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OCR GCSE PHYSICS A (J249): QUESTIONS BY TOPIC

Topic P4: Magnetism and magnetic fields (H)

GCSE Physics A Higher Tier (J249) · Topic P4

40 questions · 208 marks · Mark schemes included

OCR GCSE (9–1) Physics A (Gateway Science) J249, June 2018 – June 2025

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 Piccadilly Business Centre, Unit C, Aldow Enterprise Park
Blackett Street, Manchester, M12 6AE

HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

40 questions · 208 marks · grouped by sub-topic, lowest tariff first



SUB-TOPIC P4.1

MAGNETS AND MAGNETIC FIELDS

12 questions in this sub-topic · 36 marks · lowest tariff first



11 Which does **not** increase the magnetic effect of a solenoid?

- A Increasing the cross-sectional area of the solenoid
- B Increasing the current in the solenoid
- C Increasing the number of turns on the solenoid
- D Putting a soft iron core in the solenoid

Your answer

[1]



5 Which of these factors affects the strength of the magnetic field around a current-carrying wire?

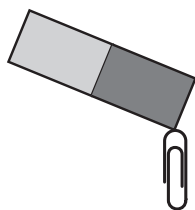
- A** Direction of the current only
- B** Size of the current only
- C** Distance from the wire only
- D** Size of the current and distance from the wire

Your answer

[1]



12 A magnet is used to pick up a paperclip.



Which statement explains why the paperclip is picked up?

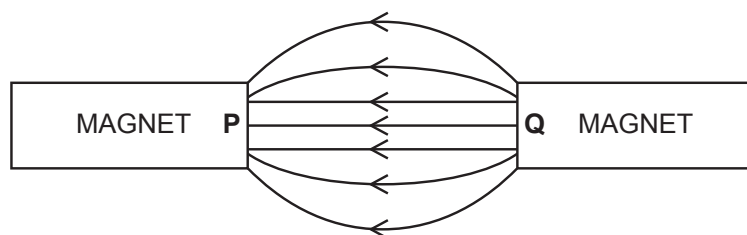
- A** The magnet is a permanent magnet and the opposite pole has been induced at the top of the paperclip.
- B** The magnet is a permanent magnet and the same pole has been induced at the top of the paperclip.
- C** The magnet is a temporary magnet and the opposite pole has been induced at the top of the paperclip.
- D** The magnet is a temporary magnet and the same pole has been induced at the top of the paperclip.

Your answer

☐

[1]

- 2 A magnetic field line diagram shows the magnetic field between the poles **P** and **Q** of two magnets.



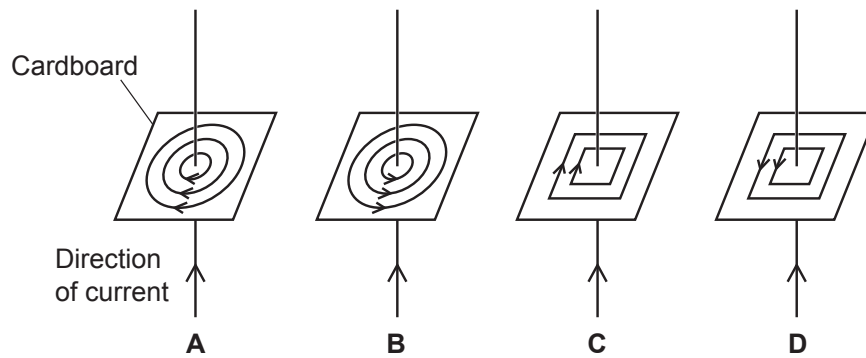
What are the poles **P** and **Q**?

	Pole P	Pole Q
A	North	North
B	North	South
C	South	North
D	South	South

Your answer

[1]

- 3 A current is passed through a straight wire.



Which diagram shows the magnetic field around the current-carrying wire?

Your answer

[1]

- 8 A student investigates the magnetic effect of a current in a solenoid with a core. The student makes four different solenoids.

Which solenoid will have the strongest magnetic field?

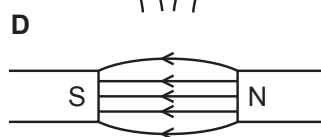
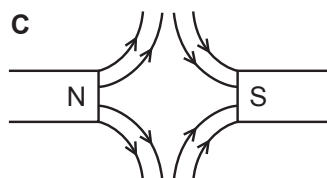
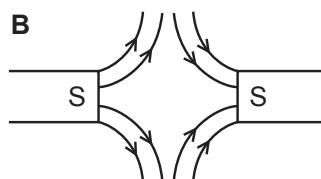
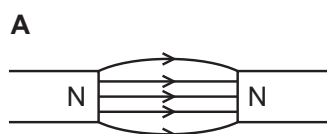
Solenoid	Number of turns	Core
A	10	Copper
B	10	Iron
C	20	Copper
D	20	Iron

Your answer

[1]



2 A student draws the magnetic field lines between the poles of two magnets.



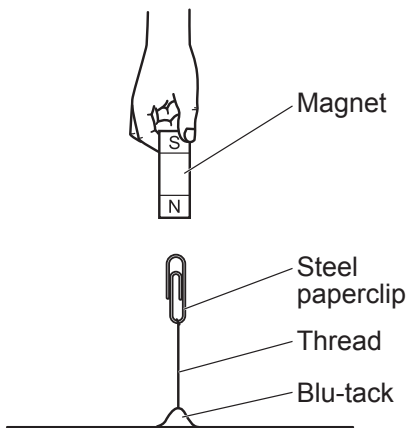
Which magnetic field line diagram is correct?

Your answer

☐

[1]

2 A student holds a bar magnet above a paperclip. The paperclip is attracted to the bar magnet.



Which row of the table correctly describes the bar magnet and paperclip?

	Bar magnet	Paperclip
A	induced magnet	induced magnet
B	induced magnet	permanent magnet
C	permanent magnet	induced magnet
D	permanent magnet	permanent magnet

Your answer

[1]

19

(a) A student investigates the magnetic field between two magnets.

(i) The student uses iron filings to show the magnetic field pattern.

Write down a different piece of equipment that the student could use to investigate the magnetic field.

..... [1]

(ii) The diagram shows the north pole of a magnet and the south pole of another magnet.

Sketch the magnetic field between the poles of the magnets.



[3]

(b) A student makes a simple solenoid by wrapping insulated copper wire around an iron nail.

(i) Why did the student use **insulated** copper wire?

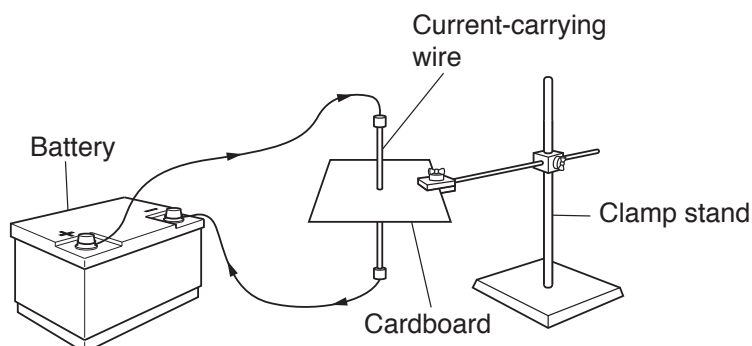
.....
..... [1]

(ii) Write down **one** factor that can affect the strength of the magnetic field of a solenoid.

..... [1]



17 A student sets up an experiment to investigate the magnetic field around a current-carrying wire.



(a) (i) Describe how the student could use this experiment and a compass to investigate the magnetic field produced by the wire.

.....

.....

.....

.....

.....

..... [3]

(ii) Draw the shape of the field which would be found around **this** wire.

[2]

(b) The behaviour of a magnetic compass is evidence that the core of the Earth is magnetic. Explain why.

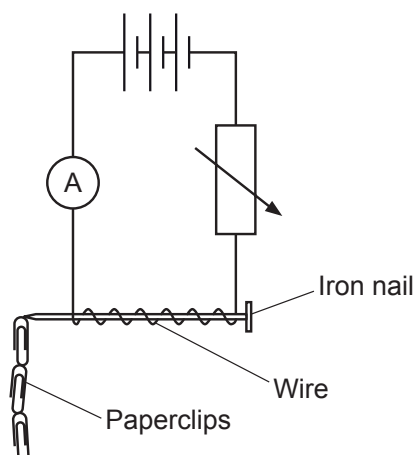
.....

.....

.....

[2]

21 A student makes a solenoid by wrapping wire around an iron nail as shown in the diagram.



The student investigates how the current in the wire affects the magnetic field of the solenoid.

(a) Suggest why the student uses an iron nail in the centre of the solenoid.

..... [1]

(b)* The student varies the current in the wire and uses the number of paperclips picked up by the solenoid as a measure of the strength of the magnetic field.

The results of this experiment are shown in the table.

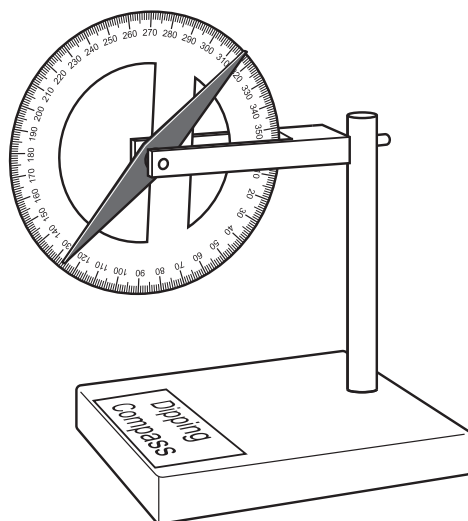
Current (A)	Number of paperclips picked up
1	5
2	11
3	17
4	22
5	28
6	32

16

(a) Fig. 16.1 shows a (dipping) compass used in schools.

It is currently showing the reading for the UK.

Fig. 16.1



(i) Describe how the position of the needle changes if the compass is moved from the equator to the poles of the Earth.

.....

.....

.....

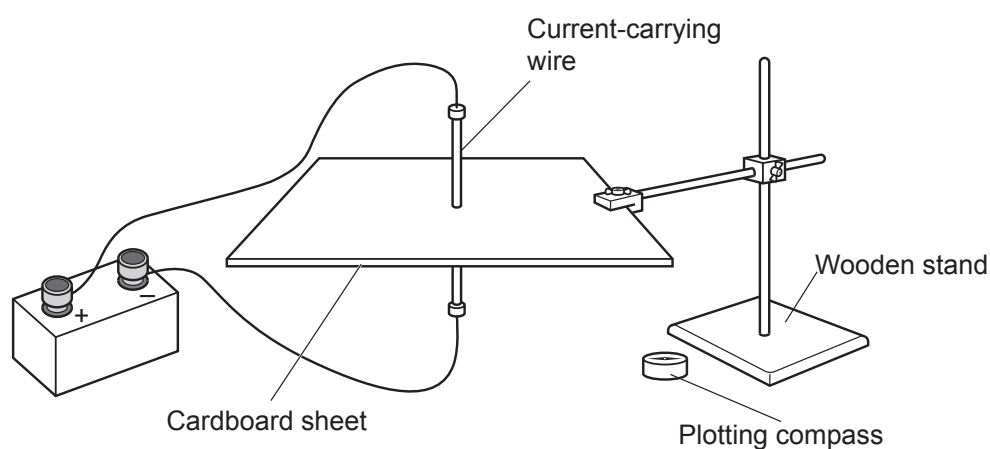
..... [2]

(ii) What does your answer to (a)(i) suggest about the Earth's core?

..... [1]

- (b) Fig. 16.2 shows the equipment a teacher sets up to demonstrate using a plotting compass to investigate the magnetic field around a current-carrying wire.

Fig. 16.2



- (i) Describe how the teacher uses this equipment to show the shape of the magnetic field around the current-carrying wire.

.....

.....

