STUDENT NUMBER: ____________________

North Sydney Boys High School
Year 12 Physics 2021
Assessment Task 2
Tuesday 16th March 2021

General Instructions

- Reading time – 5 minutes
- Working time – 60 minutes
- Board approved calculators may be used
- Write using black pen
- Write your student number at the top of every separated page
- Use the multiple choice sheet provided
- A data sheet is provided on the last page
- You are allowed to use a double-sided A4 paper with your own notes during the assessment.

Total Marks – 40

Part A - 10 marks

- Attempt Questions 1–10
- Allow about 15 minutes for this part

Part B - 30 marks

- Attempt Questions 11–19
- Allow about 45 minutes for this part

Part A /10	
Part B / 30	
Total Mark / 40	

This paper MUST NOT be removed from the examination room

Part A – 10 marks

Allow about 15 minutes for this part. Use the multiple-choice answer sheet for Questions 1–10

1. A charge of 0.7 C is moving at an angle of 38° to the vertical across magnetic field lines of strength 0.006T that are directed vertically down at a velocity of 6.2 ms^{-1}. Ignoring any effects due to gravitational fields, the shape of the path that the charge would follow as it moves through this magnetic field would be:
(A) Circular
(B) Parabolic
(C) Helical
(D) Elliptical

2. Referring to the information from question 1, the magnitude of the force that the charge would experience as it passes through this magnetic field would be:

(A) 0.026 N
(B) 0.016 N
(C) 0.0099 N
(D) 0.021 N

3. Referring to the information from question 1, the magnitude of the vertical displacement that the charge would have travelled through after a time of 6 seconds would be:

(A) 22.6 metres
(B) 0 metres
(C) 37.2 metres
(D) 29.3 metres

4. A particle with a charge of +0.6 mC is moving vertically downward through free space with a velocity of 200 ms^{-1} when it encounters a uniform electric field of strength 20 Nc^{-1} directed vertically downward. After the charge has moved through a distance of 15 metres in a direction parallel to the field, the magnitude of the amount of work done on the charge would be:

(A) 300 J
(B) 1.2 J
(C) 1.8×10^{-4} J
(D) 0.18 J

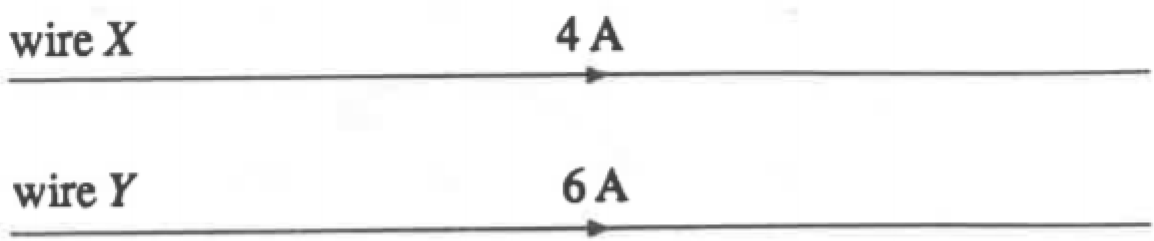
5. Referring to the information from question 4; if the mass of the charge was 3 grams, the magnitude of the change in velocity of the charge over this 15 metre distance would be closest to:

(A) 11 ms^{-1}
(B) 0.3 ms^{-1}
(C) 4 ms^{-1}
(D) 0.18 ms^{-1}

6. Referring to the information in question 4 and 5, if the electric field was now set up horizontally instead of vertically, the magnitude of the displacement of the particle 4 seconds from the instant the particle entered the field would be closest to:

(A) 800 m
(B) 800.6 m
(C) 1.2×10^{-2} m
(D) 4 m

7. Two parallel wires are brought close to each other. Wire X has a current of 4A flowing through it and wire Y has a current of 6A flowing through it. Both currents are flowing in the same direction.



