Surname		Centre Number	Candidate Number
First name(s)			0

GCSE

3420U10-1

Z22-3420U10-1

MONDAY, 20 JUNE 2022 – 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.	**10**	
2.	**12**	
3.	**6**	
4.	**13**	
5.	**12**	
6.	**7**	
7.	**7**	
8.	**13**	
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 **5(a)**.

BE*(X21-3420U10-1)

Equations

current = $\dfrac{\text{voltage}}{\text{resistance}}$	$I = \dfrac{V}{R}$
total resistance in a series circuit	$R = R_1 + R_2$
energy transferred = power × time	$E = Pt$
power = voltage × current	$P = VI$
% efficiency = $\dfrac{\text{energy [or power] usefully transferred}}{\text{total energy [or power] supplied}} \times 100$	
density = $\dfrac{\text{mass}}{\text{volume}}$	$\rho = \dfrac{m}{V}$
units used (kWh) = power (kW) × time (h) cost = units used × cost per unit	
wave speed = wavelength × frequency	$v = \lambda f$
speed = $\dfrac{\text{distance}}{\text{time}}$	
pressure = $\dfrac{\text{force}}{\text{area}}$	$p = \dfrac{F}{A}$
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	$\dfrac{V_1}{V_2} = \dfrac{N_1}{N_2}$

SI multipliers

Prefix	Multiplier
m	1×10^{-3}
k	1×10^{3}
M	1×10^{6}

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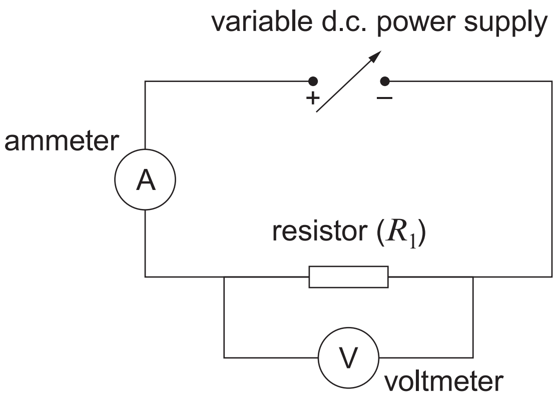
Answer **all** questions.

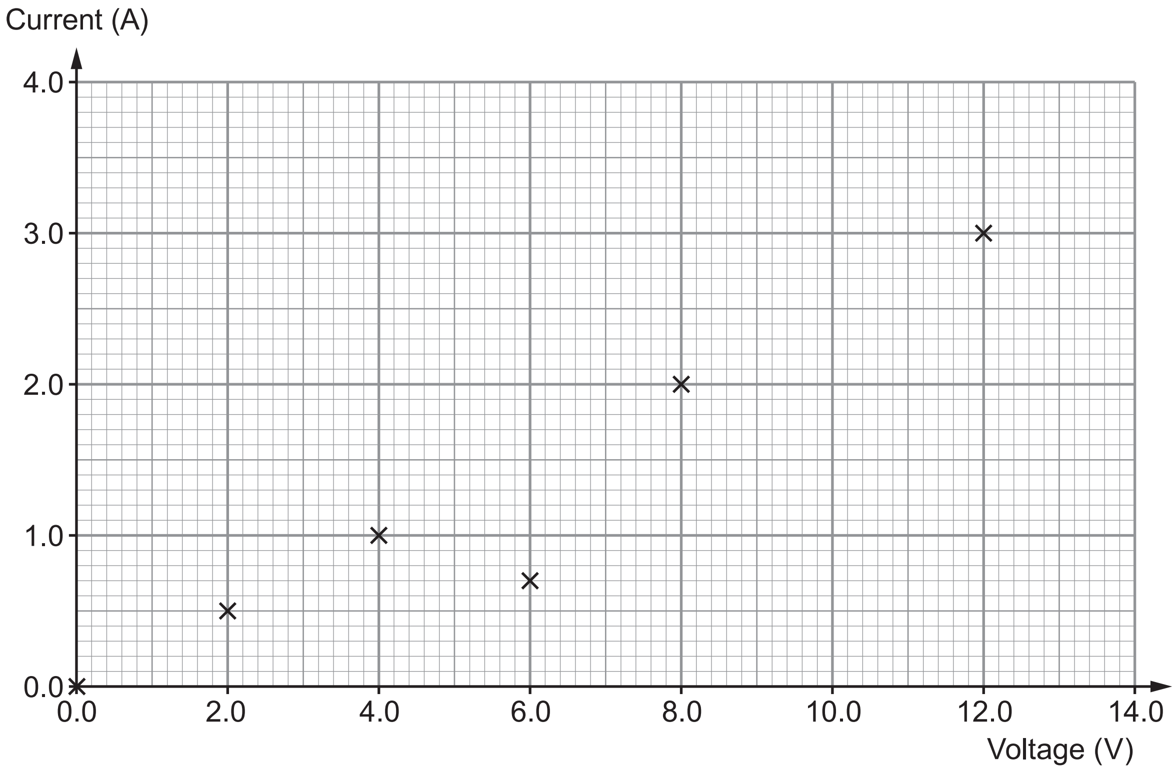
1. Paul investigated how the current changes with voltage for a resistor (R_1).
The circuit he used is shown (**Circuit 1**).



