Mr Baker's Science-Stuff

Electromagnetism and Motors

Name: ______________________

Class: ______________________

Date: ______________________

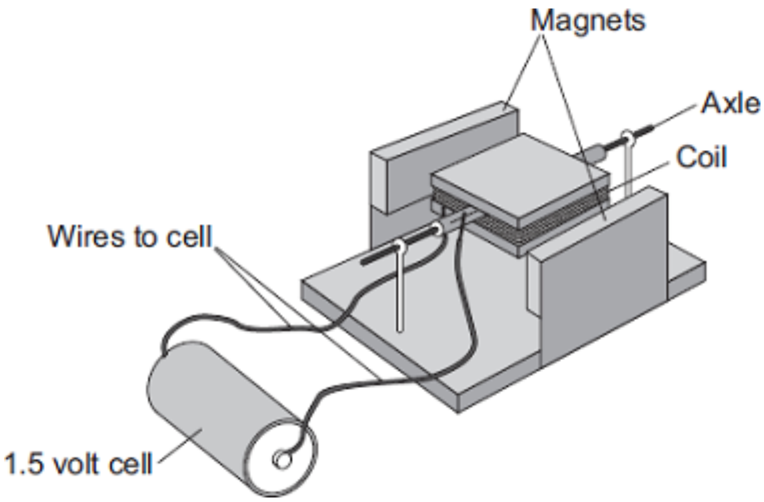
Time: **109 minutes**

Marks: **108 marks**

Comments:

Q1.

A student has made a simple electric motor. The diagram shows the electric motor.



(a) Complete the following sentence by drawing a ring around the correct line in the box.

Once the coil is spinning, one side of the coil is pushed by	the cell the coil a force	and

the other side is pulled, so the coil continues to spin.

(1)

(b) Suggest **two** changes to the electric motor, each one of which would make the coil spin faster.

1. ____

____

2. ____

____

(2)

(c) Suggest **two** changes to the electric motor, each one of which would make the coil spin in the opposite direction.

1. ____

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2. ____

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(2)

(Total 5 marks)

Q2.

(a) **Diagram 1** shows a magnetic closure box when open and shut. It is a box that stays shut, when it is closed, due to the force between two small magnets.

These boxes are often used for jewellery.

Diagram 1

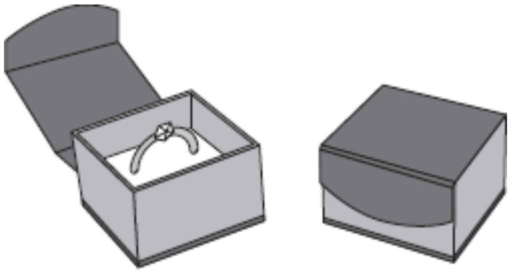
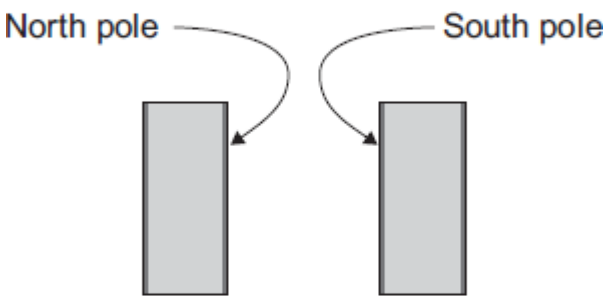


Diagram 2 shows the two magnets. The poles of the magnets are on the longer faces.

Diagram 2



(i) Draw, on **Diagram 2**, the magnetic field pattern between the two facing poles.

(2)

(ii) The magnets in the magnetic closure box must **not** have two North poles facing each other.

Explain why.

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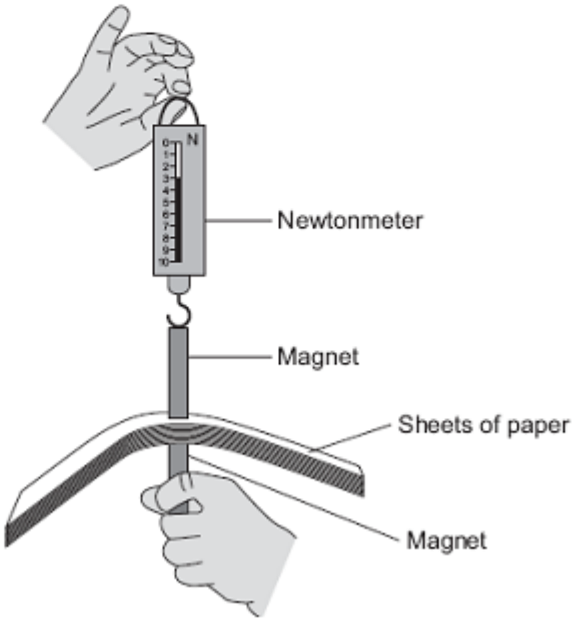
(2)

(b) A student is investigating how the force of attraction between two bar magnets depends on their separation.

She uses the apparatus shown in **Diagram 3**.

Diagram 3



She uses the following procedure:

- ensures that the newtonmeter does not have a zero error
- holds one of the magnets
- puts sheets of paper on top of the magnet
- places the other magnet, with the newtonmeter magnetically attached, close to the first magnet
- pulls the magnets apart
- notes the reading on the newtonmeter as the magnets separate
- repeats with different numbers of sheets of paper between the magnets.

The results are shown in the table.

Number of sheets of paper between the magnets	10	20	30	40	50	60	70	80	120
Newtonmeter reading as the magnets separate	3.1	2.6	2.1	1.5	1.1	1.1	1.1	1.1	1.1

(i) Describe the pattern of her results.

(2)

(ii) No matter how many sheets of paper the student puts between the magnets, the force shown on the newtonmeter never reaches zero.

Why?

(1)

(iii) The student is unable to experiment with fewer than 10 sheets of paper without glueing the magnet to the newtonmeter.

Suggest why.

(2)

(iv) Suggest **three** improvements to the procedure that would allow the student to gain more accurate results.

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(3)

(v) The thickness of one sheet of paper is 0.1 mm.

What is the separation of the magnets when the force required to separate them is 2.1 N?

____

____

____

Separation of magnets = ________________ mm

(3)

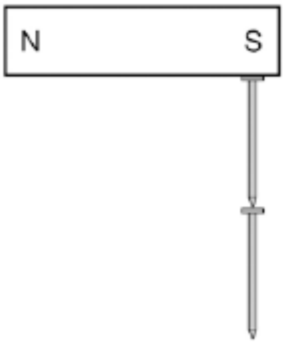
(Total 15 marks)

Q3.

Figure 1 shows two iron nails hanging from a bar magnet.

The iron nails which were unmagnetised are now magnetised.

Figure 1



(a) Complete the sentence.