From the information we can conclude that:

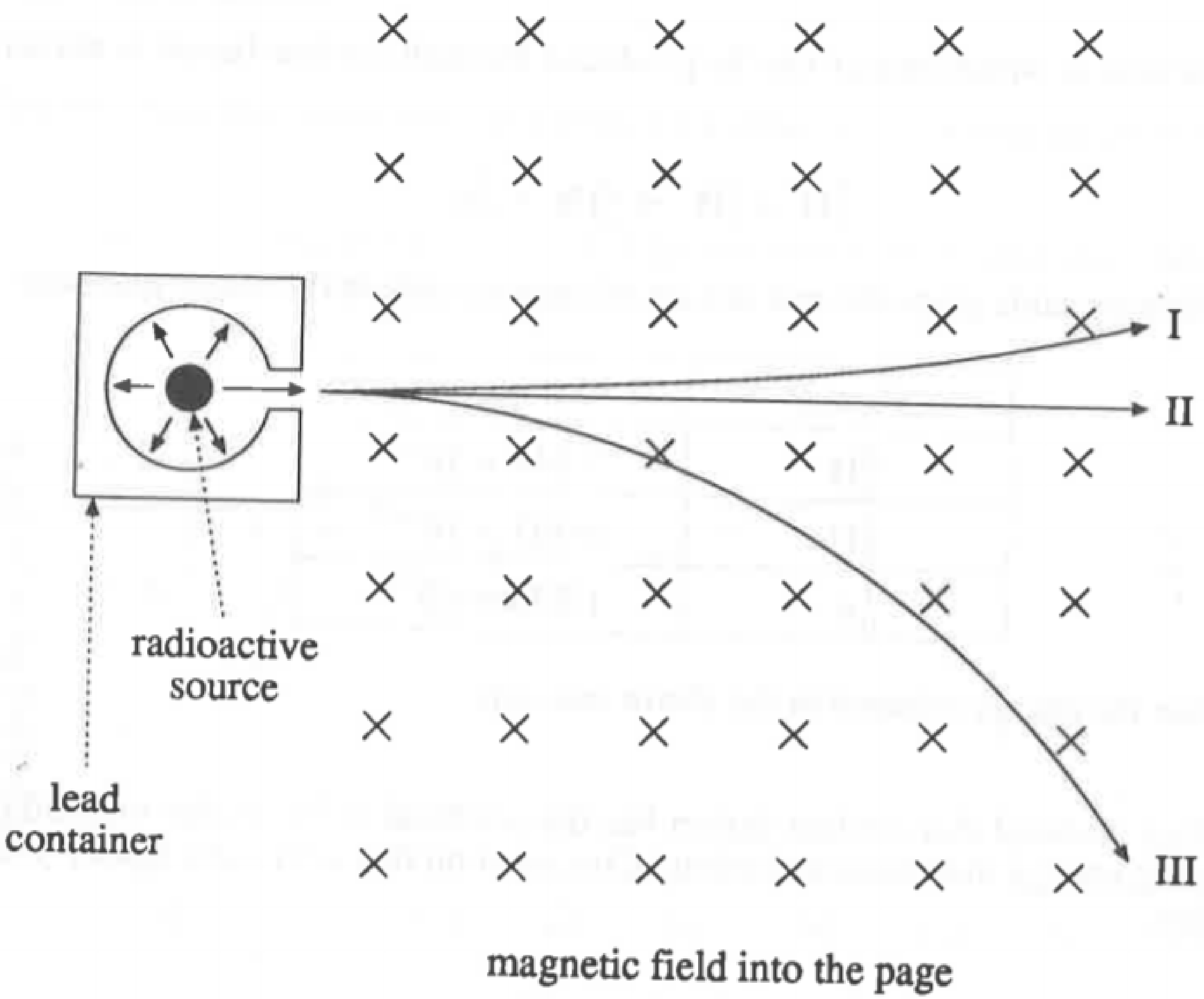
(A) the force on wire X is the same magnitude as the force on wire Y and is directed away from wire Y

(B) the force on wire X is the same magnitude as the force on wire Y and is directed towards wire Y

(C) the force on wire X is larger than the force on wire Y and is directed away from wire Y

(D) the force on wire X is smaller than the force on wire Y and is directed towards wire Y

8. Various charged and uncharged particles are sent through a magnetic field as shown below.



Assuming that all the particles enter the field at the same velocity and the magnitude of the charges on the charged particles are the same, the most likely explanation for the paths that the particles take is that:

(a) All the particles are positively charged.
(b) Particle path I is positive and more massive than particle path III, which is negative.
(c)Particle path I is positive and less massive than particle path III, which is negative.
(d) All the particles are neutral.

