OCR
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H

GCSE (9–1) Physics B (Twenty First Century Science)

J259/03 Breadth in physics (Higher Tier)

Wednesday 23 May 2018 – Afternoon

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)
- the Data Sheet for GCSE Physics B (inserted)

You may use:
- a scientific or graphical calculator
- an HB pencil

First name					
Last name					
Centre number					
Candidate number					

INSTRUCTIONS
- The Data Sheet will be found inside this document.
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **28** pages.

Answer **all** the questions.

1 Nina is writing a report about the Solar System.

She has written an introduction.

> The planets in our Solar System all move around the Sun.
> They orbit in perfect circles and in the same direction.
> Each planet has at least one moon orbiting it.
> The planets and their moons are all made of rock.

(a) Identify **two** mistakes in Nina's introduction.

1 ....

....

2 ....

....
[2]

(b) Nina wants to include a section about how the Solar System was formed.

Describe how the Solar System was formed.

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.... **[2]**

(c) Nina researches how the Sun releases energy. She finds this information in a textbook.

> The Sun releases energy by nuclear fusion. The Sun emits about 4×10^{26} J of energy every second. As a result, its mass falls by about 4 billion kilograms every second.

Explain why nuclear fusion causes the mass of the Sun to decrease.

....

.... **[1]**

2 A toothbrush uses a rechargeable battery.

(a) The energy that is stored in the battery comes from a power station.

State how the energy is transferred from the power station to the chemical store in the battery.

....

.... **[1]**

(b) The potential difference across the battery is 1.2 V.

During a typical use, 360 C of charge moves through the toothbrush motor over a time of 2 minutes.

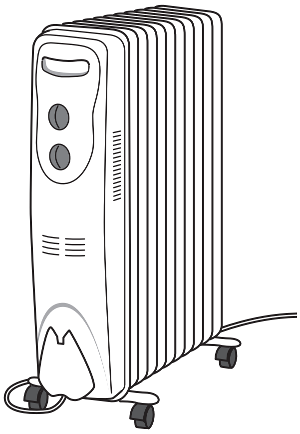
(i) Calculate the total energy transferred by the toothbrush in one day if it is used **two** times a day.

Energy transferred = ... J **[3]**

(ii) Calculate the current in the toothbrush when used for 2 minutes each time.

Current = ... A **[4]**

3 The diagram shows a common type of electric heater. It contains oil which is heated by an electrical element.



The table shows some information about the heater.

Electrical power	1500 W
Voltage rating	230 V
Specific heat capacity of oil	1600 J / kg °C
Mass of oil	4.5 kg

(a) Show that more than 700 000 J of energy is needed to heat the oil from 20 °C to 120 °C.

Use the equation:
change in internal energy = mass × specific heat capacity × change in temperature

[2]

(b) **(i)** Use your answer to **(a)** to calculate the minimum time for the oil to reach a temperature of 120 °C, starting at 20 °C.

Minimum time = ... s **[3]**

(ii) In practice, it will take longer than this for the heater to reach 120 °C.

State the reason for this.

....

.... **[1]**

4 **(a)** The maximum speed of a racing car is 320 km / hour.

Calculate this speed in metres per second.

Maximum speed = ... m / s **[2]**

(b) **(i)** A different racing car is moving with a speed of 80 m / s.

Before turning a corner, it slows down to a speed of 20 m / s.

While slowing down, it has a constant acceleration of $-40\ m/s^2$.

Calculate the distance that it travels as it slows down.

Distance travelled = ... m **[3]**

(ii) The car moves at a constant speed around the corner.

Explain why its velocity is changing as it moves around the corner.