Use a word from the box.

forced	**induced**	**permanent**

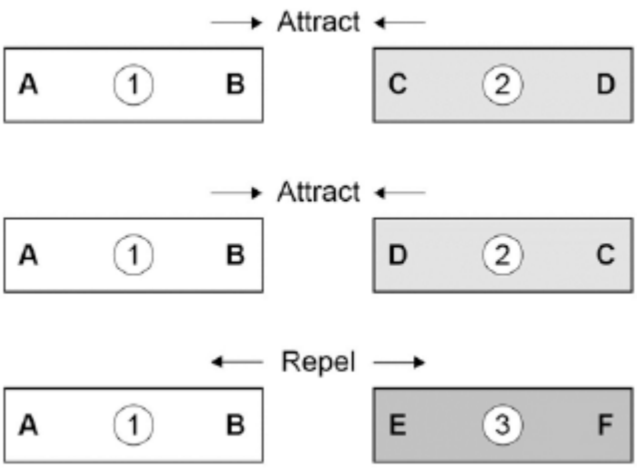
The iron nails have become ______________________ magnets.

(1)

(b) Each of the three metal bars in **Figure 2** is either a bar magnet or a piece of unmagnetised iron.

The forces that act between the bars when different ends are placed close together are shown by the arrows.

Figure 2



Which **one** of the metal bars is a piece of unmagnetised iron?

Tick **one** box.

Bar 1 ☐

Bar 2 ☐

Bar 3 ☐

Give the reason for your answer.

___

___

(2)

(c) A student investigated the strength of different fridge magnets by putting small sheets of paper between each magnet and the fridge door.

The student measured the maximum number of sheets of paper that each magnet was able to hold in place.

Why was it important that each small sheet of paper had the same thickness?

___

___

___

(1)

(d) Before starting the investigation the student wrote the following hypothesis:

'The bigger the area of a fridge magnet the stronger the magnet will be.'

The student's results are given in the table below.

Fridge magnet	Area of magnet in mm^2	Number of sheets of paper held
A	40	20
B	110	16
C	250	6
D	340	8
E	1350	4

Give **one** reason why the results from the investigation **do not** support the student's hypothesis.

___

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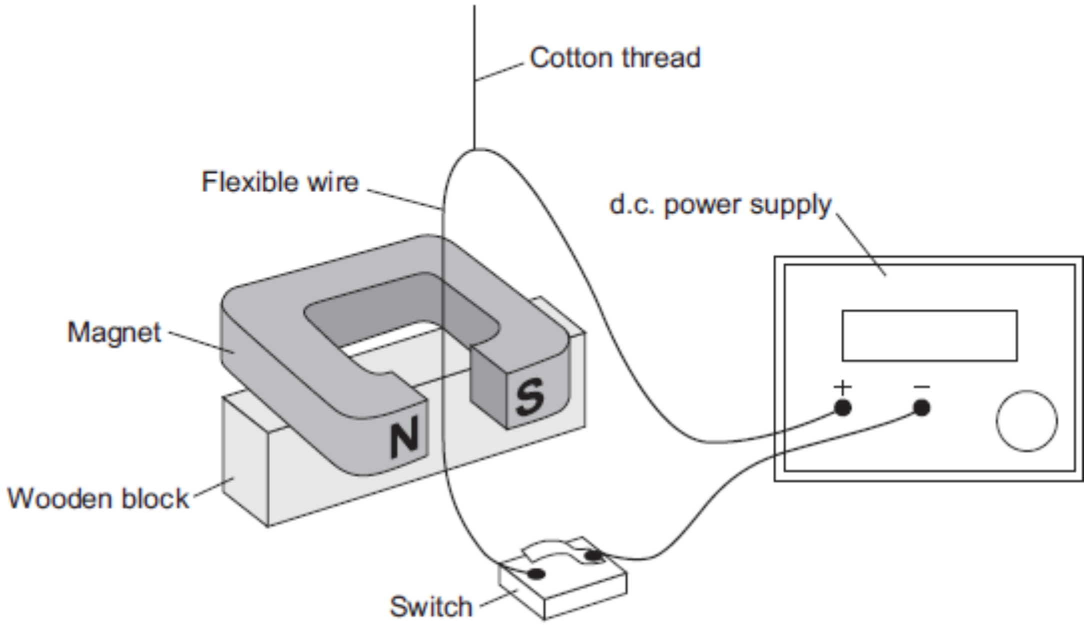
(1)
(Total 5 marks)

Q4.

The diagram shows a demonstration carried out by a teacher.



When the switch is closed, there is a current of 2 A through the wire. The wire experiences a force and moves.

(a) Use the correct word from the box to complete the sentence.

generator	**motor**	**transformer**

The demonstration shows the ____________________________ effect.

(1)

(b) State **two** changes that the teacher could make to the demonstration, each of which would increase the force on the wire. The teacher does not touch the wire.

1. ____

____

2. ____

____

(2)

(c) State **one** change that the teacher could make to the demonstration to change the direction of the force on the wire.

____

____

(1)

(d) With the switch closed, the teacher changes the position of the wire so that the force on the wire is zero.

What is the position of the wire?

Tick (✓) **one** box.

The wire is at 90° to the direction of the magnetic field.	☐
The wire is at 45° to the direction of the magnetic field.	☐
The wire is parallel to the direction of the magnetic field.	☐

(1)
(Total 5 marks)

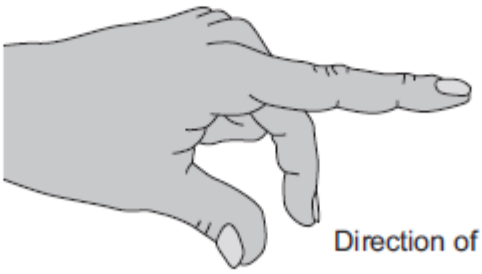
Q5.

The left-hand rule can be used to identify the direction of the force acting on a current-carrying conductor in a magnetic field.

(a) Use words from the box to label **Figure 1**.

current	**field**	**force**	**potential difference**

Figure 1



Direction of ______________________________

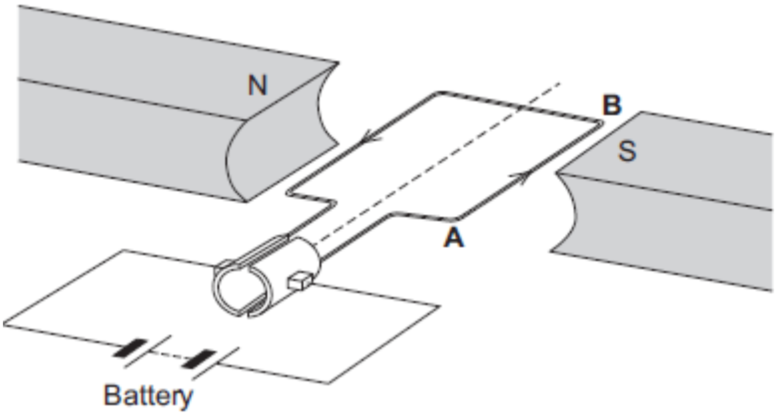
Direction of ______________________________

Direction of ______________________________

(3)

(b) **Figure 2** shows an electric motor.

Figure 2



(i) Draw an arrow on **Figure 2** to show the direction of the force acting on the wire **AB**.

(1)

(ii) Suggest **two** changes that would increase the force acting on the wire **AB**.

1. ____________________

2. ____________________

(2)

(iii) Suggest **two** changes that would reverse the direction of the force acting on the wire **AB**.