9. A proton moves through a magnetic field of strength 2 Teslas with a velocity of 150 ms^{-1} as shown below.

The magnitude of the acceleration of the proton is closest to:

(A) $4.8 \times 10^{-17}\ ms^{-2}$
(B) $300\ ms^{-2}$
(C) $2.87 \times 10^{10}\ ms^{-2}$
(D) $5.27 \times 10^{13}\ ms^{-2}$

10. Two wires, one carrying a current of 2 amps and the other carrying a current of 3 amps, both of length 4 m, cross each other perpendicularly: that is, they are 90 degrees to each other. They are separated by a distance of 1 cm at the point where they cross.
The electromagnetic force between the wires is closest to:

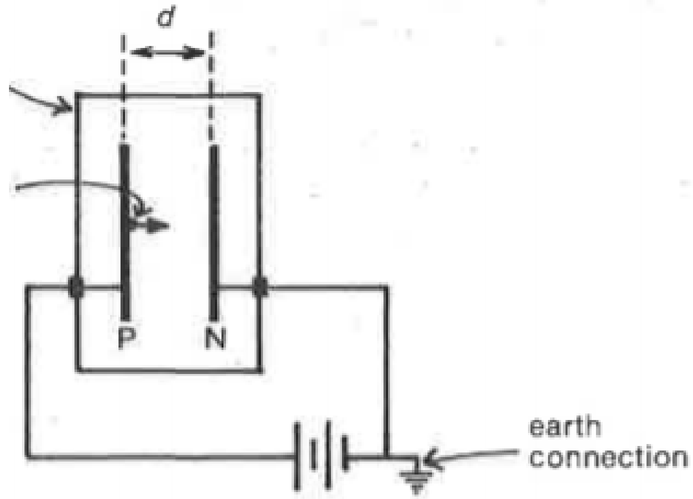
(A) 4.8×10^{-4} N
(B) 2.4×10^{-4} N
(C) 4.15×10^{-4} N
(D) 0 N

Part B – 30 marks

Allow about 45 minutes for this part. Write answers in the spaces provided

Question 11 (3 marks)

A uniform electric field is set up between two parallel charged plates P and N as shown in the figure below. There is a potential difference V between P and N which are distance d apart. The electric field provides a force F on a small plastic sphere, which is carrying a positive charge q and is on the point of moving from P to N. Assume that gravitational effects on the sphere are negligible.



In terms of V and q:

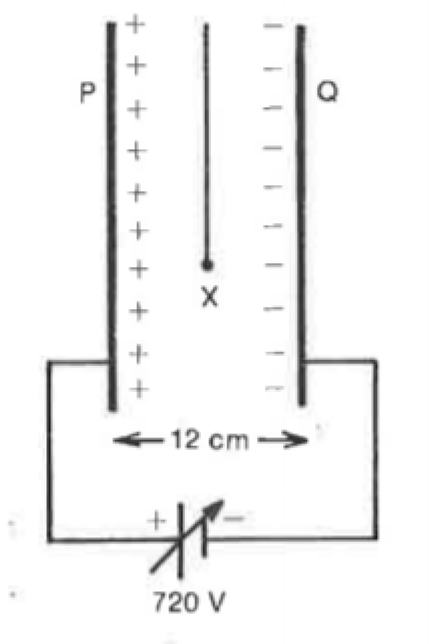
(a) How much more electrical potential energy has the sphere on P than it has on N? (1m)

(b) What must be the increase in the kinetic energy of the sphere as it moves from P to N? (1m)

(c) How much work is done by the electric field in moving the sphere from P to N? (1m)

Question 12 (5 marks)

Two insulated brass plates, P and Q, stand vertically 12 cm apart, and are connected as shown in the figure below to a 720 V supply. When a small positively charged sphere at the end of an insulating rod is placed as illustrated at the point X, 6.0 cm from the plate,P , the electrical force acting on it is 12 mN to the left.