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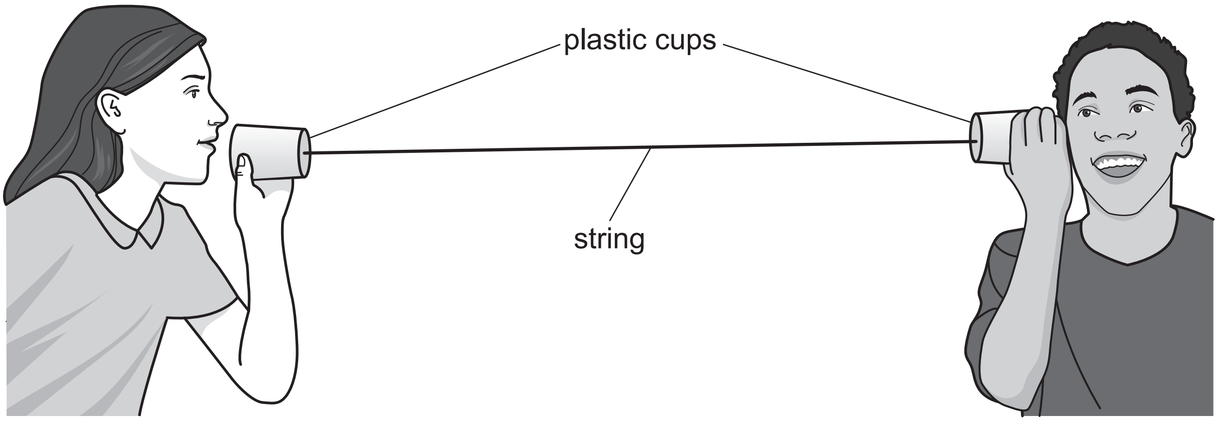
.... **[2]**

5 Eve and Amir make a toy telephone out of plastic cups and string.



Sound waves in the air change when they become sound waves in the string.

(a) How do the **speed**, **frequency** and **wavelength** of the sound waves change when they leave the air and enter the string?

Put one tick (✓) in each row. One has been done for you.

	Increase	**Decrease**	**Stay the same**
Speed	✓		
Frequency			
Wavelength			

[2]

(b) The speed of sound in the string is 600 m/s.

Calculate the frequency of a sound with wavelength 1.2 m in the string.

Frequency = ... Hz **[3]**

6 James and Mia investigate their hearing.

James uses an app on his phone to make sounds with different frequencies.

For each frequency, he starts with the volume on his phone set at zero.

Then he turns the volume up step by step until Mia can just hear the sound.

The results show the volume setting needed before Mia can hear the noise for each frequency.

Frequency (Hz)	Volume setting
55	13
110	11
220	7
440	1
880	1
1760	1

(a) Explain why Mia finds it easier to hear some of these frequencies.

....

....

.... **[2]**

(b) They repeat the experiment.

This time there is a wall between the phone and Mia. They want to see what effect the wall has on the results.

(i) Suggest **one** variable that should be controlled to make this new experiment a fair comparison with the first experiment.

....

.... **[1]**

(ii) The volume setting needed for each frequency is higher in the new experiment.

Describe how the sound waves reach Mia and why they sound more faint.

....

....

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.... **[2]**

(c) Mia reads on the internet that the human ear is most sensitive at a frequency about 2000 Hz.

Describe how James and Mia could improve their experiment to test this hypothesis.

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....

....

.... **[3]**

7 Ali investigates electromagnetic induction.

He pushes a magnet quickly into a coil of wire. He uses an ammeter to record the biggest current produced in the coil.

He repeats the experiment for coils with different numbers of turns.

Table 7.1 shows his results.

Number of turns	Current (mA)
200	1.1
400	3.0
600	5.4
800	6.7
1000	9.1
1200	11.0

Table 7.1

(a) Explain why a current is produced in the coil.

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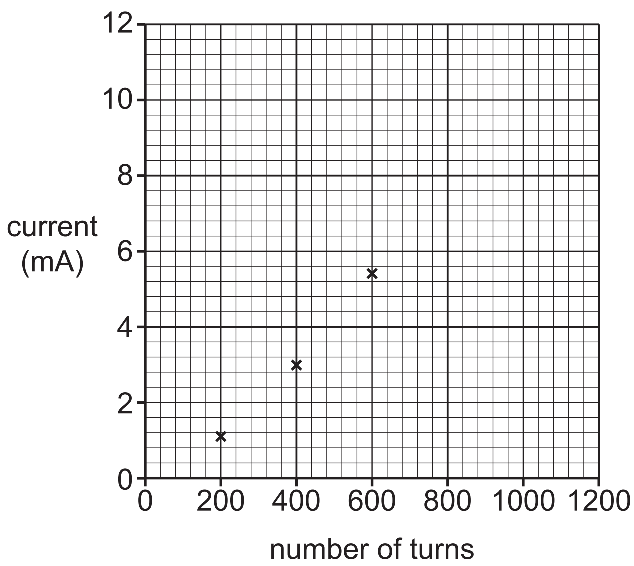
....

