1. When an electric motor is switched on, it has a very large current through it, but this rapidly drops to a much smaller value.

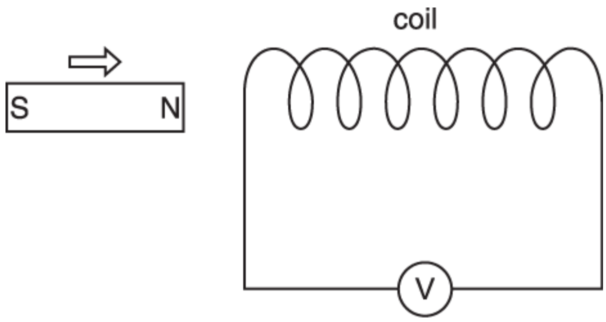
Which **two** of the following statements can explain this observation?
Put ticks (✓) in the boxes after the **two** correct statements.

The turning motor acts as a generator which produces a p.d. opposing the battery p.d.	☐
As the motor speeds up, the friction in the turning parts becomes smaller.	☐
Friction in the motor dissipates energy resulting in more energy taken from the supply.	☐
Current heats the coils in the motor which makes their resistance increase.	☐
As the motor turns faster, the force needed to turn it decreases	☐

[2]

2(a). Maria is investigating the generation of electricity.

She pushes the north pole of a magnet into a coil of wire. The coil is connected to a sensitive voltmeter.



The voltmeter gives a reading when the magnet is moving.

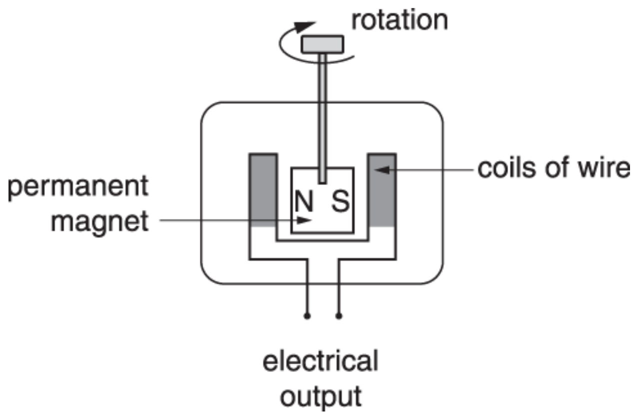
(i) What is the name of the process that produces the voltage?

____ [1]

(ii) State one change that Maria can make to produce a voltage in the opposite direction.

____ [1]

(b). Maria investigates an a.c. generator (dynamo) from a bicycle.



A voltage is produced when the magnet rotates.

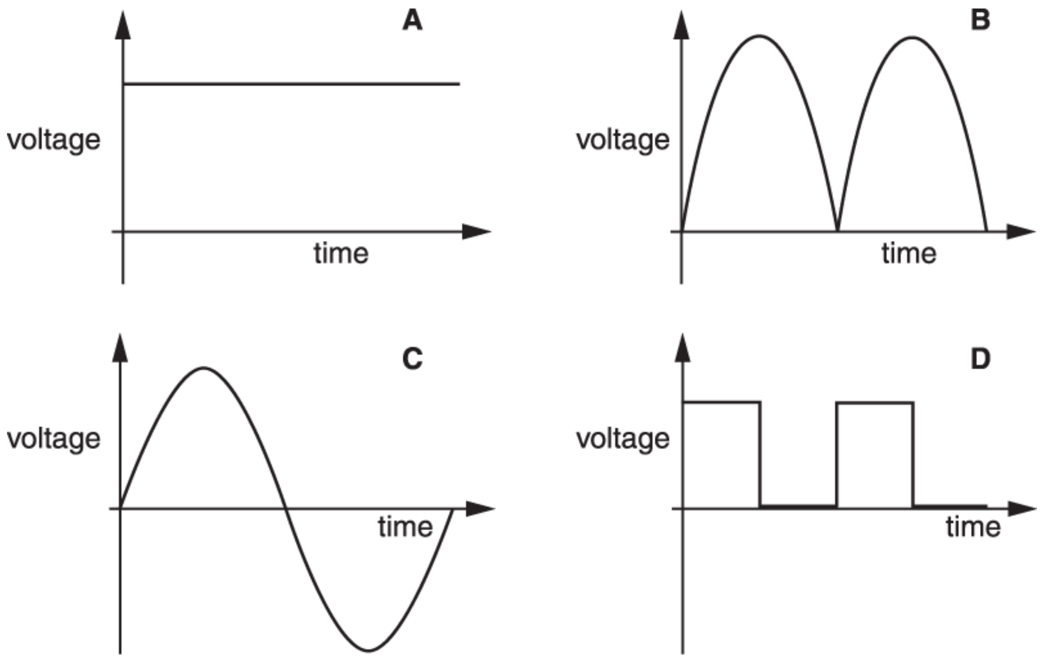
(i) She connects a lamp to the output of the generator.
The lamp glows more brightly when she rotates the magnet faster.
State why the lamp glows more brightly.

