Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3420UA0-1

Z22-3420UA0-1

MONDAY, 20 JUNE 2022 – MORNING

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.	**11**	
4.	**7**	
5.	**6**	
6.	**15**	
7.	**10**	
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 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**.

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Equations

current = $\frac{\text{voltage}}{\text{resistance}}$	$I = \frac{V}{R}$
total resistance in a series circuit	$R = R_1 + R_2$
total resistance in a parallel circuit	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$
energy transferred = power × time	$E = Pt$
power = voltage × current	$P = VI$
power = current^2 × resistance	$P = I^2R$
% efficiency = $\frac{\text{energy [or power] usefully transferred}}{\text{total energy [or power] supplied}} \times 100$	
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 = $\frac{\text{force}}{\text{area}}$	$p = \frac{F}{A}$
p = pressure V = volume T = kelvin temperature	$\frac{pV}{T}$ = 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	$\frac{V_1}{V_2} = \frac{N_1}{N_2}$

SI multipliers

Prefix	Multiplier
p	1×10^{-12}
n	1×10^{-9}
μ	1×10^{-6}
m	1×10^{-3}

Prefix	Multiplier
k	1×10^{3}
M	1×10^{6}
G	1×10^{9}
T	1×10^{12}

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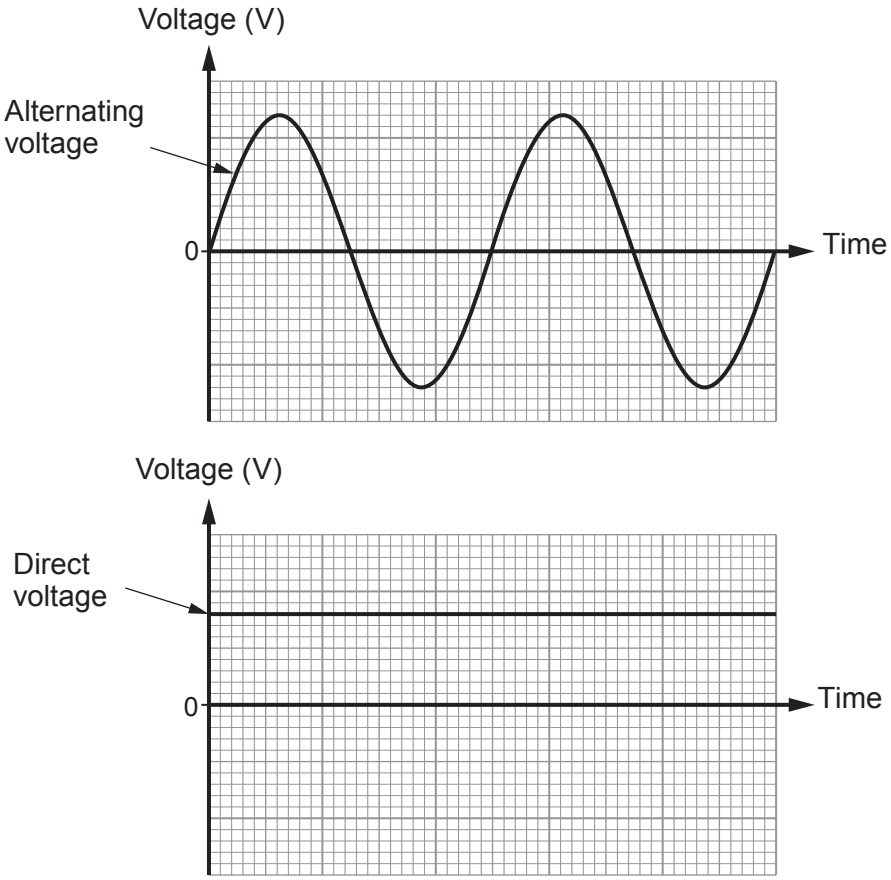
Answer **all** questions.