.... **[2]**

(b) **(i)** Complete the graph by plotting the missing results in **Table 7.1** and draw a line of best fit.



[2]

(ii) Use your line of best fit to determine the maximum current that Ali could produce if he used a coil with **700 turns**.

Maximum current = ... mA **[1]**

(iii) Amaya says that this experiment is not valid because the speed of the magnet may be different each time.

Suggest how Ali could control the speed of the magnet.

....

.... **[1]**

(c) As Ali pushes the magnet towards the coil, he feels a small repulsive force.

Explain why.

....

....

....

.... **[2]**

8 **Table 8.1** shows data for four radioactive isotopes.

Isotope	Half life	Type of decay
molybdenum-98	stable	
molybdenum-99	66 hours	beta
technetium-99m	6 hours	gamma
thallium-201	73 hours	gamma

Table 8.1

Technetium-99m is used in hospitals.

Technetium-99m is produced when molybdenum-99 emits beta radiation.

One method of producing molybdenum-99 is by firing neutrons at molybdenum-98.

(a) Complete these nuclear equations to show the production of technetium-99m.

$$^{98}_{42}\text{Mo} + ^{\cdots\cdots}_{\cdots\cdots}\text{n} \rightarrow ^{99}_{42}\text{Mo}$$

$$^{99}_{42}\text{Mo} \rightarrow ^{99}_{43}\text{Tc} + ^{\cdots\cdots}_{\cdots\cdots}\text{e}$$

[2]

(b) Molybdenum-99 is produced in nuclear reactors and then transported to hospitals. It may take several days for the molybdenum-99 to be transported.

In the hospital molybdenum-99 decays and the technetium-99m is produced as shown in part **(a)**.

Using information from **Table 8.1**, explain why technetium-99m is not transported directly to hospitals.

....

....

....

.... **[2]**

(c) Production of technetium-99m is becoming more expensive. An alternative for many medical procedures is thallium-201.

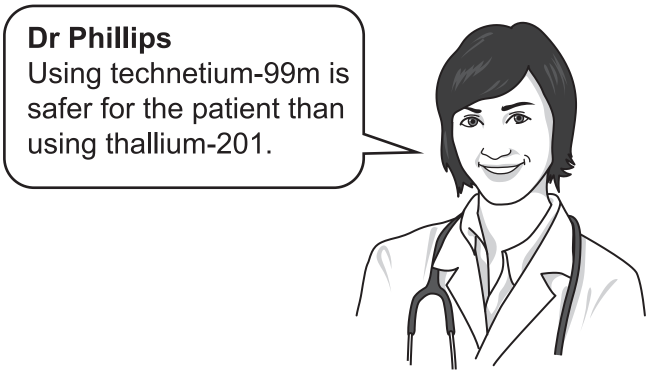
A patient is injected with a compound containing thallium-201. After 24 hours, 80% of the thallium-201 has not decayed.

A second patient is injected with a compound containing technetium-99m.

(i) Calculate the percentage of technetium-99m remaining after 24 hours.

Percentage remaining = ... % **[2]**

(ii) A doctor is deciding which radioactive isotope is best to use.



Evaluate this statement.

Use the data in **Table 8.1** and the information above in your answer.

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....

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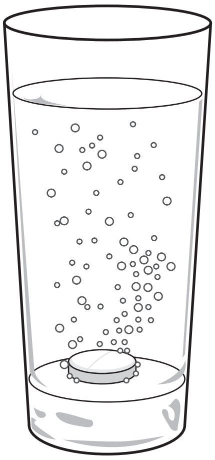
.... **[2]**

9 The picture shows a glass of water with a vitamin tablet at the bottom.



The tablet reacts with the water to produce bubbles of carbon dioxide.

