Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3420U10-1

S24-3420U10-1

MONDAY, 17 JUNE 2024 – MORNING

PHYSICS – Unit 1:
Electricity, Energy and Waves
FOUNDATION TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	3	
2.	7	
3.	10	
4.	10	
5.	13	
6.	6	
7.	5	
8.	6	
9.	8	
10.	12	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **6**.

PJ/GJR*(S24-3420U10-1)

Equations

current = $\frac{\text{voltage}}{\text{resistance}}$	$I = \frac{V}{R}$
total resistance in a series circuit	$R = R_1 + R_2$
energy transferred = power × time	$E = Pt$
power = voltage × current	$P = VI$
% efficiency = $\frac{\text{energy [or power] usefully transferred}}{\text{total energy [or power] supplied}}$ × 100	
density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$
units used (kWh) = power (kW) × time (h) cost = units used × cost per unit	
wave speed = wavelength × frequency	$v = \lambda f$
speed = $\frac{\text{distance}}{\text{time}}$	
pressure = $\frac{\text{force}}{\text{area}}$	$p = \frac{F}{A}$
change in thermal energy = mass × specific heat capacity × change in temperature	$\Delta Q = mc\Delta\theta$
thermal energy for a change of state = mass × specific latent heat	$Q = mL$
V_1 = voltage across the primary coil V_2 = voltage across the secondary coil N_1 = number of turns on the primary coil N_2 = number of turns on the secondary coil	$\frac{V_1}{V_2} = \frac{N_1}{N_2}$

SI multipliers

Prefix	Symbol	Conversion factor	Multiplier
milli	m	divide by 1000	1×10^{-3}
centi	c	divide by 100	1×10^{-2}
kilo	k	multiply by 1000	1×10^{3}
mega	M	multiply by 1 000 000	1×10^{6}

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Answer **all** questions.

1. Complete the table below about seismic waves by placing **one** tick (✓) in each row. [3]

Property	P waves	S waves	Surface waves
These waves travel the fastest.			
These waves are longitudinal.			
These waves cannot travel through liquids.			

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2. A 30 kW gas boiler is used for **700 hours** in 1 year.

(a) (i) Use the equation:

units used (kWh) = power (kW) × time (h)

to calculate the units used in 1 year. [2]

units used = ... kWh

(ii) Use the equation:

cost = units used × cost per unit

to calculate the cost of using the boiler for 700 hours. [2]

One unit of gas costs £0.12.

cost = £ ....

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(iii) Use your answer in (a)(ii) to calculate the cost of using the boiler for **1 hour**. [1]

cost = £ ....

(b) A solar water heating system costs £3600.

It is estimated to reduce gas consumption so that the boiler is used for only 650 hours instead of 700 hours.

(i) Calculate the saving made in 1 year by using the boiler for 50 hours less. [1]

saving = £ ....

(ii) Calculate the payback time of the cost of the solar water heating system. [1]

payback time = ... years

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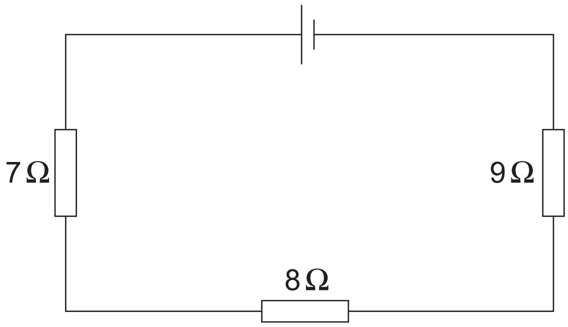
3. (a) The diagram shows three resistors connected in series.