-- [1]

(ii) The magnet is rotated at a constant speed.

Which graph shows how the voltage of this a.c. generator changes during one complete rotation of the magnet?

Put a (ring) around the letter next to the correct answer.



[1]

(iii) In some generators the coil is wound on a solid core so that a lamp lights at slower speeds of rotation.

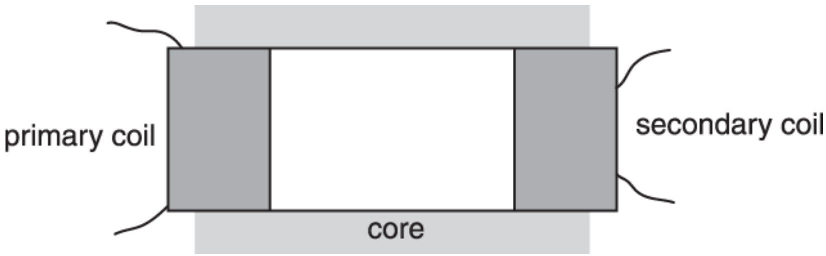
State the name of the material used for the solid core.

-- [1]

3. The electrical energy supplied to homes in the UK comes from power lines that carry the energy at very high voltage.

Transformers are used to change the voltage between the power lines and homes.

The diagram shows a transformer.



Explain how the voltage across the secondary coil is produced.

-- [3]

4. Motors and generators both contain magnets and coils of wire.

Explain the similarities and differences between a motor and a generator.

The quality of written communication will be assessed in your answer.

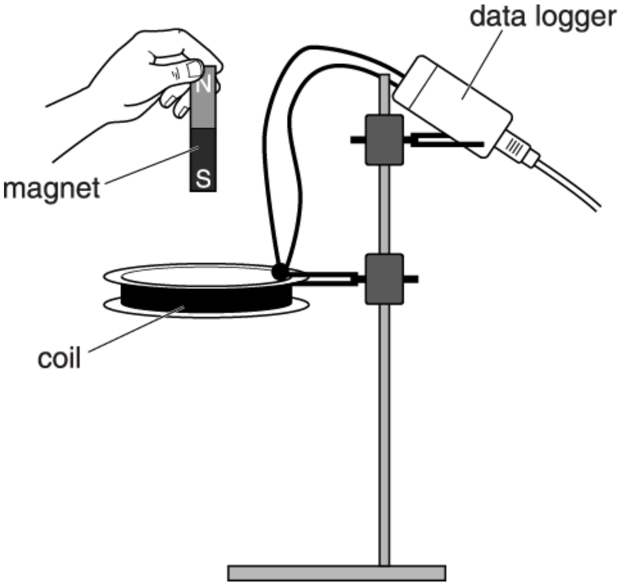
[6]