1. (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]

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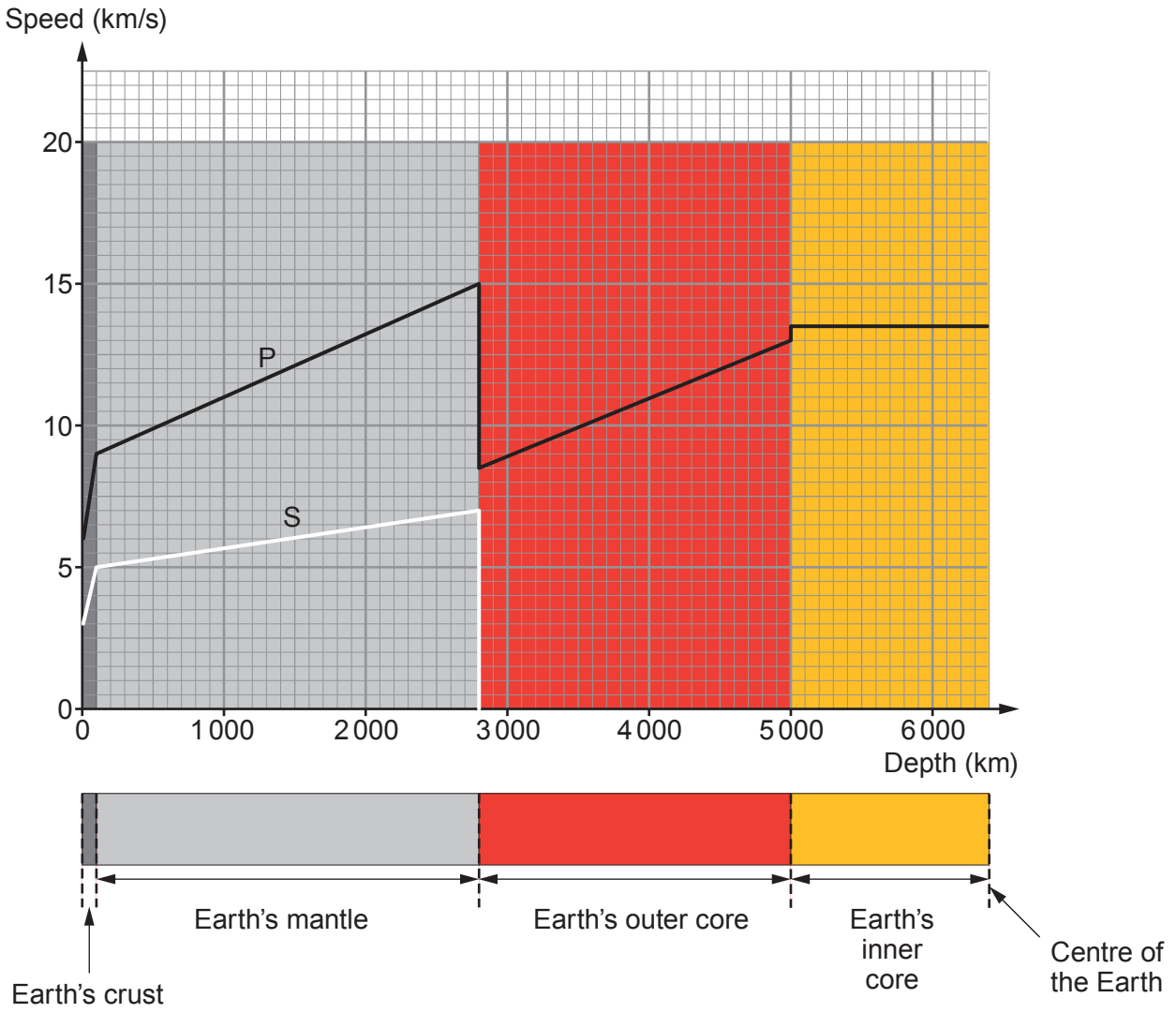
2. P and S waves are produced during an earthquake. They travel at different speeds.
The graph shows how the speed of P and S waves change with depth below the Earth's surface.



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

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.....