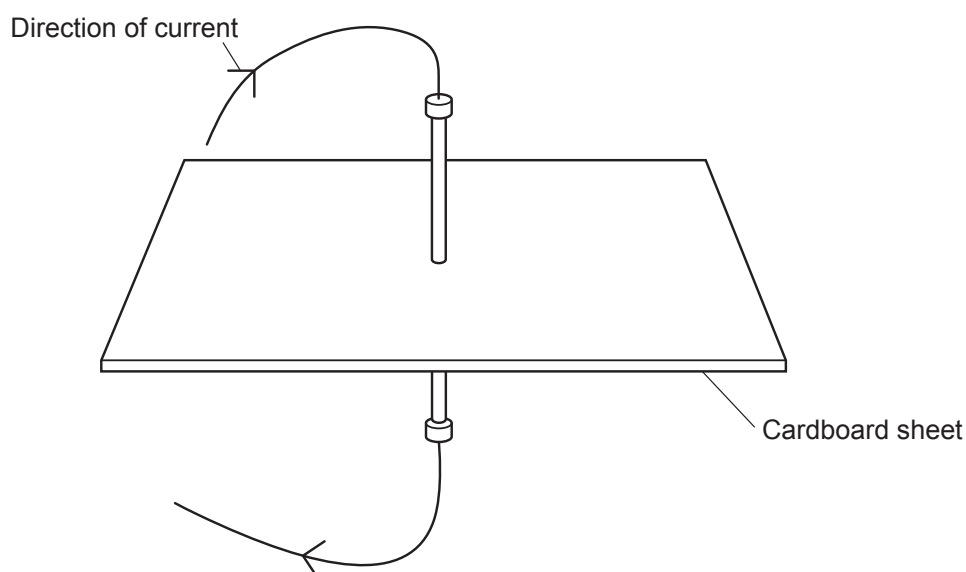
.....

.....

..... [3]

- (ii) On Fig. 16.3 sketch the magnetic field around the current carrying wire.

Fig. 16.3



[2]

Turn over

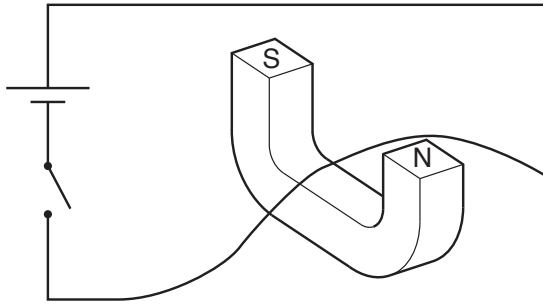
SUB-TOPIC P4.2

USES OF MAGNETISM

28 questions in this sub-topic · 172 marks · lowest tariff first



- 7 A wire is placed inside a horseshoe magnet.



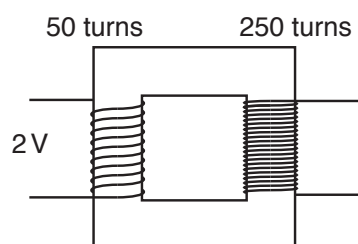
Which direction will the wire move when the switch is closed?

- A Downwards
- B Left
- C Right
- D Upwards

Your answer

[1]

8 What output voltage does the transformer produce?



A 0.2V

B 0.4V

C 5V

D 10V

Your answer

[1]

15 A 0.5 m length of wire is placed inside four different magnetic fields.

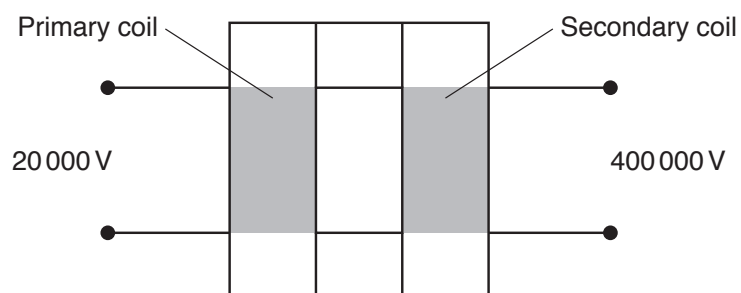
Magnetic Field	Force on wire (N)	Current in wire (A)
A	2.0	0.1
B	2.0	0.2
C	4.0	0.1
D	4.0	0.4

Which magnetic field has the **greatest** magnetic flux density?

Your answer

[1]

13 This is a diagram of a transformer used in the national grid.



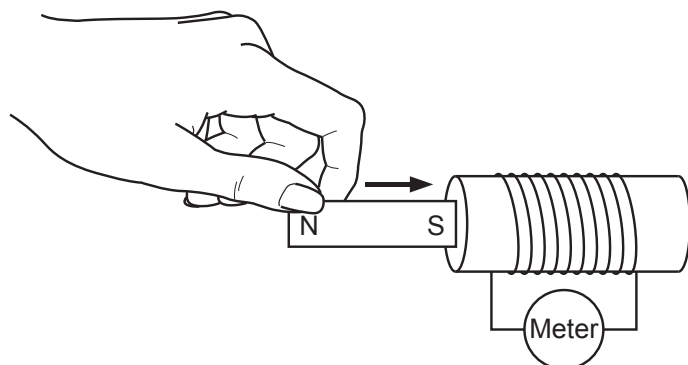
Why is this transformer used in the national grid?

- A** To decrease the power in the national grid by a factor of 20.
- B** To decrease the power loss in the national grid by a factor of 400.
- C** To increase the power in the national grid by a factor of 20.
- D** To increase the power loss in the national grid by a factor of 400.

Your answer

[1]

- 8 A student inserts a magnet into a coil of wire.



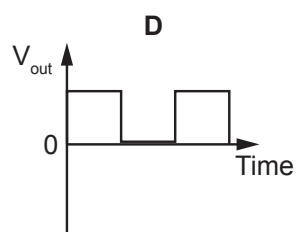
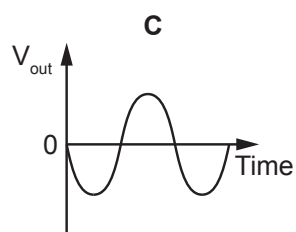
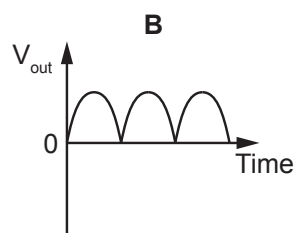
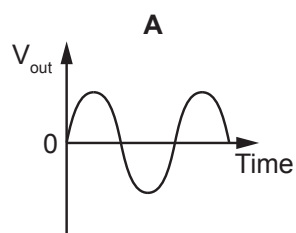
What is induced across the ends of the coil of wire?

- A Charge
- B Magnetism
- C Potential difference
- D Resistance

Your answer

[1]

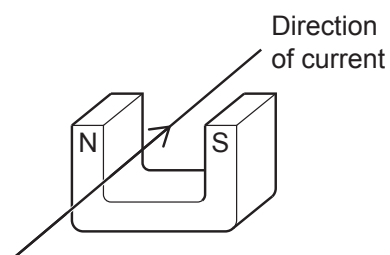
9 Which of the following graphs shows the typical output potential difference, V_{out} , for a dynamo?



Your answer

[1]

11 A wire is placed between the poles of a magnet, perpendicular to the magnetic field lines.



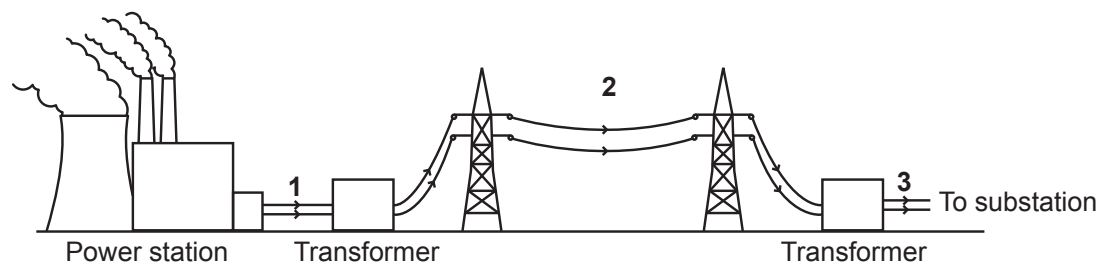
Which direction will the wire move when a current flows?

- A Down
- B Left
- C Right
- D Up

Your answer

[1]

3 The diagram shows a simplified version of the national grid.



The potential difference (p.d.) is different at each point in the national grid.

Which row in the table is correct?

	p.d. at position 1 (V)	p.d. at position 2 (V)	p.d. at position 3 (V)
A	230	5 000	11 000
B	25 000	450 000	11 000
C	450 000	150	230
D	450 000	5 000	230

Your answer

[1]

- 12** A transformer has 100 turns in the primary coil and 200 turns in the secondary coil. The potential difference across the primary coil is 30 V.

What is the potential difference across the secondary coil?

Use an equation from the data sheet to help you.

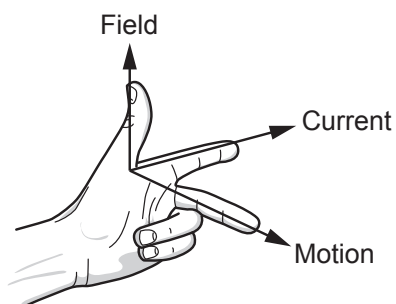
- A** 15 V
- B** 30 V
- C** 60 V
- D** 6000 V

Your answer

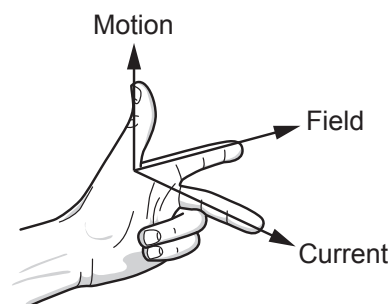
[1]

10 Which diagram shows the correct thumb and finger labels when using Fleming's left-hand rule?

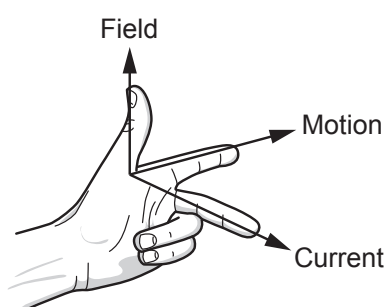
A



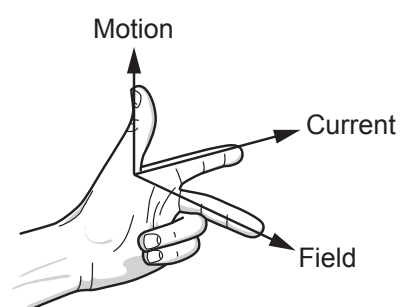
B



C



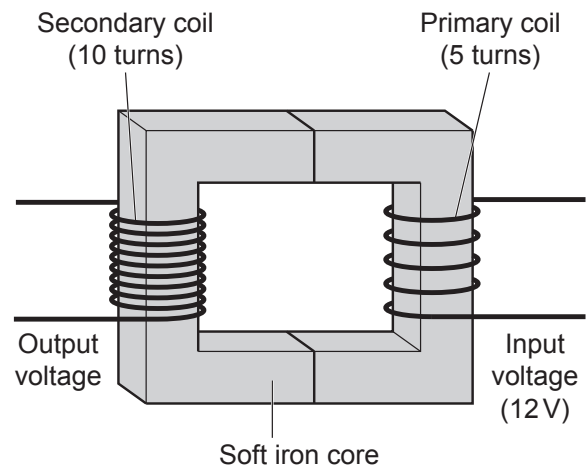
D



Your answer

[1]

14 A teacher makes a model transformer as shown in the diagram.



Which row gives the correct type of transformer and its output voltage?

	Type of transformer	Output voltage (V)
A	step-down	6.0
B	step-down	24
C	step-up	6.0
D	step-up	24

Your answer

[1]

10 Which devices convert current variations in electrical circuits into pressure variations in sound waves?

- A** Loudspeakers and headphones
- B** Loudspeakers and microphones
- C** Microphones and headphones
- D** Microphones only

Your answer

[1]



5 A current-carrying wire is in a magnetic field.

Under which conditions will the wire experience the **smallest** force?

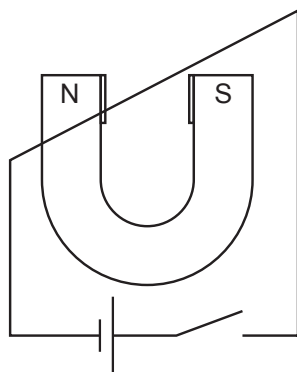
Use the Equation Sheet.