(i) Use an equation from page 2 to calculate the total resistance of the circuit. [1]

total resistance = ... Ω

(ii) The battery voltage is 12 V.
Use an equation from page 2 to calculate the current in the circuit. [2]

current = ... A

(iii) Use an equation from page 2 to calculate the power produced by the battery. [2]

power = ... W

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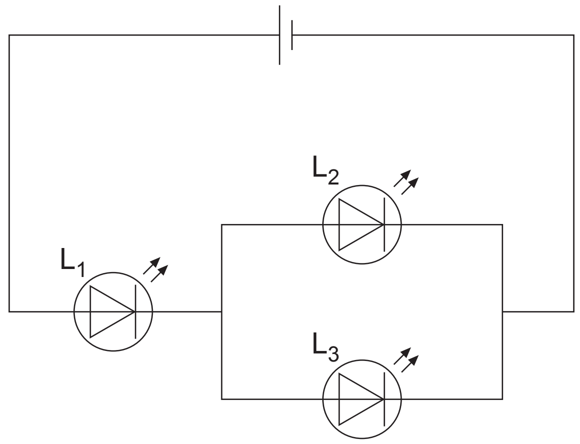
(b) The circuit below contains three **identical** components, L_1, L_2 and L_3, connected to a battery.



(i) Tick (✓) the box next to the name of these components. [1]

Lamp ☐

LED ☐

LDR ☐

(ii) The current in L_2 is 8 mA.

I. Write down the current in L_3. current = ... mA [1]

II. Write down the current in L_1. current = ... mA [1]

(iii) I. State which **two** components (L_1, L_2 or L_3) have the same voltage across them. [1]

.... and ....

II. State which **two** components (L_1, L_2 or L_3) have voltages that add up to the battery voltage. [1]

.... and ....

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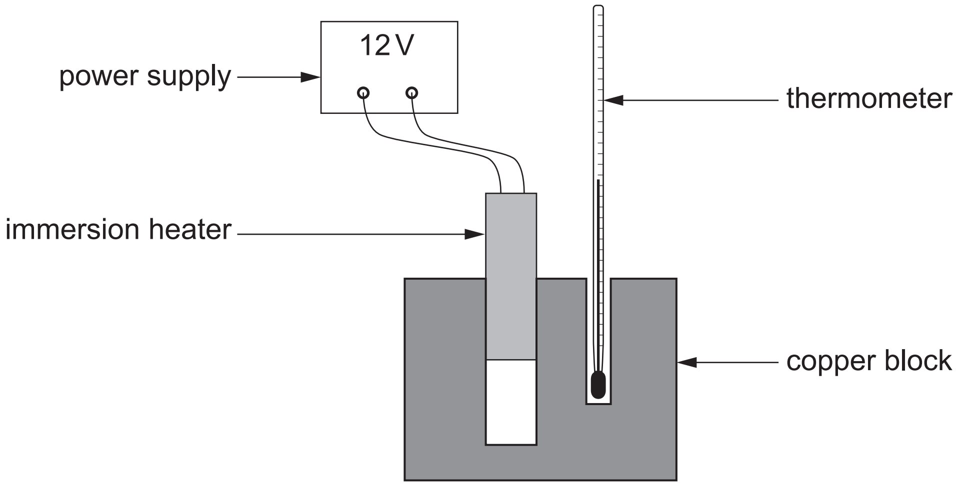
4. The apparatus used by a group of students to determine the specific heat capacity of copper is shown below.



(a) (i) The immersion heater has a power of 50 W.
It heats the copper block for 150 s.
Use the equation:

energy transferred = power × time

to calculate the energy transferred by the heater. [2]

energy transferred = ... J

(ii) The temperature of the copper block at the start of the experiment is 20 °C.
Its temperature after heating is 35 °C.
Calculate the change in temperature of the copper block. [1]

change in temperature = ... °C

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(iii) The mass of the copper block is 1 kg.

Use the answers in parts (i) and (ii) and the equation:

$$\text{specific heat capacity} = \frac{\text{energy transferred}}{\text{mass} \times \text{change in temperature}}$$

to calculate the specific heat capacity of copper. [2]

specific heat capacity, c = ... J/kg °C

(iv) Another group of students get a value for the specific heat capacity of 455 J/kg °C. The true value of the specific heat capacity of copper is 385 J/kg °C.

I. Calculate the difference between this group's value and the true value. [1]

difference = ... J/kg °C

II. Use the equation:

$$\%\ \text{difference} = \frac{\text{difference}}{\text{true value}} \times 100$$

to calculate the % difference between this group's value and the true value. [2]

% difference = ...

