Surname	Centre Number	Candidate Number
Other Names		0

wjec cbac

GCSE

3420UA0-1

S19-3420UA0-1

FRIDAY, 14 JUNE 2019 – 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.	**12**	
2.	**8**	
3.	**5**	
4.	**7**	
5.	**7**	
6.	**8**	
7.	**12**	
8.	**8**	
9.	**13**	
Total	**80**	

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01

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. Do not use correction fluid.

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.

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*(a)***.

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 = $\dfrac{\text{energy [or power] usefully transferred}}{\text{total energy [or power] supplied}} \times 100$	
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 = $\dfrac{\text{force}}{\text{area}}$	$p = \dfrac{F}{A}$
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	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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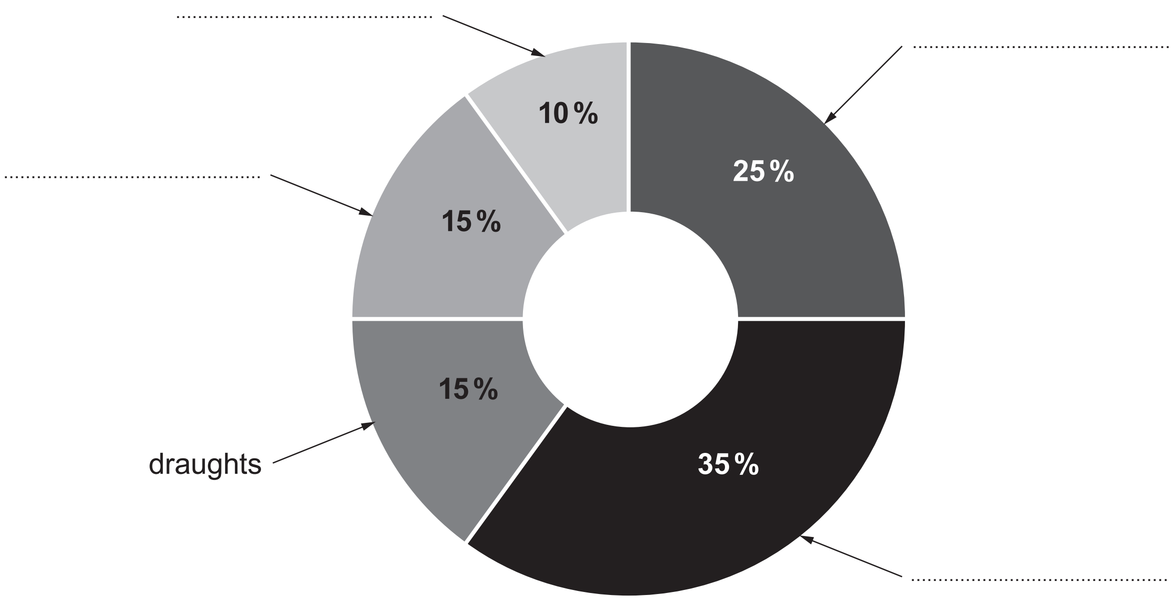
Answer **all** *questions.*

1. The Welsh Government Warm Homes Scheme, called Nest, aims to make Welsh homes warmer and more energy efficient places to live. Nest is accessible to all homeowners in Wales and provides advice on saving energy.

(a) Draughts, floors, windows, walls and the roof are the five ways energy is lost from a heated house. The pie chart shows the percentages of energy loss by each of the five ways.

Use the information below to **complete the labelling** on the pie chart. [3]
One label has been completed already.

- The percentage energy loss through the walls is greatest.
- Windows and draughts have equal percentage energy losses.
- Windows and floor percentage losses add up to equal the percentage loss through the roof.



(b) To reduce energy loss through the roof the Nest Scheme suggests the installation of fibre-glass insulation in the loft.

(i) Explain how fibre-glass reduces energy loss in the loft by convection. [2]