Circuit 1

(a) Name the device he used to measure the current. .... [1]

(b) Paul's results are shown on the graph.



(i) On the graph, **circle** the anomalous point. [1]

(ii) **Complete the graph** by drawing a suitable straight line. [1]

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(iii) I. Use the graph to state the current at 12.0 V. [1]

Current = ... A

II. Use the equation:

$$\text{resistance} = \frac{\text{voltage}}{\text{current}}$$

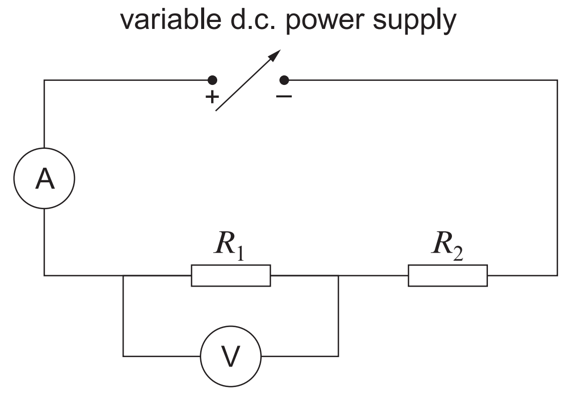
to calculate the resistance of the resistor (R_1) at 12.0 V. [2]

Resistance of R_1 = ... Ω

(iv) State what the graph shows about the resistance of the resistor (R_1) as the voltage changes. [1]

....

(c) The original circuit is then adapted by adding a second, **identical** resistor (R_2) in series with R_1.
This circuit is shown below **(Circuit 2)**.



Circuit 2

Complete the following sentences by <u>underlining</u> the correct word or phrase in each bracket. [3]

The total resistance in circuit 2 is (**double / the same as / half**) the total resistance of circuit 1.

When the d.c. power supply is set at the same voltage, the voltmeter reading in circuit 2 is (**double / the same as / half**) the voltmeter reading in circuit 1.

The current in circuit 2 is (**double / the same as / half**) the current in circuit 1.

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2. The diagram shows regions of the electromagnetic (em) spectrum.
The regions are in order.

radio waves	microwaves	infra-red	visible light	ultraviolet	X-rays	gamma rays

(a) **Tick** (✓) the **three** correct statements. [3]

The frequency of em waves decreases from radio waves to gamma rays. ☐

All em waves travel at the same speed in a vacuum. ☐

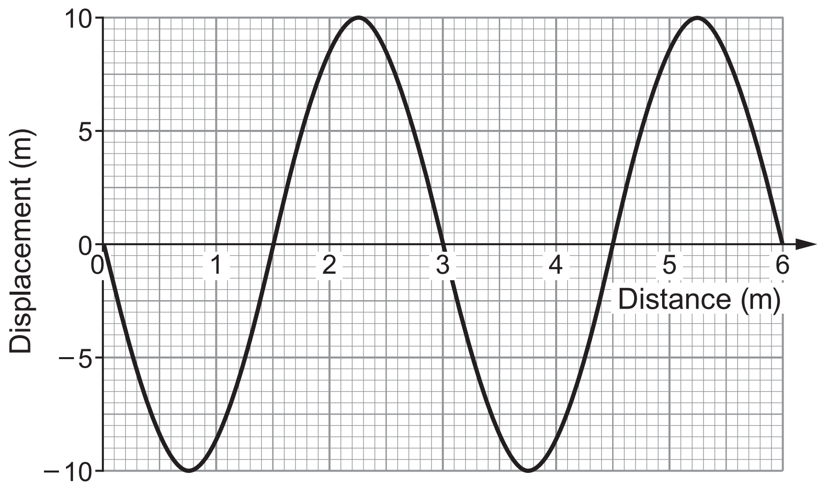
Gamma rays can be emitted from radioactive materials. ☐

The wavelength of em waves decreases from radio waves to gamma rays. ☐

Radio waves, microwaves, infra-red and visible light are all ionising radiations. ☐

All em waves are longitudinal. ☐

(b) The graph below shows a wave diagram.



Use the following values to answer the questions below. You may use each value once, more than once or not at all.

2	3	5	6	10

(i) I. State the amplitude of the wave. .... m [1]

II. State the number of complete waves shown. .... waves [1]

III. State the wavelength of the wave. .... m [1]

Examiner only

(ii) I. Complete the following sentences by underlining the correct phrase in each bracket. [2]

The wave has a frequency of (**7.5 Hz / 7.5 cm/s / 7.5 cm**).

