Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3420UA0-1

S23-3420UA0-1

MONDAY, 19 JUNE 2023 – AFTERNOON

PHYSICS – Unit 1:
Electricity, Energy and Waves

HIGHER TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**13**	
3.	**6**	
4.	**11**	
5.	**7**	
6.	**11**	
7.	**14**	
8.	**11**	
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 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 **3**.

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Equations

current = $\dfrac{\text{voltage}}{\text{resistance}}$	$I = \dfrac{V}{R}$
total resistance in a series circuit	$R = R_1 + R_2$
total resistance in a parallel circuit	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$
energy transferred = power × time	$E = Pt$
power = voltage × current	$P = VI$
power = current^2 × resistance	$P = I^2R$
% efficiency = $\dfrac{\text{energy [or power] usefully transferred}}{\text{total energy [or power] supplied}}$ × 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 = $\dfrac{\text{force}}{\text{area}}$	$p = \dfrac{F}{A}$
p = pressure V = volume T = kelvin temperature	$\dfrac{pV}{T}$ = constant
	T / K = θ / °C + 273
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	$Q = mL$
force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength × current × length	$F = BIl$
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	Symbol	Conversion factor	Multiplier
pico	p	divide by 1 000 000 000 000	1×10^{-12}
nano	n	divide by 1 000 000 000	1×10^{-9}
micro	μ	divide by 1 000 000	1×10^{-6}
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}
giga	G	multiply by 1 000 000 000	1×10^{9}
terra	T	multiply by 1 000 000 000 000	1×10^{12}

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3420UA01 03

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Answer **all** questions.

1. The table below gives information about four types of power station.

The table ranks the power stations in order from 1 to 4 for three different features. Rank 1 is best and rank 4 is worst.

Power station	Efficiency	Rank	Running cost	Rank	Emissions	Rank
Type A	25%	4	Second highest	3	Highest polluting emissions	4
Type B		1	Practically zero	1	No emissions	1
Type C	35%	3	Highest	4	Has cleaner emissions than type A power stations	2
Type D	40%	2	Second lowest	2	Cleaner emissions than type C power stations but produces radioactive waste	3

(a) Use the information in the table to answer the following questions.

(i) Gareth says that the best type of power station to recommend overall by ranking is **type B**. Explain whether you agree with him. [2]

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(ii) The energy sources for different types of power station are **fossil fuel**, **nuclear** and **hydroelectric**.

Complete the table below for the energy sources for types **A**, **B**, **C** and **D**. [3]
Each energy source may be used once, more than once, or not at all.

Type	Energy source
A	…………………………
B	…………………………
C	…………………………
D	…………………………

(b) Use the information below and an equation from page 2 to calculate the % efficiency of a **type B** power station. [2]

Input energy = 200 000 MJ
Heat energy produced = 30 000 MJ
Electrical energy produced = 170 000 MJ

% efficiency = ……………….

7

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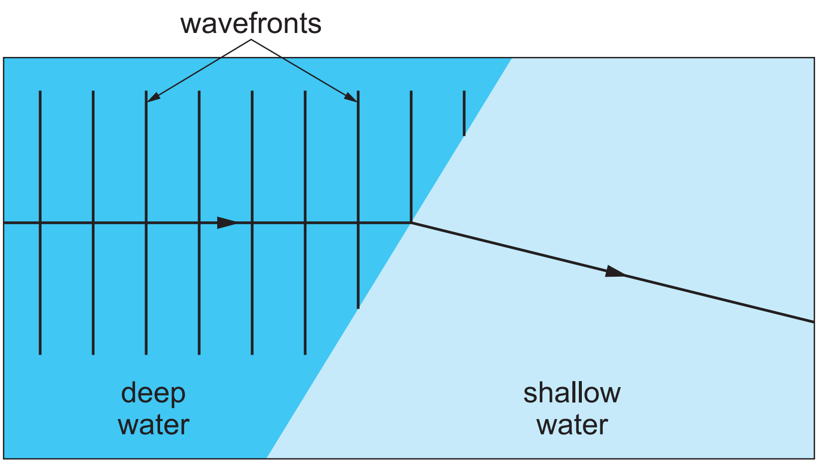
2. Water waves refract when they travel from deep water to shallow water.

Refraction happens because the speed of the wave changes.