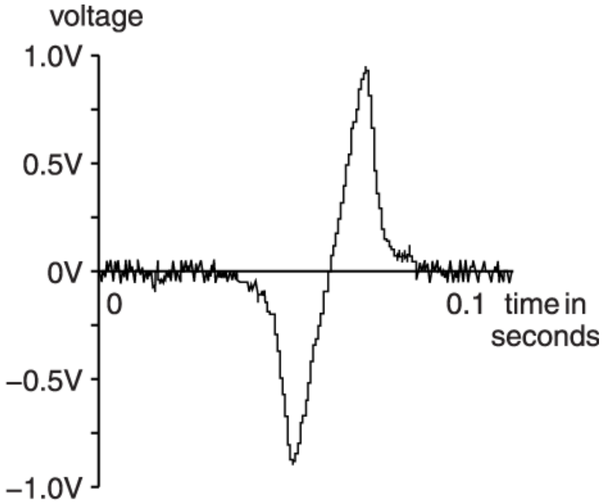
5(a). Ali does an experiment using a coil of wire and a magnet.

He connects the coil of wire to a data logger.

He then drops the magnet through the coil.

Ali displays the data as a graph showing how the voltage across the coil changes with time.





Why is there a voltage across the coil?

[1]

(b). This effect described in Ali's experiment is used in power stations to produce electricity.

Compare the electricity produced by a power station with the electricity produced in this experiment.

Use information from the graph.

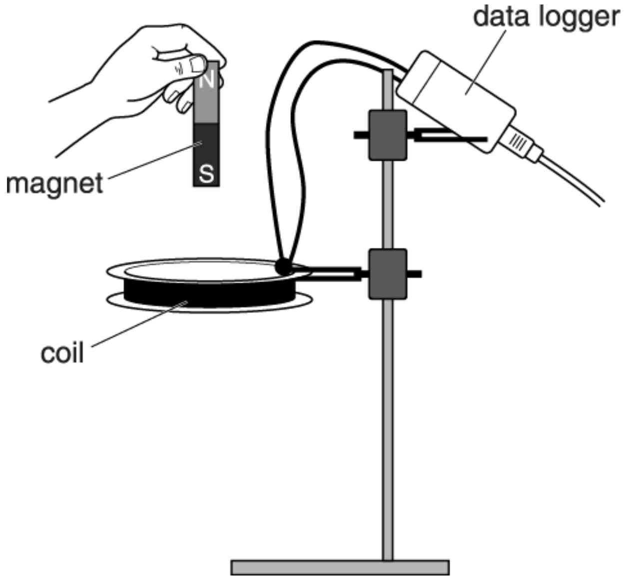
[2]

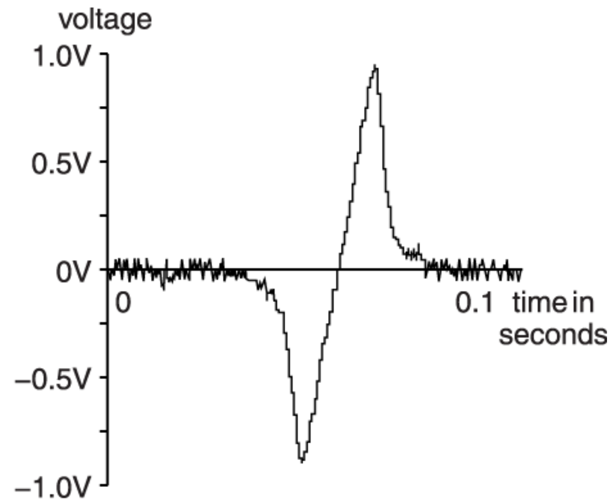
6(a). Ali does an experiment using a coil of wire and a magnet.

He connects the coil of wire to a data logger.

He then drops the magnet through the coil.

Ali displays the data as a graph showing how the voltage across the coil changes with time.





(i) Complete the sentences about this experiment.

Put a (ring) around each correct answer.

As the magnet drops into the coil, it [induces / magnetises / resists] a voltage across the coil.

induces
magnetises
resists

The voltage becomes negative when the magnet [goes into / comes out of / spins in] the coil.

goes into
comes out of
spins in

This process is called [electromagnetic induction. / potential energy. / the motor effect.]

electromagnetic induction.
potential energy.
the motor effect.

[3]

(ii) State **two** ways that Ali could increase the voltage across the ends of the coil of wire.