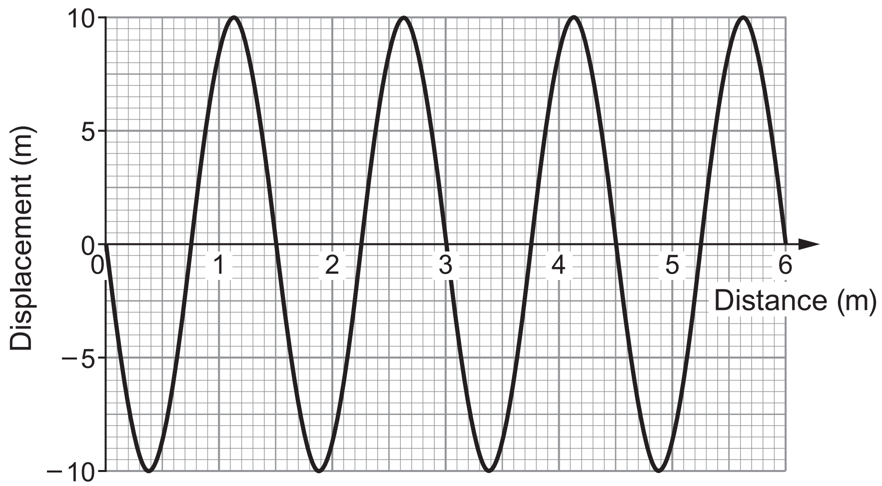
This means 7.5 waves pass a point each (**second / minute / hour**).

II. Use information from parts (b)(i) and (ii) to calculate the wave speed.
Use the equation:

wave speed = wavelength × frequency [2]

Wave speed = ... m/s

(c) The speed of the wave remains constant but its **frequency is doubled**.
A student draws a diagram of the expected wave. It is shown below.



Explain whether you agree with the student's diagram of the wave. [2]

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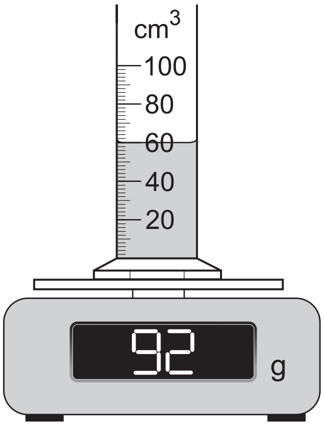
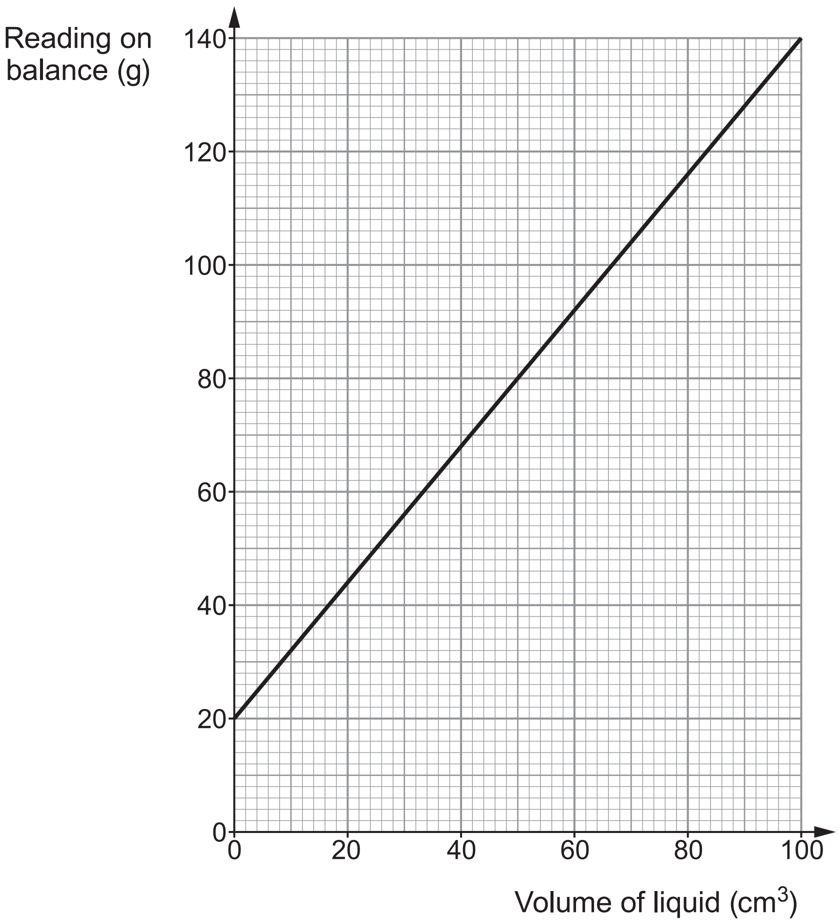
3. Kylie carries out an experiment, in class, to measure the density of a liquid.
She places an empty measuring cylinder on a balance and pours the liquid into it.
She records the reading from the balance for different volumes of liquid.
Her results are shown in the table and on the graph.

