Materials
For this paper you must have:
- Ruler
- Pencil, Rubber, Protractor and Compass
- Scientific calculator, which you are expected to use when appropriate

Instructions
- Answer all questions
- Answer questions in the space provided
- All working must be shown
- Do all rough work in this book. Cross out any rough work you don’t want to be marked

Information
- The marks for the questions are shown in brackets
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.

<table>
<thead>
<tr>
<th>current</th>
<th>field</th>
<th>force</th>
<th>potential difference</th>
</tr>
</thead>
</table>

Figure 1

Direction of ________________

Direction of ________________

Direction of ________________

(b) Figure 2 shows an electric motor.

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

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

1. ______________________________________________________________________

2. ______________________________________________________________________

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

1. ______________________________________________________________________

2. ______________________________________________________________________
A student used an electric motor to lift a mass. This is shown in **Figure 3**.

![Figure 3](image)

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.

<table>
<thead>
<tr>
<th>Test</th>
<th>Electrical input power in watts</th>
<th>Work done lifting the mass in joules</th>
<th>Time taken to lift the mass in seconds</th>
<th>Output power in watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20</td>
<td>24</td>
<td>2.4</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>40</td>
<td>24</td>
<td>1.2</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>60</td>
<td>24</td>
<td>0.8</td>
<td>30</td>
</tr>
<tr>
<td>D</td>
<td>80</td>
<td>24</td>
<td>0.2</td>
<td>120</td>
</tr>
</tbody>
</table>

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

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

Efficiency = ____________________

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

Efficiency = ____________________

(1)
This question is about magnetism.

(a) Which two materials are magnetic?

Tick two boxes.

- Carbon
- Cobalt
- Copper
- Nickel
- Sodium

(b) Describe how you could find the magnetic field pattern of a permanent bar magnet.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(iii) Suggest a reason for this anomalous result.

___________________________________________________________________
___________________________________________________________________

(Total 12 marks)
A student investigates how the number of turns of wire on a solenoid affects the strength of the solenoid.

To test the strength of the solenoid she looks at how many paper clips the solenoid could lift.

**Figure 1** shows how she sets up the equipment.

She keeps the current through the coil constant throughout the experiment.

![Figure 1](image_url)

The table below shows the student’s results.

<table>
<thead>
<tr>
<th>Number of turns of wire on solenoid</th>
<th>Number of paper clips picked up by solenoid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test 1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>30</td>
<td>11</td>
</tr>
<tr>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>50</td>
<td>21</td>
</tr>
<tr>
<td>60</td>
<td>25</td>
</tr>
</tbody>
</table>
Use the data from the table above to complete the graph in Figure 2.

- The first two points have been plotted for you.
- Draw a line of best fit.

**Figure 2**

(d) Describe the pattern shown in the graph.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(e) Use your graph to predict how many paper clips the solenoid will pick up when 80 turns of wire are used.

Number of paper clips picked up = _________________

(Total 11 marks)
A student is investigating the strength of electromagnets.

**Figure 1** shows three electromagnets.

The student hung a line of paper clips from each electromagnet.

**Figure 1**

No more paper clips can be hung from the bottom of each line of paper clips.

(a) (i) Complete the conclusion that the student should make from this investigation.

Increasing the number of turns of wire wrapped around the nail will ______________ the strength of the electromagnet.

(ii) Which **two** pairs of electromagnets should be compared to make this conclusion?

**Pair 1**: Electromagnets __________ and __________

**Pair 2**: Electromagnets __________ and __________

(iii) Suggest **two** variables that the student should control in this investigation.

1. _______________________________________________________________________
2. _______________________________________________________________________

2
(b) The cell in electromagnet A is swapped around to make the current flow in the opposite direction. This is shown in Figure 2.

Figure 2

What is the maximum number of paper clips that can now be hung in a line from this electromagnet?

Draw a ring around the correct answer.

fewer than 4 4 more than 4

Give one reason for your answer.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(2)

(c) Electromagnet A is changed to have only 10 turns of wire wrapped around the nail.

Suggest the maximum number of paper clips that could be hung in a line from the end of this electromagnet.

Maximum number of paper clips = _________________________

(1)

(Total 7 marks)
Figure 1 shows a traditional transformer.

(a) (i) Which metal should the core of the transformer be made from?

Tick (√) one box.

- aluminium
- copper
- iron

(ii) What would the reading be on the voltmeter shown in Figure 1?

Draw a ring around the correct answer.

2 V 10 V 50 V

Give the reason for your answer.

____________________________________________________________________________________

____________________________________________________________________________________

(1)
(b) Figure 2 shows a tablet computer and its charger.

The charger contains a switch mode transformer.

(i) Use the correct answer from the box to complete the sentence.

| 200 | 1000 | 20 000 |

Switch mode transformers operate at frequencies from 50 kHz to ______________ kHz.

(ii) Give one advantage of a switch mode transformer over a traditional transformer.

____________________________________________________________
____________________________________________________________

(Total 5 marks)

(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)
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.

![Equipment Diagram]

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)
Figure 1 shows a magnet moving into a coil of wire. This movement causes a reading on the voltmeter.

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

<table>
<thead>
<tr>
<th>generated</th>
<th>induced</th>
<th>produced</th>
</tr>
</thead>
</table>

Moving the magnet into the coil of wire causes a reading on the voltmeter because a potential difference is ________________ across the ends of the wire.

(b) A student investigated how the number of turns on the coil of wire affects the maximum voltmeter reading. The student changed the number of turns on the coil of wire, then moved the magnet into the coil. The student recorded the maximum voltmeter reading.

To obtain valid data, suggest two variables that the student should control in this investigation.

1. _________________________________________________________________
   __________________________________________________________________

2. _________________________________________________________________
   __________________________________________________________________
(c) The student’s results are shown in Figure 2.

![Figure 2](image)

(i) One of the results is anomalous.
Suggest a reason for the anomalous result.

___________________________________________________________________

(1)

(ii) Draw a line of best fit on Figure 2.

(1)

(d) A data-logger can automatically record and store data.

It may have been better for the student to have used a data-logger in his investigation rather than a voltmeter.

Suggest one reason why.

___________________________________________________________________

___________________________________________________________________

(1)

(Total 6 marks)
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? _____________________

(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

(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?

__________________________________________________________________________

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

1. ____________________________________________________________

2. ____________________________________________________________

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](image)

(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](image)

What type of error does the ammeter have?

__________________________________________________________________________________

(1)

(Total 10 marks)
Iron is a metal that has many uses.

(a) Iron is extracted from iron ore. Part of the process involves reduction of the ore with carbon monoxide.

Iron ore contains iron oxide (Fe$_2$O$_3$).

Write a balanced equation for the reaction of iron oxide with carbon monoxide.

___________________________________________________________________

(b) Explain why this reaction is a redox reaction.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

Steel is an alloy of iron. Steel is used to make cars.

After its useful life a car is taken to a scrapyard for recycling.

(c) Suggest four benefits of recycling a car body.

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___________________________________________________________________

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___________________________________________________________________
(d) Figure 1 shows an electromagnet being used to lift a car in a scrapyard.

Figure 1

An electromagnet is made up of a solenoid.

Figure 2 shows a solenoid.

Figure 2

Draw the magnetic field of the solenoid on Figure 2.

(2)
(e) In a scrapyard, an electromagnet is used to lift and release cars so they can be moved around.

Suggest **two** ways a solenoid could be made to lift and release cars in a scrapyard.

Explain why each suggestion would be useful in the scrapyard.

___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

(4)
(Total 15 marks)
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.

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

(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)