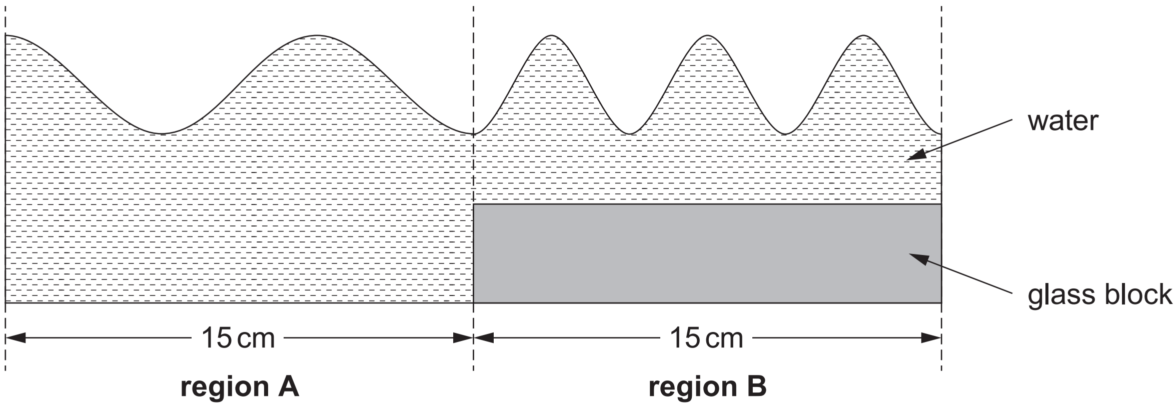
The wavelength also changes because the frequency is constant.

Students use a ripple tank to investigate this effect.

(a) **Complete the diagram below** to show the water waves in shallow water. [3]



(b) The depth of the shallow water can be changed by using glass blocks of different thicknesses.



Regions **A** and **B** are both 15 cm long.

(i) I. How many waves are shown in **region A**? .... [1]

II. Calculate the wavelength of the waves in **region A**. [1]

wavelength = ... cm

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(ii) John says that the wave speed in **region B** is greater than the wave speed in **region A**. Explain whether John is correct. [2]

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(c) In another experiment using a different tank, students investigate how the depth of water affects wave speed.

They change the depth of the water using different thickness glass blocks.

The water level is kept constant at 10 cm.

The table below shows their results.

Thickness of glass block (cm)	Depth of water (cm)	Wave speed (cm/s)
8	2	60
6	4	75
4	....	82

(i) **Complete the table.** [1]

(ii) Use the equation:

$$\text{wavelength} = \frac{\text{wave speed}}{\text{frequency}}$$

to calculate the wavelength of water waves of frequency 50 Hz when the thickness of the glass block is 6 cm. [2]

wavelength = ... cm

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(iii) Janet states that when the thickness of the glass block decreases by 2 cm the wave speed increases by a quarter.
Explain to what extent Janet is correct. [3]
Space for calculations.

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13

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3. A saucepan is used to heat water on a gas cooker.

Explain, **in terms of particles**, the processes of conduction through the metal base of the saucepan **and** convection in the water. [6 QER]

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3420UA01 09

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4. One type of petrol car costs £12 500 to buy.
The equivalent model as an electric car costs £24 500.

(a) The electric car travels 240 km on a full charge.
It takes 8 hours to fully charge the electric car battery.
A home charging point is rated at 7 kW.
Homes are charged 30 p for each kWh of electricity used.

Use the information above and equations from page 2 to calculate the cost, **in £**, to travel 240 km. [3]

charging cost for 240 km = £ ....

(b) Fuel consumption for the petrol car is 15 km/l (kilometres per litre).

The cost of petrol is £1.60 per litre.

(i) Calculate the fuel cost if the petrol car is driven 240 km. [2]

fuel cost for 240 km = £ ....

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(ii) Both cars are driven 14 400 km per year.

I. Calculate the difference in running costs for one year. [2]

difference in running costs per year = £ ....