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(b) Tick (✓) the boxes next to **two** improvements that could be made to this experiment that would lead to a more accurate value for the specific heat capacity of copper. [2]

Use a heater with a larger power ☐

Heat the block for longer ☐

Wrap the block in insulating material ☐

Push the heater fully into the block ☐

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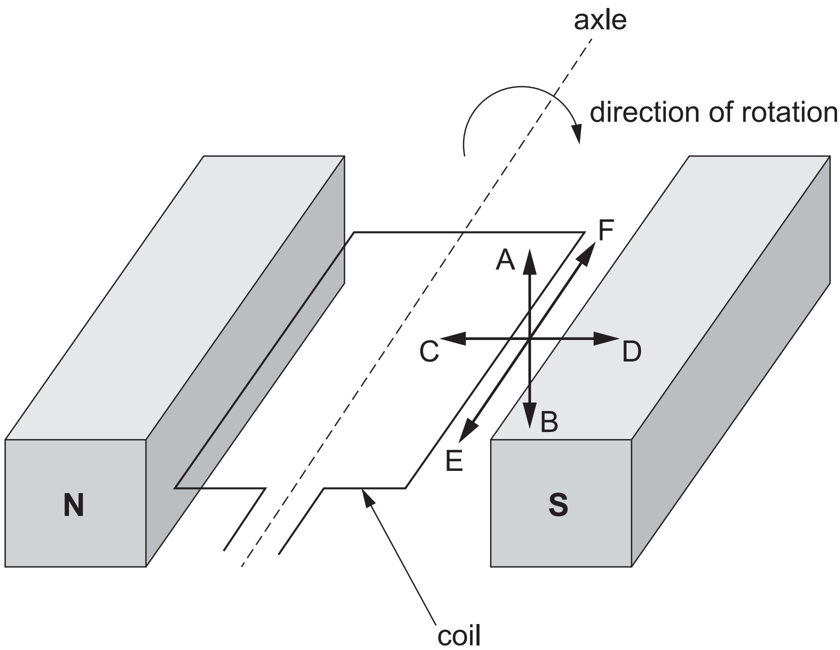
5. The operation of electric generators can be explained by electromagnetic induction.

(a) The diagram shows part of an a.c. generator.



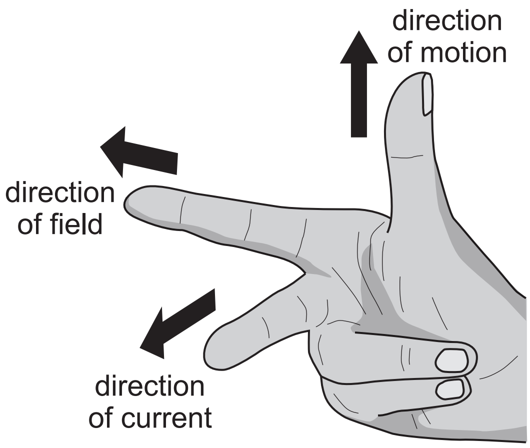
(i) State the direction (A, B, C, D, E or F) in which the magnetic field acts. [1]

Direction = ...

(ii) State the direction (A, B, C, D, E or F) in which the right hand side of the coil moves. [1]

Direction = ...

(iii) Use Fleming's right hand rule to determine the direction (A, B, C, D, E or F) of the induced current in the right hand side of the coil. [1]



Direction = ...