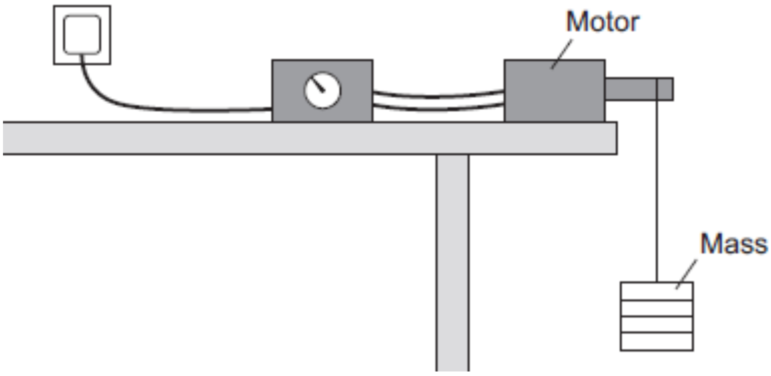
1. ____________________

2. ____________________

(2)

(c) A student used an electric motor to lift a mass. This is shown in **Figure 3**.

Figure 3



The student varied the electrical input power to the motor. For each different electrical input power, he recorded the time taken to lift the mass and calculated the output power of the motor.

The results are shown in the table.

Test	Electrical input power in watts	Work done lifting the mass in joules	Time taken to lift the mass in seconds	Output power in watts
A	20	24	2.4	10
B	40	24	1.2	20
C	60	24	0.8	30
D	80	24	0.2	120

The result for **Test D** is anomalous.

(i) Calculate the efficiency of the motor in **Test D**.

____

____

Efficiency = ____________________

(2)

(ii) Comment on your answer to part (c)(i).

____

____

(1)

(iii) Suggest a reason for this anomalous result.

____

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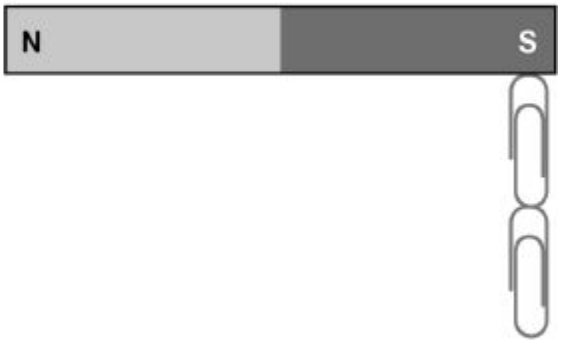
(1)
(Total 12 marks)

Q6.

Figure 1 shows two paper clips hanging from a bar magnet.

Figure 1



The paper clips have become magnetised.

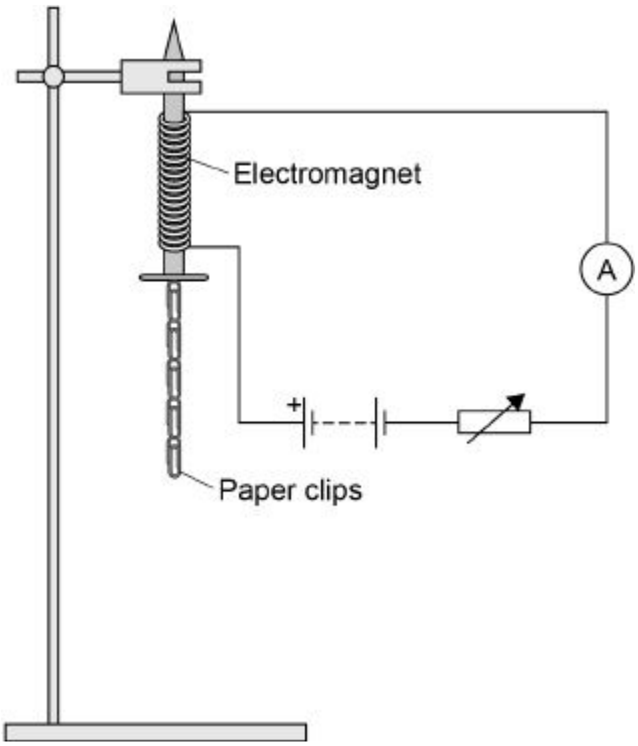
(a) Label the north and south poles of both paper clips.

(1)

A student investigated how the number of turns of wire on an electromagnet affects the strength of the electromagnet.

Figure 2 shows the equipment used by the student. Throughout the investigation the student kept the current through the wire constant.

Figure 2



(b) The student measured the strength of the electromagnet by counting the number of paper clips the electromagnet could hold.

Explain why it was important that the paper clips were all the same size.

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(2)

The table below shows the student's results.

Number of turns of wire on the electromagnet	**Number of paper clips held**
10	3
20	6
30	9
40	12

(c) Describe the pattern shown in the table.

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___

___

(2)

(d) The student then used 50 turns of wire on the electromagnet.

The electromagnet picked up 18 paper clips. This was more paper clips than the student had expected.

Which **one** is the most likely cause of this result?

Tick **one** box.

The paper clips used with 50 turns were larger than the others.	☐
There were less than 50 turns of wire on the electromagnet.	☐
Some of the paper clips were already magnetised.	☐

(1)

(e) The student repeated the measurement for 50 turns of wire three more times.

This gave her the following set of results.

18 16 14 15

Explain what the student should now do with the **four** results for 50 turns of wire.

___

___

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___

___

(3)

(f) The student wrote the hypothesis:

'Increasing the current through the wire will make the electromagnet stronger.'

Describe how the student should change the investigation to test this hypothesis.

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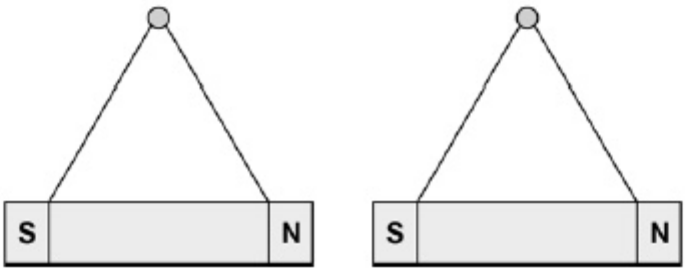
(3)

(Total 12 marks)

Q7.

Figure 1 shows two bar magnets suspended close to each other.

Figure 1



(a) Explain what is meant by the following statement.

'A non-contact force acts on each magnet'.

___

___

___

___

(2)

(b) Describe how to plot the magnetic field pattern of a bar magnet.

___

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___

___

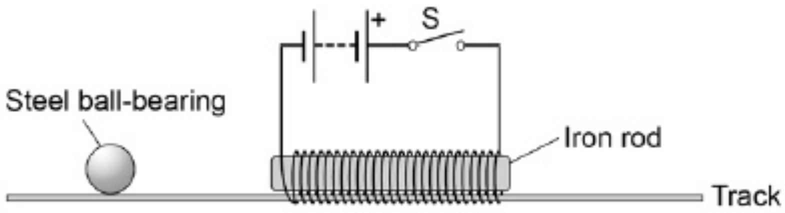
___

(3)

A student has set up the apparatus shown in **Figure 2**.

The iron rod is fixed to the track and cannot move.

Figure 2



(c) The student gives the steel ball bearing a gentle push in the direction of the iron rod.

At the same time the student closes the switch **S**.

Explain the effect on the motion of the ball bearing when the switch **S** is closed.