Volume of liquid (cm^3)	Reading on balance (g)
20	44
40	68
60	92
80	116
100	140





Use the information above to answer the following questions.

(a) State the mass of the empty measuring cylinder. .... g [1]

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(b) Calculate the mass of liquid in the measuring cylinder when its volume is 100 cm^3. [2]

Mass of liquid = ... g

(c) Use an equation from page 2 to calculate the density of the liquid that Kylie used and state the unit of your answer. [3]

Density = ...

Unit = ...

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4. A Welsh farmer decides to purchase a wind generator to provide some electrical energy for his farm.
A selection of wind generators is available.

	Wind generator 1	Wind generator 2	Wind generator 3
Cost to buy and install (£)	1800	3000	2925
Expected lifetime (years)	15	15	15
Estimated number of units produced per year (kWh)	2000	4000	3000
Cost per unit (£)	0.15	0.15	0.15
Estimated saving per year (£)		600	450
Estimated payback time (years)		5.0	6.5

(a) (i) Use the equation:

estimated saving per year = units produced per year × cost per unit

and data from the table to calculate the estimated saving per year if **wind generator 1** was installed. [1]

Estimated saving per year = £ ....

(ii) Use the equation:

$$\text{estimated payback time} = \frac{\text{cost to buy and install}}{\text{estimated saving per year}}$$

and data from the table to calculate the estimated payback time for **wind generator 1**. [2]

Estimated payback time = ... years

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(b) (i) A salesperson suggests to the farmer that **wind generator 3** is better than **wind generator 2** because it is cheaper.
Explain, using information from the table, if the salesperson's suggestion is correct over a 5-year timescale. [2]

....

....

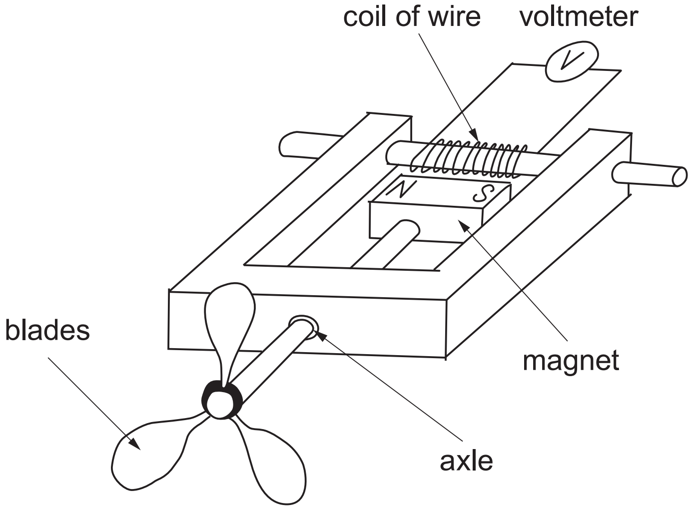
....

(ii) Give **two** reasons why the payback time can only be an estimate. [2]

1. ....

2. ....

(c) A wind generator only operates in certain wind speeds.
The diagram below shows a student's design for measuring wind speed.



(i) When the wind blows a reading on the voltmeter is obtained.
The following sentences describe the different stages.

A The magnetic field lines cut through the coil of wire.
B The blades rotate.
C The magnet rotates.
D This induces a voltage in the coil of wire.

Put the letters **A**, **B** and **C** in the boxes to correctly describe the process of inducing a voltage in the coil of wire. The final box has already been completed, [2]

	→		→		→	**D**

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

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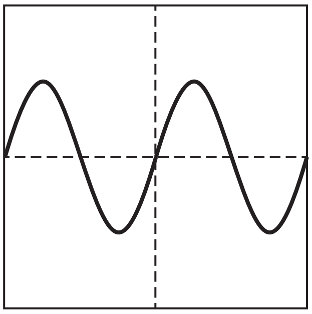
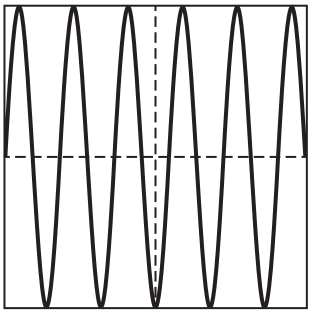
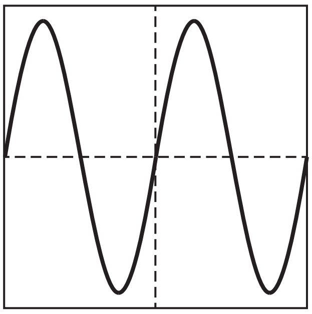
(ii) When the wind speed is **2 m/s** the alternating voltage produced is shown below.