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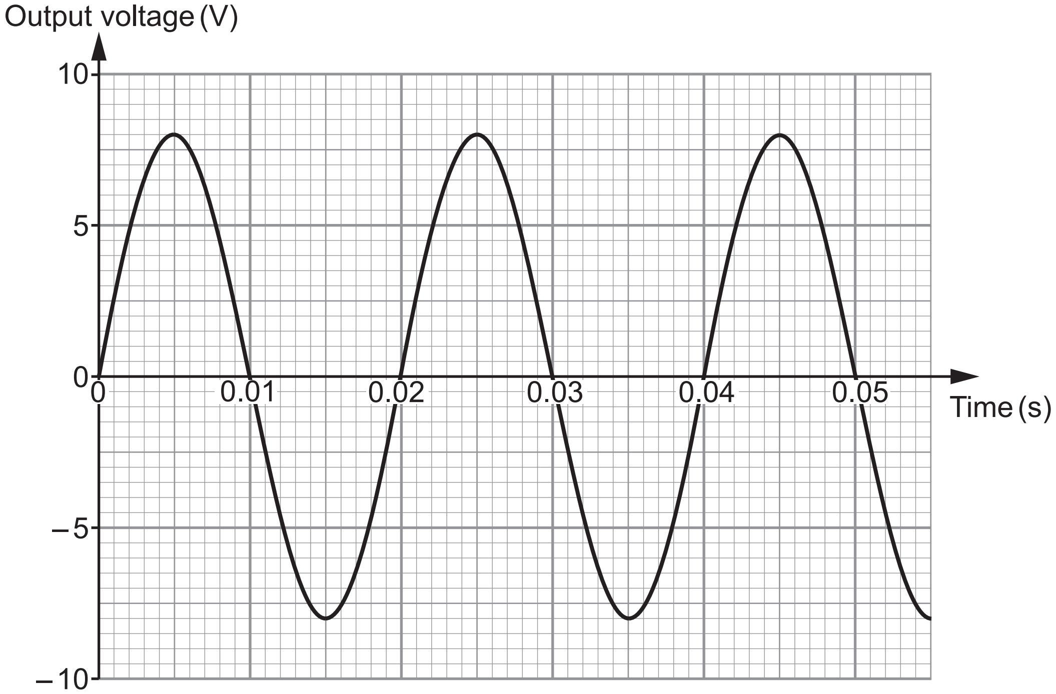
(iv) When the coil spins, a voltage is produced.
This is shown on the graph.



I. Use the graph to find the maximum voltage produced by the generator. [1]

maximum voltage = ... V

II. Use the graph to find the time for one rotation (spin) of the coil. [1]

time = ... s

III. **Complete the table** below to show the effect of each change made.
Use the words **increases**, **decreases** or **no effect**.
Three boxes have been completed for you. [3]

Change made	Effect on maximum voltage	Effect on time for 1 rotation (spin)
Stronger magnets	increases	no effect
More turns on the coil	....	no effect
Coil spins slower	....	....

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 (3420U10-1) **Turn over.**

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(b) Transformers also work by electromagnetic induction.

(i) Tick (✓) the boxes next to the **three** correct statements about transformers. [3]

Transformers change a.c. to d.c. ☐

Transformers change d.c. voltages. ☐

The core is made from iron. ☐

There is an electric current in the core. ☐

The primary coil creates an alternating magnetic field. ☐

Transformers can increase or decrease voltages. ☐

(ii) A transformer increases voltage from 12 V to 36 V.
The primary coil contains 20 turns of wire.
Use the equation:

$$N_2 = N_1 \times \frac{V_2}{V_1}$$

to calculate the number of turns in the secondary coil, N_2. [2]

N_2 = ...

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6. Radio waves is one region of the electromagnetic spectrum.
List the other regions of the electromagnetic spectrum and describe their similarities and differences.
Description of uses is not required. [6 QER]