(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]

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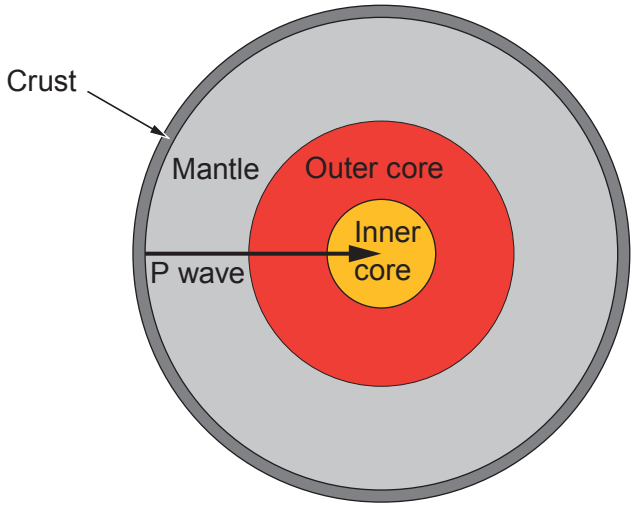
(ii) A P wave (shown in Diagram 1) travels a distance of 6 300 km in a straight line to the centre of the Earth in a time of 550 s.

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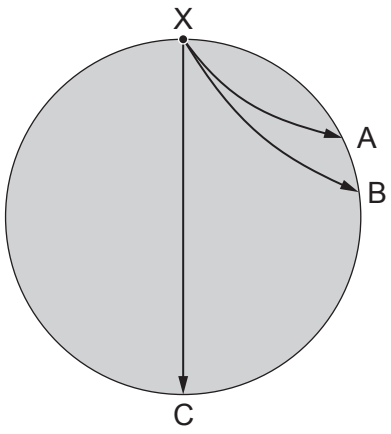
(d) Diagram 2 shows waves passing through the Earth following an earthquake at point X.

Diagram 2



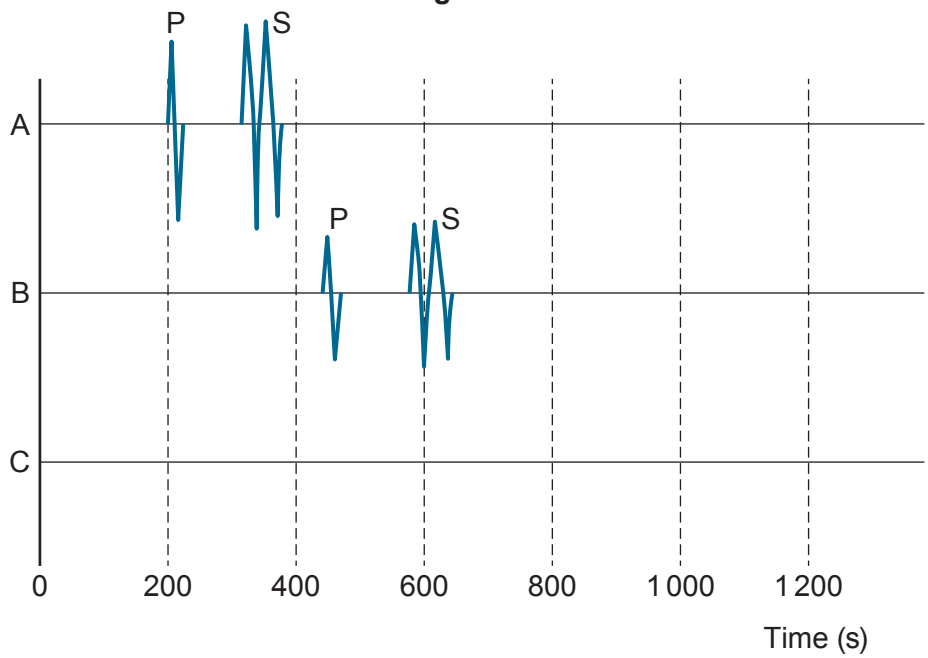
Monitoring stations at A, B and C detect the earthquake by signals that they receive.