II. Calculate the payback time of the **extra cost** if the electric car is bought instead of the petrol car. [2]

payback time = ... years

(c) It is often claimed that electric cars are environmentally friendly because they do not produce greenhouse gases when used.
Explain whether you agree. [2]

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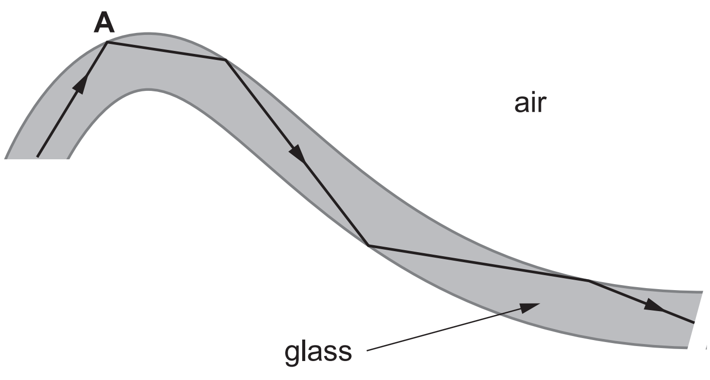
5. The table below gives examples of transverse and longitudinal waves.

Transverse waves	Longitudinal waves
light	sound
S waves	P waves

(a) Describe the difference between transverse and longitudinal waves. [2]

(b) Light waves can travel through an optical fibre in the way shown in the diagram.



(i) Name the effect where light changes direction as shown at point **A**. [1]

(ii) Explain why light waves travel through the fibre as shown. [2]

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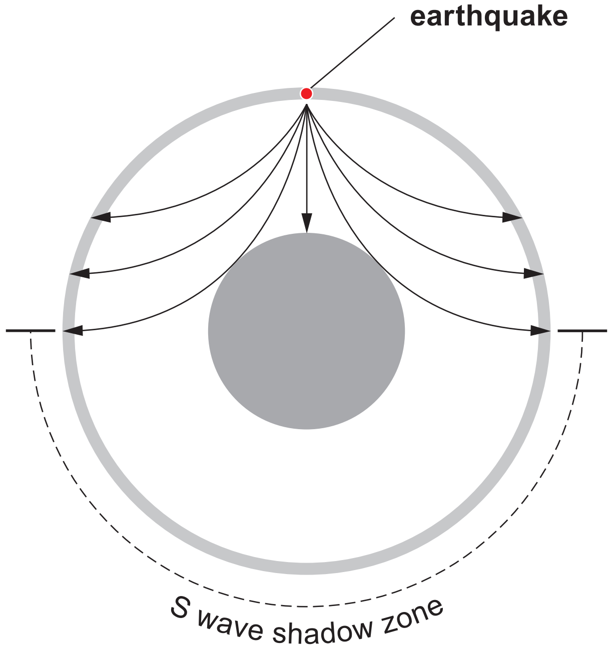
(c) The diagram below shows an S wave shadow zone.



Explain how this led to the development of a model for the structure of the Earth. [2]

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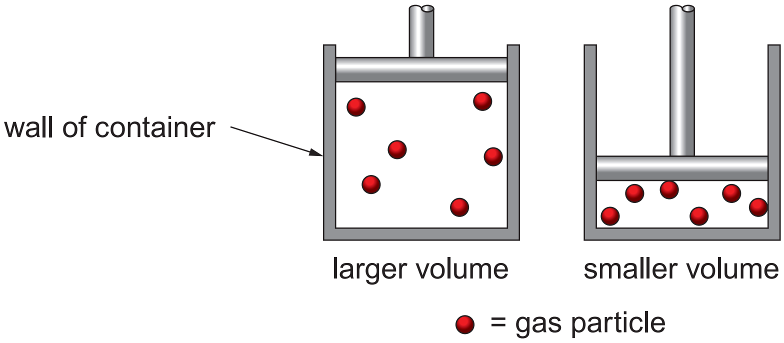
6. Kinetic theory is used to explain the behaviour of gases.

(a) A fixed mass of gas is kept at a constant temperature in a container. Explain why the pressure increases when its volume is decreased. [3]



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(b) Students are given data about the behaviour of a fixed mass of gas kept at **constant pressure**. The volume of the gas changes with temperature as shown in the table below.

Temperature (°C)	Volume (cm^3)
−223	20
−173	40
−73	80

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(i) Chris states that

$$\frac{\text{volume}}{\text{temperature}} = \text{constant}$$

when temperatures are measured in °C. Explain whether the results agree. [2]
Space for calculations.

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(ii) The students plot a graph of the results opposite. Explain how they can use the graph to determine the value of absolute zero in °C. [2]

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(c) A balloon is filled to a volume of 2 800 cm^3 at 7 °C (280 K).
The balloon is heated to a temperature of 67 °C.
The pressure remains constant.