1 ____

2 ____

[2]

(b). The effect described in part **(a)** is used in power stations to produce electricity.

(i) What is the name of the device that uses this effect in a power station?

Draw a (ring) around the correct answer.

generator **motor** **pylon**

[1]

(ii) Compare the electricity produced by a power station with the electricity produced in this experiment.

Use information from the graph.

____

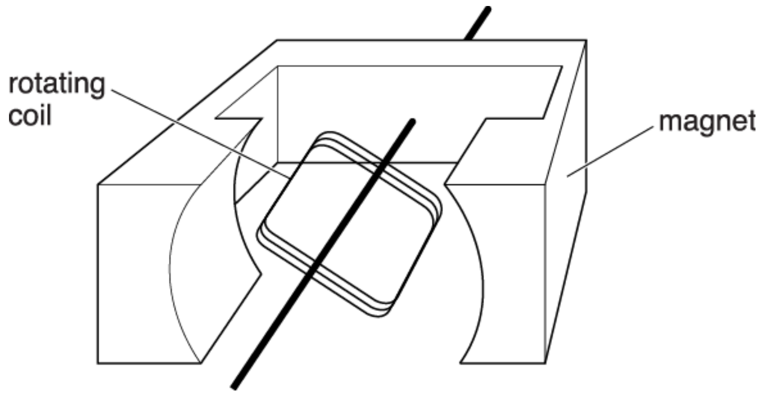
____

____

____

____ **[2]**

7. The simplified diagram shows a generator.



Which one of the following combinations of changes to this generator would be **certain** to result in a larger voltage being generated?

Put a tick (✓) in the box next to the correct combination.

Using a weaker magnet and rotating the coil faster. ☐

Using a stronger magnet and rotating the coil faster. ☐

Using a weaker magnet and rotating the coil slower. ☐

Using a stronger magnet and rotating the coil slower. ☐

[1]

8(a). 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

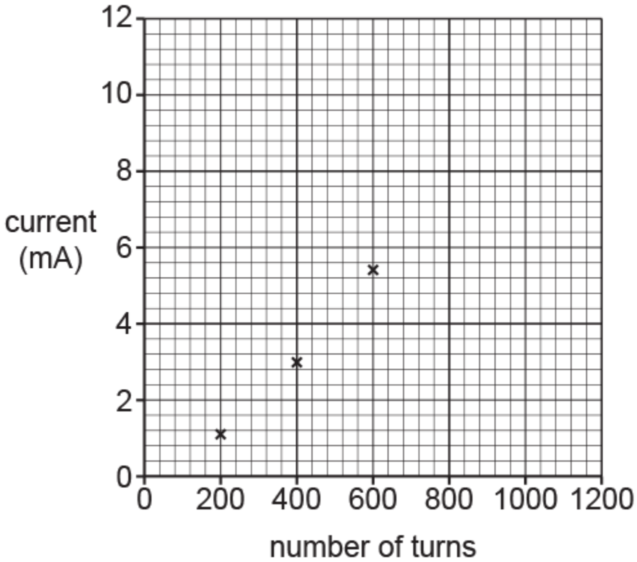
Table 7.1

Explain why a current is produced in the coil.

-- [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]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			The turning motor acts _ _ _ (1) Current heats the coils _ _ _ (1)	2	
			Total	2	
2	a	i	(Electromagnetic) induction	1	**Examiner's Comments** Most candidates scored 3 or more marks for this question, showing understanding of electromagnetic induction. The correct term is not known by most candidates.
		ii	Idea of opposite relative movement (with the same pole) / Idea of using the other pole (in the same direction)	1	
		ii			If two changes are given ensure that they don't cancel out eg. 'push S pole into other end' = 0 **Examiner's Comments** Most candidates scored 3 or more marks for this question, showing understanding of electromagnetic induction. Many answers indicated a change in direction or use of the south pole, but ambiguous terms such as rotate or spin the magnet were not accepted.
	b	i	more power / more work done per second / more energy per second / more current / more voltage	1	**Examiner's Comments** Most candidates scored 3 or more marks for this question, showing understanding of electromagnetic induction. About half the candidates gave acceptable answers such as more current, more voltage or more power. Those that chose more energy often did not get the mark as they failed to link it to time i.e. increased rate of energy transfer.