(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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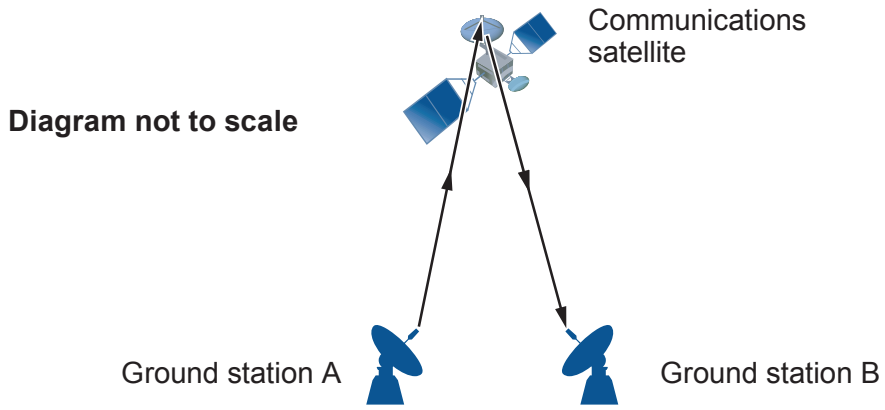
3. This question is about geostationary and geosynchronous satellites.

(a) **Place a tick (✓) or a cross (×) in each box** in the table below.
One box has been completed for you. [4]

	Geosynchronous satellite	Geostationary satellite
Stays above the same point on Earth at all times	×	
Orbits Earth once in 24 hours		
Orbits above the equator		
Must pass over the North pole and South pole		

(b) The diagram shows a communications satellite relaying a signal between ground stations A and B.



(i) Satellite communication uses microwaves of wavelength of 0.08 m.

Use the equation:

wave speed = frequency × wavelength

to calculate the frequency of the microwaves and state its unit.
(Speed of light, c = 3 × 10^8 m/s) [4]

Frequency = ...

Unit = ...

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(ii) The time delay between transmitting the signal at A and receiving it back on Earth at B is 0.24 s.
Use an equation from page 2 to calculate the distance from the satellite to the ground stations. [3]
(Speed of light, $c = 3 \times 10^8$ m/s)

Distance = ... m

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4. A group of students investigate density using an electronic balance, a measuring cylinder, water and some small steel ball bearings.

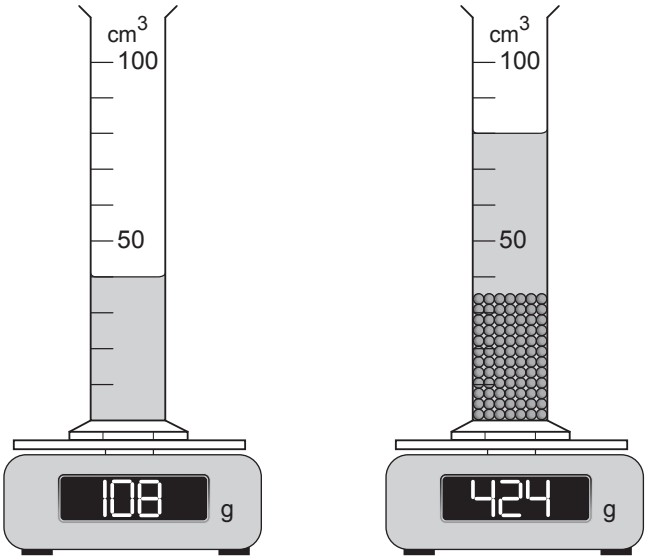
They set the balance to zero and place a measuring cylinder on to the balance.

They then add water at 10 cm^3 intervals and record both the mass and volume.

At some point they start adding the steel ball bearings instead of water, and record the mass and volume each time the water level rises by 10 cm^3.

They continue until the final volume of 100 cm^3 is reached.

The arrangement is shown below.



The students produce a table of their results, which is shown below.

Volume (cm^3)	Mass (g)
0	68
10	78
20	88
30	98
40	108
50	187
60	266
70	345
80	424
90	503
100	582

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(a) One member of the group claims that water has a density value of 1 g/cm^3. Explain whether her claim is correct. [No calculations are required.] [1]

.....

.....

(b) (i) State the volume at which they start adding the steel ball bearings. [1]

Volume = ... cm^3

(ii) Give a reason for your answer. [1]

.....