The tablet stays at the bottom of the glass. The bubbles rise to the top of the glass.

(a) Which **two** of the statements below, taken together, explain why the bubbles rise but the tablet sinks?

Tick (✓) **two** boxes.

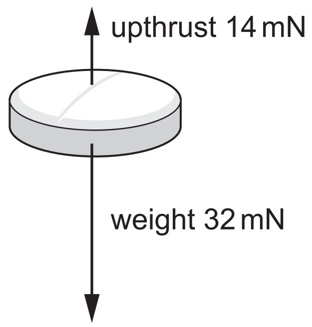
The bubbles are made of gas, but the tablet is solid.	☐
The material in the tablet is denser than water.	☐
The tablet is heavier than the bubbles.	☐
The water pressure at the bottom of the glass is greater than the water pressure at the top.	☐
Water is denser than the gas in the bubbles.	☐

[1]

(b) The diagram below is a free-body diagram for the tablet resting on the bottom of the glass.

Two of the forces acting on the tablet have already been drawn.

Draw **one** further force for the tablet and label it with its name and magnitude.



[2]

(c) **(i)** Explain what causes the force of upthrust that acts on the tablet.

....

....

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.... **[2]**

(ii) The upthrust on the tablet is bigger than the upthrust on any one bubble.

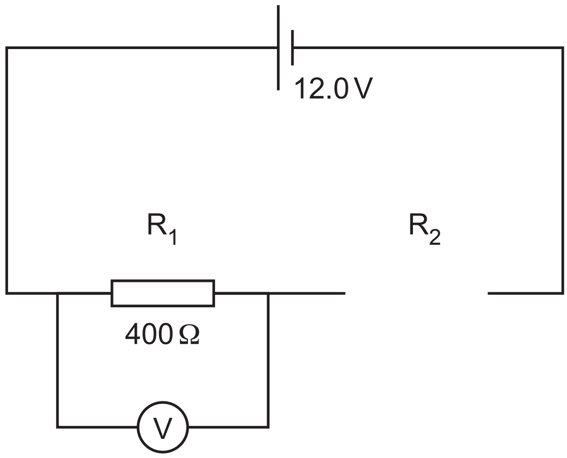
Give a reason for this.

....

.... **[1]**

10 Alex wants to use a thermistor as a temperature sensor.

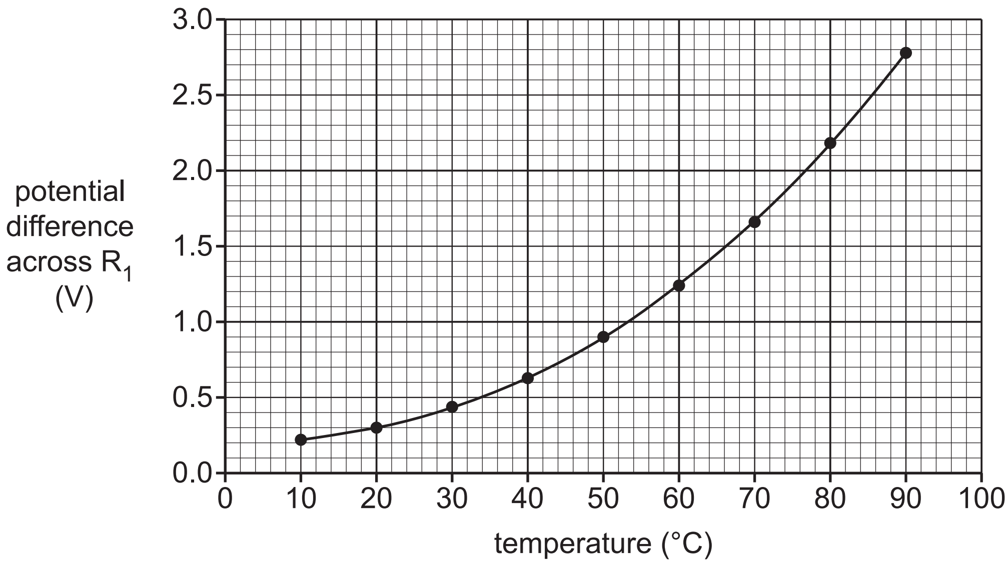
He sets up the circuit shown below.