	Magnetic flux density of field (mT)	Current in wire (A)	Length of wire (m)
A	6	4	0.8
B	8	4	0.5
C	8	5	0.4
D	12	6	0.2

Your answer

[1]

- 8 A current-carrying wire is placed between the two poles of a horseshoe magnet.



The circuit is switched on.

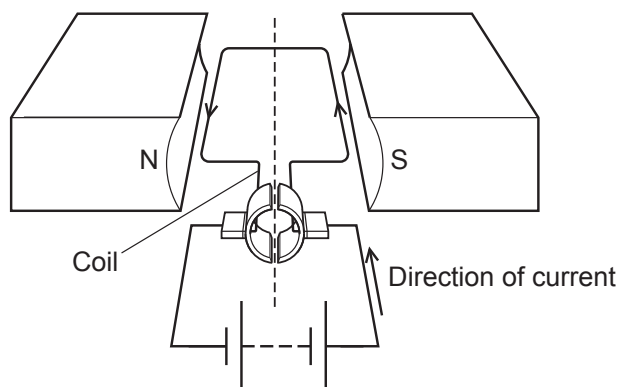
In which direction does the wire move?

- A Down
- B Left
- C Right
- D Up

Your answer

[1]

21 A student investigates a simple electric motor as shown in the diagram.



(a) (i) Suggest why the coil turns when a current flows.

.....
 [1]

(ii) In which direction will this motor turn?
 State the name of the rule you used to work this out.

Direction

Name of rule

..... [2]

(b) Suggest **two** ways in which the size of the force on the coil could be increased.

1

2

[2]

16 This question is about how electricity is transferred from a power station to homes.

- (a) Draw:
- **one** line to connect **each** type of transformer with the **one** box that describes what it does
 - **one** line to connect what each type of transformer does with the **one** box that gives the reason for its use.

Type of transformer	What it does	Reason for its use
Step-down transformer	Decreases current	For safety
Step-up transformer	Decreases potential difference	Increases heat losses
	Generates current	Reduces heat losses

[2]

- (b) The table shows information for a transformer.

Potential difference across primary coil	132 000 V
Current in secondary coil	1800 A
Potential difference across secondary coil	33 000 V

Calculate the current in the primary coil of the transformer.

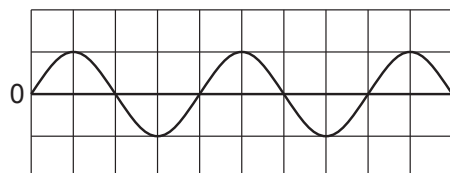
Use the Equation Sheet.

Current in primary coil = ... A [2]

(c) A teacher connects the primary coil of a transformer to the domestic mains supply.

The teacher uses an oscilloscope to view the potential difference across the secondary coil of the transformer.

The graph shows the oscilloscope trace.



Use the graph to explain which type of current is supplied by the mains supply.

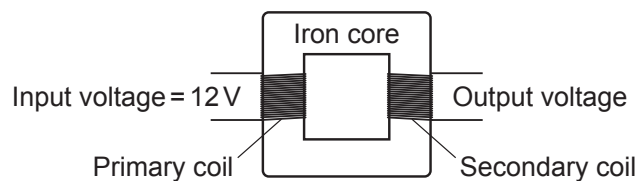
Type of current

Explanation

[2]

20 A student investigates building model transformers in the laboratory.

Look at the diagram.



The student builds four different transformers, each with different primary and secondary coils.

Using an input voltage of 12V the student measures the output voltage.

Look at the results.

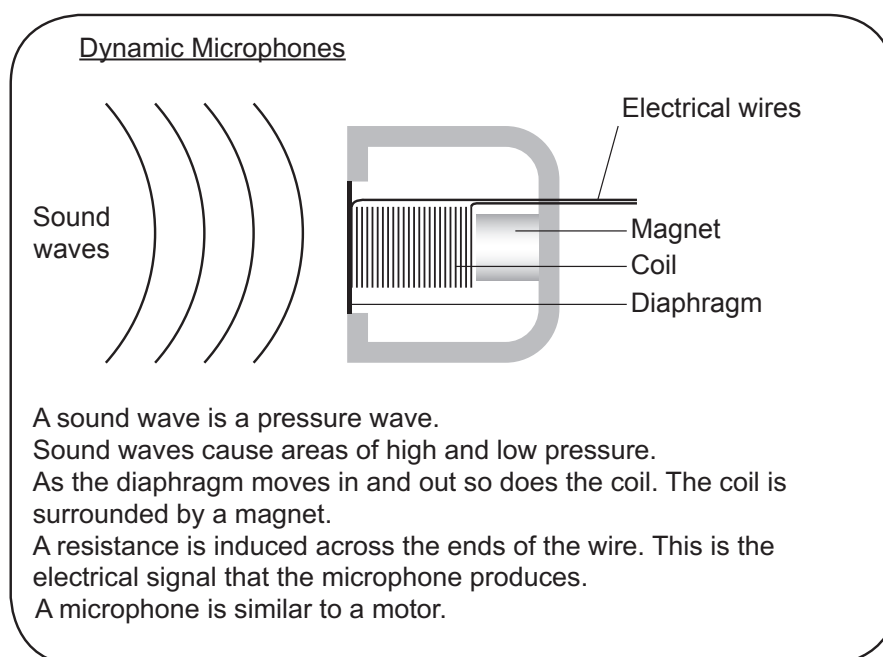
Attempt	Number of turns in primary coil	Number of turns in secondary coil	Output voltage (V)
A	100	200	23
B	200	100	6
C	300	600	23
D	600	300	6

(a)* Explain how a transformer works and if this data supports the expected output voltages.

[6]

- (b) A student completes a project on how dynamic microphones work.

Look at her project. The student uses two incorrect words in her work.



- (i) Identify **one** of the incorrect words **and** write a correct sentence to replace the mistake.

Incorrect word

Corrected sentence

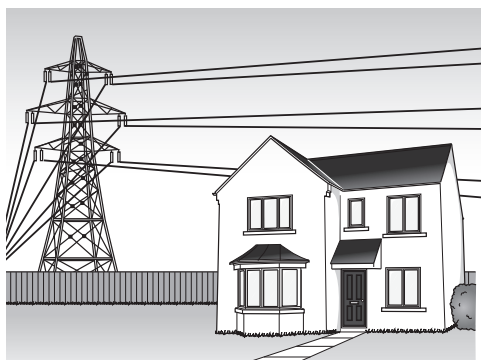
[2]

- (ii) Name a device which uses this effect in reverse.

..... [1]

20 Energy is transferred at high voltages in the national grid.

(a) This house is near to a transmission line.



Explain why radio waves may be produced by the transmission line.

.....
.....
..... [2]

(b) Explain why it is more efficient to transfer energy at high voltages.

.....
.....
..... [2]

(c) The transmission line has a power loss of 6.156 kW.

Its resistance is $15.39\ \Omega$.

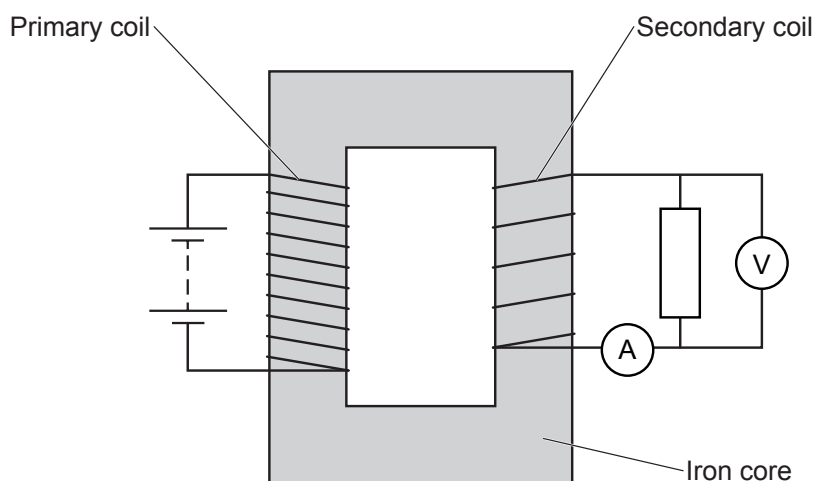
Calculate the current in the transmission line.

Current = ... A [5]

23 A student investigates the relationship between

- the number of turns of wire on the secondary coil of a transformer
- the potential difference across the secondary coil
- the current in the secondary coil.

The diagram shows the equipment the student uses to make their transformer.



- (a) When the battery is connected to the primary coil the transformer does **not** work and the voltmeter reads zero.

Describe what change the student needs to make to their equipment so that the voltmeter shows that there is a continuous potential difference across the secondary coil.

Explain your answer.

Change

.....

Explanation

.....

[2]

(b) The student changes the equipment in the diagram so that the transformer works.

The student obtains the results shown in the table.

Number of turns on secondary coil	Potential difference across secondary coil (V)	Current in secondary coil (A)
160	6.4	0.47
120	4.8	
80	3.2	0.94

(i) Describe the relationship between the number of turns on the secondary coil and the potential difference across the secondary coil.

.....

.....

..... [2]

(ii) Calculate the current in the secondary coil when there are 120 turns on the secondary coil.

Assume the transformer is 100% efficient.

Use the Equation Sheet.

Current = ... A [3]

(iii) The potential difference across the primary coil in the student's transformer is 12V.

The student suggests that this transformer is the same as the type of transformer used between a power station and the power lines.

Explain why this type of transformer is **not** the same as the type of transformer used between a power station and the power lines.

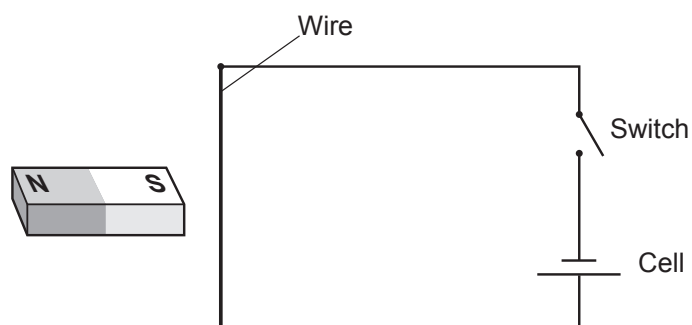
.....

.....

..... [2]



- 20** A student places a wire near a magnet. The wire is connected in series to a cell and a switch, as shown in the diagram.



- (a)** Explain what will happen to the wire when the switch is closed.

.....

 [2]

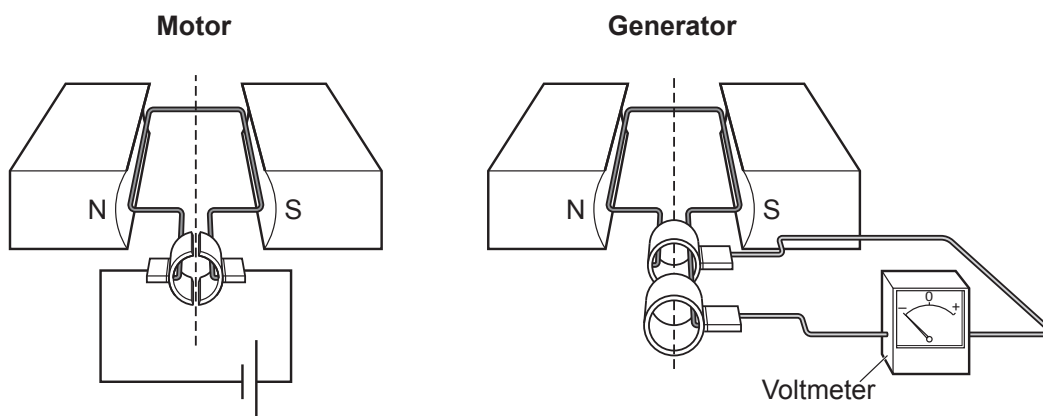
- (b)** A wire of length 0.25 m experiences a force of 0.15 N when a current of 5.0 A flows.

Calculate the magnetic flux density of the field.

Use an equation from the data sheet to help you.

Magnetic flux density = ... T [3]

(c) The student looks at diagrams of a motor and a generator.



(i) Compare the similarities **and** differences of a motor and a generator. Include ideas about how they work.

.....

.....