Use the equation:

$$\frac{pV}{T} = \text{constant}$$

to calculate the new volume of the balloon. [4]
[T (K) = θ (°C) + 273]

volume = ... cm^3

11

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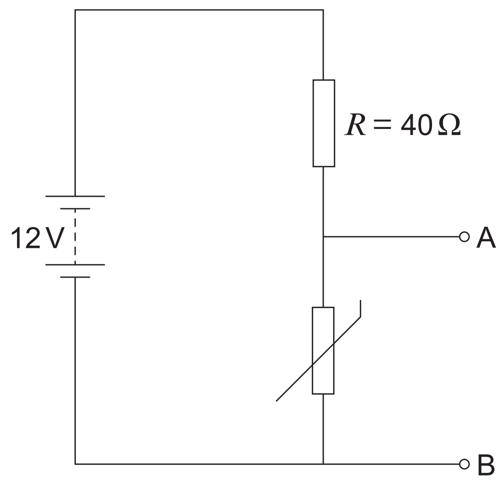
7. The circuit below is used to investigate how the resistance of a thermistor changes as temperature increases.



(a) **Add an ammeter and a voltmeter** to the diagram so the necessary measurements can be taken. [2]

(b) **Plot the results shown** below on the grid opposite and draw a curve of best fit. [2]

Temperature (°C)	Resistance of thermistor (Ω)
0	120
25	92
50	70
75	52
100	40
125	30

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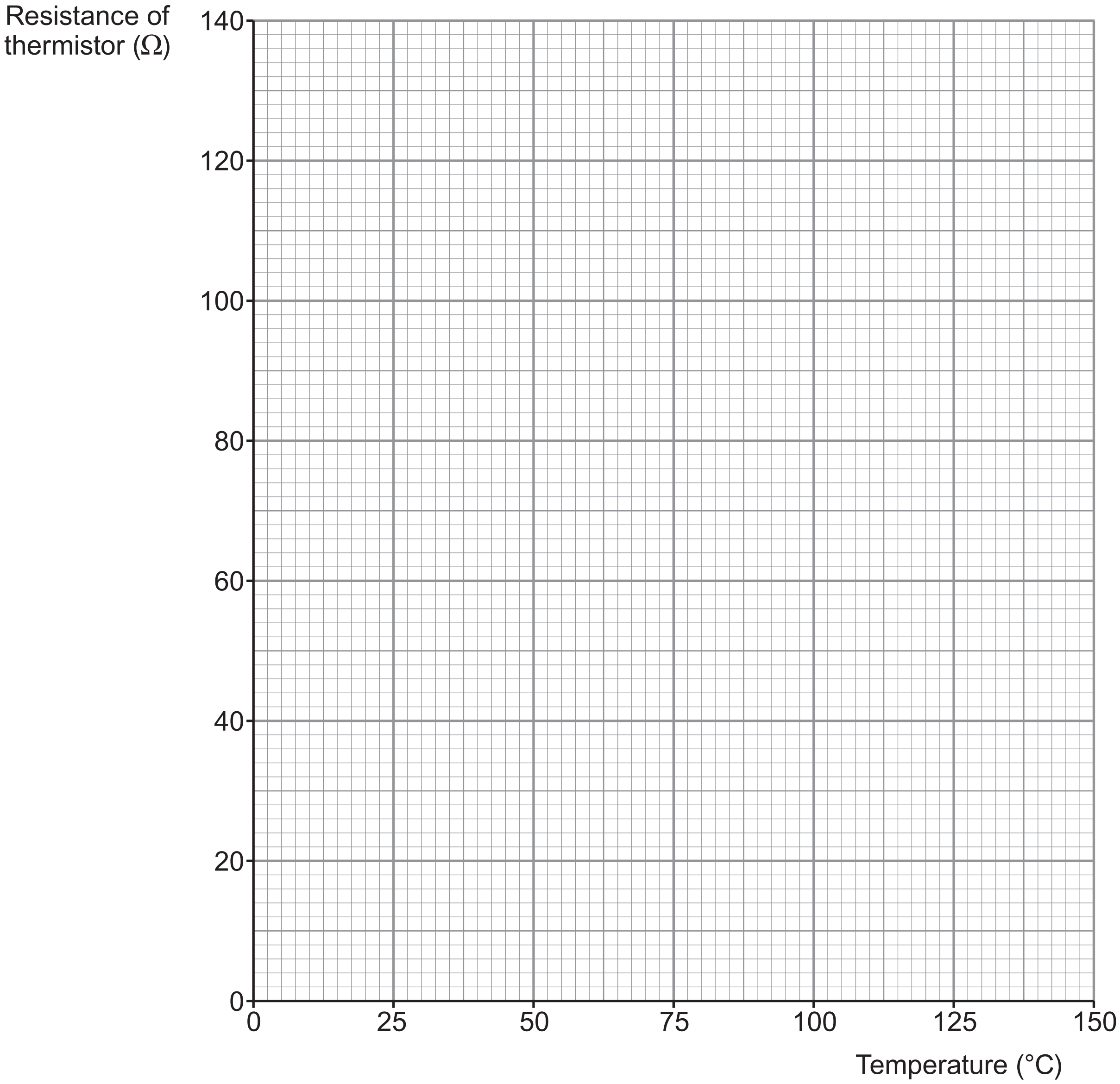