(a) Specify fully the electric field strength between the plates (2m)

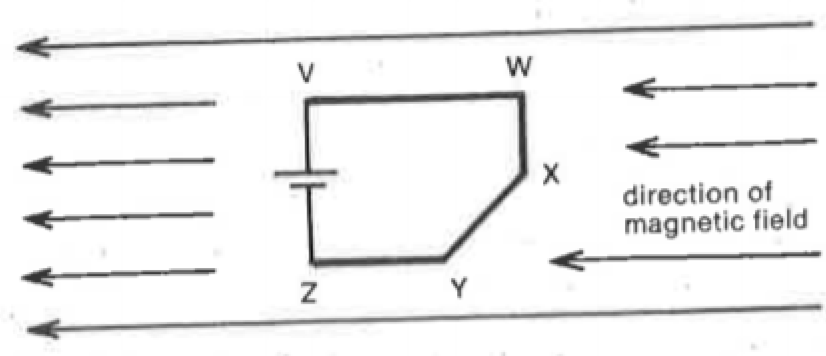
(b) What is the charge on the sphere? (1m)

(c) The separation of the plates is increased to 16 cm. What is now the magnitude of the electric force on the charged sphere? (1m)

(d) With the plates again 12 cm apart, the voltage selector on the power supply is adjusted. If the new force on the sphere is 1.6 mN, what is now the potential difference across the plates? (1m)

Question 13 (3 marks)

A current-carrying loop of wire VWXYZ is placed in a magnetic field which is directed to the left, as indicated in the figure below.



What is the direction of the magnetic force acting on section:

(a) WX? (1m)

(b) XY? (1m)

(c)YZ? (1m)

Question 14 (3 marks)

Two positive charges, identical in mass and charge, enter a uniform electric field. One charge enters the field with no velocity. The other charge enters the field with a velocity that is in the same direction as the field. Mathematically or otherwise, explain why the magnitude of the change in velocity of the moving charge will always be less than the change in velocity of the stationary charge after both have moved through the same distance in the field. In your answer you should compare the work done on both charges for this distance in the field.

Question 15 (5 marks)

A stream of positive ions each carrying a charge q travels vertically downwards between two charged, vertical plates between which the electric field strength is 2.0 x 10^4 Vm^{-1} towards the west. A magnetic field at right angles to the electric field and of flux density 4.0 mT between the plates keeps the beam travelling in a straight line.

(a) What is the net force on each ion due to the electric and magnetic fields? (1m)

(b) What must be the direction of the magnetic field? (1m)

(c)In terms of q, specify fully the electric force acting on each ion. (1m)

(d) In terms of q and v, the speed of the ions, specify fully the magnetic force on each ion. (1m)

(e) Deduce the value for the speed v. (1m)

Question 16 (3 marks)

In an experiment, two 50 cm long sections of wire are mounted parallel to each other. They exert a repulsive force of 4×10^{-6} N on each other when they each carry a current of 5A.

(a) How far apart are the wires spaced? (2m)

(b) Are the currents in the wires in the same or opposite directions? (1m)

Question 17 (3 marks)

Using the formula for the force on a charge q moving through a magnetic field B with a velocity v, and simple kinematics and circuit theory, derive an expression for the force on a wire of length l carrying a current I in a magnetic field B. Show all the steps involved in your derivation.

Question 18 (3 marks)

Using the relationship between magnetic force and the resulting centripetal force that occurs when a charged particle moves perpendicularly through a uniform magnetic field, and for circular motion kinematics, $\mathbf{v} = 2\pi r/T$, show mathematically or otherwise that the period of rotation of the particle through the field is independent of its speed through the magnetic field.