.....

.....

.....

..... [3]

(ii) How does the output current of an alternator differ from that of a dynamo?

.....

.....

..... [2]

- 20 (a) Explain **two** similarities and **two** differences between the operation of a loudspeaker and the operation of a microphone.

Similarities

.....

.....

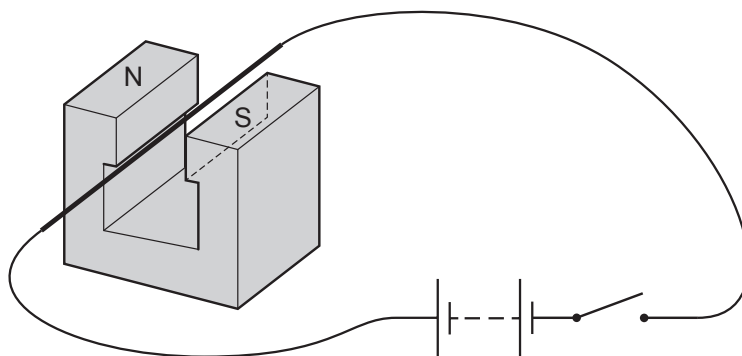
Differences

.....

.....

[4]

- (b) The diagram shows a current-carrying wire in the magnetic field between the North pole and the South pole of a magnet.



Describe and explain what happens to the wire when the switch is **closed**.

.....

.....

.....

.....

..... [3]

- (c) A current of 5.0 A passes through a wire with a length of 0.75 m .

The wire is in a field of magnetic flux density 0.30 T .

Calculate the force acting on the wire.

Give your answer to **2** significant figures.

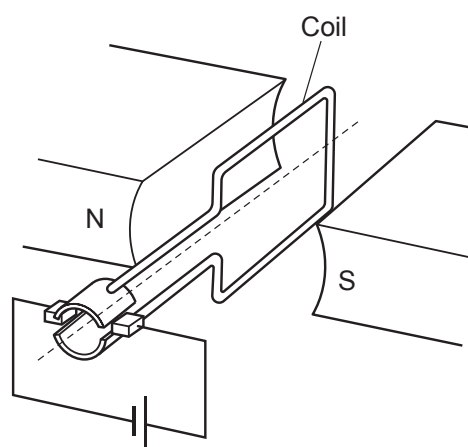
Use the Equation Sheet.

Force = ... N [3]

22

(a) Fig. 22.1 shows a diagram of a simple electric motor.

Fig. 22.1



Explain why the coil rotates when a current passes through it.

.....

 [2]

(b)

(i) Fig. 22.2 shows a diagram of a dynamo and Fig. 22.3 shows a diagram of an alternator.

Describe **two similarities** and **two differences** between how these devices work.

Fig. 22.2

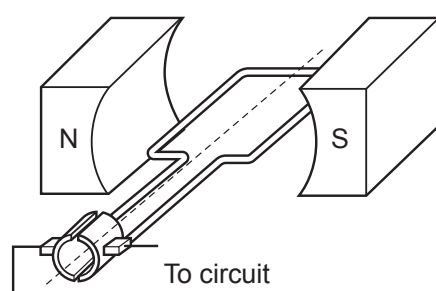
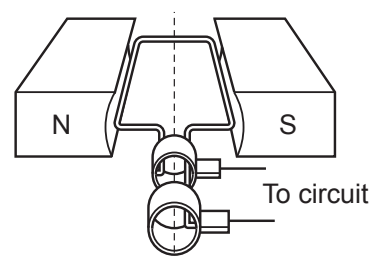


Fig. 22.3



Similarities

1
 2

Differences

1
 2

[4]

(ii) Suggest **one** way to increase the output of these devices.

..... [1]

(c) A conductor in a magnetic field of magnetic flux density 1.5 T experiences a force of 0.81 N.

The current in the conductor is 1.2 A.

Calculate the length of the conductor.

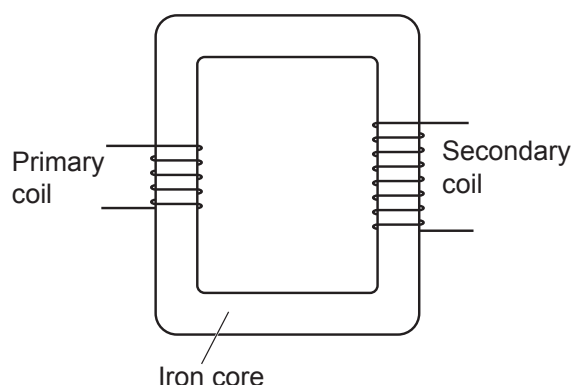
Use the Equation Sheet.

Length = ... m [3]



21 A transformer can be used to change the potential difference (p.d.) of an electrical supply.

The diagram shows a simple transformer.



(a) A student writes four statements about how a transformer works.

- A** This induces an alternating p.d. in the secondary coil.
- B** This produces a changing magnetic field in the iron core.
- C** There is an alternating p.d. across the primary coil.
- D** This produces an alternating current in the primary coil.

Put the steps in the correct order. The first one has been done for you.

C			
----------	--	--	--

[2]

(b) Explain why a transformer does **not** work if the current in the primary coil is direct current (d.c.).

.....

..... **[2]**

(c) A step-up transformer increases the potential difference from 230 V a.c. to 4600 V a.c.

There are 25 turns on the primary coil.

Calculate the number of turns on the secondary coil.

Use the Equation Sheet.

(d) A high potential difference can be dangerous. Suggest how.
..... [1]

(e) Generators, motors, microphones and headphones all use magnetism to work.

Draw lines to connect each **device** with the correct description of **how it works**.

Device	How it works
generator	The movement of a wire in a magnetic field induces a potential difference across the wire.
headphones	A current in a wire in a magnetic field causes rotation.
microphone	Pressure variations in sound waves are converted into current variations in electrical circuits.
motor	Current variations in electrical circuits are converted into pressure variations in sound waves.

[2]

21 (a) This question is about an electric kettle.

(i) An electric kettle is filled with water, connected to the mains and switched on.

The electricity for the kettle is generated in a coal-fired power station.

Describe the energy transfer that occurs when the kettle is switched on.

Include ideas about energy stores in your answer.

.....
.....
..... **[2]**

(ii) The mains supply has a potential difference of 230 V.

The kettle has a current of 5.0 A. The kettle is switched on for 2.0 minutes.

Calculate the total energy transferred to the kettle in 2.0 minutes.

Total energy transferred = ... J **[4]**



- (b) (i) **Table 21.1** gives some information about a different kettle.

Energy transferred to the kettle	525 000 J
Mass of water	1.2 kg
Starting temperature of water	25 °C
Final temperature of water	100 °C
Specific heat capacity of water	4200 J/kg °C

Table 21.1

Calculate the efficiency of the kettle described in **Table 21.1**.

Give your answer as a percentage.

Use an equation from the data sheet.

Efficiency = ... % [5]

- (ii) Explain why the efficiency of the kettle is less than 100%.

.....
 [1]

- (c) The water can also be heated using a 12V heater.

A transformer is used to change a 120V supply into 12V.

The current in the secondary coil is 9.0A.

Calculate the current in the primary coil.

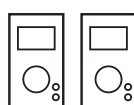
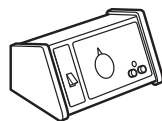
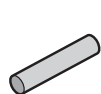
Use an equation from the data sheet.

Current = ... A [2]



- 21 (a)** A student investigates how the potential difference across the secondary coil of a transformer changes with the number of turns on the secondary coil.

The diagram shows the student's equipment.



Soft iron rod a.c. power supply Voltmeters Insulated wire Connecting wires

Describe a method that the student uses to obtain valid results.

You can include a labelled diagram to support your answer.

.....

.....

.....

.....

.....

..... [4]

- (b) A transformer is used to change the potential difference (p.d.) of a supply.

The table shows the data for this transformer.

Number of turns on the primary coil	3540
Number of turns on the secondary coil	300
p.d. across primary coil	230 V
Current in secondary coil	4.62 A

- (i) Calculate the p.d. across the secondary coil of the transformer.

Use the Equation Sheet.

p.d. across the secondary coil = ... V [3]

- (ii) Calculate the current in the primary coil of the transformer.

Use the Equation Sheet.

Current in primary coil = ... A [3]

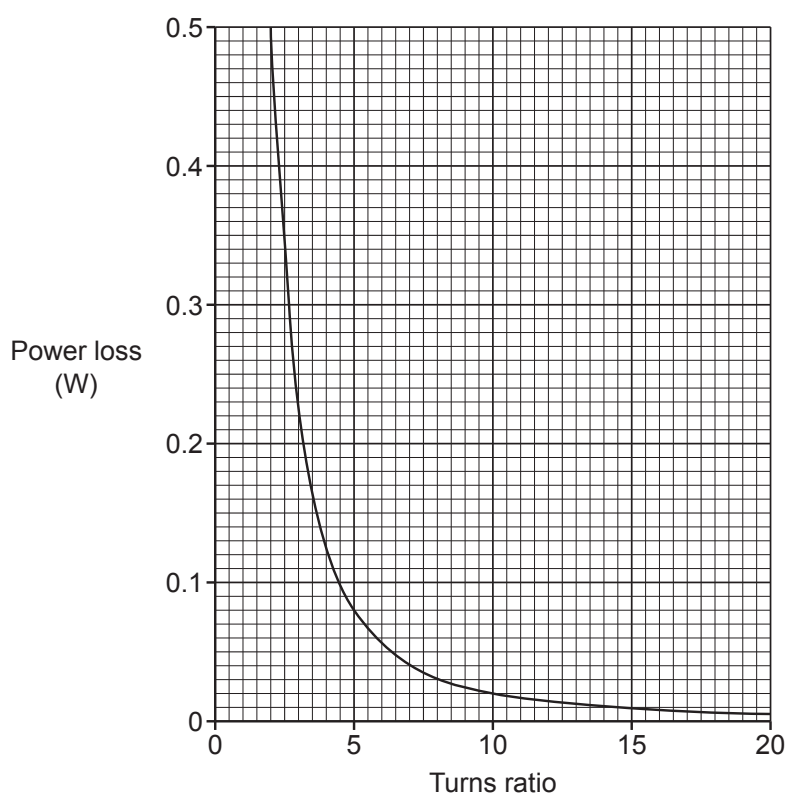


- (c) A teacher calculates power losses in a model power line.

The teacher changes the 'turns ratio' of a step-up transformer using the equation:

$$\text{turns ratio} = \frac{\text{number of turns in secondary coil}}{\text{number of turns in primary coil}}$$

The graph shows how power loss in the power line changes with the turns ratio.



- (i) A student says, 'As the turns ratio doubles, the power loss halves.'

Use data from the graph to explain why the student is **incorrect**.

.....

.....

..... [2]

(ii) Explain why step-up transformers are used in the national grid.

.....

.....

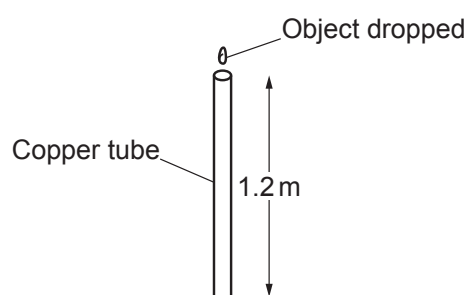
.....

..... [2]



- 23** A student drops a piece of metal and a small magnet through a vertical copper tube. They record the time taken for each object to pass through the tube.

The diagram shows how they set up the experiment.



The student records their results in a table.

	Time taken to fall through the copper tube (s)					
	1	2	3	4	5	Mean
Magnet	1.13	1.11	1.12	1.11	1.13	
Metal	0.44	0.45	0.46	0.44	0.43	0.4444

- (a) (i) Calculate the mean time that the magnet takes to pass through the copper tube.

..... [1]

- (ii) The student has made a mistake when recording their results in the table.

Identify the mistake and suggest a correction.

Mistake:

Correction: [2]

- (iii) The student claims that their data shows that their experiment is reproducible. Explain if the student is correct.

..... [1]

- (iv) Why did the student repeat their experiment 5 times and calculate a mean?

..... [1]

- (b) (i) Calculate how many times longer it took the magnet to fall compared to the piece of metal.