.....

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

Density of steel = ... g/cm^3

(d) State **two** improvements that could be made to this experiment that would lead to a more accurate value for the density of steel. [2]

1. .....

2. .....

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5. A family buys an old house that has poor insulation.

They lay fibre-glass insulation with a reflective coating in the loft and replace the old single-glazed windows with double glazing that has a reflective coating on the glass.

Explain how heat loss by **conduction**, **convection** and **radiation** could be reduced by making these two improvements. [6 QER]

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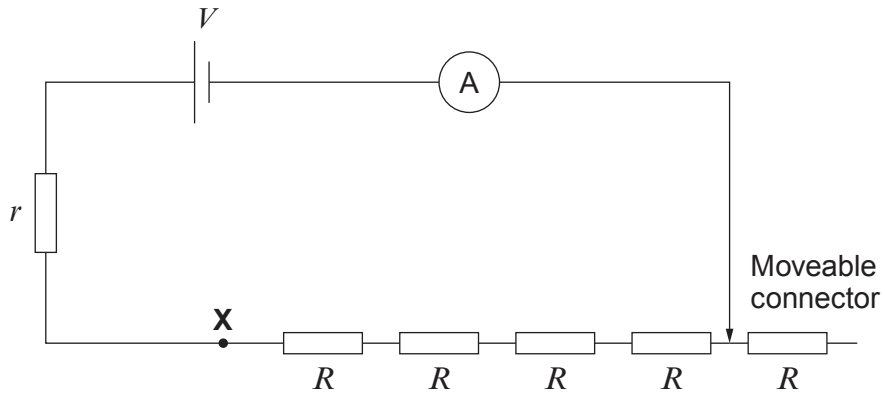
6. A student sets up the following experiment to find how current is related to the number of identical resistors, R, in the circuit.
She uses a power supply that provides a constant voltage, V, and includes a safety resistor, r, in the circuit as shown.



(a) The moveable connector is moved to point **X** in the circuit. Explain why the ammeter might be damaged if there was no safety resistor, r, included in the circuit. [2]

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(b) The student takes a series of readings of current as the number of resistors in the circuit is increased.
Her results are shown below.

Number of resistors, R	Total circuit resistance (Ω)	Current, I (A)			$\frac{1}{\text{current}}$ $\left(\frac{1}{\text{A}}\right)$
		First reading	Second reading	Mean	
0	10	1.200	1.200	1.200	0.83
1	30	0.390	0.410	.....	2.5
2	50	0.230	0.250	0.240	4.2
4	90	0.133	0.133	0.133	7.5
5	110	0.110	0.108	0.109	9.2

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Refer to the table to answer the following questions.

(i) **Complete** the missing mean value in the table. [1]
Space for calculation.

(ii) State the value of the resistance of the safety resistor, r. [1]