Question 19 (2 marks)

An electron is fired into a region of space where an electric field and a magnetic field are present.
In the space below, sketch the orientation of these two fields if the electron is to pass through the region undeflected. (ignore gravitational effects)

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D

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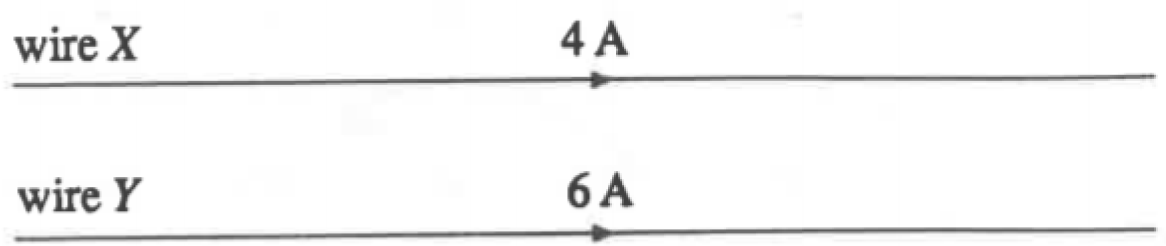

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B

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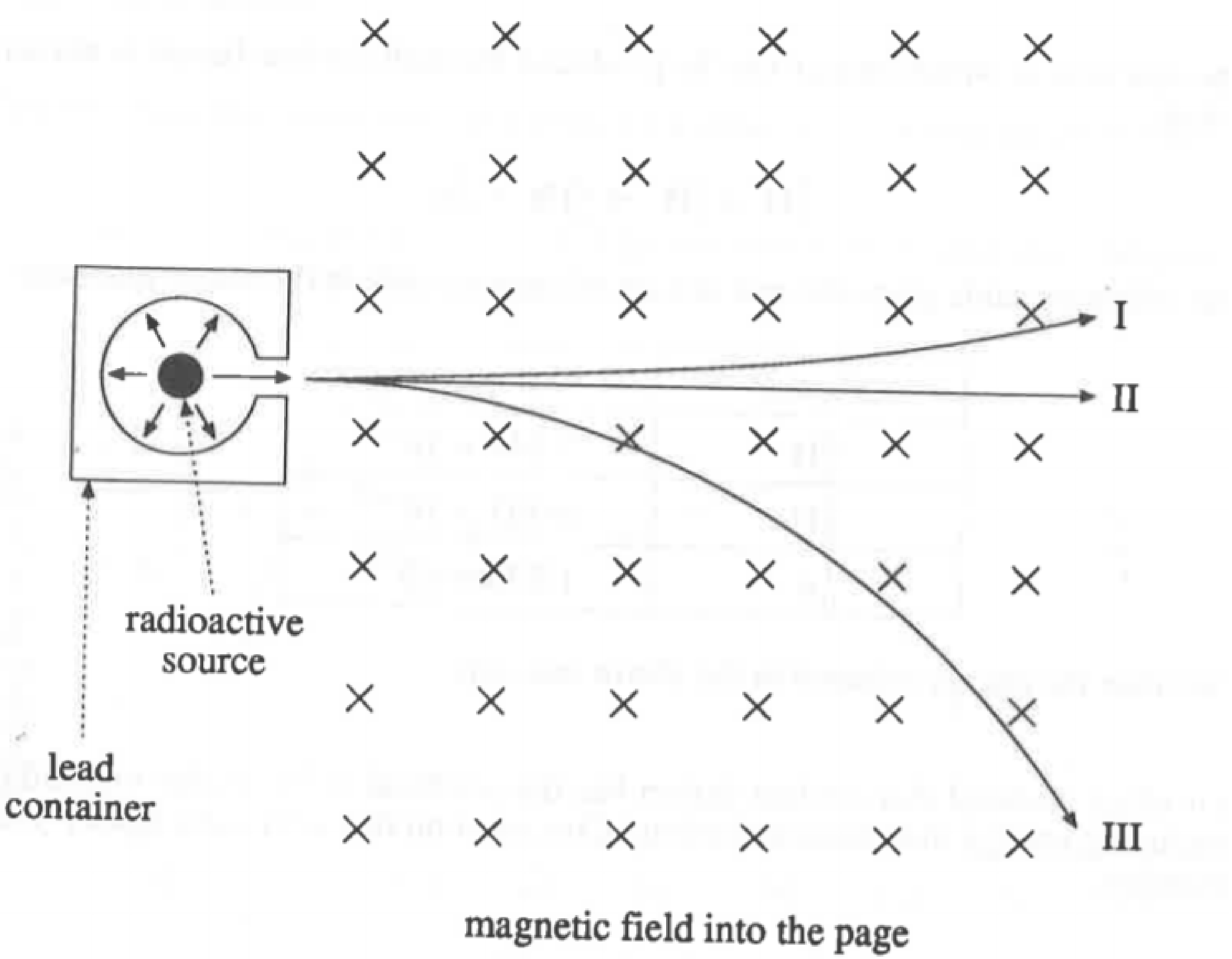