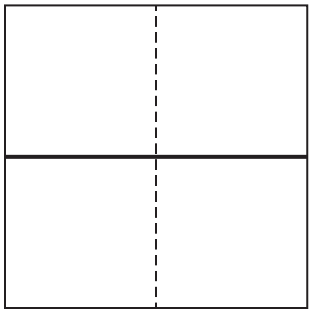
The following traces **X**, **Y** and **Z** are produced during different wind conditions.



Trace **X**



Trace **Y**



Trace **Z**

I. State which trace (**X**, **Y** or **Z**) is produced when the wind speed is **faster than 2 m/s**.

Trace .... [1]

II. State which trace (**X**, **Y** or **Z**) is produced when **the wind stops**.

Trace .... [1]

(d) When the student's design is built it is found that the voltmeter is not sensitive enough to measure a wind speed less than 0.5 m/s.

(i) Suggest **one** change that can be made to the **magnet** so that wind speeds less than 0.5 m/s can be measured by the voltmeter. [1]

....

(ii) Suggest **one** change that can be made to the **coil of wire** so that wind speeds less than 0.5 m/s can be measured by the voltmeter. [1]

....

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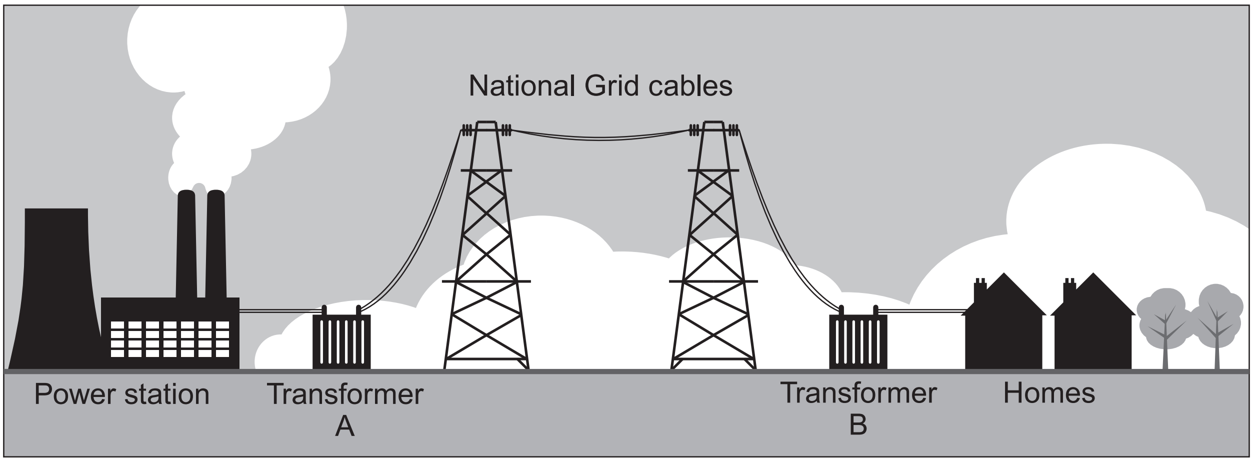
5. The National Grid includes a large network of cables that connects power stations to homes.



(a) Describe the purpose of transformers A and B in the National Grid.

Include in your answer:

- how electrical energy is transmitted **efficiently**
- how electrical energy is transferred **safely** to homes. [6 QER]

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(b) Some houses have solar panels on their roof.
They produce electricity.
Explain why these houses are still connected to the National Grid. [2]

....

....

....

(c) A housing development of 20 new houses needs to be connected to the National Grid.
Each house requires a **maximum current of 60 A**.

(i) Calculate the total current needed if all 20 houses are using the maximum current. [1]

Total current = ... A

(ii) The mains voltage in the houses is 230 V a.c.

I. Use the equation:

power = voltage × current

to calculate the maximum total power supplied to the 20 houses. [2]

