Electromagnetic Induction and Transformers

Questions

Q1.

(i) Figure 17 shows the output from a battery.

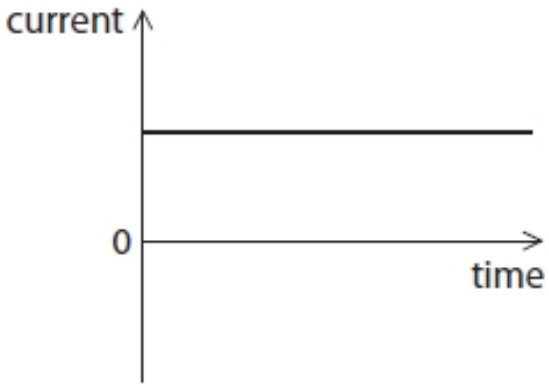

Figure 17

Explain why a transformer will not work with the input current as shown in Figure 17.

(2)

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.....

(ii) A transformer has 30 turns on the primary coil and 150 turns on the secondary coil.

A potential difference of 25 V is applied across the primary coil.
Calculate the potential difference across the secondary coil.
Use an equation selected from the list of equations at the end of this paper.

(3)

potential difference = ... V

(Total for question = 5 marks)

Q2.

The transformer in a battery charger has a primary coil and a secondary coil.

The voltage across the primary coil = 230 V.

The voltage across the secondary coil = 15 V.

The current in the secondary coil is 3.1 A.

Calculate the current in the primary coil.

Use the equation

$$\text{primary current} = \frac{\text{secondary voltage} \times \text{secondary current}}{\text{primary voltage}}$$

(2)

current = ... A

(Total for question = 2 marks)

Q3.

This question is about using the mains electricity supply.

A transformer is used to connect a laptop computer to the mains electricity supply.

The input voltage to the transformer is 230 V.
The output current from the transformer is 2.37 A.
The transformer has an output voltage of 19.0 V.
The transformer used is 100% efficient.

Calculate the input current to the transformer.

Use the equation

input current × input voltage = output current × output voltage

(3)

input current = ... A

(Total for question = 3 marks)

Q4.

The primary coil of a different transformer is connected to the 230 V mains supply.

The voltage across the secondary coil is 15 V.

The primary coil has 600 turns.

Calculate the number of turns on the secondary coil.

Use an equation selected from the list of equations at the end of the paper.

(2)

number of turns = ...

(Total for question = 2 marks)

Q5.

Figure 18 shows a transformer.

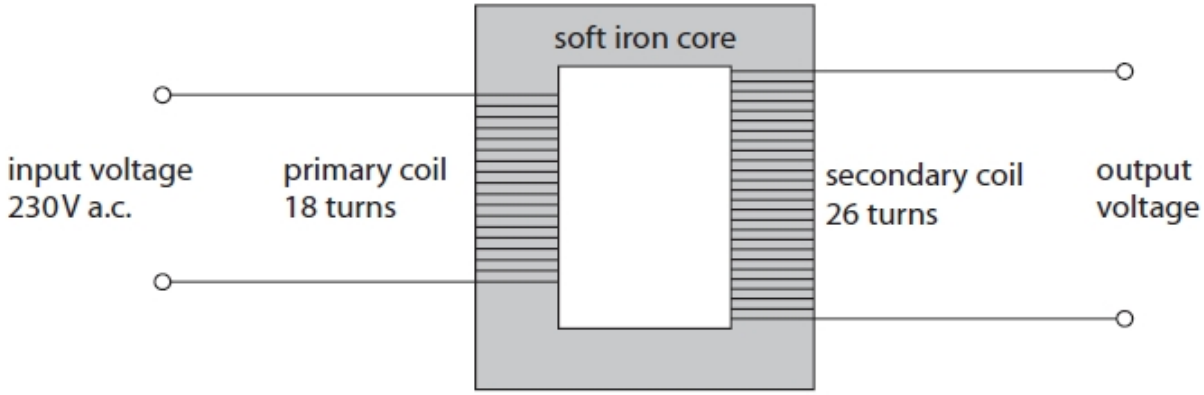

Figure 18

(i) State the purpose of the transformer shown in Figure 18.