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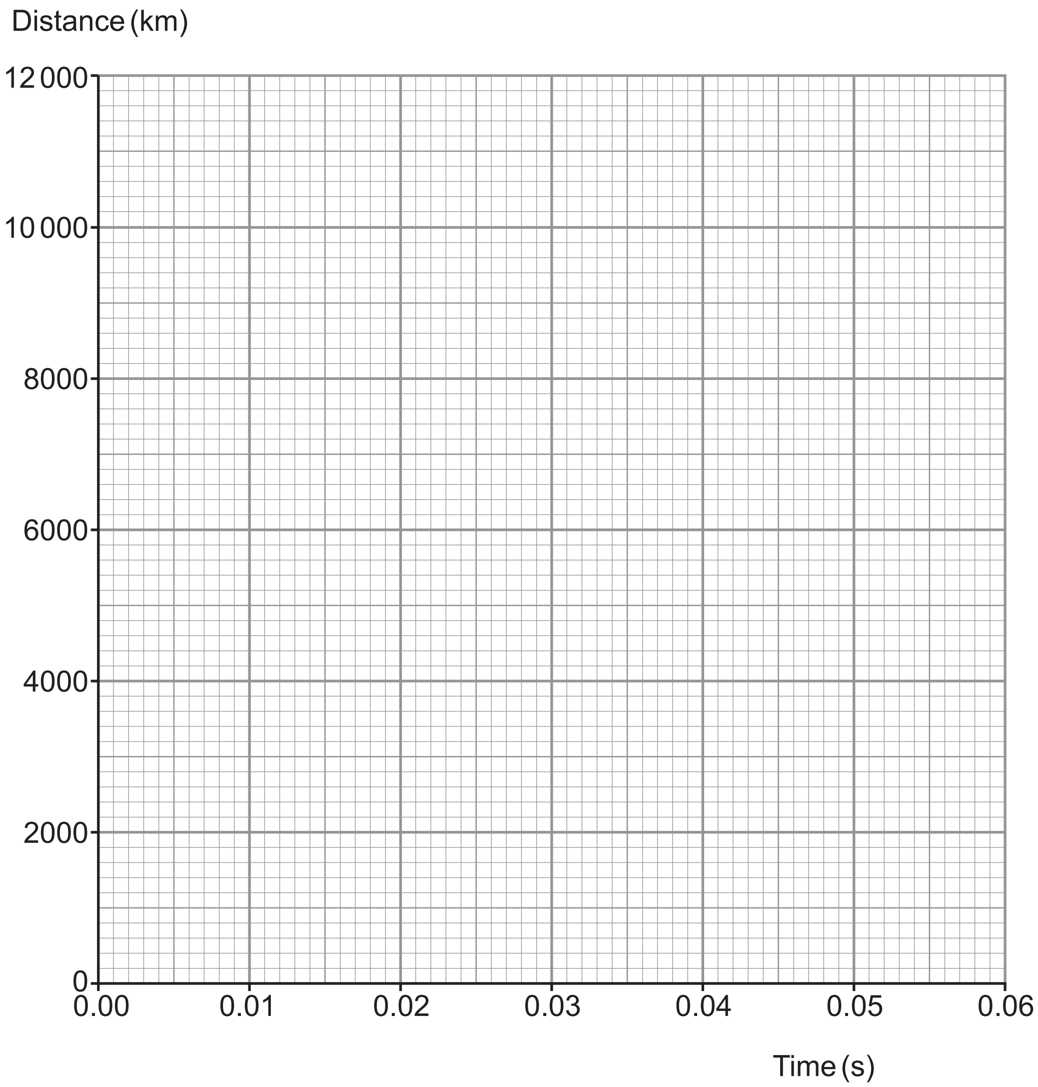
7. Communication between the UK and USA can be made by optical fibres or by geostationary satellites.

The table below shows the time taken by infra-red waves to travel different distances through an optical fibre.

Distance (km)	2000	4000	6000	8000	10 000
Time (s)	0.01	0.02	0.03	0.04	0.05

(a) Use the data to plot a graph on the grid below and draw a suitable straight line. [3]



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(b) An infra-red signal sent from the UK to the USA by optical fibre travels 9000 km.
A microwave signal sent from the UK to the USA by geostationary satellite travels 72 000 km and takes 0.24 s.
Chris thinks it is quicker to send signals by geostationary satellite.

Use a value from the graph to explain whether you agree with Chris. [2]

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5

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8. The diagram below shows a hydraulic jack system.
The pressure in the fluid throughout the system is constant.