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(4)
(Total 9 marks)

Q8.

(a) Electromagnets are often used at recycling centres to separate some types of metals from other materials.

Give **one** reason why an electromagnet would be used rather than a permanent magnet.

____

____

(1)

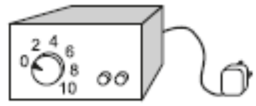
(b) **In this question you will gain marks for using good English, organising information clearly and using scientific words correctly.**

Some students want to build an electromagnet.

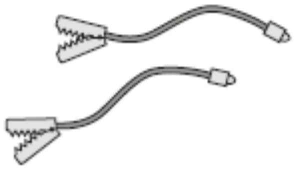
The students have the equipment shown below.


Insulated wire

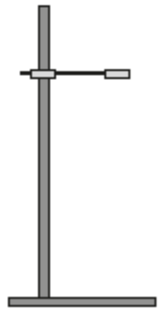

Iron nail



Power supply


Connecting leads


Steel paperclips


Wooden clamp and stand

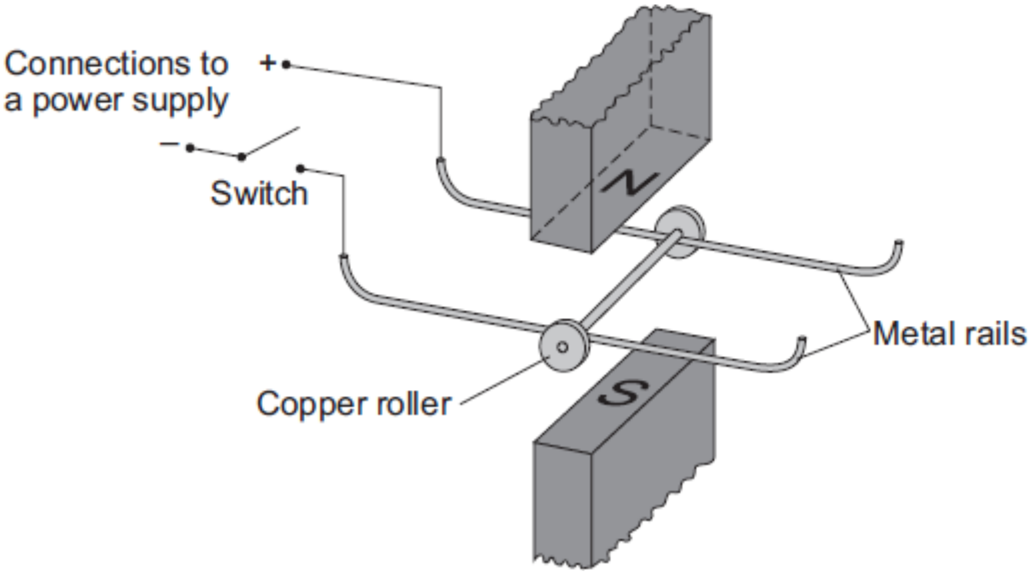
Describe how the students could build an electromagnet. Include in your answer how the students should vary and test the strength of their electromagnet.

(6)

(Total 7 marks)

Q9.

(a) A science technician sets up the apparatus shown below to demonstrate the motor effect. He uses a powerful permanent magnet.



The copper roller is placed across the metal rails. When the switch is closed, the copper roller moves to the right.

(i) Complete the sentence by drawing a ring around the correct line in the box.

This happens because copper is

an electrical conductor.
an electrical insulator.
a magnetic material.

(1)

(ii) Suggest **one** change that the technician can make which will cause the copper roller to move faster.

____

____

(1)

(iii) Suggest **two** changes which the technician can make, each of which will separately cause the copper roller to move to the left.

1. ____

____

2. ____

____

(2)

(b) Many electrical appliances, such as vacuum cleaners, drills and CD players, contain electric motors. As more electrical appliances are developed, more electricity needs to be generated. Generating electricity often produces pollutant gases.

(i) Complete the sentence by drawing a ring around the correct line in the box.

Generating more electricity to power the increasing number of electrical

	an ethical	
appliances used raises	an environmental	issue.
	a political	

(1)

(ii) The number of electrical appliances used in the world's richest countries is increasing yet many people in the world's poorest countries have no access to electricity.

What type of issue does this inequality between people in different countries raise?

____

(1)
(Total 6 marks)

Q10.

The circle in **Figure 1** represents a straight wire carrying a current. The cross shows that the current is into the plane of the paper.

Figure 1

(a) Complete **Figure 1** to show the magnetic field pattern around the wire.

(2)

(b) The magnetic flux density 10 cm from the wire is 4 microtesla.

Which of the following is the same as 4 microtesla?

Tick **one** box.

4×10^{-2} T ☐

4×10^{-3} T ☐

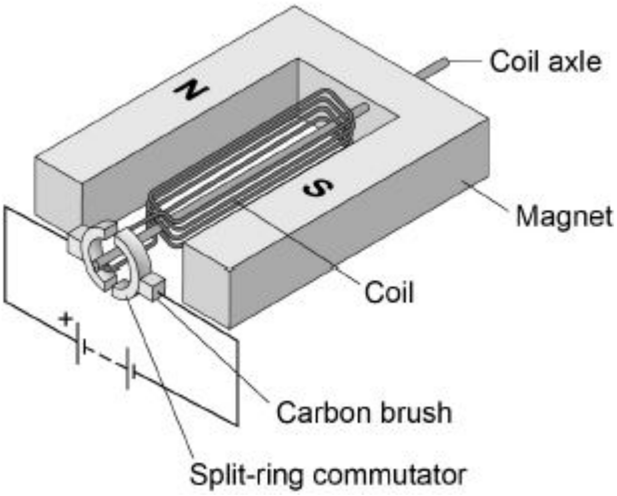
4×10^{-6} T ☐

4×10^{-9} T ☐

(1)

(c) **Figure 2** shows a simple electric motor.

Figure 2



When there is a current in the coil, the coil rotates continuously.

Explain why.

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(4)
(Total 7 marks)

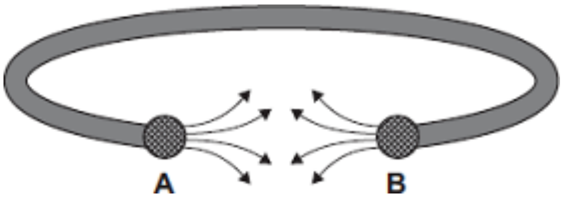
Q11.

(a) Some people wear magnetic bracelets to relieve pain.

Figure 1 shows a magnetic bracelet.

There are magnetic poles at both **A** and **B**.
Part of the magnetic field pattern between **A** and **B** is shown.

Figure 1



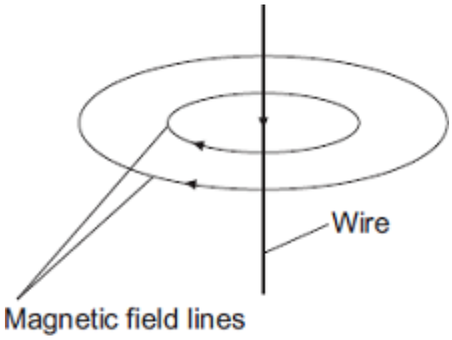
What is the pole at **A**? ______________________

What is the pole at **B**? ______________________

(1)

(b) **Figure 2** shows two of the lines of the magnetic field pattern of a current-carrying wire.