(a) Draw the symbol for a thermistor in the space labelled R_2. **[1]**

(b) To investigate the sensitivity of the thermistor, Alex places it in a water bath with a temperature control.

He records the potential difference across R_1 for different temperatures set by the water bath. His results are shown in the graph.



(i) Describe and explain the relationship shown in the graph.

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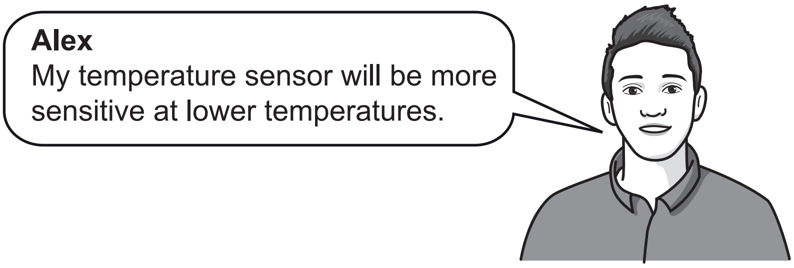
.... **[3]**

(ii) Alex plans to use the sensor to monitor temperature in a greenhouse. To find the temperature, Alex will measure the potential difference across R_1.

He will then read the temperature off the graph.



Evaluate Alex's statement using evidence from the graph.

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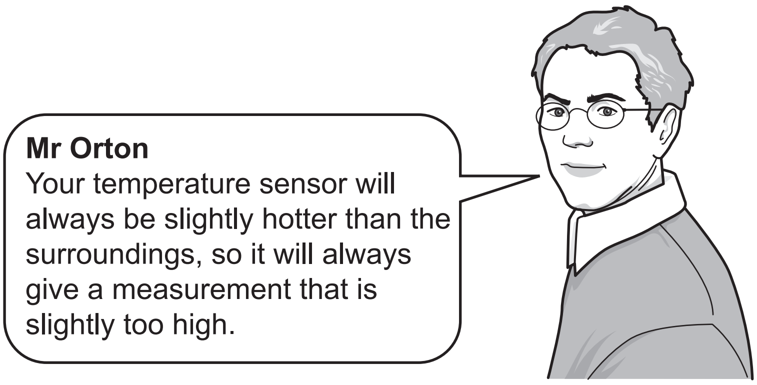
.... **[2]**

(c) Mr Orton, Alex's teacher, says that his temperature sensor will not work properly.



(i) What is the name of this type of error?

.... **[1]**

(ii) Explain why Mr Orton is correct, and suggest how this problem could be reduced.

....

....

....

.... **[2]**

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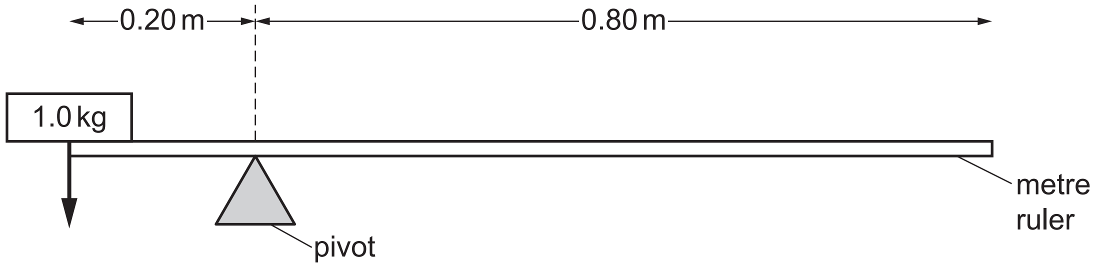
11 Jack investigates using weights to balance a seesaw. He makes the seesaw out of a metre ruler with a pivot placed at the 20 cm mark, as shown in the diagram.

He places a 1.0 kg mass with its centre exactly at one end of the metre ruler.