(1)

.....

(ii) Calculate the output voltage of the secondary coil.

Use an equation selected from the list of equations at the end of this paper.

(3)

output voltage = ... V

(Total for question = 4 marks)

Q6.

There is a changing magnetic field in the core of a transformer.

(i) Describe the cause of the changing magnetic field in the core of the transformer.

(2)

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(ii) A potential difference of 230 V is applied across the primary coil of a transformer.

There is a potential difference of 15 V across the secondary coil.
The primary coil has 2000 turns.
Calculate the number of turns in the secondary coil.
Use an equation selected from the list of equations at the end of this paper.

(3)

..... turns

(Total for question = 5 marks)

Q7.

There is an alternating current of 3 A in the primary coil of a transformer.

There is an alternating current of 6 A in the secondary coil of the transformer.

The transformer is 100% efficient.

(i) The size of the potential difference (voltage) across the secondary coil is

(1)

- ☒ A twice the size of the current in the primary coil
- ☒ B half the size of the current in the primary coil
- ☒ C twice the size of the voltage across the primary coil
- ☒ D half the size of the voltage across the primary coil

(ii) Explain how an alternating current in the primary coil causes an alternating current in the secondary coil of the transformer.

(3)

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(Total for question = 4 marks)

Q8.

Figure 17 is a diagram representing a loudspeaker.

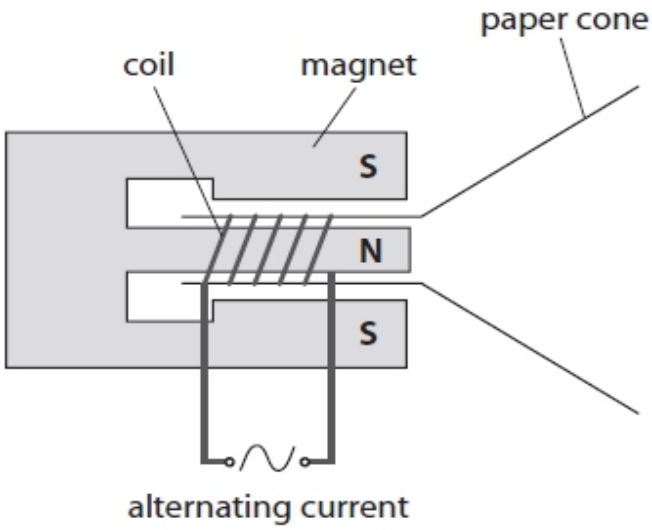

Figure 17

Explain how sound is produced when an alternating current is supplied to the coil of the loudspeaker.

(4)

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(Total for question = 4 marks)

Q9.

* Figure 19 shows a coil of wire that is being rotated between the poles of a magnet.