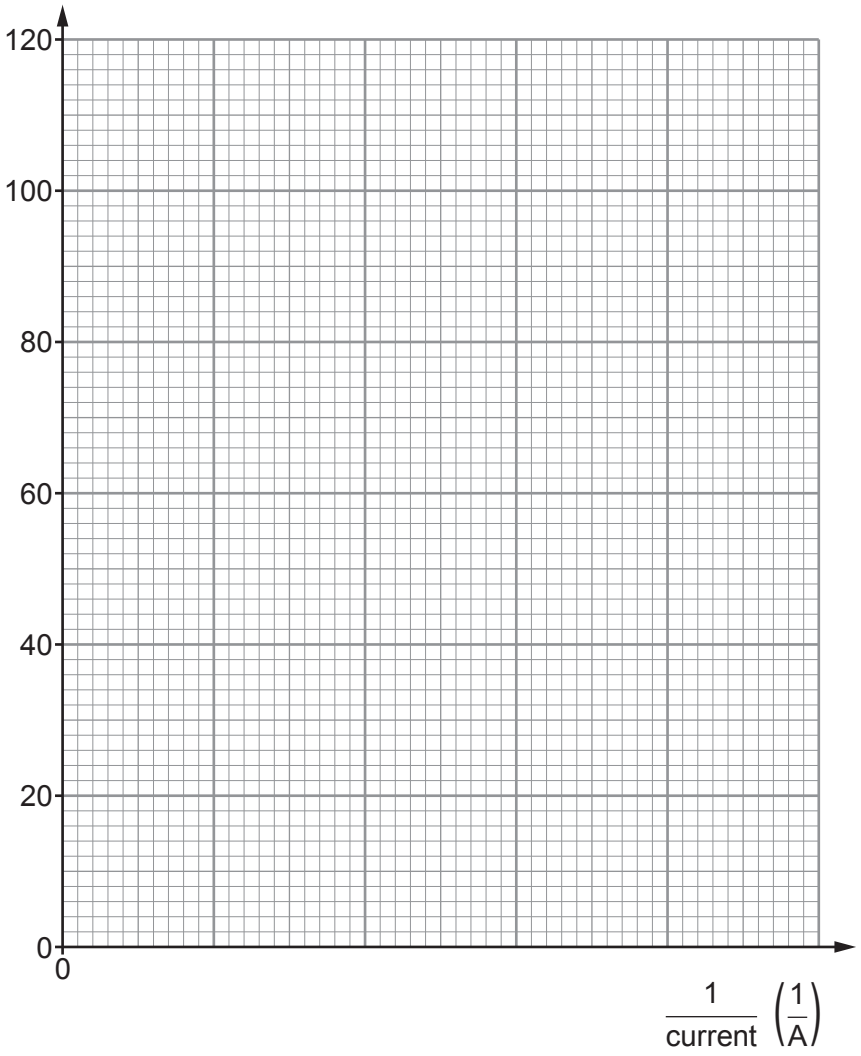
Resistance = ... Ω

(iii) Determine the value of the resistance of each resistor, R. [1]

Resistance = ... Ω

(iv) Plot the results on the grid below and draw a suitable line. [3]

Total circuit resistance (Ω)



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(c) Use your answer to part (b)(iii) and the graph to determine the current when 3 of the resistors labelled R are included in the circuit. [3]

Current = ... A

(d) (i) The gradient of the graph gives the value of the voltage of the battery. Calculate its value and show your workings. [2]

Voltage = ... V

(ii) Describe **one** other way that the battery voltage could be calculated. [2]
No calculations are required.

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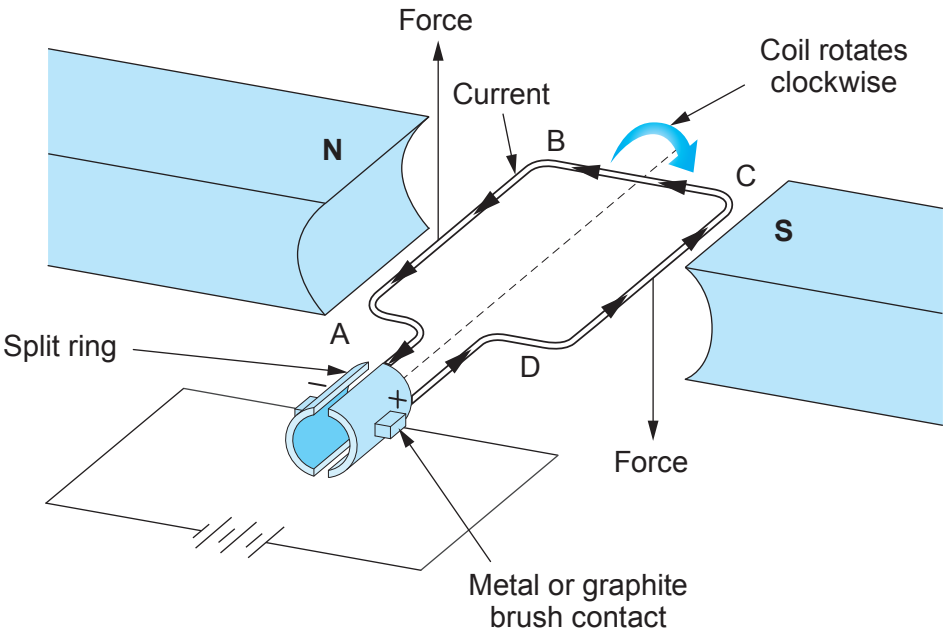
7. The diagram shows a simple d.c. electric motor consisting of a single turn of wire ABCD.