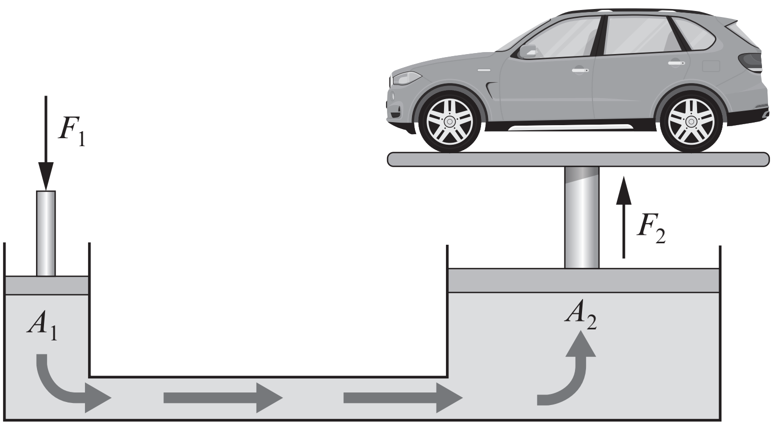

Diagram not drawn to scale

(a) A force F_1 of size 25 N is applied to a piston of area A_1 equal to 10 cm^2.
Use an equation from page 2 to calculate the pressure created in the fluid. [2]

pressure = ... N/cm^2

(b) Use the equation:

force = pressure × area

to calculate the force F_2 if the area A_2 equals 4000 cm^2. [2]

force = ... N

(c) The jack works because hydraulic fluids cannot be compressed.
Explain, **in terms of molecules**, why the jack will not work if it contains air. [2]

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6

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9. (a) A group of students was asked to find the density of an object.
They made the following measurements.

mass of the object = 15 g
volume of water in measuring cylinder = 20 cm^3
volume of water and object = 25 cm^3

Use the results to answer the following questions.

(i) Calculate the volume of the object. [1]

volume = ... cm^3

(ii) Use an equation from page 2 to calculate the density of the object. [2]

density = ... g/cm^3

(iii) The teacher said the object was made from one of the materials in the table below.

Material	Density (g/cm^3)
cork	0.2
magnesium	1.7
aluminium	2.7
steel	7.8
iron	7.8
copper	8.5
lead	11.3

Ffion thought the object was made of aluminium.
Use the data in the table to explain whether you agree with Ffion. [2]

....

....

....

 (3420U10-1)

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(b) The group is given a solid object that floats on water.
Describe how they would change the experiment to find the density of this object.
They still use the measuring cylinder partly filled with water. [3]

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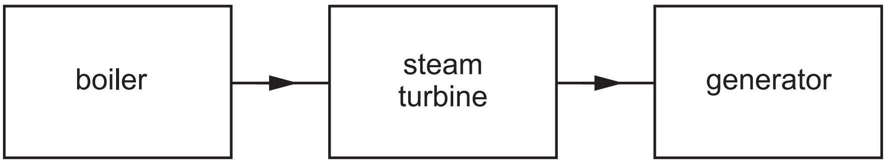
10. The block diagram below represents a fossil fuel power station.



(a) (i) Use the words in the block diagram to explain how electricity is generated in a fossil fuel power station. [3]

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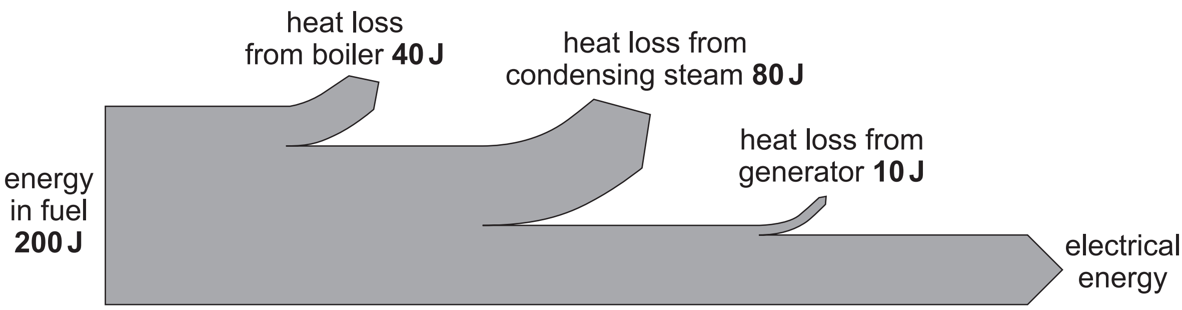
....