Question			Answer/Indicative content	Marks	Guidance
		ii	C	1	**Examiner's Comments** Most candidates scored 3 or more marks for this question, showing understanding of electromagnetic induction. A majority of candidates chose the correct graph.
		iii	Iron / cobalt / nickel	1	Not steel **allow** Fe / Co / Ni **Examiner's Comments** Most candidates scored 3 or more marks for this question, showing understanding of electromagnetic induction. Iron was the most common correct answer, given by about half the candidates. Common wrong materials were copper, steel, (just) metal and magnet.
			Total	5	
3			changing current / ac (in primary / input) (1); magnetic field (in core) (1); (magnetic field) is changing (which induces voltage) (1)	3	

Question			Answer/Indicative content	Marks	Guidance
					if no other mark awarded **allow** lower voltage output / less turns on secondary (ORA) **Examiner's Comments** The working of a transformer was not known by the majority of candidates. Many seemed to be describing a generator with spinning magnets. Those who showed understanding usually mentioned the magnetic field in the core but omitted the alternating current in the primary coil or that the magnetic field is changing. A compensatory mark was awarded to those candidates who stated that the output/secondary voltage is lower than the input/primary voltage. However, they often left it as either an increase or decrease, without stating which.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
4			**(Level 3)** Detailed descriptions of the generator and the motor. Some correct comparison of the two. Quality of written communication does not impede communication of the science at this level. (5–6 marks) **(Level 2)** Brief description of how a motor works and how a generator works or a more detailed description of either one. Quality of written communication partly impedes communication of the science at this level. (3–4 marks) **(Level 1)** Brief description of how a motor works or how a generator works. May be some confusion of difference between them. Quality of written communication impedes communication of the science at this level. (1–2 marks) **(Level 0)** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to A** **Indicative scientific points:** **Motor:** • electricity / current produces rotation • uses direct current • attempt to describe use of commutator. **Generator:** • rotation of coil produces electricity • no need for commutator / explains slip rings • example shown produces alternating current • reference to power station / dynamo etc. **Both:** • (stationary) magnetic field • rotating coil • difference between ac and dc • graphs of ac and dc. **Accept** higher level answers regarding interaction of magnetic field and current. **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** <u>Examiner's Comments</u> This was a challenging six-mark extended writing question. The majority of candidates scored 0 marks on this question. The best responses took time to carefully describe how a motor works, using appropriate technical terms, before doing the same for a generator, then finally comparing the two. The majority of the candidates that scored any marks did so for a basic description of a generator as a rotating/moving coil (or magnet) producing electricity in the coil, although many also confusingly described a motor as a generator, therefore restricting their performance to level one. Even basic

Question			Answer/Indicative content	Marks	Guidance
					knowledge of the workings of a motor, as demonstrated here was extremely limited, and technical details such as the commutator for the motor and/or slip rings for the generator were seen in only a minority of responses. The correct use of the term induction was occasionally seen in reference to the generator, but also incorrectly in reference to the motor.
			Total	6	
5	a		(electromagnetic) induction / because magnetic field is changing	1	**allow** idea of magnet moving near a coil of wire leads to voltage **allow** induced or induction for 1 mark **Examiner's Comments** Overall, this question produced a good spread of marks. Almost all candidates could identify the cause of the voltage in the coil.
	b		any 2 from voltage from power station is higher experiment produces one cycle, power station is continuous higher frequency in a power station owtte both change from positive to negative owtte	2	**accept** 230V if clearly referring to mains **ignore** reference to more electricity **accept** comparison of time of cycles **accept** both are alternating voltage / current **Examiner's Comments** There were a range of responses, with able candidates usually producing good answers, although a significant minority lost out by not clearly comparing the power station to the coil in the experiment.
			Total	3	