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D

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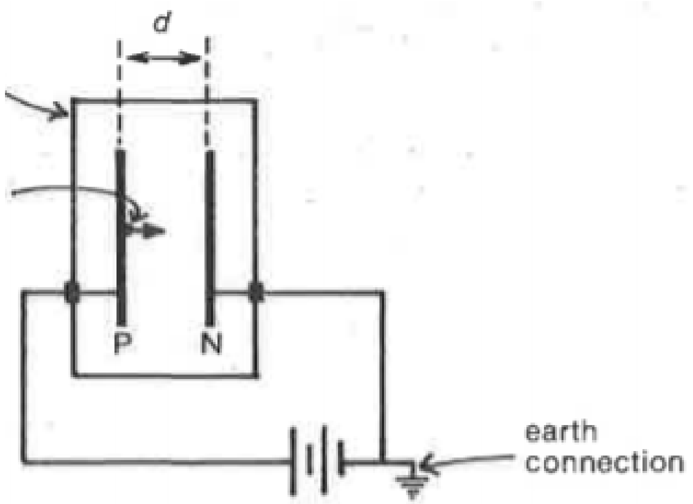
Question 11 (3 marks)

A uniform electric field is set up between two parallel charged plates P and N as shown in the figure below. There is a potential difference V between P and N which are distance d apart. The electric field provides a force F on a small plastic sphere, which is carrying a positive charge q and is on the point of moving from P to N. Assume that gravitational effects on the sphere are negligible.



In terms of V and q:

(a) How much more electrical potential energy has the sphere on P than it has on N? (1m)

Vq

(b) What must be the increase in the kinetic energy of the sphere as it moves from P to N? (1m)

Vq

(c) How much work is done by the electric field in moving the sphere from P to N? (1m)

Vq

Notes from marker

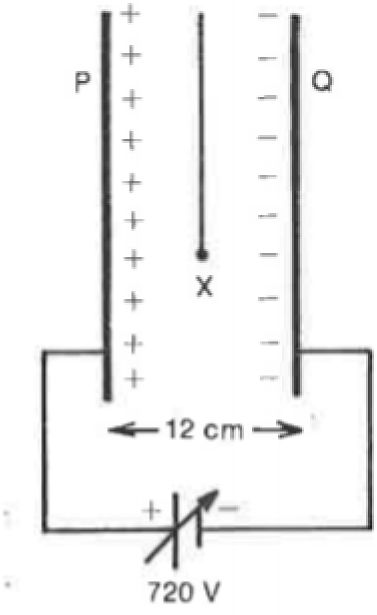
The question says "in terms of V and q", so that is the only answer.

This was not particularly well done by the cohort.

Noter from marker: The majority of students correctly answered these questions. Only some students were not able to work out.

Question 12 (5 marks)

Two insulated brass plates, P and Q, stand vertically 12 cm apart, and are connected as shown in the figure below to a 720 V supply. When a small positively charged sphere at the end of an insulating rod is placed as illustrated at the point X, 6.0 cm from the plate,P, the electrical force acting on it is 12 mN to the left.



(a) Specify fully the electric field strength between the plates (2m)

$E = V/d = 720/0.12 = 6000Nc^{-1}$ to the right

Notes from marker:

Well done by most students. However, some students have not provided the direction.