(c) The resistance of the resistor, R, remains constant at 40 Ω.

(i) Calculate the voltage across the terminals AB when the temperature is 100 °C. [3]

voltage = ... V

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(ii) Tom says as temperature increases the current increases.
Explain whether you agree. [2]

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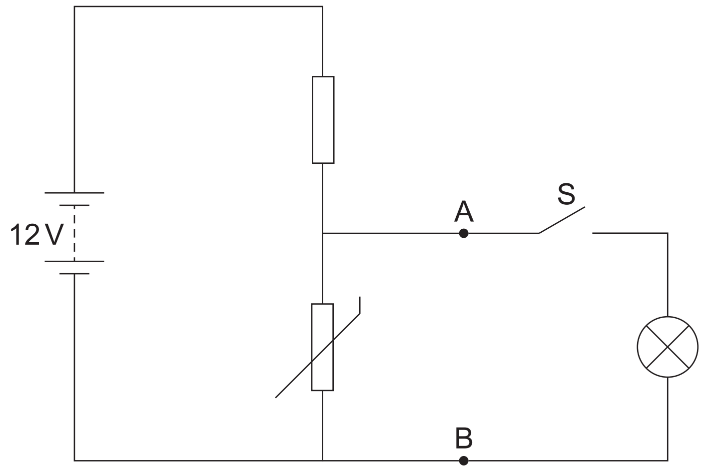
(d) A lamp and a switch are now connected across the terminals AB, as shown in the diagram below.



(i) The lamp has a power of 3 W at 12 V.
Use equations from page 2 to calculate the resistance of the lamp at this power and voltage. [3]

resistance = ... Ω

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(ii) The switch, S, is now closed. Explain, without calculation, what happens to the total resistance of the circuit. [2]

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14

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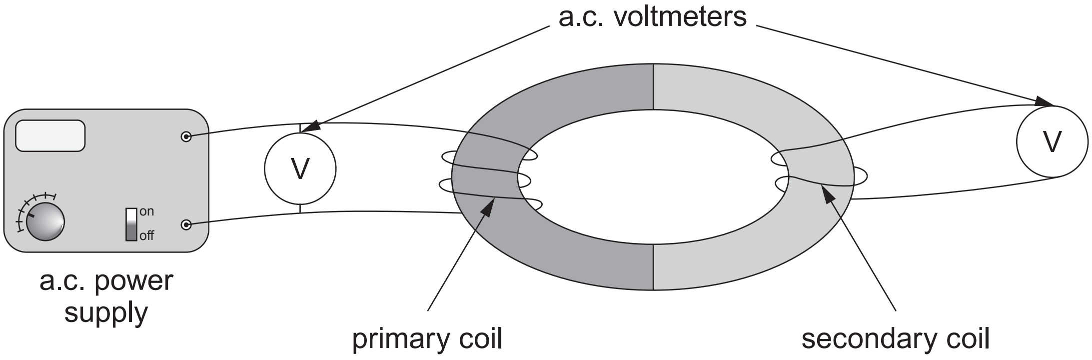
8. Transformers are used to change the size of an a.c. voltage.

(a) Describe how the apparatus in the diagram below is used to investigate the effect of the number of turns on the secondary coil on the output of a transformer. [4]



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(b) Explain why transformers only change a.c. voltages. [2]

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(c) Explain how step-up transformers increase the efficiency of the National Grid system. [2]

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(d) A transformer is used to reduce the 230 V mains voltage to 11.5 V to run a television. The primary coil of the transformer has 600 turns.
Use an equation from page 2 to calculate the number of turns on the secondary coil. [3]

number of turns = ...

11

END OF PAPER

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

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