Question			Answer/Indicative content	Marks	Guidance
6	a	i	induces (1) goes into (1) electromagnetic induction (1)	3	one mark per correct word / phrase **Examiner's Comments** In part (i) most candidates were able to get two or all three correct choices. 'Electromagnetic induction' was well known as the third answer. The second answer 'goes into' was less well known with incorrect answers spread equally between the distracters. Many candidates were able to identify a correct change to increase the voltage.
		ii	**any two from:** increase the number of turns / put turns closer together increase the speed of the magnet / throw the magnet down increase the strength of the magnet / use more magnets	2	**accept** coils for turns **do not accept** more wire **accept** more powerful magnet **do not accept** 'bigger' or 'larger' applied to turns or magnet **do not accept** just change for any mp **Examiner's Comments** In part (ii). Those who did not gain marks included those using phrases such as 'bigger or larger magnets' or 'more wire'. Candidates need to use more specific terms to this sort of question. However, most did use the qualifiers 'greater' or 'more' rather than just 'change'.
	b	i	generator	1	**Examiner's Comments** Most candidates chose the correct answer in part (i).

Question			Answer/Indicative content	Marks	Guidance
		ii	Any 2 from; voltage from power station is higher experiment produces one cycle, power station is continuous higher frequency in a power station owtte both change from positive to negative owtte	2	**accept** 230V if clearly referring to mains **ignore** reference to more electricity **accept** comparison for time of cycles **accept** both are alternating voltage / current Examiner's Comments Part (ii) was not answered well. The phrase 'the electricity is greater from the power station', given by many candidates, did not gain a mark. Those who did give a correct answer usually said that the voltage would be greater. Very few candidates mentioned anything about frequency, production time or alternating current, so few were able to achieve both marks.
			Total	8	
7			2nd box (stronger magnet, faster spin)	1	Examiner's Comments This question was well answered.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
8	a		changing magnetic field (around coil) ✓ induces a p.d. / voltage ✓	2 (AO 1.1 ×2)	**ALLOW** magnetic field is cut (by coil) **ALLOW** produces p.d./voltage <u>Examiner's Comments</u> This question assesses specification statement 3.7.1. Many candidates used the term 'induction' given in the stem of the question and referred only to current being induced. More able candidates recalled that potential difference must be produced in order to drive the current. Only the higher ability candidates were able to link the movement of the magnet into the coil to the idea that the magnetic field changes around the coil, or that the magnetic field cuts the coil.
	b	i	all points plotted correctly at (800, 6.7) (1000, 9.1) (1200,11) ✓ line of best-fit ✓	2 (AO 2.2) (AO 1.2)	To within ± 0.5 small divisions in each direction **IGNORE** lobf below 200 turns <u>Examiner's Comments</u> This question was generally answered very well with most candidates gaining both marks. Common errors were to start the best fit line at the origin or not use a ruler.
		ii	correct value read from candidate's line, to within half a small square ✓	1 (AO 2.2)	<u>Examiner's Comments</u> Almost all candidates were able to read their graph correctly to gain this mark.
		iii	use motor/machine/electrical device/mechanical device/pendulum (to pull magnet at fixed speed) ✓	1 (AO 3.3b)	**ALLOW** drop magnet from fixed height <u>Examiner's Comments</u> Most candidates found it quite difficult to suggest that either a motor or a machine could be used to control the speed of the motor. A common response was to explain what is meant by speed. These responses described the idea of moving the magnet a certain distance in a certain time without explaining how that could be done.

Question			Answer/Indicative content	Marks	Guidance
	c		current in coil generates a magnetic field ✓ which opposes the change causing it / is a like pole ✓	2 (AO 1.1 ×2)	**DO NOT ALLOW** references to positive / negative / charges <u>Examiner's Comments</u> Only the higher ability candidates scored one or more marks on this second synoptic question which assesses specification statements 3.7.3 and 4.1.1. Many candidates have the misconception that magnetic fields can be described, like static electricity, in terms of positive and negative charges. A common error therefore was to state that like charges repel. Where candidates gained one mark, this was generally for identifying that like poles were repelling. Only a very small number of candidates were also able to explain that the magnetic field of the coil was due to the current in it.
			Total	8	