(b) What is the charge on the sphere? (1m)

$F = Eq$, so $q = F/E = 12 \times 10^{-3} /6000 = 2 \times 10^{-6}$ coulomb

Notes from marker: The majority of students correctly answered this question.

(c) The separation of the plates is increased to 16 cm. What is now the magnitude of the electric force on the charged sphere? (1m)

$E = 720/0.16 = 4500\ Nc^{-1}$

$F = Eq = 4500 \times 2x10^{-6}$

$= 9\text{x}10^{-3}$ N

Notes from marker

The majority of students correctly answered this question. Well done by most. Only a few made some mistakes, especially in calculation.

(d) With the plates again 12 cm apart, the voltage selector on the power supply is adjusted. If the new force on the sphere is 1.6 mN, what is now the potential difference across the plates? (1m)

F = Eq, so E =F/q = $1.6\text{x } 10^{-3}/2\text{x}10^{-6} = 8 \text{ x } 10^{2}\ \text{Nc}^{-1}$

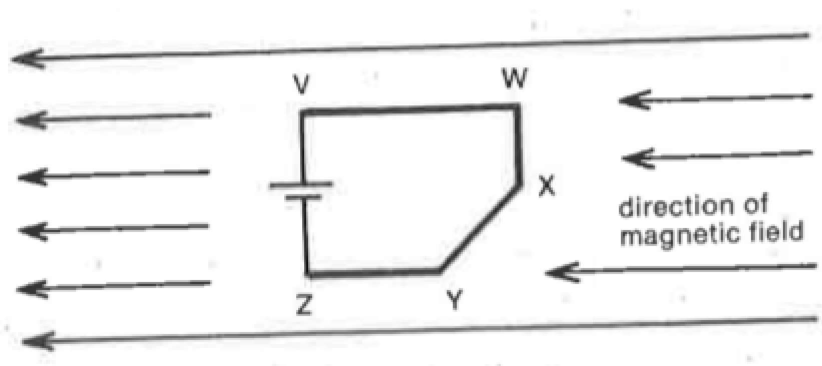
V = Ed = $8 \text{ x } 10^{2} \text{ x } 0.12 = 96$ volts

Notes from marker:

Overall very good responses. Most students were able to provide a correct answer.

Question 13 (3 marks)

A current-carrying loop of wire VWXYZ is placed in a magnetic field which is directed to the left, as indicated in the figure below.



What is the direction of the magnetic force acting on section:

(a) WX? (1m)___________Into page

(b) XY? (1m)___________Into page

(c)YZ? (1m) Zero

Notes from marker: The majority of students correctly answered these questions. Only a few made some mistakes to specify the direction of the magnetic force.

Question 14 (3 marks)

Two positive charges, identical in mass and charge, enter a uniform electric field. One charge enters the field with no velocity. The other charge enters the field with a velocity that is in the same direction as the field. Mathematically or otherwise, explain why the magnitude of the change in velocity of the moving charge will always be less than the change in velocity of the stationary charge after both have moved through the same distance in the field. In your answer you should compare the work done on both charges for this distance in the field.

Since work = Vq, and since V=Ed, so for a uniform field, the voltage drop is the same for a set distance, so Vq is the same, so the work done is the same for both charges. (1m)

Since the force on the charges is the same no matter what the speed is (F=Eq), then the acceleration of the charges will be the same, (since a = F/m) (1m)

Using the simple logic that the charge that is already moving will cover the distance through the field in less time than the initially stationary charge; this means that the force, and so the acceleration will act for a shorter time on the already moving charge, which means it's change in velocity will be less. (remember that acceleration is metres per second PER SECOND, so the increase in velocity of the moving charge will be less.

Notes from marker

Most students were able to state that the force, and therefore the acceleration are the same.

Mistakes were made in clearly explaining the work relationships and energy transformations

Question 15 (5 marks)

A stream of positive ions each carrying a charge q travels vertically downwards between two charged, vertical plates between which the electric field strength is 2.0 x 10^4 Vm^{-1} towards the west. A magnetic field at right angles to the electric field and of flux density 4.0 mT between the plates keeps the beam travelling in a straight line.