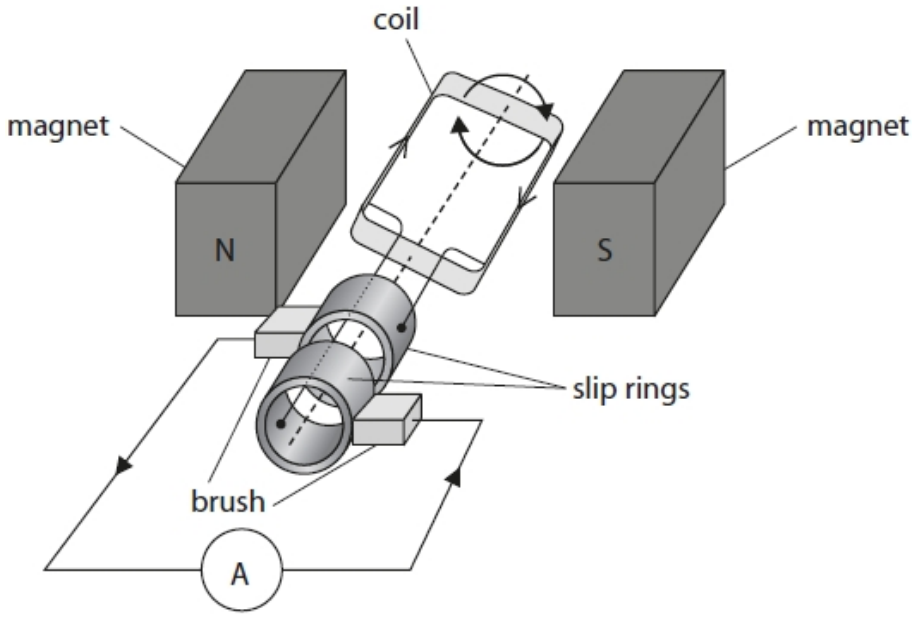

Figure 19

Figure 20 shows how the current in the coil changes during one complete rotation of the coil.

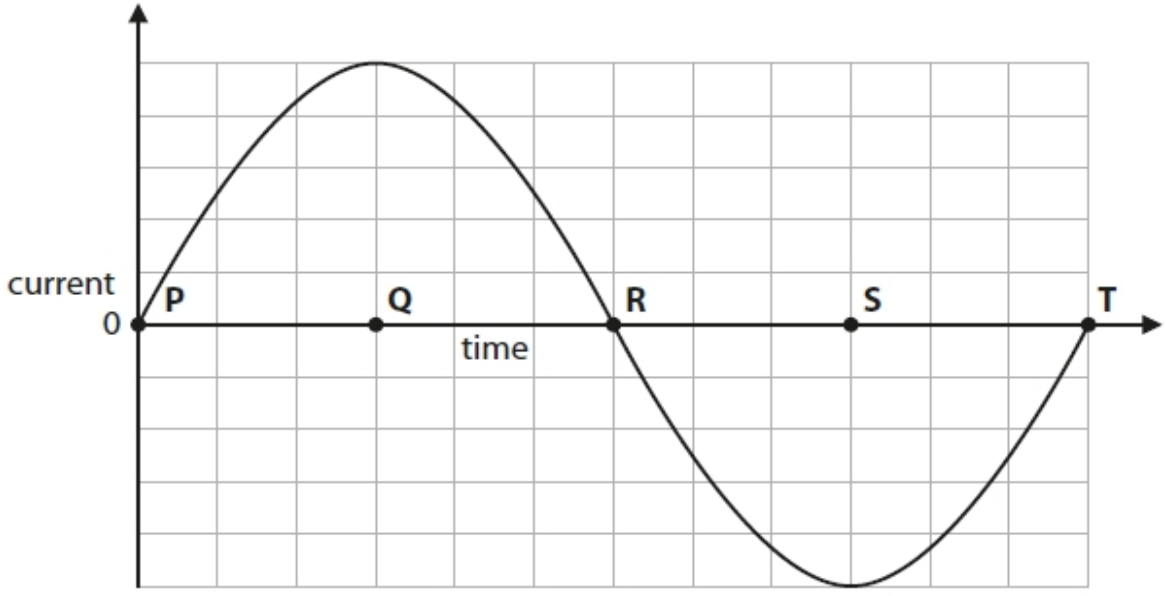

Figure 20

Explain why the current changes in the way shown by the graph in Figure 20.

Your answer should include details of the position of the coil relative to the magnet at each of the times labelled P, Q, R, S and T.
You may use diagrams to help your answer.

(6)

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(Total for question = 6 marks)

Q10.

Complete the following sentences using one of the phrases from the box below.

efficiency is reduced the national grid a power station heat loss is reduced a transformer

(i) Electrical power is generated at

(1)

.....

(ii) Electricity is transmitted over long distances by transmission lines that are part of

(1)

.....

(iii) Electricity is transmitted at high voltages so that

(1)

.....

(Total for question = 3 marks)

Q11.