Maximum power = ... W

II. Convert your answer for the maximum power into kW. [1]

Maximum power = ... kW

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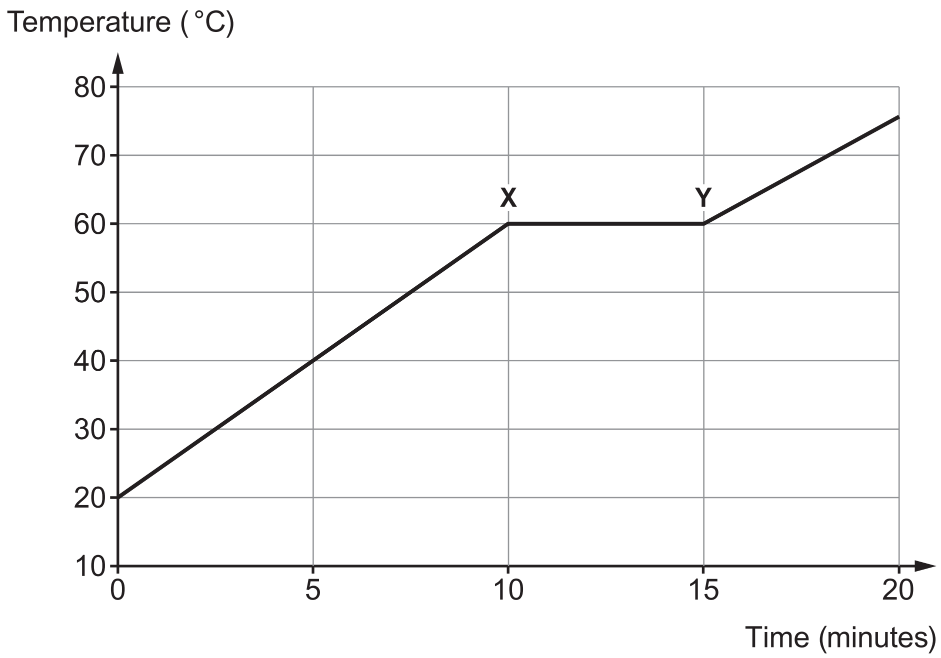
6. The graph below shows the results obtained when **36 g of solid wax** was heated using a heater. The temperature of the wax was recorded every minute.



(a) Explain why the energy supplied from the heater between **points X and Y** doesn't produce a rise in temperature of the wax. [2]

....

....

....

(b) (i) Use the equation:

thermal energy supplied = mass × specific latent heat

to calculate the amount of thermal energy supplied to the 36 g of wax between **points X and Y**. [2]
(Specific latent heat of fusion (L_f) for wax = 220 J/g)

Thermal energy supplied = ... J

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(ii) All the energy is transferred from the heater to the wax during the 5 minute interval between **X and Y**.

I. Calculate the time, in seconds, of the interval between **X and Y**. [1]

Time = ... s

II. Use the equation:

$$\text{power} = \frac{\text{energy transferred}}{\text{time}}$$

to calculate the power of the heater. [2]

Power of heater = ... W

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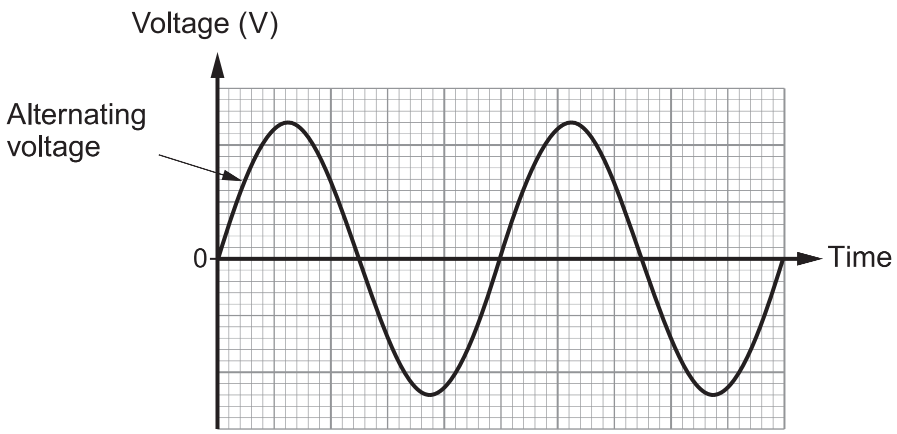
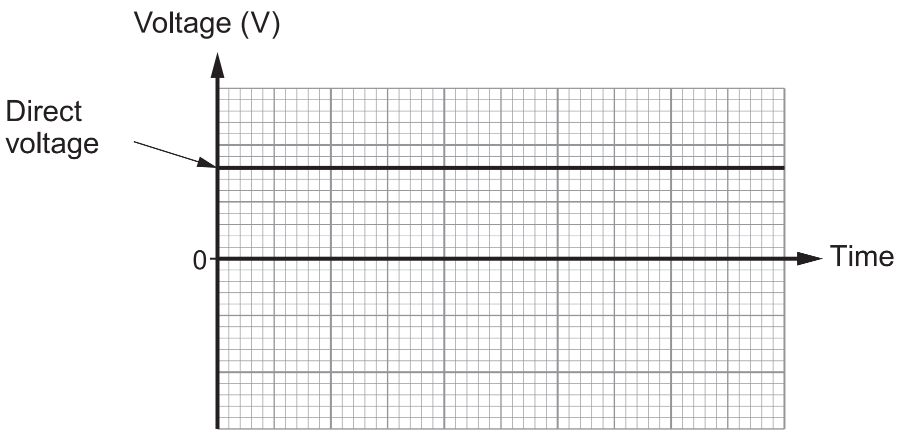
7. (a) The mains electricity supply to homes is at a voltage of 230 V a.c.
In contrast to this, batteries supply d.c.
These are each shown in the diagrams below.





An alternating voltage changes in size, but a direct voltage keeps the same size.
State **one** other difference between the two. [1]

....