(a) What is the net force on each ion due to the electric and magnetic fields? (1m)

Zero (since $F_{el} = F_{mag}$)

Notes from marker

Well done by most candidates

(b) What must be the direction of the magnetic field? (1m)

North

Notes from marker

Very poorly done by most candidates. We'll need to work on our ability to think in 3 dimensions.

(c)In terms of q, specify fully the electric force acting on each ion. (1m)

$F = Eq = 2 \times 10^4\ q$ Newtons to the west

Notes from marker

Well done by most candidates

(d) In terms of q and v, the speed of the ions, specify fully the magnetic force on each ion. (1m)

$F = Bqv = 4 \times 10^{-3}\ qv$

Notes from marker

Well done by most candidates

(e) Deduce the value for the speed v. (1m)

$Bqv = Eq$, so $v = Eq/Bq = E/B = 2x10^4/4x10^{-3} = 5x10^6\ ms^{-1}$

Notes from marker

Well done by most candidates, though some had trouble deriving the relationship, so lost a mark

Question 16 (3 marks)

In an experiment, two 50 cm long sections of wire are mounted parallel to each other. They exert a repulsive force of 4×10^{-6} N on each other when they each carry a current of 5A.

(a) How far apart are the wires spaced? (2m)

$F = \text{Ц}_0/2\pi \text{ x } I_1I_2l/d$, so $d = \text{Ц}_0/2\pi I_1I_2l/F =$

$= 4\pi \text{ x } 10^{-7} \text{ x } 5 \text{ x } 5 \text{ x } 0.5/2\pi \text{ x } 4 \text{ x } 10^{-6}$

$= 0.625$m

Notes from marker

Well done by most candidates

(b) Are the currents in the wires in the same or opposite directions? (1m)

Opposite

Notes from marker

Well done by most candidates

Question 17 (3 marks)

Using the formula for the force on a charge q moving through a magnetic field B with a velocity v, and simple kinematics and circuit theory, derive an expression for the force on a wire of length l carrying a current I in a magnetic field B. Show all the steps involved in your derivation.

$F = Bqv \sin\boldsymbol{\theta}$ but $v = l/t$ (1m)

So, $F = Bql/t \sin\boldsymbol{\theta} = B\, q/t\, l \sin\boldsymbol{\theta}$

But $q/t = I$, (1m)

So, $F = BIl \sin\boldsymbol{\theta}$

Notes from marker

Well done by most candidates

Question 18 (3 marks)

Using the relationship between magnetic force and the resulting centripetal force that occurs when a charged particle moves perpendicularly through a uniform magnetic field, and for circular motion kinematics, $\mathbf{v} = \mathbf{2\pi r/T}$, show mathematically or otherwise that the period of rotation of the particle through the field is independent of its speed through the magnetic field.

$F_{mag} = F_{cen}$ so $Bqv = mv^2 / r$ (1m)

Re-arranging, we get $Bq = mv/r$

, but $v = 2\pi r/T$,

So substituting, you get $Bq = m2\pi r/Tr$ (1m)

so $Bq = 2\pi m/T$, so $T = 2\pi m/Bq$ (1m)

So no v required!

Notes from marker

Well done by most candidates, though some students had trouble or were careless with their algebra.

Question 19 (2 marks)

An electron is fired into a region of space where an electric field and a magnetic field are present.
In the space below, sketch the orientation of these two fields if the electron is to pass through the region

undeflected. (ignore gravitational effects)

One example is this:

+ +
____

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

____
- -

In this case, when an electron comes in from the left, it could go through undeflected (if the fields are of correct strength)

There are many other ways you could orientate the fields to get the correct answer.
E.g:

__________________________________ direction of E field (to the right, or left)
__________________________________ direction of B fiels (to the right or left)

I.e. , as long as the field directions are parallel, and the charge moves in this direction also, there will be NO deflection

Notes from marker

Well done by most candidates, though some students forgot to indicate what the moving charge was doing.