Figure 15 shows three stages of a magnet moving into and then out of a coil of wire.

The coil is connected to a milliammeter.

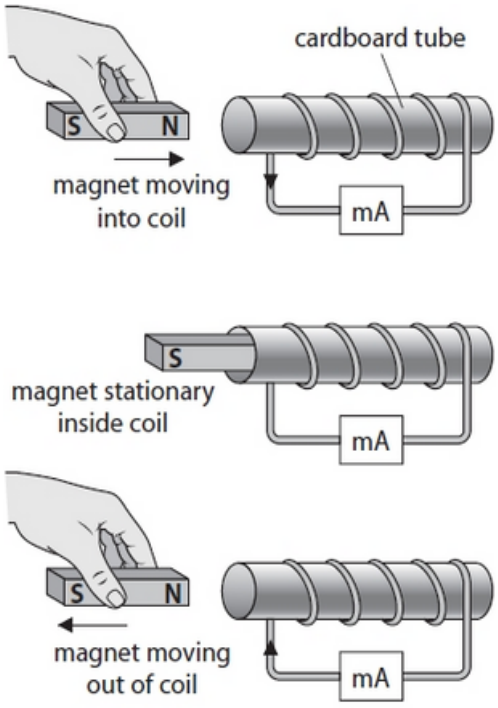


Figure 15

(i) Which row of the table shows the deflection on the milliammeter for the three stages in Figure 15?

(1)

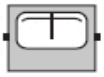
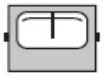
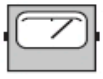
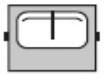
	magnet moving into coil	magnet stationary inside coil	magnet moving out of coil
☒ A			
☒ B			
☒ C			
☒ D			

Figure 16

(ii) Give two ways of increasing the deflections on the milliammeter shown in Figure 16.

(2)

1 .....

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2 .....

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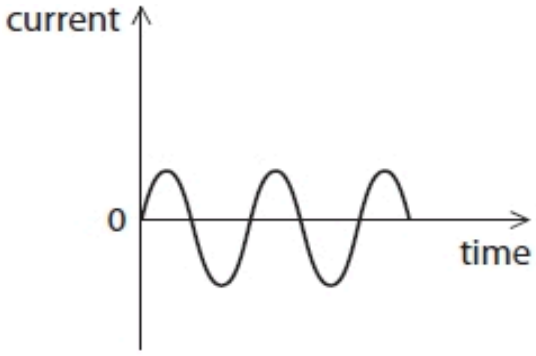
(Total for question = 3 marks)

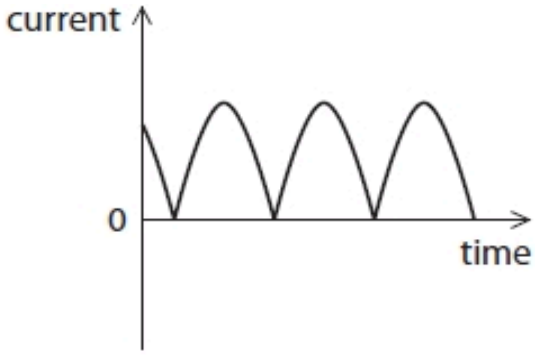
Q12.

Which of these could be the output for a dynamo?

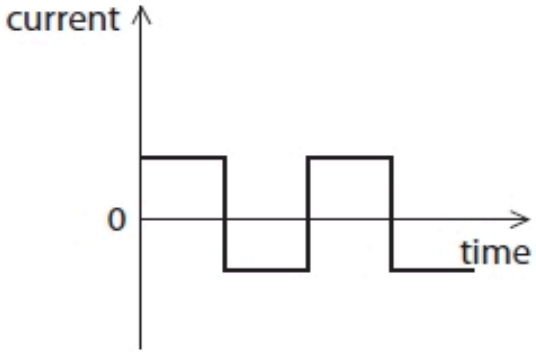
(1)