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(b) Household circuits may be protected by a series of devices. These include:

- a miniature circuit breaker (mcb)
- a fuse in a plug
- a residual current circuit breaker (rccb).

The list below gives three situations in which one or another of these devices stop the power from being supplied.

1. An electric lawn mower cuts through the cable.
2. Too much current flows in a ring main because too many appliances are being used at the same time.
3. The live wire in a kettle touches its neutral wire.

(i) Select and explain one situation above that puts the **user** in danger of an electric shock **and** which one of the devices should be used to keep the user safe. [2]

....

....

....

(ii) State **two** advantages of an mcb over a fuse in a household circuit. [2]

1. ....

2. ....

(c) Describe the function of the live and neutral wires in household circuits. [2]

Live wire: ....

....

Neutral wire: ....

....

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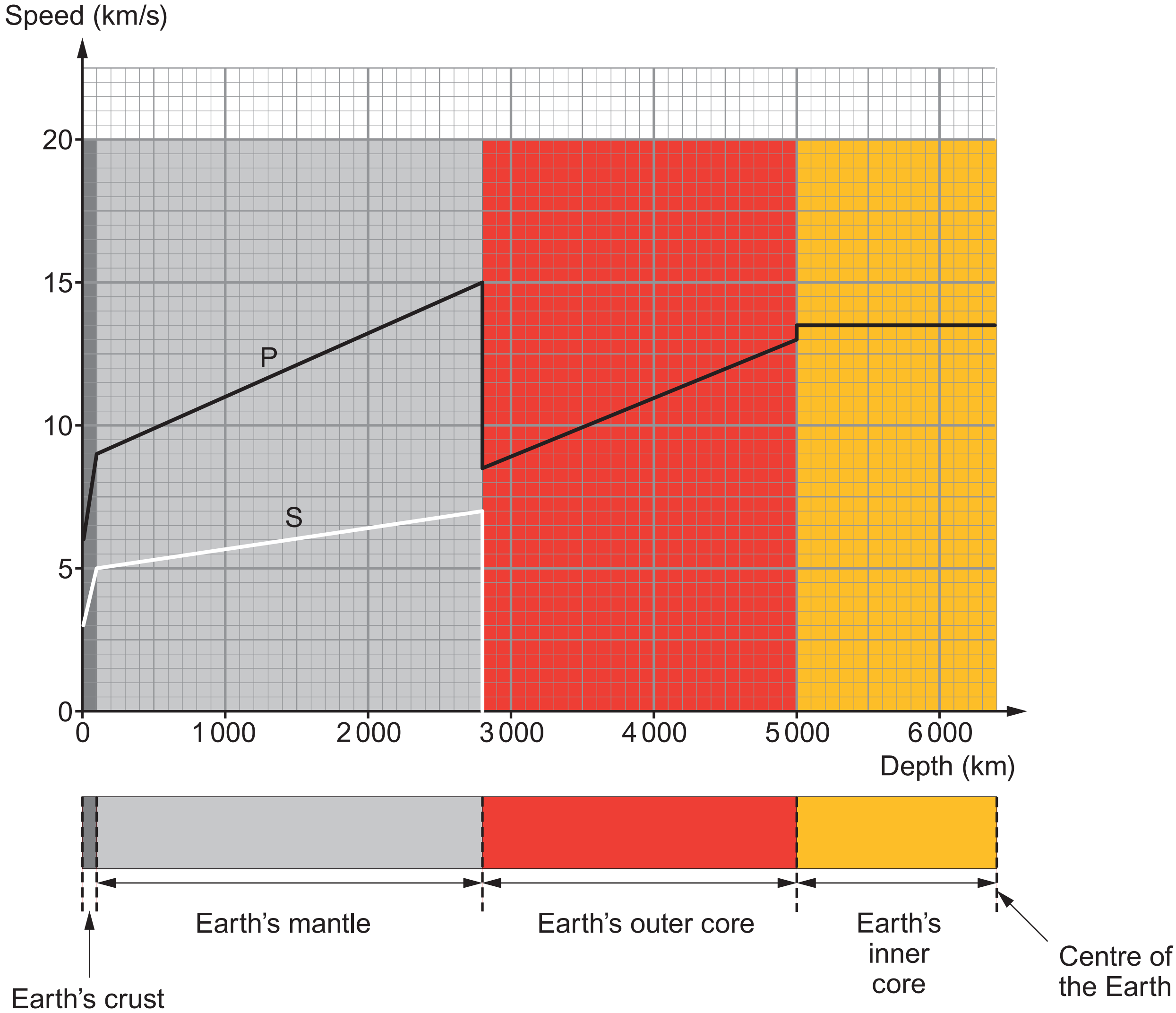
8. P and S waves are produced during an earthquake. They travel at different speeds.
The graph shows how the speed of P and S waves change with depth below the Earth's surface.



(a) P waves are longitudinal waves.
Explain what is meant by a longitudinal wave. [2]

....

....

