage uncertainty in the measurement of r. **1**

(ii) Calculate the percentage uncertainty in the measurement of B. **3**

(iii) Calculate the absolute uncertainty in the value of the current in the wire. **2**

(c) The student measures distance r, as shown in Figure 14, using a metre stick. The smallest scale division on the metre stick is 1 mm.

Suggest a reason why the student's estimate of the reading uncertainty in r is not ±0·5 mm. **1**

11. (a) State what is meant by the term *electric field strength*. **1**

(b) A, B, C and D are the vertices of a square of side 0·12 m.

Two +4·0 nC point charges are placed at positions B and D as shown in Figure 11A.

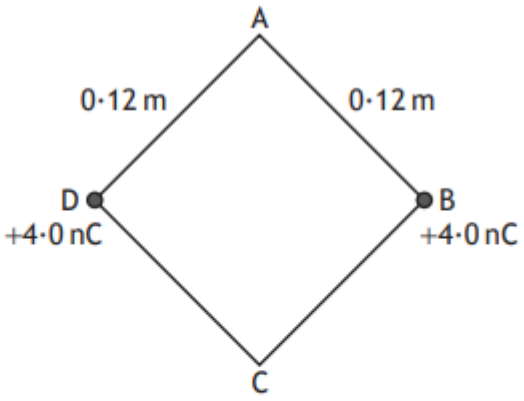

Figure 11A

(i) Show that the magnitude of the electric field strength at position A is $3{\cdot}5 \times 10^3\,N\,C^{-1}$. **3**

(ii) A +1·9 nC point charge is placed at position A.

Calculate the magnitude of the force acting on this charge. **3**

(iii) State the direction of the force acting on this charge. **1**

(iv) A fourth point charge is now placed at position C so that the resultant force on the charge at position A is zero.

Determine the magnitude of the charge placed at position C. **4**

12. A velocity selector is used as the initial part of a larger apparatus that is designed to measure properties of ions of different elements.

The velocity selector has a region in which there is a uniform electric field and a uniform magnetic field. These fields are perpendicular to each other and also perpendicular to the initial velocity v of the ions.

This is shown in Figure 12A.

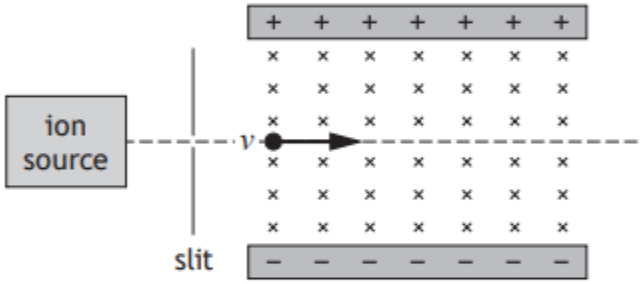

Figure 12A

A beam of chlorine ions consists of a number of isotopes including $^{35}Cl^{+}$.

The magnitude of the charge on a $^{35}Cl^{+}$ ion is $1{\cdot}60 \times 10^{-19}$ C.

The magnitude of electric force on a $^{35}Cl^{+}$ chlorine ion is $4{\cdot}00 \times 10^{-15}$ N.

The ions enter the apparatus with a range of speeds.

The magnetic induction is 115 mT.

(a) State the direction of the magnetic force on a $^{35}Cl^{+}$ ion. **1**

(b) By considering the electric and magnetic forces acting on a $^{35}Cl^{+}$ ion, determine the speed of the $^{35}Cl^{+}$ ions that will pass through the apparatus without being deflected. **3**

(c) $^{35}Cl^{+}$ ions that are travelling at a velocity less than that determined in (b) are observed to follow the path shown in Figure 12B.

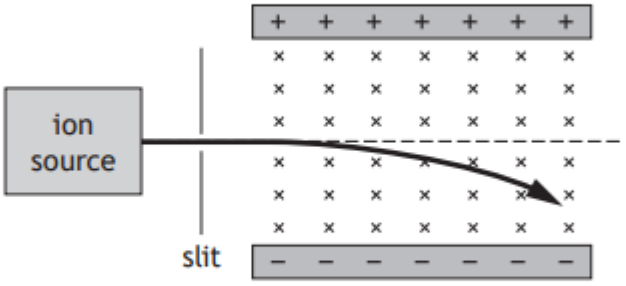

Figure 12B

Explain, in terms of their velocity, why these ions follow this path. **2**

(d) $^{37}Cl^{2+}$ ions are also present in the beam. $^{37}Cl^{2+}$ ions have a greater mass and a greater charge than $^{35}Cl^{+}$ ions. Some $^{37}Cl^{2+}$ ions also pass through the apparatus without being deflected.

State the speed of these ions.

You must justify your answer. **2**

CfE AH Exemplar paper

15. (a) An uncharged conducting sphere is suspended from a fixed point X by an insulating thread of negligible mass as shown in Figure 15A.

A charged plate is then placed close to the sphere as shown in Figure 15B.