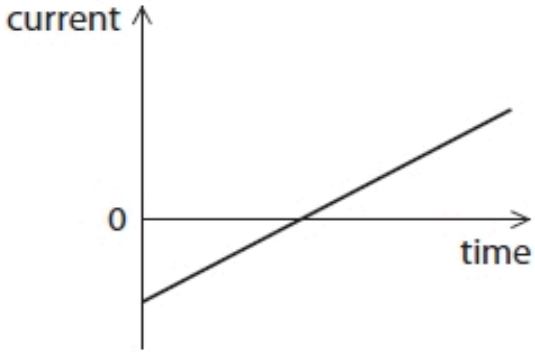
☒ A



☒ B



☒ C



☒ D

(Total for question = 1 mark)

Q13.

A teacher is demonstrating electromagnetic induction.
The teacher has a bar magnet, a coil of wire and a sensitive voltmeter.

(i) Draw a diagram to show how the teacher should arrange the apparatus.

(1)

(ii) Explain how the teacher could use this apparatus to demonstrate the factors affecting the size and direction of the induced potential difference.

(4)

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(Total for question = 5 marks)

Q14.

In a small transformer

- the primary voltage is 230 V
- the primary current is 0.020 A
- the secondary voltage is 5.0 V

Calculate the secondary current.

Use the equation

$$I_s = \frac{V_p \times I_p}{V_s}$$

(2)

secondary current = ... A

(Total for question = 2 marks)

Q15.

* High voltage transmission cables and transformers are used in the national grid.

Explain how using high voltage transmission cables and transformers allows the distribution of electrical power around the United Kingdom to be as efficient as possible.
Refer to the following equations in your answer.

$$P = I^2 \times R$$

$$V_p \times I_p = V_s \times I_s$$

(6)

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(Total for question = 6 marks)

Mark Scheme – Electromagnetic Induction and Transformers

Q1.

Question Number:	Answer	Additional Guidance	Mark
(i)	an explanation linking: (p.d. / current is only induced by a) changing magnetic field (1) a changing current (is needed to create a changing magnetic field) (1)	 alternating magnetic field the voltage/current (as shown) is not changing	(2) AO 1 1

Question Number:	Answer	Additional Guidance	Mark
(ii)	substitution into $\frac{V_p}{V_s}=\frac{N_p}{N_s}$ (1) $\frac{25}{V_s}=\frac{30}{150}$ rearrangement (1) $V_s = \frac{25\times150}{30}$ evaluation (1) (V_s =) 130 (V)	substitution and rearrangement in either order $\frac{V_s}{25}=\frac{150}{30}$ allow 120 or 125 award full marks for correct answer without working	(3) AO 2 1

Q2.

Question number	Answer	Additional guidance	Mark
	substitution (1) $\frac{15 \times 3.1}{230}$ evaluation (1) 0.20 (A)	 allow any value that rounds to 0.20; e.g. 0.2022 award full marks for the correct answer without working	**(2)**

Q3.

Question number	Answer	Additional guidance	Mark
	   substitution (1) $(I_p) \times 230 = 19 \times 2.37$ rearrangement (1) $(Ip\ ) = (19.0 \times 2.37) \div 230$ evaluation (1) input current = 0.196 (A)	rearrangement and substitution in either order allow numerical values written above equation $input\ voltage = (output\ voltage \times output\ current) \div input\ voltage$ award full marks for any answer that rounds to 0.2(00) (A) award 1 mark for 5.1(07) (substitution with upside down rearrangement) award full marks for correct answer without working	**(3)** **AO2**

Q4.

Question number	Answer	Additional guidance	Mark
	substitution into $\frac{Vp}{Vs} = \frac{Np}{Ns}$ (1) $\frac{230}{15} = \frac{600}{Ns}$ Rearrangement and evaluation (1) $(Ns =)\ \frac{600 \times 15}{230}$ = 39	allow substitution and rearrangement in either order accept values that round to 39 e.g. 39.13 award full marks for the correct answer without working. if no other marks scored then award 1 mark for answers of that round to 0.026 (eg 0.255) (substitution mark)	**(2)** **AO2**

Q5.