Figure 2



The direction of the current is reversed.

What happens to the direction of the lines in the magnetic field pattern?

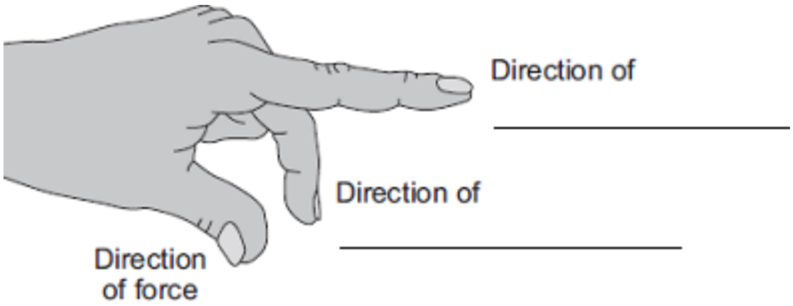
____

(1)

(c) Fleming's left-hand rule can be used to identify the direction of a force acting on a current-carrying wire in a magnetic field.

(i) Complete the labels in **Figure 3**.

Figure 3

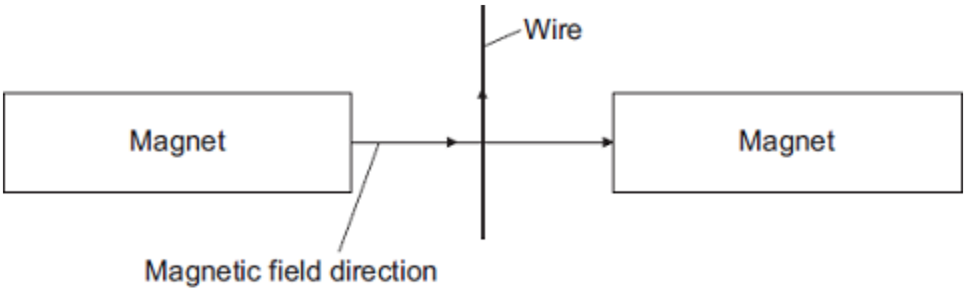


(2)

(ii) **Figure 4** shows:

- the direction of the magnetic field between a pair of magnets
- the direction of the current in a wire in the magnetic field.

Figure 4



In which direction does the force on the wire act?

____

(1)

(iii) Suggest **three** changes that would **decrease** the force acting on the wire.

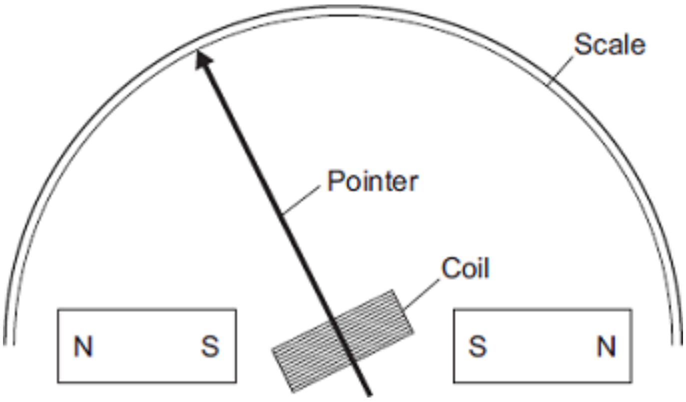
1. ______________________________
2. ______________________________
3. ______________________________

(3)

(d) **Figure 5** shows part of a moving-coil ammeter as drawn by a student.

The ammeter consists of a coil placed in a uniform magnetic field.
When there is a current in the coil, the force acting on the coil causes the coil to rotate and the pointer moves across the scale.

Figure 5



(i) The equipment has **not** been set up correctly.

What change would make it work?

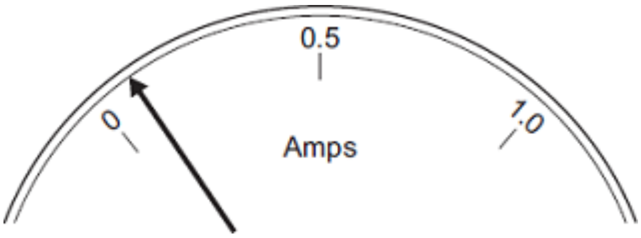
____

____

(1)

(ii) **Figure 6** shows the pointer in an ammeter when there is no current.

Figure 6



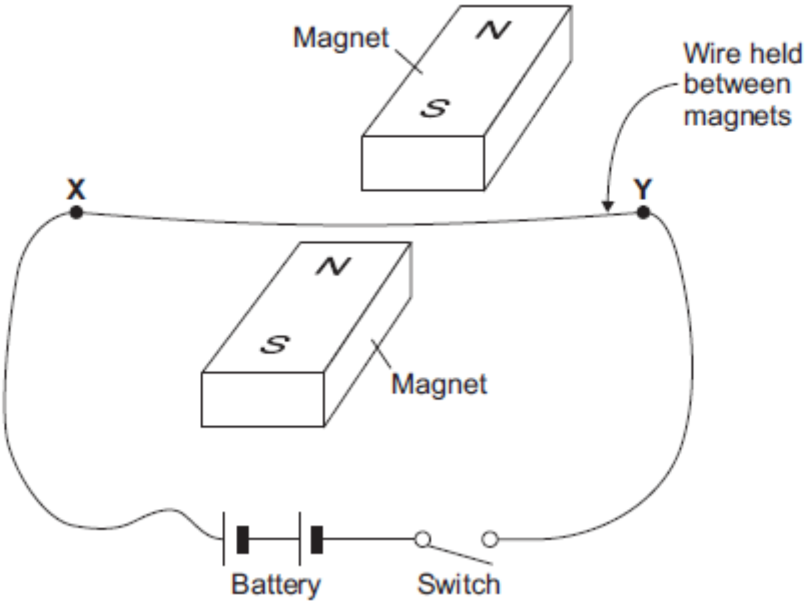
What type of error does the ammeter have?

____

(1)
(Total 10 marks)

Q12.

The diagram shows apparatus set up by a student.



Closing the switch creates a force that acts on the wire **XY**.

(a) (i) Explain why a force acts on the wire **XY** when the switch is closed.

___

___

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___

___

(3)

(ii) The force causes the wire **XY** to move.
Draw an arrow on the diagram above to show the direction in which the wire **XY** will move.

(1)

(iii) State the effect that this experiment demonstrates.

___

(1)

(b) The student replaced the battery with a low frequency alternating current (a.c.) power supply.

The student closed the switch.

(i) Describe the movement of the wire.

___

(1)

(ii) Give a reason for your answer to part (i).