(a) Calculate the moment of the 1.0 kg mass about the pivot, in units of Nm.

Use the equation: moment of a force = force × distance (normal to the direction of the force)

gravitational field strength = 10 N / kg

Moment = ... Nm **[3]**

(b) Jack predicts where he should put masses on the right-hand side of the seesaw to make it balance.

He then carefully places those masses at points which make the seesaw balance and measures the actual distances to the pivot.

The table shows his results.

Mass (g)	**Predicted distance to pivot (m)**	**Measured distance to pivot (m)**
400	0.50	0.46
600	0.33	0.31
800	0.25	0.23
1000	0.20	0.19

(i) The measured distances to the pivot are all slightly smaller than the predicted distances to the pivot.

Explain why.

....

.... **[1]**

(ii) Suggest **one** way to improve his experiment to remove this difference.

....

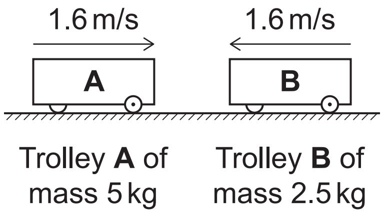
.... **[1]**

12 Trolley **A** of mass 5.0 kg moves at a constant speed of 1.6 m/s.

(a) Calculate the momentum of trolley **A**.

Momentum = ... kg m/s **[2]**

(b) Trolley **B** of mass 2.5 kg heads straight towards the first trolley in the opposite direction at the same speed of 1.6 m/s.



The two trolleys collide and stick together.

(i) Show that the velocity of the joined-up trolleys after the collision is about 0.5 m/s.

[4]

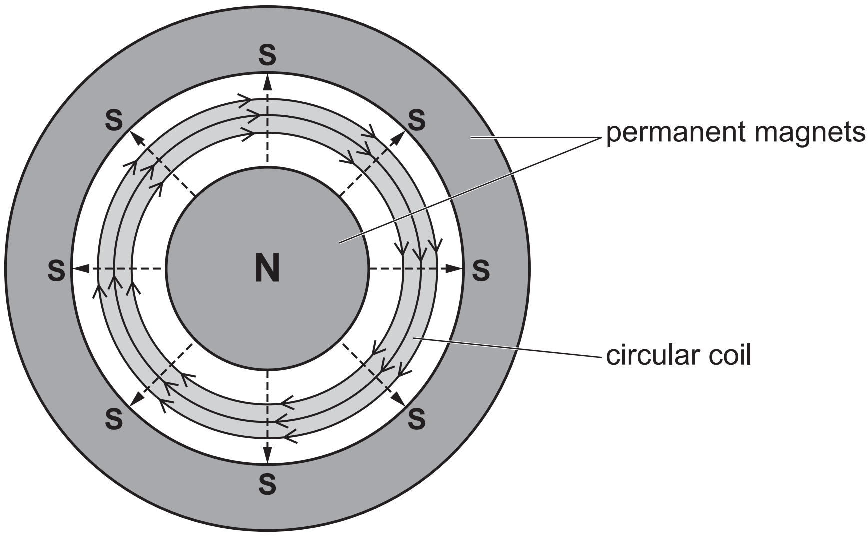
(ii) The collision takes a total time of 0.20 s.

Calculate the average force acting on trolley **A** during the collision.

Average force = ... N **[4]**

13 The diagram shows part of a loudspeaker. It contains specially-shaped permanent magnets with south poles, **S**, in a ring around the outside and a circular north pole, **N**, in the centre.

In the gap between the shaped magnets there is a circular coil carrying electrical current.



The direction of the magnetic field between the poles is shown as - - - - - - - ►.

The magnetic field through the coil has strength 0.40 T.

The coil has circumference 25 mm and has 200 turns. The diagram shows only 3 turns of this coil.

A clockwise current of 0.60 A in the coil produces a force on the coil.

(a) What is the direction of the force on the coil?

Tick (✓) **one** box.

Anti-clockwise	☐
Clockwise	☐
Into the page	☐
Out of the page	☐

[1]

(b) Calculate the magnitude of the force acting on the coil.

Force = ... N **[4]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).