Question number	Answer	Additional guidance	Mark
(i)	{step up/increase}(output) voltage or {stepdown/ decrease}(output) current		(1)

Question number	Answer	Additional guidance	Mark
(ii)	substitution (1) $\frac{230}{V_s} = \frac{18}{26}$ rearrangement (1) $(V_s =) \frac{230 \times 26}{18}$ evaluation (1) 330(V)	substitution and re-arrangement in either order allow 332 (.2) (V) allow answers between322 (V) and 333 (V)where candidates have truncated an intermediate calculation 159.2 (V), 160 (V) gains 1 mark award full marks for the correct answer without working	(3)

Q6.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to an alternating /changing current (1) in the primary coil (1)	ignore references to voltage / potential difference AC accept switch on or off	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	substitution into $\frac{Vp}{Np} = \frac{Vs}{Ns}$ (1) $\frac{230}{2000} = \frac{15}{Ns}$ rearrangement (1) $(N_S =) \frac{2000 \times 15}{230}$ evaluation (1) 130 (turns)	rearrangement and substitution can be in either order $\frac{230}{15} = \frac{2000}{Ns}$ using $\frac{Vp}{Vs} = \frac{Np}{Ns}$ accept answers that round to 130 or 131 (arising from rounding of intermediate evaluations) award full marks for the correct answer without working	(3)

Q7.

Question number	Answer	Additional guidance	Mark
i	D half the size of the voltage across the primary coil A and B are incorrect because the voltage will not necessarily be twice or half the value of the current C is incorrect because the voltage across secondary coil will be less than that across the primary coil		**(1)** **AO2**

Question number	Answer	Additional guidance	Mark
ii	an explanation linking **three** of magnetic field in primary / secondary coil / core (due to current) (1) magnetic field is alternating (1) (this magnetic) field cuts/links secondary coil (1) induces an alternating voltage (across secondary coil) (1)		**(3)** **AO1**

Q8.

Question number	Answer	Additional guidance	Mark
(b)	an explanation linking in a logical order any four of the following:- (alternating) current produces (changing) magnetic field (around coil)(1) the coil is in a magnetic field (of fixed magnets) (1) (varying current in magnetic field) produces a force (1) the force on the coil /cone (continuously) changes direction (1) the paper cone /coil vibrates/ moves to and fro (1)	 magnetic fields interact making the air molecules (in the cone) vibrate	**(4)**

Q9.

Question number	Indicative content	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • coil moving/cuts through magnetic field • coil experiences changing magnetic field • induces a voltage/current in the coil • size of voltage/current depends on rate of change of magnetic field • rate of change depends on angle between direction of movement and direction of field. • greatest (rate of) change when coil moving perpendicular to field. • maximum current at Q and S • coil is horizontal at Q and S • coil moving vertically up at Q and down at S • direction of current at Q opposite to S. • no change when coil moving parallel to field. • zero current at P, R and T • coil vertical at P, R, and T Credit can be given for correctly labelled diagrams	**(6)** **AO2 and AO3**

Level	Mark	Descriptor
	0	• No awardable content
Level **1**	1–2	• Interpretation and evaluation of the information attempted but will be limited with a focus on mainly just one variable. Demonstrates limited synthesis of understanding. (AO3) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3–4	• Interpretation and evaluation of the information on both variables, synthesising mostly relevant understanding. (AO3) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5–6	• Interpretation and evaluation of the information, demonstrating throughout the skills of synthesising relevant understanding. (AO3) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance isolated facts about interaction of electric current and magnetic fields **or** one salient feature of the graph	Possible candidate responses the coil experiences a changing magnetic field as it rotates. Size of the (induced) current varies.
Level 2	3–4	Additional guidance simple description of why current changes (either in direction or magnitude) **and** reference to at least one relevant point on the graph.	Possible candidate responses at position R the (plane of the) coil is parallel to the field and there is no current **Or** at position Q the coil is moving quickly through the field and the current is large.
Level 3	5–6	Additional guidance Full description of why current changes in magnitude or direction **and** reference to at least two relevant points on the graph	Possible candidate responses At Q, the coil is horizontal and moving most quickly across the field so the current is at its greatest. At R the coils is vertical and moving parallel to the field so there is no current.