(b) Use the graph to calculate the difference in speed between the P wave and the S wave at a depth of **100 km**. [2]

Speed difference = ... km/s

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(c) (i) Bob claims that the maximum speed of P waves is greater in solids than in liquids. Explain, using data from the graph, whether Bob's claim is correct. [2]

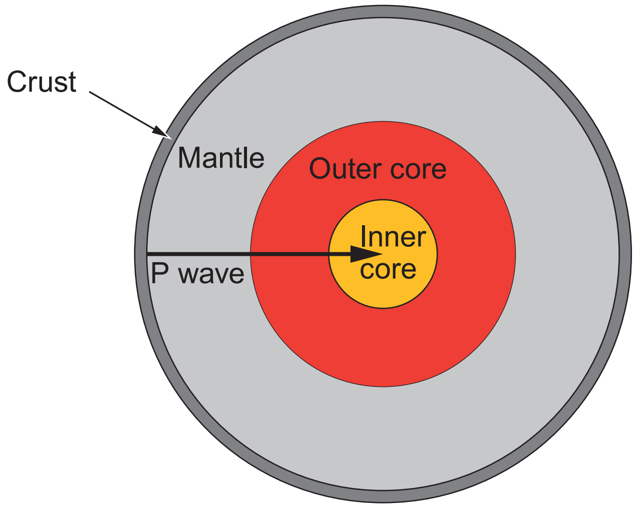
....

....

....

(ii) A P wave (shown in Diagram 1) travels a distance of 6 300 km in a straight line to the centre of the Earth in a time of 550 s.

Diagram 1



Bob states that the mean speed of the P wave over this distance is equal to its actual speed only at the depth of 3 500 km. Use an equation from page 2 to show whether Bob's statement is correct. [3]
Space for calculations.

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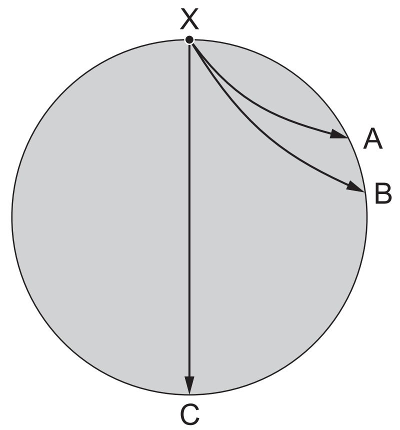
(d) Diagram 2 shows waves passing through the Earth following an earthquake at point X.

Diagram 2



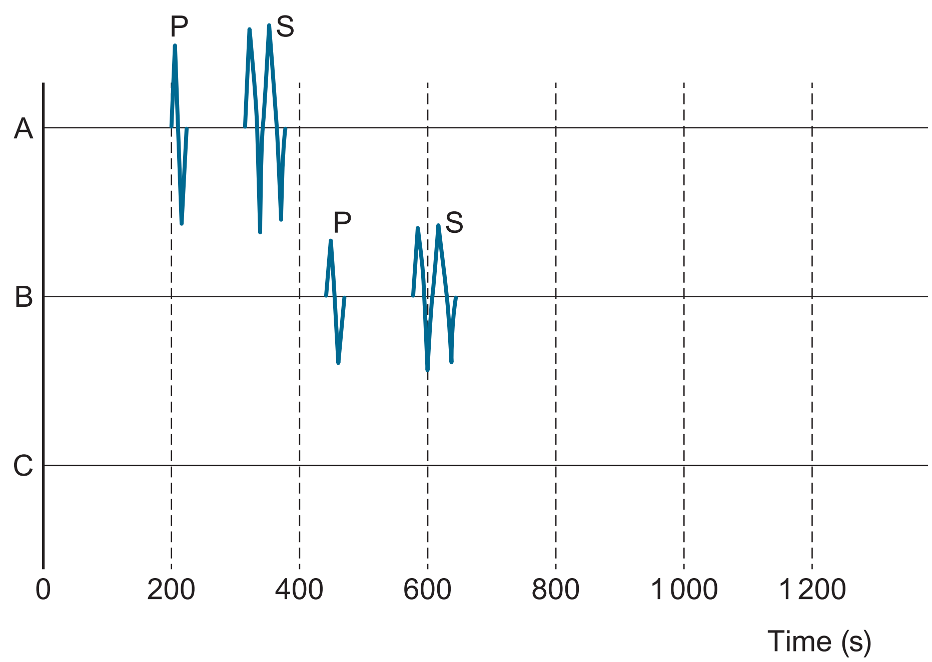
Monitoring stations at A, B and C detect the earthquake by signals that they receive.

(i) Use the time given in part (c)(ii) to state the time taken for the P wave to travel from **X to C** (ignore the Earth's crust in this). [1]

Time = ... s

(ii) The signals received at monitoring stations A and B are shown in Diagram 3. **Add to Diagram 3** the signal that you would expect to be received at station C. [3]

Diagram 3



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

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