___

___

___

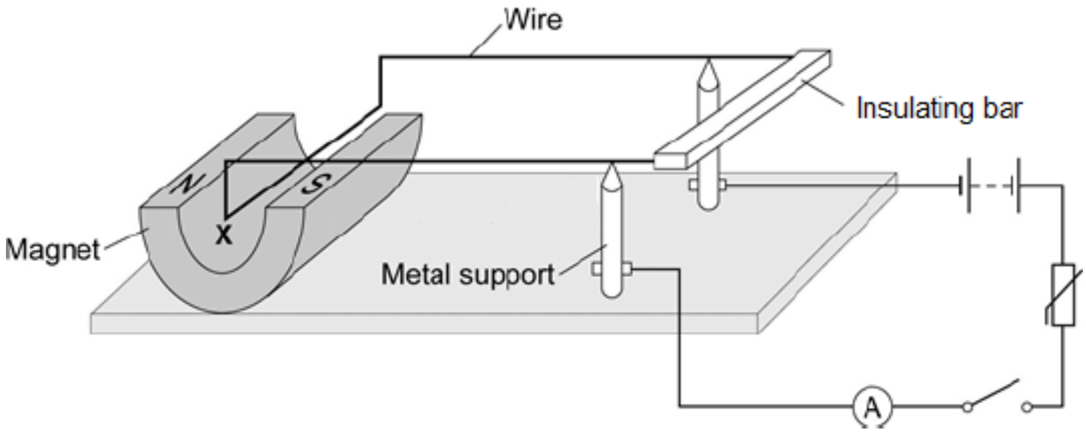
(1)

(Total 7 marks)

Q13.

Figure 1 shows a piece of apparatus called a current balance.

Figure 1



When the switch is closed, the part of the wire labelled **X** experiences a force and moves downwards.

(a) What is the name of the effect that causes the wire **X** to move downwards?

___

(1)

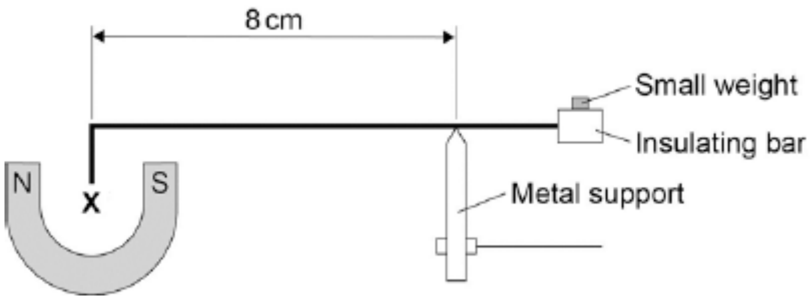
(b) Suggest one change you could make to the apparatus in **Figure 1** that would increase the size of the force that wire **X** experiences.

___

(1)

(c) **Figure 2** shows how a small weight placed on the insulating bar makes the wire **X** go back and balance in its original position.

Figure 2



The wire **X** is 5 cm long and carries a current of 1.5 A.

The small weight causes a clockwise moment of 4.8×10^{-4} Nm.

Calculate the magnetic flux density where the wire **X** is positioned

Give the unit.

___

___

___

___

___

___

___

Magnetic flux density = ______________ Unit ______________

(6)

(Total 8 marks)

Mark schemes

Q1.

(a) a force

1

(b) any **two** from:

- more powerful magnet
  *do **not** allow 'bigger magnet'*
- reduce the gap (between magnet and coil)
- increase the area of the coil
- more powerful cell
  *do **not** allow 'bigger cell'*
  accept battery for cell
  accept add a cell
  accept increase current / potential difference
- more turns (on the coil)
  allow 'more coils on the coil'
  *do **not** allow 'bigger coil'*

2

(c) reverse the (polarity) of the cell
allow 'turn the cell the other way round'
accept battery for cell

1

reverse the (polarity) of the magnet
allow 'turn the magnet the other way up'

1

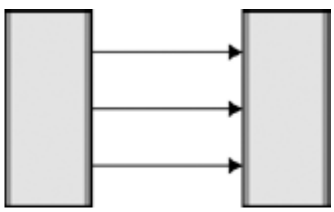
[5]

Q2.

(a) (i) field pattern shows:
some straight lines in the gap

1

direction N to S



1

(ii) north poles repel

1

(so) box will not close

1

(b) (i) as paper increases (rapid) decrease in force needed

1

force levels off (after 50 sheets)

1

(ii) the newtonmeter will show the weight of the top magnet

1

(iii) (top) magnet and newtonmeter separate before magnets separate

accept reverse argument

1

(because) force between magnets is greater than force between magnet and hook of newtonmeter

1

(iv) any **three** from:

- means of reading value of force at instant the magnets are pulled apart
- increase the pulling force gently
  or
  use a mechanical device to apply the pulling force
- clamp the bottom magnet
- use smaller sheets of paper
- fewer sheets of papers between readings (smaller intervals)
- ensure magnets remain vertical
- ensure ends of magnet completely overlap
- repeat the procedure several times for each number of sheets and take a mean
- make sure all sheets of paper are the same thickness

3

(v) 3 (mm)

*30 × 0.1 ecf gains **2** marks*

*2.1 N corresponds to 30 sheets gains **1** mark*

3

[15]

Q3.

(a) induced

1

(b) bar 2

1

(the same end) of bar 1 attracts both ends of bar 2

or

only two magnets can repel so cannot be bar 1 or bar 3

1

(c) so the results for each magnet can be compared

or

so there is only one independent variable

fair test is insufficient

allow different thickness of paper would affect number of sheets each magnet could hold

accept it is a control variable

1

(d) because the magnet with the biggest area was not the strongest

accept any correct reason that confirms the hypothesis is wrong eg smallest magnet holds more sheets than the largest

1

[5]

Q4.

(a) motor

1

(b) increase the strength of the magnetic field

accept use a stronger magnet

use a larger / bigger magnet is insufficient

*do **not** accept move magnets closer*

1

increase the (size of the) current

accept use a current greater than 2 (A)

accept increase the p.d. / voltage (of the power supply)

increase the power supply is insufficient

1

(c) any **one** from:

- (reverse the) direction of the current

  accept swap the wires at the power supply connections

  swap the wires around is insufficient
- (change the) direction of the magnetic field

  accept turn the magnet around

  *do **not** accept use an a.c. supply*

1

(d) The wire is parallel to the direction of the magnetic field.

1

[5]

Q5.

(a) field

correct order only

1

current

1

force

accept motion
accept thrust

1

(b) (i) arrow pointing vertically downwards

1

(ii) increase current / p.d.

accept voltage for p.d.

1

increase strength of magnetic field

accept move poles closer together

1

(iii) reverse (poles of) magnets

1

reverse battery / current

1

(c) (i) 1.5 or 150%

efficiency = 120 / 80 (× 100)
*gains **1** mark*
an answer of 1.5 % or 150
*gains **1** mark*

2

(ii) efficiency greater than 100%
or
output is greater than input
or
output should be 40 (W)

1

(iii) recorded time much shorter than actual time

accept timer started too late
accept timer stopped too soon

1

[12]

Q6.