Number of times longer: [1]

- (ii) Calculate the mean speed of the metal through the copper tube.

Write your answer to **2** significant figures.

Use the equation: distance travelled = speed $\times$ time

Mean speed = ... m/s [4]

- (c) Explain why the magnet took longer to fall than the piece of metal.

Include ideas about electromagnetic induction in your answer.

.....

.....

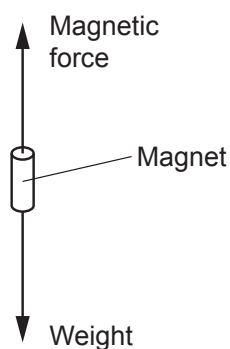
.....

.....

.....

..... [3]

- (d) The diagram shows a free-body force diagram for when the magnet is at a point in the middle of the tube.



Explain the motion of the magnet.

.....

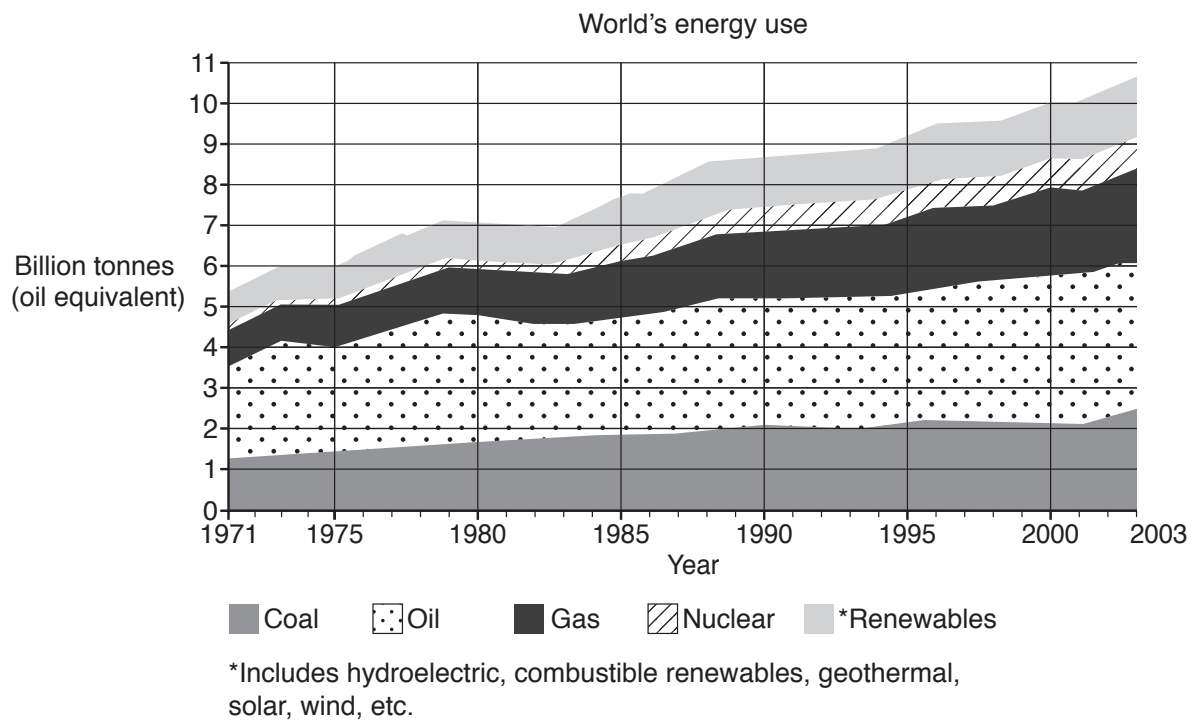
.....

.....

..... [2]

16 The graph shows how the World's energy use has changed from the year 1971 to the year 2003.

It also shows the amount of different energy sources used.



- (a) (i)** Approximately how much did the total World's energy use increase from the year 1971 to the year 2003?

Answer = ... billion tonnes (oil equivalent) **[1]**

- (ii)** Which energy source had the **greatest** use in the year 2003?

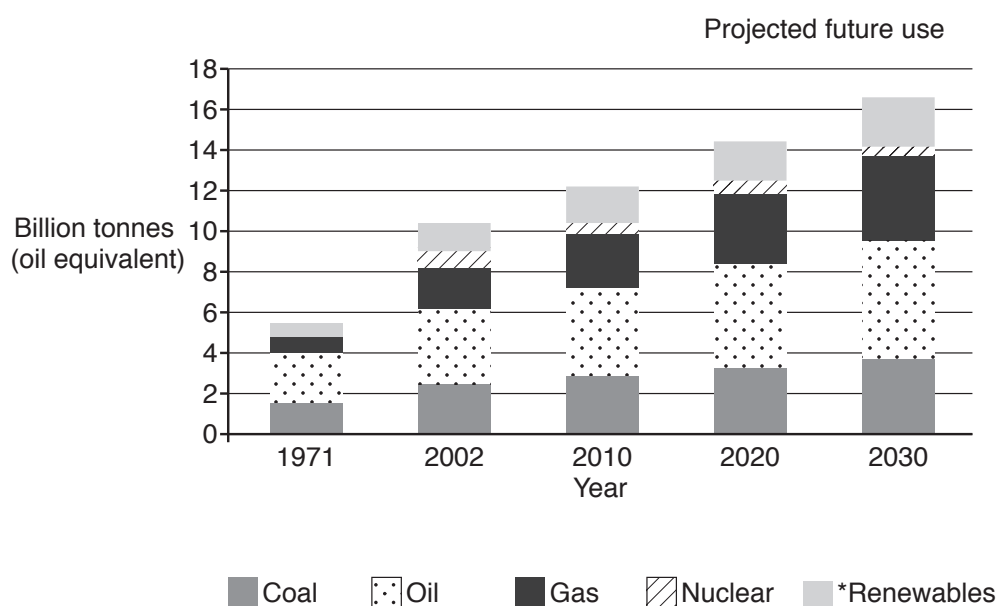
..... **[1]**

- (iii)** The total energy use in the year 2003 was 10.6 billion tonnes (oil equivalent).

Approximately what percentage of this amount was due to fossil fuel use?

- (b) Scientists are researching the World's energy use for the future.

The graph shows some of their research.



*Includes hydroelectric, geothermal, solar, wind etc.

- (i) The future demand for fossil fuels is expected to increase.

Give two reasons why scientists are worried about this increase in demand.

1.
 2.
- [2]

- (ii) In the UK the government is closing coal fired power stations and planning for new nuclear power stations to be built.

Suggest why the government wants more nuclear power stations.

-
-
- [2]

- (c) Power stations in the UK generate electricity at 25 kV a.c.

The voltage is then increased to 400 kV a.c. and distributed by power lines.

- (i) Write down the full name of the device used to **increase** the voltage.

..... [1]

- (ii) Why is it important to increase the voltage in these power lines?

..... [1]

- (iii) The high voltages across the power lines are reduced to 230 V a.c. for use in the home.

A phone charger changes the 230 V a.c. to a 5 V d.c.

Explain the difference between d.c. and a.c.

.....

 [2]

- (d) A domestic wind turbine has a power rating which varies from 1.0 kW to 3.0 kW.

- (i) The domestic wind turbine has an electrical resistance of $23\ \Omega$.

It generates a current of 11 A on a windy day.

Calculate the **power** output in kW of the turbine on this day.

Answer = ... kW [4]

- (ii) Suggest why the manufacturer gives a range for the power rating of the wind turbine.

.....
 [1]

- (iii) Using just **one** domestic wind turbine may be an unreliable source of power for a house.

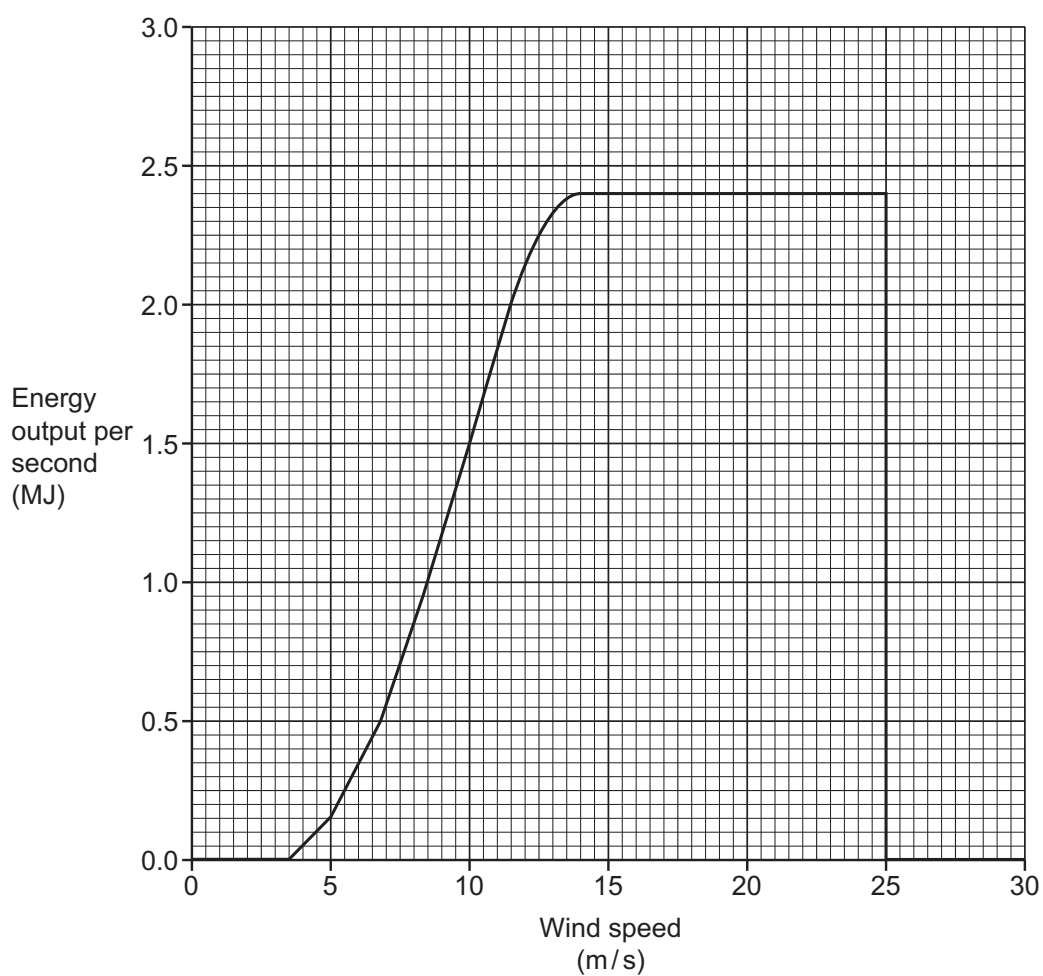
State a reason why.

.....
 [1]



- 21 (a) Fig. 21.1 shows how the energy output per second of a wind turbine depends on the wind speed.

Fig. 21.1



- (i) Suggest a reason why energy output per second is zero when the wind speed is:

1 Less than 3.5 m/s.

.....
.....

2 Greater than 25 m/s.

.....
.....

[2]

- (ii) The wind turbine has an efficiency of 0.35.

Calculate the input energy per second when the wind speed is 10 m/s.

Use **Fig. 21.1** and the Data Sheet.