(ii) Neve says that fossil fuel power stations are about 35% efficient.
Jacob says they are less than 30% efficient.
Use the information in the Sankey diagram below and an equation from page 2 to explain whether you agree with Neve or Jacob. [3]



Space for calculation.

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 (3420U10-1) **Turn over.**

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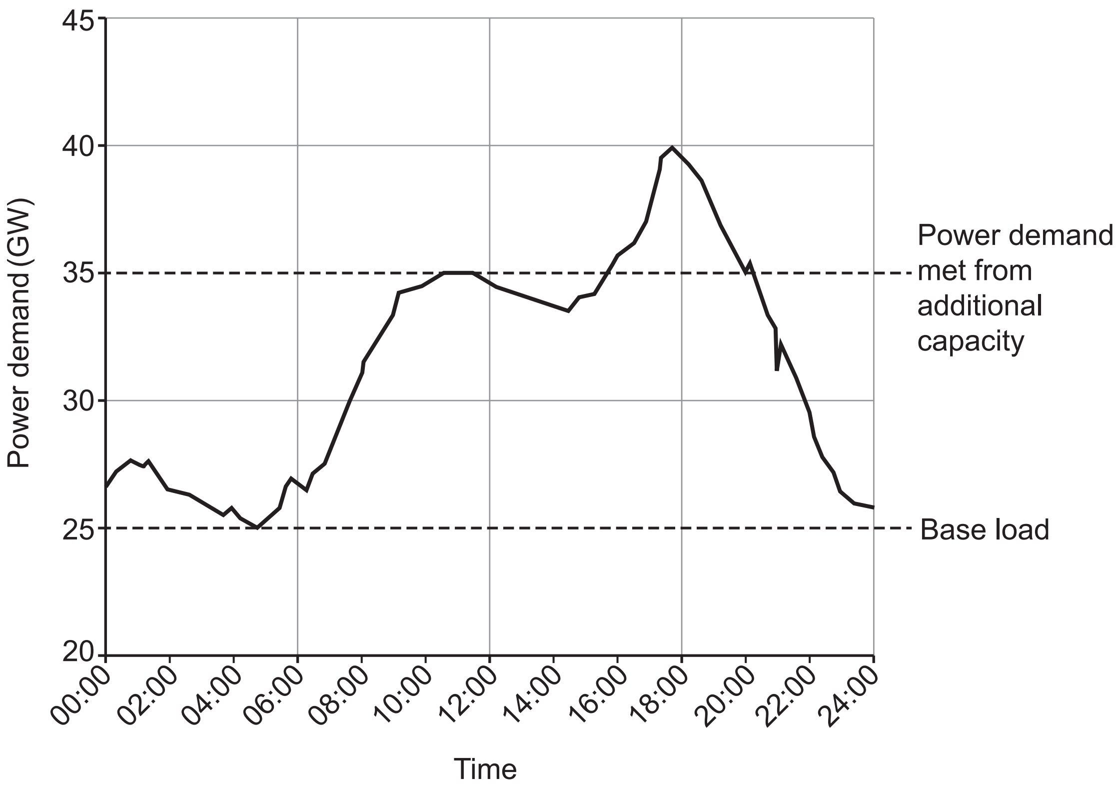
(b) Power stations are connected to the National Grid.
The power demand on a particular day is shown below.



(i) The graph shows that the base load is 25 GW. State what is meant by this. [1]

....

....

(ii) State the peak power demand on the National Grid on the day shown in the graph. [1]

peak power demand = ... GW

 (3420U10-1)

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(iii) The Dinorwig power station is a pumped storage hydro-electric scheme.

Dinorwig has six 0.3 GW generators.
It is used to provide additional power once demand rises above 35 GW.
Once operating at maximum output, it can provide power for 6 hours before running out of water.

Rowan says that Dinorwig can provide power for the whole time that demand is over 35 GW.
However, he says that it will not be able to supply enough power to meet all the demand above 35 GW shown in the graph.
He also says that about 3 GW will need to be imported from overseas.

Explain whether you agree with Rowan.
Include data in your answer. [4]

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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