(a) top of each paper clip labelled N / north

both parts required

and
bottom of each paper clip labelled S / south

1

(b) so the paper clips have the same weight / mass

1

which allows the results for different numbers of turns to be compared (fairly)

allow <u>fair test</u>

allow the control variable (is the weight / mass of a paper clip)
allow to obtain valid results
ignore accurate results

1

(c) as the number of turns increases so does the number of paper clips (held)
allow positive correlation

1

in a linear pattern
*directly proportional scores **2** marks*
*allow a correct description of directly proportional for **2** marks*

1

(d) some of the paper clips were already magnetised

1

(e) discount the result of 18
ignore repeat experiment / measurements

1

as the three new results are similar (and not close to 18)

1

and use 15 (the mean of the new results)
allow find the mean of the remaining results (16,14 and 15)
if no other marks have been awarded: calculate the mean (of all four results) (1)
round down to 15 (1) − this mark only scores if the mean of 15.75 has been calculated

1

(f) keep number of turns constant
allow a specific number of turns

1

(use the variable resistor to) change the current (several times)
change the p.d. is insufficient

1

(for each current value) count how many paper clips the electromagnet will hold

1

[12]

Q7.

(a) the magnets are not touching

1

but (each) experiences a force
allow but there is a force of attraction between them

1

(b) place a (plotting) compass near the (north / south) pole of the magnet and mark the direction that the compass points

1

move the (plotting) compass around the bar magnet (to the other pole) marking at (regular) intervals the direction the compass points

1

join the points up and add an arrow pointing from the north pole to the south pole

1

(c) (closing switch S) causes a current in the coil

allow switches on the electromagnet

1

a magnetic field is created

1

a force of attraction acts on the ball bearing

1

so the ball bearing accelerates (towards the iron rod)

1

[9]

Q9.

(a) (i) an electrical conductor

1

(ii) increase current

accept increase p.d. / voltage

or

use stronger magnets

accept move magnets closer

*do **not** accept use larger magnets*

1

(iii) reverse the poles / ends (of the magnet)

either order

1

reverse the connections (to the power supply)

1

(b) (i) environmental

1

(ii) ethical

allow political (instability)

allow economic (migration)

1

[6]

Q10.

(a) at least three circles drawn

1

clockwise arrows on circles

*allow **1** mark for one or two circles with clockwise arrows*

1

(b) 4×10^{-6}

1

(c) the sides of the coil (parallel to the magnet) experience a force (in opposite directions)

allow the current creates a magnetic field
ignore Fleming's Left Hand Rule

1

the forces cause moments that act in the same (clockwise / anticlockwise) direction
or
the moments cause the coil to rotate (clockwise / anticlockwise)

allow the magnetic fields interact to create a pair of forces (acting in opposite directions)
or
allow the magnetic fields interact causing the coil to rotate

1

(each half-revolution) the two halves of the (rotating) commutator swap from one (carbon) brush to the other

1

(each half-revolution) the commutator reverses the current (in the coil)
or
keeping the forces in the same direction (keeping the coil rotating)

allow keeps the current in the same direction relative to the (permanent) magnetic field

1

[7]

Q11.

(a) north (pole)

accept N

north (pole)

both needed for mark

1

(b) reverses

accept changes direction

1

(c) (i) first finger:
(direction of) (magnetic) field

1

second finger:
(direction of) (conventional) current

1

(ii) into (plane of the) paper

1

(iii) less current in wire

accept less current / voltage / more resistance / thinner wire

1

weaker field

allow weaker magnets / magnets further apart

*do **not** accept smaller magnets*

1

rotation of magnets (so) field is no longer perpendicular to wire

1

(d) (i) reverse one of the magnets

*do **not** accept there are no numbers on the scale*

1

(ii) systematic or zero error

accept all current values will be too big

accept it does not return to zero

accept it does not start at zero

1

[10]

Q12.

(a) (i) (closing the switch makes) a current (through the wire)

1

(the current flowing) creates a magnetic field (around the wire)

1

this field interacts with the permanent magnetic field

accept links / crosses attracts / repels is insufficient

1

(ii) arrow drawn showing upwards force on XY

judge vertical by eye the arrow must be on or close to the wire XY

1

(iii) motor

accept catapult

1

(b) (i) the wire moves up and down

or

the wire vibrates

back and forth or side to side is insufficient for vibrate

1

(ii) the force (continually) changes direction (from upwards to downwards, on the wire)

accept the direction of the magnetic field (of the wire) changes

1

[7]

Q13.

(a) motor effect 1

(b) increase the strength of the magnet

or

increase the current 1

(c) $4.8 \times 10^{-4} = F \times 8 \times 10^{-2}$ 1

$F = 6 \times 10^{-3}$ (N) 1

$6 \times 10^{-3} = B \times 1.5 \times 5 \times 10^{-2}$ 1

$B = \frac{6 \times 10^{-3}}{7.5 \times 10^{-2}}$ 1

$B = 8 \times 10^{-2}$ or 0.08 1

*allow 8×10^{-2} **or** 0.08 with no working shown for **5** marks*

*a correct method with correct calculation using an incorrect value of F gains **3** marks*

Tesla

accept T 1

do not accept t

[8]

Q1.

Nearly three quarters of students answered part(a) correctly. In (b)&(c), although better answered than in previous series, students continue to have difficulties describing accurately what changes need to be made to a motor to cause different effects. Some still only state what needs to be changed without specifying in what way it is changed, in many of the answers the descriptions were too vague to merit a mark.

Q4.

(a) Nearly three quarters of the students scored this mark.

(b) Many students who did not score either mark were along the right lines and mentioned both current and the strength of the magnet, but did not state that these needed to be increased. A number of students gave vague answers such as 'increase the power supply' rather than indicating that an increase in potential difference or current was needed. Only one fifth of the students scored both marks, with a further third of the students scoring one mark.

(c) Just under half of the students scored this mark. A large proportion of the students who failed to score this mark suggested using an a.c. supply. Some students also gave answers in terms of changing the cotton thread.

(d) Approximately three quarters of the students scored this mark.

Q5.

(a) Three quarters of students gained all three marks on this question for correctly matching the field, current and force to the three digits of Fleming's left hand.

(b) (i) Half of the students failed to score the mark here for showing the direction of the force on the wire in the field. Among the various incorrect responses were: arrows pointing up, not down; curved arrows; arrows pointing towards the axis and those who did not read the question and put an arrow somewhere else and not on, or even close to, the wire AB.

(ii) Three quarters of the students scored both marks here for correctly suggesting an increase in the current and an increase in the magnetic field strength would increase the force acting on the wire. Suggestions that using a coil or using bigger magnets were not acceptable. Some students did not give comparative answers, eg changing the field or current, and did not score.

(iii) Three quarters of the students scored two marks, probably following on from their knowledge that allowed them to get 2 marks from ii. In many cases instead of 'reverse' they would use 'swap' or 'switch' and many wanted to say how they would reverse the magnetic field or current rather than simply saying that it needed to be reversed. Only a small number wanted to include an iron core. Some lost marks by being too imprecise with their answers such as 'move the magnets around' while others got confused about the split ring commutator.

(c) (i) Three-quarters of students gained full marks on this question with a common error being omitting the % from the 150 for the final answer. 150% was more commonly presented than 1.5. In some instances students selected the correct equation and wrote it out but failed to substitute correct numbers in the equation or showed no working and thus the origins of some answers couldn't be scrutinised. The number 24 cropped up in calculations a few times either subtracting from the power or substituting in place of output power; these students were clearly confused as to what work done was.

(ii) Most students realised that the efficiency couldn’t be >100% or that output (energy or power) was greater than input. Where this wasn’t achieved it was for saying that it was an anomaly without any further detail; saying it was different from the other; or just saying that it was impossible without further explanation.