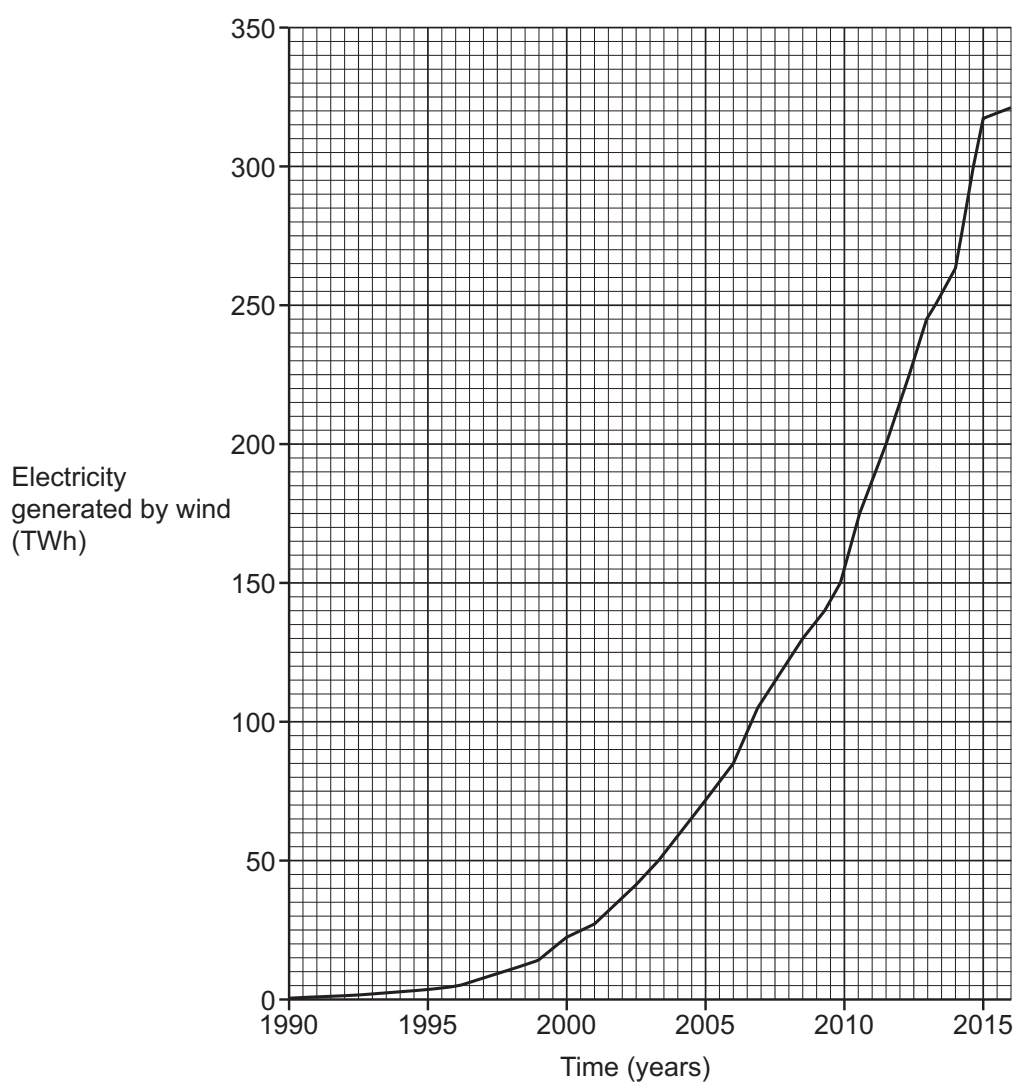
Give your answer to **2** significant figures.

Input energy per second = ... MJ [5]



- (b) Fig. 21.2 shows how the amount of electricity generated by wind in Europe has changed with time.

Fig. 21.2



- (i) State the amount of electricity generated by wind in 2012 in joules.

$$1 \text{ TWh} = 3.6 \times 10^{15} \text{ J}$$

Give your answer in standard form.

Electricity generated = ... J [2]



(ii) Suggest **two** reasons for the change shown in **Fig. 21.2**.

1

.....

2

.....

[2]

(c) The wind turbine generates electricity at 900 V.

The wind turbine is connected to the national grid using a transformer.

- (i) The potential difference across the primary coil is 900 V.
The potential difference across the secondary coil is 36 000 V.
The current in the primary coil is 2800 A.

Calculate the current in the **secondary** coil.

Use the Data Sheet.

Current = ... A [2]

(ii) Explain why the use of the transformer in (c)(i) reduces power loss in the national grid.

.....

.....

.....

.....

.....

..... [3]



(iii) Another transformer has a power input of 864 900 W.

The current in the primary coil is 1860 A.

Calculate the resistance of the primary coil.

Use the equation: $\text{power} = (\text{current})^2 \times \text{resistance}$

Resistance = ... Ω [3]



MARK SCHEMES

official Pearson Edexcel mark schemes



Question			Answer	Marks	AO element	Guidance
11			A ✓	1	1.2	



Question				Answer	Marks	AO element	Guidance
5				D ✓	1	1.1	



Question				Answer	Marks	AO element	Guidance
12			A		1	1.1	



Question				Answer	Marks	AO element	Guidance
2				C ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
3				B ✓	1	1.2	



Question	Answer	Marks	AO element	Guidance
8	D ✓	1	2.2	

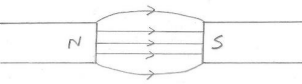


Question	Answer	Marks	AO element	Guidance
2	D ✓	1	1.2	



Question	Answer	Marks	AO element	Guidance
2	C	1	1.2	



19	(a)	(i)	Using a (plotting) compass ✓	1	1.2	IGNORE iron filings, pencil ALLOW qualified extra magnet with method IGNORE unqualified magnet
	(a)	(ii)	A minimum of 2 lines connected between the poles ✓ A minimum of 4 lines correctly drawn between the poles with 2 straight and one each side curved ✓ Correct direction drawn on a minimum of one (not contradicted) field line (N to S) ✓	3	3 × 1.2	Typical answer for 3 marks: Straightness judged by eye  IGNORE lines drawn to unseen poles or the same magnet
	(b)	(i)	To avoid a short-circuit / current flow in <u>nail</u> / <u>nail</u> becoming live / AW ✓	1	3.3a	IGNORE unqualified safety / danger IGNORE heat / shock
	(b)	(ii)	Any one from: Length of wire ✓ Number of turns / coils ✓	1	1.1	ALLOW (cross-sectional) area, current or pd/voltage ALLOW change / removal of core material from iron

17	(a)	(i)	Any three from: place the compass onto the card or near to the wire (and turn on the current) ✓ plot / observe the direction of the compass / needle ✓ repeat idea of tip-to-tail / plotting onto the card ✓ repeat at different distances from the centre ✓	3	3 x 1.2	
		(ii)	one or more circles around wire ✓ clockwise arrow(s) ✓	2	2 x 2.2	DO NOT ALLOW a spiral BUT ALLOW if clockwise direction shown by an arrow on the spiral
	(b)		always points to North / South ✓✓ OR Points to (magnetic) North / South ✓ line up with the magnetic field lines of the Earth ✓ OR Compass needle shows (an angle of) dip ✓ Dip (angle) changes (from equator) ✓	2	2 x 1.1	ALLOW Points North / South wherever you are ✓✓

Question	Answer	Marks	AO element	Guidance
21 (a)	To increase the magnetic effect / magnetic field strength / magnetic flux density✓	1	1.2	IGNORE iron is a magnetic material
(b) *	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed description of the trend using data from the table and detailed suggestions on how to ensure accurate and valid results. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Clear description of the trend and some simple suggestions to ensure accurate or valid results. OR Clear suggestions to ensure accuracy and a simple description of the trend. OR Detailed description of the trend shown or detailed suggestions on how to ensure accurate and valid results. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Basic description of the trend indicated. OR Some simple suggestions to ensure accurate or valid results. <i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i>	6	2 x 3.3a 2 x 3.3b 2 x 3.1a	AO3.1a Analyses the results to interpret the trend. For example: - as current increases the number of paperclips picked up / strength of magnetic field increases - uses data / calculations to demonstrate trend - at 1A 5 paperclips are picked up, at 2A (double) 11 paperclips are picked up (2.2x) - differences between each successive increase calculated e.g. 1A to 2A = 6 - ratio number of paper clips to current calculated - appropriate conclusion - as current doubles the number of paperclips picked up (approximately) doubles - the relationship is (not) linear with reason AO3.3a and AO3.3b Analyses the information to develop/improve experimental procedures. For example: - use same size / mass / type of paperclips - repeat readings to take a mean / discard anomalies - measure current to more decimal places / better accuracy / nearest 0.1A / nearest 0.01A - check ammeter for zero error - use the same nail throughout - use the same number of turns - use the same length of solenoid / fix solenoid to core - use a wider range of currents - allow the coil to cool between readings - hold /fix the coil the same distance from the paperclips on each attempt
	0 marks No response or no response worthy of credit.			



16	(a)	(i)	(The needle) is horizontal / 0° / 180° at/near the equator ✓ (The needle) is vertical / 90° / 270° at/near the poles ✓	2	1.2 x2	ALLOW 2 marks for needle changes from horizontal to vertical ALLOW 1 mark for needle changes from vertical to horizontal ALLOW parallel to the earth (at the equator) ALLOW perpendicular / at right angles (at the pole(s)) IGNORE changes position unqualified.
		(ii)	(The Earth's core) is magnetic ✓	1	1.1	ALLOW (bar) magnet / (core is) electromagnetic
	(b)	(i)	Any three from: Place the plotting compass onto the cardboard sheet ✓ Mark the direction of the compass needle (with a dot) ✓ Move the plotting compass to another of these marks / dots / arrows and repeat ✓ Connect the marks / dots / arrows together to show the field ✓	3	3.3a x3	ALLOW 1 mark for using the plotting compass to show the magnetic field if no other marking points scored
		(ii)	One (or more) circles drawn around the current-carrying wire ✓ Correct direction of the field shown (clockwise) ✓	2	2.2 x2	DO NOT ALLOW crossing lines. accept <u>small</u> gaps in circles. ALLOW 2 marks for a minimum of 3 circles drawn with increasing distance between the field lines (with no arrows)

Question			Answer	Marks	AO element	Guidance
7			A ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
8			D ✓	1	2.2	



Question			Answer	Marks	AO element	Guidance
15			C ✓	1	2.1	



Question			Answer	Marks	AO element	Guidance
13			B✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
8			C		1	1.1	



Question				Answer	Marks	AO element	Guidance
9				B	1	2.1	



Question				Answer	Marks	AO element	Guidance
11			A		1	2.1	



Question			Answer	Marks	AO element	Guidance
3			B ✓	1	2.1	



Question				Answer	Marks	AO element	Guidance
12				C ✓	1	2.1	



Question	Answer	Marks	AO element	Guidance
10	B	1	1.2	



Question	Answer	Marks	AO element	Guidance
14	D	1	2.1	



Question	Answer	Marks	AO element	Guidance
10	A	1	1.1	



Question	Answer	Marks	AO element	Guidance
5	D	1	2.2	



Question	Answer	Marks	AO element	Guidance
8	D	1	1.1	



21	(a)	(i)	force (exerted) on the wire / coil ✓ or interaction between the magnetic field around the wire and the (permanent) magnet / AW ✓	1	1.1	
		(ii)	clockwise ✓ (Fleming's) left hand rule ✓	2	2.2 1.2	ALLOW <u>left</u> hand side up / <u>right</u> hand side down
	(b)		Any two from: increase the current (in the coil) ✓ increase the number of coils ✓ increase the length of the coil (in the magnetic field) ✓ increase the strength of the magnet / magnetic field ✓	2	2 x 1.2	ALLOW increase potential difference / p.d. / voltage IGNORE size of magnet IGNORE (soft) iron core



16	(a)		2	2 × 1.1	Mark independently Correct matching of both transformers to what they do Correct matching of what they do to reason If no other marks scored: ALLOW 1 mark for step-down transformer → decreases pd → for safety OR step-up transformer → decreases current → reduces heat losses
	(b)	First check the answer on the answer line If answer = 450 (A) award 2 marks $132\,000 \times I_p = 1800 \times 33\,000$ ✓ OR $(I_p =) 1800 \times 33\,000 \div 132\,000$ ✓ $(I_p =) 450$ (A) ✓	2	2 × 2.1	ALLOW substitution into any correct rearrangement of the equation ALLOW equation in letters/words rearranged $(I_p =) V_s I_s \div V_p$
	(c)	Alternating (current) / a.c. ✓ p.d./voltage/current/it changes direction / becomes + and – / changes polarity ✓	2	1 × 1.1 1x3.2b	ALLOW p.d./voltage/current/it/oscilloscope trace/charge <u>flow</u> goes in both directions or both ways or two ways or different ways ALLOW oscillates/fluctuates across the centre/zero IGNORE just changes or switches / goes up and down / alternates IGNORE charge changes from positive to negative