(a) Describe how Fleming's left-hand rule can be used to show that the side **AB** of the wire moves upwards. [3]

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(b) By considering the current in **AB**, explain how the split ring allows the coil to continue to rotate. [2]

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Examiner only

(c) The sides AB and CD have lengths of 6.0 cm and the side BC has a length of 3.0 cm. The magnetic field has a strength of 0.04 T and a current of 0.7 A passes through the coil.

(i) Use the equation:

force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength × current × length

to calculate the force on side **AB** of the coil. [3]

Force = ... N

(ii) Describe the effect on the force, on side **AB** of the coil, of doubling **both** the battery voltage **and** the number of coils. [2]

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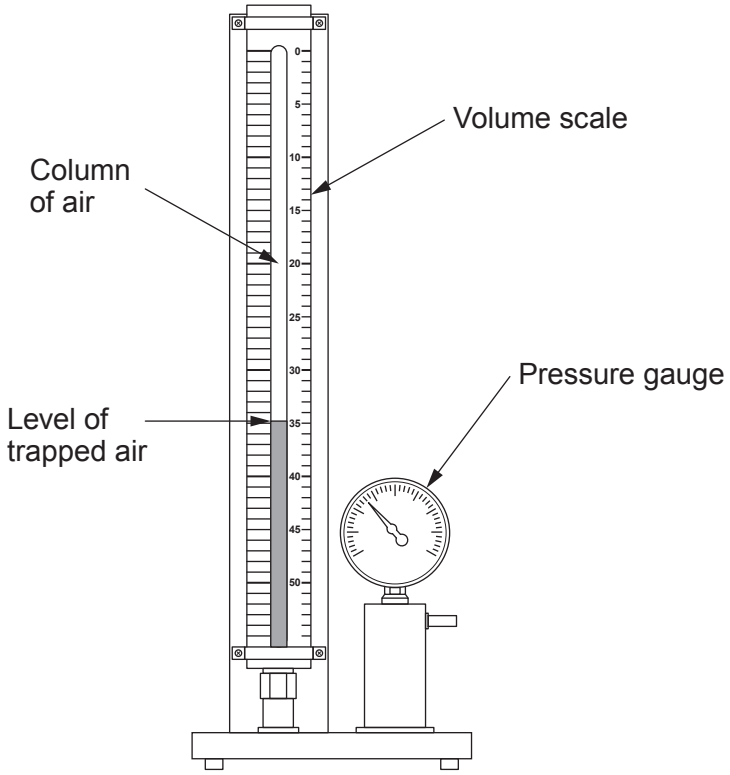
8. (a) The volume of a gas is related to its pressure.
A mass of air is contained in a glass tube that is attached to a pressure gauge.



(i) When the pressure shown by the pressure gauge increases and the temperature is constant, the volume of the column of air decreases.
Describe the effect, if any, on the motion of the molecules and on the collisions with the container. [2]

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(ii) At a pressure of 1.2×10^5 Pa, the volume is 18 cm^3.
Explain, without calculation, what happens to the volume when the pressure is increased to 2.4×10^5 Pa at constant temperature. [2]

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(b) In another experiment, air initially at 27 °C is kept at constant volume. The air pressure is increased from 2.4×10^5 Pa, to 3.0×10^5 Pa.

(i) State the initial temperature in Kelvin. [1]

Temperature = ... K

(ii) Use an equation from page 2 to calculate the **change in temperature** of the air. [3]

Change in temperature = ... K

(c) A mass of 5×10^{-3} kg of air requires 105.5 J of thermal energy to increase its temperature by 21 °C.

Use the equation:

$$\Delta Q = mc\Delta\theta$$

to calculate the specific heat capacity, c, of air. [3]

Specific heat capacity = ... J / kg °C

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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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