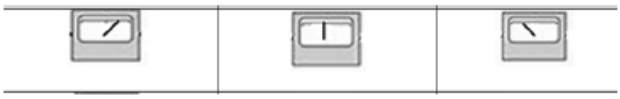
Q10.

Question Number:	Answer	Mark
(i)	a power station	(1) AO 1 1

Question Number:	Answer	Mark
(ii)	the national grid	(1) AO 1 1

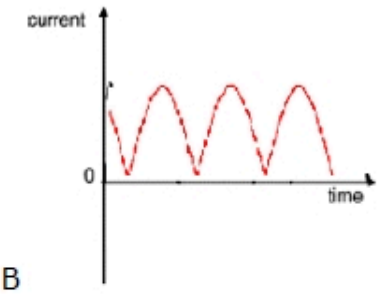
Question Number:	Answer	Mark
(iii)	heat loss is reduced	(1) AO 1 1

Q11.

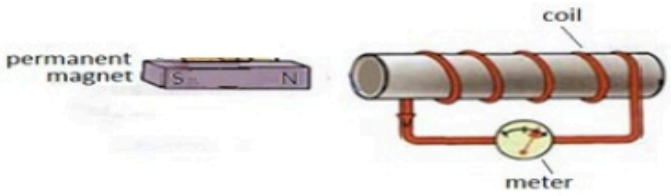
Question number	Answer	Mark
(i)	C  A and B are incorrect because there is no current when the magnet is station in the coil. D is incorrect because there is always a current when the magnet is moving in th coil	(1)

Question number	Answer	Additional guidance	Mark
(ii)	any two from moving the magnet faster (1) using a stronger magnet (1) more turns/rotations on the coil (1)	 do not allow increase size of coil	(2)

Q12.

Question Number:	Answer	Mark
	 B **The only correct answer is B** ***A*** *is incorrect because it shows an alternating current which is produced by an alternator and not by a dynamo* ***C*** *is incorrect because it shows a square waveform which is not produced by a dynamo* ***D*** *is incorrect because it shows current linearly increasing with time and this is not produced by a dynamo*	**(1)** AO 3 2b

Q13.

Question Number	Answer	Additional guidance	Mark
(i)	a diagram that has the meter connected across the ends of a coil and a magnet orientated parallel to the axis of the coil; for example 	poles need not be labelled	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation linking move magnet towards coil and then away from coil (1) with note change in 'direction' of **meter** (1) move magnet quickly then slowly (1) with larger / smaller **meter** reading (1)	 change poles of magnet allow use of ± in digital meters change speed of movement of magnet or changes to the number of turns ignore changes to size/strength of magnet	(4)

Q14.

Question Number:	Answer	Additional Guidance	Mark
	substitution (1) $(I_s) = \frac{230 \times 0.02}{5.0}$ evaluation (1) 0.9(A)	accept 0.92 (A) award full marks for the correct answer without working	**(2)** AO 2 1

Q15.

Question Number	Answer	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1(6 marks) Understanding of physics • (long) transmission wires have resistance • reduced p.d. at the destination • (thermal) energy is dissipated in the transmission wires • this creates a power loss (refers to $P=I^2R$) • transformers are used to step up to a high voltage for transmission • this means a low current (refers to $V_PI_P=V_SI_S$) • so power loss is small(er) • transformers used to step down to a safer voltage for consumers • consumer wires are shorter and so power loss is less of an issue	**(6)** AO 1 1

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• An explanation that demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) • Presents an explanation that is not logically ordered and with significant gaps. (AO1)
Level 2	3-4	• An explanation that demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) • Presents an explanation of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5-6	• An explanation that demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)