20	(a)*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed explanation about how a transformer works. AND A quantitative link between coil and potential difference ratios to inform judgement that the data supports the expected output voltages. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Simple explanation of how a transformer works. AND A quantitative link between coil and potential difference ratios to inform judgement that the data supports the expected output voltages. OR Detailed explanation about how a transformer works. AND A qualitative link between coil and potential difference ratios to inform judgement that the data supports the expected output voltages. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i>	6	1.1x3 3.1a x2 3.2ax1	AO1.1 Demonstrates knowledge and understanding of scientific ideas to give an explanation of how a transformer works For example: • Alternating current / ac / voltage / potential difference • (induces) (alternating) pd / current in secondary • Linking different numbers of coils to changing potential differences (or currents) • More secondary coils = bigger output potential difference • Alternating current in primary coil induces alternating magnetic field in the iron core • Alternating magnetic field in the iron core induces alternating potential difference in the secondary coil • An alternating current flows if the output is connected to a circuit • Ratio of potential differences depends on ratio of coils • Step up transformers increase potential difference and have more secondary coils ORA AO3.1a Analyse information and ideas to interpret – quantitative • Correct equation selected from data sheet • Data from table processed • For A and C expect secondary pd of 24 V • For B and D expect secondary pd of 6 V
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Question	Answer	Marks	AO element	Guidance
	Level 1 (1–2 marks) Simple explanation of how a transformer works. OR A quantitative link between coil and potential difference ratios to inform judgement that the data supports the expected output voltages. OR A qualitative link between coil and potential difference ratios to inform judgement that the data supports the expected output voltages. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>			AO3.1a Analyse information and ideas to interpret - qualitative For example: • Double the number of secondary coils (compared to primary) and the output potential difference is doubled (compared to input) • Halve the number of secondary coils (compared to primary) and the output potential difference is halved (compared to input) • In transformer A the number of coils increases by 100% and the voltage increases by almost 100%/AW • In transformer B the number of coils decreases by 50% and the voltage decreases by 50%/AW • In transformer C the number of coils increases by 100% and the voltage increases by almost 100%/AW • In transformer D the number of coils decreases by 50% and the voltage decreases by 50%/AW AO3.2a Analyses information and ideas to make judgements • Data supports the expected output voltages • Energy losses in A and C • B and D are efficient ALLOW voltage for potential difference and vice versa



	(b)	(i) Incorrect word (A) resistance (is induced across the ends of the wire) ✓ Corrected sentence (A) potential difference/voltage (is induced across the ends of the wire) ✓ OR Incorrect word (A microphone is similar to a) motor ✓ Corrected sentence (A microphone is similar to a) generator ✓	2	2.1 x2	ALLOW current is induced ALLOW dynamo
		(ii) Loudspeaker/speaker/headphones ✓	1	1.1	IGNORE phone



20	(a)	A.C. (transmitted in power lines) / (electrical/electron/particle) oscillations / AW ✓ BUT Alternating currents/(electrical/electron/particle) oscillations produce (radio) waves/electromagnetic radiation ✓✓	2	2×1.1	
	(b)	(High voltage means) lower current ✓ Less heating/heat loss/power loss/energy wasted or more useful energy transmitted / ORA ✓	2	2×1.1	IGNORE no energy losses / prevent energy loss / AW ALLOW more efficient / (wires at) lower temperature
	(c)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 20 (A) award 5 marks Recall $I^2 = P / R$ ✓ 6.156 kW = 6156 W ✓ ($I^2 =$) 6156 / 15.39 OR ($I^2 =$) 400 ✓ ($I =$) $\sqrt{400}$ ✓ ($I =$) 20 (A) ✓	5	1.2 2.1 2.1 2.1 2.1	ALLOW correct equation in any form DO NOT ALLOW marks to be awarded from incorrect equation e.g. $I = P / R$ Award marks if 6.156kW has not been correctly converted to W E.g. ($I^2 =$) 0.4 or 6.156/15.39 ✓✓ ($I =$) $\sqrt{0.4}$ ✓✓✓ $I = 0.63$ ✓✓✓✓

23	(a)		Use an a.c. supply / alternating current/ potential difference. ✓ Transformers require (a.c. to create) an alternating/changing magnetic field ✓	2	3.1b 3.3b	
	(b)	(i)	As the number of turns increases the potential difference increases/ ORA ✓ BUT Number of turns is directly proportional to potential difference ✓✓	2	2 × 3.2a	ALLOW linear relationship ALLOW as number of turns doubles/halves, potential difference doubles/halves / they are (directly) proportional / number of turns is 25 times the potential difference / constant of proportionality is 25 or 0.04 / ratio of number of turns to potential difference is always 25 for 2 marks
		(ii)	First check the answer on the answer line If answer = 0.63 award 3 marks select and substitute: $3.2 \times 0.94 = 4.8 \times \text{current}$ ✓ rearrangement: (current =) $3.2 \times 0.94 \div 4.8$ ✓ evaluation: (current =) 0.63 (A) ✓	3	3 × 2.2	ALLOW 0.627 or 0.626(66...) ALLOW use of top row of table instead $6.4 \times 0.47 = 4.8 \times \text{current}$ ALLOW substitution and rearrangement in either order. ALLOW rearrangement in words or symbols ALLOW (current =) $6.4 \times 0.47 \div 4.8$

Question			Answer	Marks	AO element	Guidance
23		(iii)	This is a step-down transformer / transformer between power station and transmission lines is step-up ✓ (Transformers between power station and power lines) need to transfer power to power lines at (very) high voltage / low current ✓	2	1.1 3.2b	ALLOW (transformers between power station and power lines) need to reduce (thermal) energy lost to surroundings / reduce (thermal) energy dissipation / reduce energy lost as heat / reduce power loss (in transmission wires) IGNORE voltage increases

20	(a)	Any two from: the magnet will exert a force on the wire OR the wire will move ✓ (current in the wire) creates a magnetic field ✓ the magnetic fields of the magnet and wire interact / AW ✓	2	1.2 x 2	ALLOW attracted / repelled for force
	(b)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.12 (T) award 3 marks ($F = BIL$) $B = F / (IL)$ ✓ $= 0.15 / (5.0 \times 0.25)$ ✓ $= 0.12$ (T) ✓	3	1.2 2.1 2.1	
	(c) (i)	Maximum two from: Both rotate (on an axis) ✓ Both have a (fixed) magnet surrounding a coil / AW ✓ Maximum two from: In the motor energy is transferred from the electrical energy store to the kinetic energy store ✓ In the generator energy is transferred from the kinetic energy store to the electrical energy store ✓ In the motor the current (and magnetic field) causes motion ✓	3	1.1 x 3	IGNORE Thermal energy store IGNORE Thermal energy store

Question	Answer	Marks	AO element	Guidance
	In the generator motion (and magnetic field) causes current (in the wire) ✓ (the generator) has slip rings and the (motor) a split ring commutator ✓			
	(ii) Alternator output is <u>alternating current</u> / <u>a.c.</u> ✓ Dynamo output is <u>direct current</u> / <u>d.c.</u> ✓	2	1.1 x 2	

20	(a)	<u>Similarities</u> Any two from: Both have alternating / changing current / p.d. / voltage ✓ Both use coil / magnets / magnetic field ✓ Both have (moving) diaphragms ✓ The frequency of the sound equals the frequency of the current ✓ <u>Differences</u> A microphone converts sound (waves) into current / p.d. / electrical signal ✓ A speaker converts current / p.d. / electrical signal into sound (waves) ✓	4	4 x 1.1	IGNORE reference to energy (as it is not relevant to the operation of the transducers) ALLOW a.c. for alternating current ALLOW cone for diaphragm ALLOW in a microphone the cone / diaphragm / magnet moves to produce a current ALLOW in a speaker a current makes a cone / diaphragm / magnet move
	(b)	The (current in the wire) produces a magnetic field ✓ The magnetic field of the magnet and the magnetic field of the wire interact (to exert a force on each other) ✓ The wire experiences a force / moves <u>downwards</u> ✓	3	2.2 2.2 2.2 3.2a	
	(c)	First check the answer on answer line If answer = 1.1 (N) award 3 marks ($F = BIL$) $F = 0.30 \times 5.0 \times 0.75$ ✓ $F = 1.125$ (N) ✓ $F = 1.1$ (N) 2 SF ✓	3	2.1 2.1 1.2	

22	(a)		Any two from: Current (in the coil) causes a magnetic field ✓ magnetic field of the current-carrying wire <u>interacts</u> with magnetic field of the magnets AND causes a <u>force</u> (to act on the wire) ✓ the forces on either side of the coil are opposite / one side of the coil the force is up and the other is downwards / (idea that) these two forces work together to cause rotation around the axle ✓	2	1.2 x2	IGNORE statement of Fleming's left-hand rule
	(b)	(i)	Similarities: Both rotate a coil in a magnetic field / between magnets ✓ Both induce a (variable) pd / current when rotated ✓ Differences: Alternator <u>generates</u> ac / dynamo <u>generates</u> dc ✓ Dynamo uses split ring commutator / alternator uses slip rings ✓	4	2.1 x4	ALLOW voltage for pd DO NOT ALLOW both use electromagnetism DO NOT ALLOW reference to a.c. and/or d.c. ALLOW induces / creates / produces for generates
		(ii)	Any one from: Spin the coil faster ✓ More turns on the coil ✓ Increase the strength of magnetic field / use stronger magnets ✓	1	1.2	IGNORE bigger magnet, longer coil ALLOW more coils ALLOW flux density for field
22	(c)		First check the answer on the answer line If answer = 0.45 (m) award 3 marks (F = BIL) L = F / (IB) ✓ L = 0.81 / (1.2 x 1.5) ✓	3	1.2 2.1	ALLOW two marks for 9/20 ALLOW 1 mark for correct substitution into unrearranged equation

Question	Answer	Marks	AO element	Guidance
	L = 0.45 (m) ✓		2.1	

Question	Answer	Marks	AO element	Guidance
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21	(a)	(C) D B A ✓✓	2	2 × 1.2	All 3 correct = 2 marks 1 or 2 correct = 1 mark
	(b)	The current only flows in one <u>direction</u> / AW ✓ Magnetic field remains steady / does not change / AW ✓	2	2 × 1.2	IGNORE electricity ALLOW voltage / p.d for current IGNORE magnetic field not induced
	(c)	First check the answer on the answer line If answer = 500 (turns) award 3 marks $N_s = N_p \frac{V_s}{V_p}$ ✓ $= \frac{25 \times 4600}{230}$ ✓ $= 500$ (turns) ✓	3	1.2 2.1 2.1	IGNORE unarranged formula $V_p/V_s = N_p/N_s$ ALLOW Any transformer equation <u>rearrangement</u> ALLOW All correctly substituted numbers
	(d)	(electric) shock ✓	1	3.2b	IGNORE unqualified can kill you / dangerous IGNORE heat / burns / fires ALLOW electrocution, cardiac arrest / AW

(e)		generator The movement of a wire in a magnetic field induces a potential difference across the wire. headphones A current in a wire in a magnetic field causes rotation. microphone Pressure variations in sound waves are converted into current variations in electrical circuits. motor Current variations in electrical circuits are converted into pressure variations in sound waves.	2	2 × 1.1	All 4 lines correct = 2 marks 2 or 3 lines correct = 1 mark
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21	(a)	(i)	(From) <u>Chemical</u> energy (store) ✓ (To) <u>Thermal</u> energy (store of the water in the kettle) ✓	2	2 × 2.1	ALLOW chemical energy store decreases ALLOW thermal energy store increases ALLOW heat / internal energy for thermal IGNORE sound/electrical energy IGNORE intermediate energy transfers/stores and any energy transfers/stores after thermal (store of the water)
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 138 000 (J) award 4 marks (Recall: energy transferred =) power × time ✓ (Power = 5.0 × 230 =) 1150 ✓ (Time = 2 × 60 =) 120 ✓ (Energy transferred =) 1150 × 120 = 138 000 (J) ✓	4	1.2 2.1 2.1 2.1	ALLOW equation in any form ALLOW ecf for incorrect power calculated ALLOW ecf for incorrect/no conversion of time