(iii) This question was not well answered with most students scoring zero. The common themes for the incorrect answers were suggestions that the power was incorrectly calculated (output / input power or the output and input power were transposed), the stopwatch was misread or that there was a timing error, rather than identifying that the recorded time was too short.

Q6.

(a) Just over 60% of the students correctly indicated the north and south ends of both paper clips. Most of the other students indicated only a north pole on the top paper clip and a south pole at the lower end of the second paper clip.

(b) Many of the students stated that keeping all of the paper clips the same size would make it a ‘fair test’. Fewer suggested that the paper clips should all have the same weight or mass to allow for a fair comparison of the results. Common incorrect answers referred to current travelling in the paper clips or implied that larger paper clips would take more of a share of the magnetic field.

(c) 92% of the students scored at least one mark. Few of the students failed to recognise that the number of paper clips increased as the number of turns of wire increased. Many scored two marks by stating that the relationship was directly proportional or described the number of paper clips held increasing by three for every ten extra turns of wire on the electromagnet.

(d) Just over 80% of the students scored this mark.

(e) 78% of students scored one mark for this question. Few of the students picked up on 18 paper clips being an anomalous result and as such should be disregarded as the three remaining results were similar. A mean of the three similar results could then be found and used in the table. Students scoring one mark calculated the mean of all four results but did not gain a second mark for rounding down to the nearest whole paper clip.

(f) Most of the students appreciated that the current would need to be changed, with many specifying how. Fewer students explicitly stated that the number of turns needed to be kept constant. Only a minority explained that the number of paper clips held could be used to show the strength of the electromagnet.

Q8.

Foundation

(a) Many students thought that an electromagnet could somehow be adjusted to pick up a variety of specific metals. It was also not uncommon to see students stating that the electromagnet could separate metals, failing to realise that they were comparing the electromagnet with a permanent magnet, which would also be able to separate metals.

(b) The vast majority of students attempted this question, but many struggled to describe how to put an electromagnet together, and in particular it was not uncommon for students to connect the ends of the nail to the power supply. There was also a small minority of students who tried to express the intention to strip the ends of the insulating wire and attach crocodile clips to this, but actually described stripping the entire insulating wire. A few students thought that the insulating wire was to keep their electromagnet thermally insulated. Of those who did manage to describe the construction of an electromagnet well, most could describe a test to see if their electromagnet was working, but many struggled to increase the strength of the electromagnet, with comments indicating that they should turn up the power on the power supply, rather than increasing p.d., current or number of turns on the coil. Just less than half of students accessed Levels 2 or 3.

Higher

(a) Nearly four fifths of students answered this question correctly. The most common reason for not answering correctly was for stating that the electromagnet could separate metals, failing to realise that they were comparing the electromagnet with a permanent magnet, which would also be able to separate metals.

(b) Many students struggled to describe how to construct an electromagnet; in particular it was not uncommon to see students connecting the ends of the nail to the power supply, or failing to make clear whether the insulating wire or the iron nail was connected to the power supply. Most students who managed to do this correctly went on to describe a test for the strength of the electromagnet, although a significant number of students merely tested whether the electromagnet could pick up paperclips, and did not count how many. A number of students were confused between changing the strength of the electromagnet and testing the strength of it; it was not uncommon to see students stating that an electromagnet could be tested by adding more turns to the coil on the nail. About a third of students gave Level 3 responses to this question. A common reason for a student reaching Level 2 but not getting into Level 3 was that they talked about increasing the power from the power supply, rather than increasing the current or potential difference. Just under a quarter of students gave Level 2 responses.

Q9.

(a) (i) Although over half of candidates knew that the experiment worked because copper is an electrical conductor, just under half of candidates thought it was because copper is a magnetic material.

(ii) Nearly three quarters of candidates were able to describe an acceptable way to increase the speed of the copper roller. However in this question and the next many candidates suggested tilting the rails to achieve the desired effect.

(iii) Candidates lost marks in this question by not explaining clearly enough what they meant, for example several mentioned moving the battery to the other side without mentioning reversing the current or the connections and there were many incorrect answers relating to the switch. However, more than two fifths of candidates gained at least one mark. The most common correct answer related to reversing the magnetic field in some way.

(b) (i) This was well answered with nearly all candidates gaining the mark.

(ii) This was well answered with nearly two thirds of candidates giving the correct type of issue.

Q10.

(a) Many diagrams looked like the field around a bar magnet or solenoid. Shapes similar to the electric field around a point charge were also drawn.

(b) About half of students knew the value equivalent to 4 microtesla.

(c) Very few students gave a coherent, detailed answer to this question. Most concentrated on what made the coil move, although ideas were not always expressed with clarity. It was unusual to see an answer that considered moments. The action of the commutator was not understood well and its function was often not mentioned. Some students appreciated that current direction needed to be reversed but thought an alternating current was the solution. There were significant numbers of students unsure whether the question was about an electric motor or a generator. Many answers made reference to induced currents in the coil and the coil cutting field lines to induce a potential difference.

Q11.

(a) Just over half of the students knew that a magnetic field of repulsion between two poles with lines of force moving outward from the poles was that between two north poles.

(b) Nearly all students knew that reversing the current through a wire also reversed the direction of the field lines associated with it.

(c) (i) Three-quarters of students knew which directions the first two fingers represent in Fleming's left-hand rule.

(ii) Students were given a diagram of a wire carrying a current in a magnetic field. Using Fleming's left-hand rule the wire would move into the paper. Many students were able to use the rule successfully, but their answers were ambiguous, such as 'downwards' and 'away from you'. Less than a fifth of students scored the mark.

(iii) Over three quarters of the students knew that decreasing the current and the strength of the magnetic field would decrease the force acting on the wire. Only a tenth of the students knew that rotating the magnets so that the field was no longer perpendicular to the wire would also have the same effect.

(d) (i) Most students observed that two south poles facing each other would not give a uniform magnetic field and suggested that one of the magnets should be rotated.

(ii) Less than three quarters of students knew that an ammeter pointing to a value above zero when no current was in it, had a systematic or zero error.

Q12.

(a) (i) Just over one tenth of the students gave excellent and detailed descriptions of why a force acted on the wire, with a clear understanding of the interaction between the magnetic field due to the current in the wire and that of the permanent magnet. In contrast, a significant number of students answered only in terms of a current carrying conductor experiencing a force when placed at an angle to a permanent magnetic field. Consequently, it was usually impossible to give credit for two of the three marking points. Such answers usually gained just one mark for stating that closing the switch caused a current in the wire.

(ii) Just under half the students correctly drew in the upwards force on the wire. Many of the rest had the force moving towards one pole or the other of the permanent magnets, i.e. parallel with the permanent field rather than perpendicular to it.

(iii) Only about one half of the students correctly stated this to be the motor effect. Many students simply quoted this to be electromagnetism and some mentioned Fleming's Left Hand Rule.

(b) (i) About two thirds of the students failed to describe the movement of the wire as slowly vibrating up and down. Some thought it would not move at all, and others simply stated that the wire would move the other way.

(ii) Less than one fifth of the students were successful in their answers. The vast majority gave as their explanation that the current was alternating, which was given in the question, rather than stating that this would lead to the force continually changing direction by virtue of the direction of the magnetic field of the wire changing.