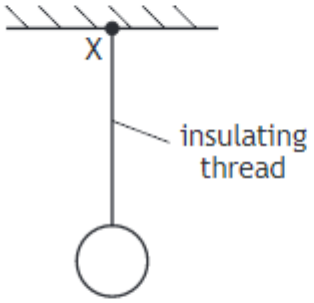

Figure 15A

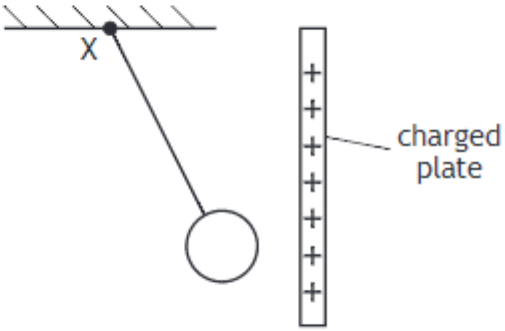

Figure 15B

Explain why the uncharged sphere is attracted to the charged plate. You may use a diagram to help explain your answer. **1**

(b) The sphere is now given a negative charge of 140 nC and placed between a pair of parallel plates with a separation of 42 mm as shown in Figure 15C.

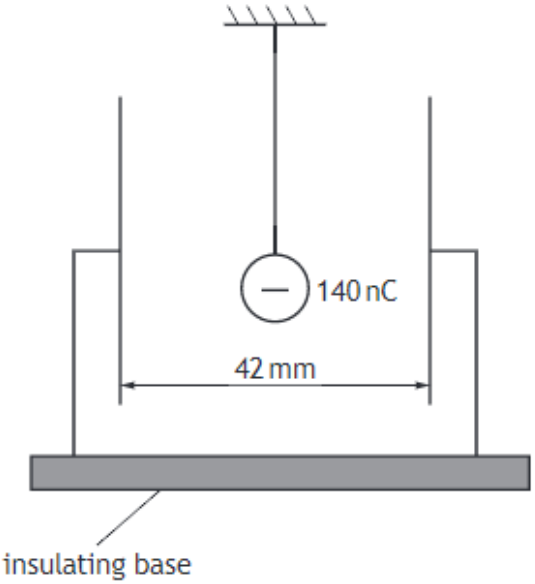

Figure 15C

When a potential difference is applied to the plates the sphere is deflected through an angle θ as shown in Figure 15D.

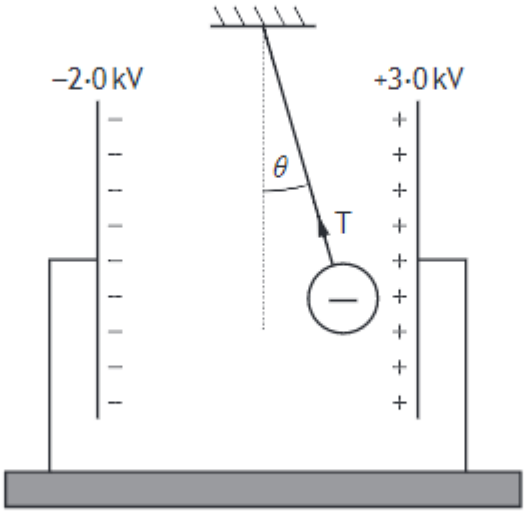

Figure 15D

(i) Calculate the electric field strength between the plates. **3**

(ii) Calculate the electrostatic force acting on the sphere due to the electric field. **3**

(iii) The mass of the sphere is $4{\cdot}0 \times 10^{-3}$ kg.

Calculate the magnitude and direction of the tension T in the supporting thread. **4**

(c) The plates are now moved a short distance to the right without touching the sphere. The distance between the plates is unchanged.

State whether the angle θ increases, decreases or stays the same.

You must justify your answer. **2**

10. (a) Two point charges Q_1 and Q_2 are separated by a distance of 0·60 m as shown in Figure 10A. The charge on Q_1 is −8·0 nC. The electric field strength at point X is zero.

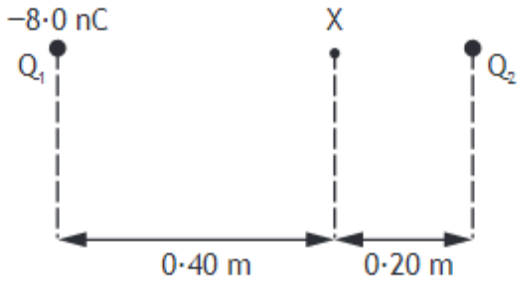

Figure 10A

(i) State what is meant by *electric field strength*. **1**

(ii) Show that the charge on Q_2 is −2·0 nC. **2**

(iii) Calculate the electrical potential at point X. **5**

10. **(continued)**

(b)

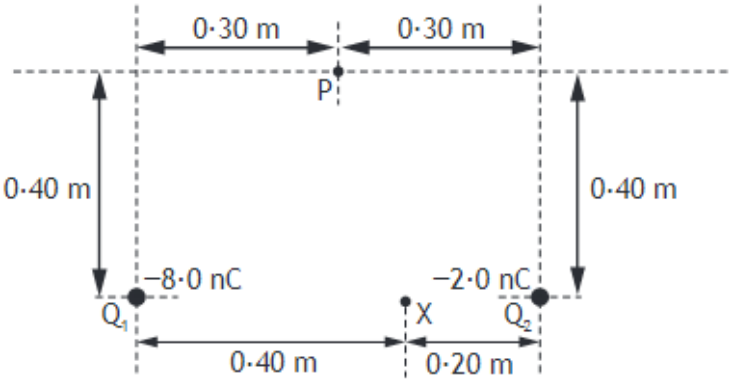

Figure 10B

(i) Calculate the electrical potential at point P. **3**

(ii) Determine the energy required to move a charge of +1·0 nC from point X to point P. **4**