Question			Answer	Marks	AO element	Guidance
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 72 (%) award 5 marks Select from data sheet: change in thermal energy = mass × specific heat capacity × change in temperature (no mark) (change in thermal energy =) $1.2 \times 4200 \times 75$ ✓ (change in thermal energy =) 378 000 (J) ✓ (Recall: efficiency =) useful output energy transfer / input energy transfer OR (Efficiency =) 378 000 / 525 000 ✓ (Efficiency =) 0.72 ✓ (Efficiency =) 72 (%) ✓	5	1.2 2.1 1.2 2.1 1.2	ALLOW ecf for incorrect thermal energy calculated ALLOW 4 marks for answer of 0.72 (%)
	(b)	(ii)	some energy is transferred to the (thermal energy store of the) kettle/surroundings/air ✓	1	2.1	IGNORE sound
	(c)		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.9 (A) award 2 marks (Rearrangement: $I_p = I_s \times V_s / V_p$) ✓ OR ($I_p =$) $12 \times 9.0 / 120$ ✓ ($I_p =$) 0.9 (A) ✓	2	1.2 2.1	

21	(a)	Any four from: Wrap coil(s) around a (soft iron) rod ✓ Connect a voltmeter across secondary coil / measure p.d. across secondary coil ✓ Connect (a.c. power) supply to primary coil ✓ Change the number of turns in the secondary coil ✓ Keep p.d. of the a.c. supply/primary p.d. constant ✓ Keep number of turns in the primary coil constant ✓	4	4 × 3.3a	ALLOW marks awarded from a clear diagram ALLOW coils side by side or on top of one another ALLOW dependent variable is p.d. across secondary coil DO NOT ALLOW d.c. power supply or cell/battery in diagram ALLOW independent variable is number of turns ALLOW p.d. of a.c. supply/primary p.d. is a control variable ALLOW control variable is number of turns in primary coil
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Question			Answer	Marks	AO element	Guidance
21	(b)	(i)	First check the answer on answer line If answer = 19.5 (V) award 3 marks Rearrangement: $(V_s =) V_p \times (N_s \div N_p)$ ✓ $(V_s =) 230 \times (300 \div 3540)$ ✓ $(V_s =) 19.5 (V)$ ✓	3	1.2 2.1 2.1	ALLOW 19 (V) or 19.49 (V) ALLOW 1 mark for correct substitution into unrearranged equation, e.g., $230 / V_s = 3540 / 300$
		(ii)	First check the answer on answer line If answer = 0.39 (A) award 3 marks Rearrangement: $(I_p =) (I_s \times V_s) \div V_p$ ✓ $(I_p =) 4.62 \times 19.5 \div 230$ ✓ $(I_p =) 0.39 (A)$ ✓	3	1.2 2.1 2.1	ALLOW ECF from (c)(i) ALLOW $(I_p =) (I_s \times N_s) \div N_p$ ALLOW $(I_p =) 4.62 \times 300 \div 3540$ ALLOW 1 mark for correct substitution into unrearranged equation, e.g., $230 \times I_p = 4.62 \times 19.5$ OR $3540 \times I_p = 4.62 \times 300$
	(c)	(i)	Candidate states turns ratios from 2 different points on the graph ✓ Candidate concludes that as turns ratio doubles then power loss is not half / power loss decreases by a factor of 4 / $\times \frac{1}{4}$ / quarters ✓	2	3.1a 3.1a	e.g., at a ratio of 5, power loss = 0.08 (W) but at a ratio of 10, power loss = 0.02 (W) ALLOW tolerance of $\pm \frac{1}{2}$ small square ALLOW e.g., power loss at a ratio of 10 should be 0.04 (W)

21	(c)	(ii)	Any two from: Transformers increase voltage/p.d. (before national grid) / AW ✓ Transformers decrease current ✓ Transformers decrease power/energy losses ✓	2	2 × 1.2	ALLOW energy losses are proportional to the current squared / less heat lost to the surroundings / high current causes large energy losses / more efficient energy transfer DO NOT ALLOW stops power/energy losses
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23	(a)	(i)	1.12 (s)	1	1.2	
		(ii)	(Mistake) Mean for metal / 0.4444 ✓ (Correction) Calculate mean to two significant figures / 0.44 ✓	2	3.2a 3.3b	ALLOW correct reference to significant figures or decimal places ALLOW decimal places for significant figures ALLOW three significant figures / 0.444
		(iii)	No, as no-one else has completed the experiment / AW ✓	1	3.2b	ALLOW has not repeated the experiment with <u>different equipment</u> or <u>different techniques</u>
		(iv)	Any one from: Reduce random errors ✓ To see if the experiment was repeatable ✓ To check for anomalies / outliers ✓ To increase precision ✓	1	3.2a	ALLOW reduce errors IGNORE accurate / reliable / valid
	(b)	(i)	$(1.12 \div 0.44) = 2.5$ ✓	1	2.1	ALLOW ECF from (a)(i) ALLOW any number which rounds to 2.5 ALLOW 2.55
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.7 award 4 marks (Mean) speed = distance / time ✓ = $1.2 / 0.44$ ✓ = 2.73 ✓ = 2.7 ✓	4	1.2 2.1 2.1 1.2	ALLOW ECF for use of time = 1.12 s ALLOW 1.07 for two marks ALLOW 1.1 for three marks Correct re-arrangement ALLOW $1.2 / 0.444$ or $1.2 / 0.4444$ ALLOW 2.702 or 2.7002 or $2.\dot{7}$ or $2.\dot{7}\dot{2}$ or 2.72 DO NOT ALLOW $2.\dot{7}$

Question	Answer	Marks	AO element	Guidance
(c)	Any three from: falling magnet produces a changing magnetic field ✓ magnetic field / magnet induces a potential difference / current (in the copper / tube) ✓ magnetic field due to current in copper is produced ✓ this magnetic field due to the current opposes the original magnetic field of the magnet ✓	3	3 x 1.2	IGNORE copper becomes a magnet
(d)	Forces are equal ✓ Magnet is travelling at a constant speed / terminal velocity / magnet is not accelerating ✓	2	2 x 2.1	ALLOW resultant force is zero ALLOW balanced IGNORE equilibrium

16	a	i	5.2 (billion tonnes oil equivalent) ✓	1	3.1a	ALLOW answers between 5.0 and 5.5 IGNORE wrong units
		ii	Oil ✓	1	3.1a	
		iii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 78 (%) award 2 marks 8.3 / 10.6 (x 100) ✓ =78 (%) ✓	2	2 x 3.1a	ALLOW answers that round between 77(%) and 80(%) ✓✓ ALLOW 8.2 / 10.6 (x 100) OR 8.4 / 10.6 (x 100) OR 8.5 / 10.6 (x 100) OR answers that round between 0.77 and 0.80
	b	i	Fossil fuel may run out / is non-renewable / be in short supply / become very costly ✓ Named damage to environment: Eg (increased) greenhouse gases / global warming / sea levels rise / carbon dioxide / climate change / acid rain ✓	2	3.1b 3.1b	ALLOW being used faster than being produced / finite resource ALLOW ice caps melting / droughts and storms / more polluting gases / other named polluting gases e.g. SO ₂ / carbon emissions IGNORE just pollution or bad for the environment / more CFCs
		ii	To meet demand for electricity / not enough energy from renewable resources ✓ Less named damage to environment: (decreased) greenhouse gases / global warming / sea levels may fall / carbon dioxide / climate change / acid rain / ORA for coal ✓	2	1.2 1.2	ALLOW will not run out as fast (as coal) / to preserve fossil fuels / produces more energy (per kg than coal) ALLOW less polluting gases / carbon emissions / ice caps melting / droughts and storms IGNORE just less pollution or just better for the environment / less CFCs
	c	i	Step-up transformer ✓	1	1.1	

Question			Answer	Marks	AO element	Guidance
		ii	Reduce energy wastage / loss ✓	1	1.1	ALLOW less heat loss / reduce current / reduce power loss / more useful power out / more efficient / less heating of wires DO NOT ALLOW no energy losses / prevent energy loss / AW
		iii	d.c – (current / voltage / charge flow / it) has one direction or polarity ✓ a.c.- (current / voltage / charge flow / it) (continually) changes direction or polarity ✓	2	1.1 1.1	ALLOW dc only positive / only negative IGNORE electricity ALLOW current / voltage alternates OR positive and negative
	d	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 2.8 (kW) award 4 marks (P =) I ² x R ✓ 11 x 11 x 23 or 11 ² x 23 or 121 x 23 ✓ = 2783 ✓ Conversion to kW = 2.8 ✓	4	 1.2 2.1 2.1 2.1	ALLOW 2.78 kW or 2.783 kW ✓✓✓✓ ALLOW equation in any form ALLOW ECF candidates answer to 3 rd marking point converted to kW
		ii	Wind speed varies / AW ✓	1	2.1	ALLOW it depends on the strength of the wind / how windy it is / AW IGNORE there might not be any wind / wind changes direction / AW
		iii	(Idea of) not always enough wind / demand may exceed supply / AW ✓	1	2.1	ALLOW (it) may not generate enough power / energy / AW

Question	Answer	Marks	AO element	Guidance
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21	(a)	(i)	1 Not enough wind/force/energy/speed to turn the turbine ✓ 2 (Speed too high so) could damage the turbine / turbine is shut down to stop damage/for safety reasons ✓	2	2 × 3.2a	ALLOW turbine does not turn ALLOW idea of (the turbine/it) being damaged/broken
		(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4.3 (MJ) award 5 marks (Useful output energy transfer per second =) 1.5 (MJ) ✓ Efficiency = Useful output energy transfer ÷ Input energy transfer ✓ (Input energy transfer =) $1.5 \div 0.35$ ✓ (Input energy transfer =) 4.2857... ✓ (Input energy transfer =) 4.3 (MJ) ✓	5	2.2 1.2 2 × 2.1 1.2	ALLOW equation in any form ALLOW 4.2857... × 10 ⁶ or 4.3 × 10 ⁶ for 4 marks ALLOW an incorrect answer rounded to 2 sig. fig. for this mark
	(b)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 7.7×10^{17} (J) award 2 marks 215 (TWh) from graph ✓ ($215 \times 3.6 \times 10^{15}$ =) 7.7×10^{17} (J) ✓	2	2 × 1.2	ALLOW 210 – 220 (TWh) from graph ALLOW 1 mark for any correct conversion into J e.g. $210 \times 3.6 \times 10^{15} = 7.6 \times 10^{17}$ (J) $220 \times 3.6 \times 10^{15} = 7.9 \times 10^{17}$ (J) IGNORE answer not in standard form

Question			Answer	Marks	AO element	Guidance
21	(b)	(ii)	Any two from: More wind turbines have been built ✓ Modern turbines have a better design / are more efficient ✓ (wind turbines) do not produce air pollution/harmful gases/ carbon dioxide/greenhouse gases / do not contribute to global warming/greenhouse effect/climate change ✓ (idea that wind turbines) conserve/reduce use of fossil fuels ✓ (Idea of) renewable energy ✓ (wind turbines) have low fuel/running costs once set up ✓	2	2 × 1.1	IGNORE increased demand ALLOW better technology IGNORE no pollution / better for the environment unless qualified IGNORE sustainable ALLOW reduce use of finite resources / fossil fuels are running out ALLOW high cost of fossil fuels
	(c)	(i)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 70 (A) award 2 marks Rearrangement: Current in secondary coil = current in primary coil × potential difference across primary coil ÷ potential difference across secondary coil OR $2800 \times 900 \div 36000$ ✓ (Current in secondary coil =) 70 (A) ✓	2	2 × 2.1	ALLOW rearranged equation in symbols or numbers

Question			Answer	Marks	AO element	Guidance
21	(c)	(ii)	Any three from: It is a <u>step-up</u> transformer / to increase p.d. ✓ Decrease current (in power lines) ✓ less energy wasted/lost / less heat in power lines / less thermal transfer ✓ (idea that) power loss depends on current² ✓	3	3 × 1.1	ALLOW voltage ALLOW ORA for high current IGNORE just ideas about efficiency DO NOT ALLOW so no power wasted / no energy wasted (as heat in power lines) / no thermal transfer IGNORE less power loss
		(iii)	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.25 (Ω) award 3 marks Rearrangement: resistance = power ÷ (current)² ✓ (Resistance =) 864 900 ÷ 1860² or 864 900 ÷ 3 459 600 ✓ (Resistance =) 0.25 (Ω) ✓	3	1 × 1.2 2 × 2.1	Allow ¼ (Ω)