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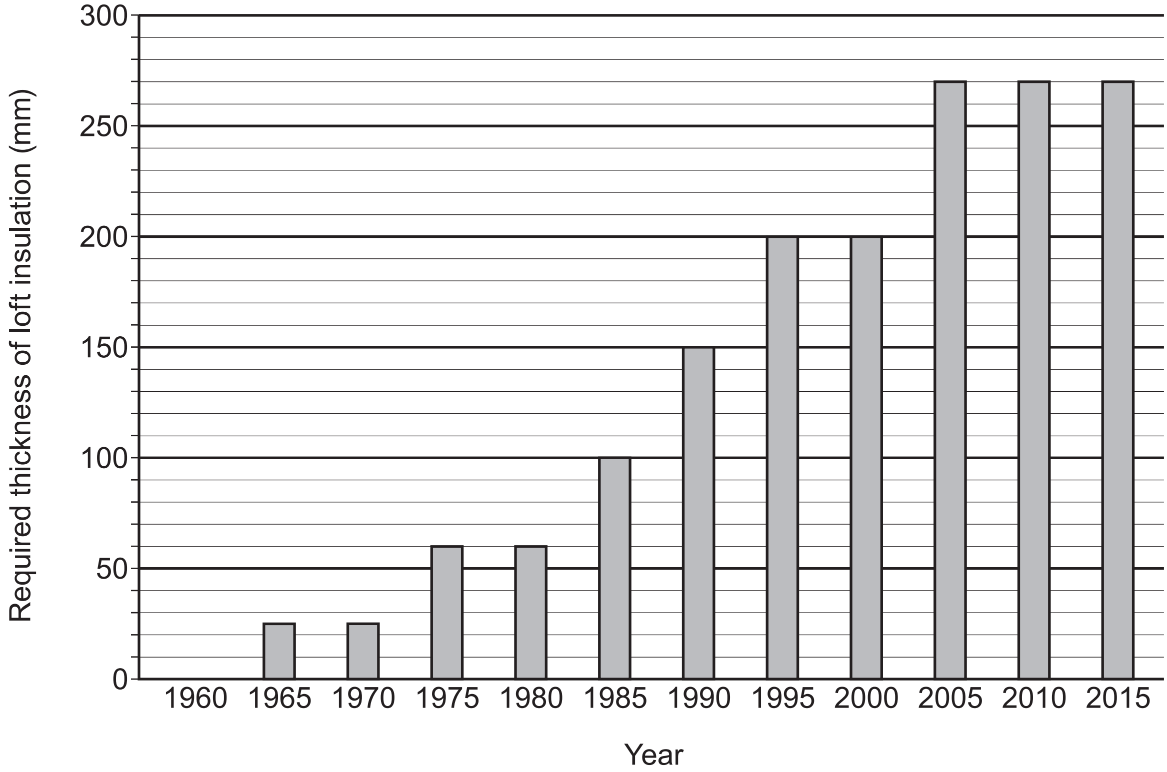
(ii) There are strict regulations about the minimum thickness of insulation that must be installed in the loft of a new house. The graph shows how the required thickness of loft insulation has changed since 1960.



Use information from the graph to tick (✓) the **three** correct statements. [3]

Every five years the required thickness of loft insulation increases. ☐

The required thickness of loft insulation in 2000 is 8 times thicker than in 1970. ☐

In 1960 houses did not lose any energy through their roof. ☐

A house built in 1980 needs 210 mm of loft insulation added to bring it up to 2015 standards. ☐

The **general** trend of the graph indicates that the required thickness of loft insulation has increased at an increasing rate. ☐

The required thickness of loft insulation will remain constant after 2015. ☐

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(iii) A homeowner must install loft insulation in a new extension. **It has a loft area of 120 m^2.** The insulation must be at least 270 mm thick to meet building regulations.

There is a selection of fibre-glass insulations available.

	Insulation 1 (270 mm thick)	Insulation 2 (350 mm thick)	Insulation 3 (300 mm thick)
Installation cost (£/m^2)	3.50	5.55	4.50
Estimated saving per year (£)	84	111	98
Payback time (years)	5.0	6.0	

Calculate the payback time if **insulation 3** was installed in the 120 m^2 extension. [2]

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Payback time = ... years

(iv) The homeowner considers installing **insulation 1** as it is cheapest but the builder says that **insulation 2** should be installed as it will save more money over 40 years. Explain, with calculations, whether the builder is correct. [2]

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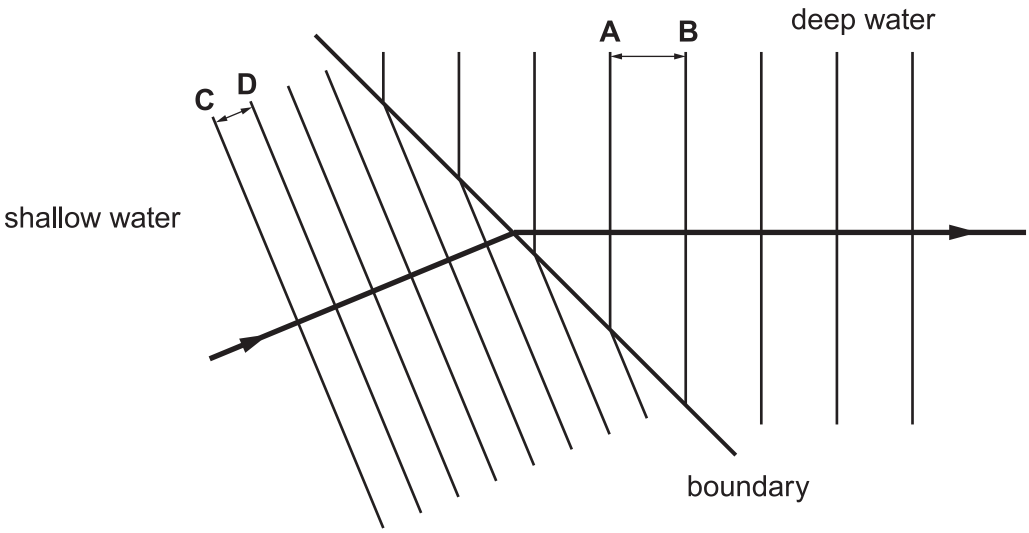
2. In class, a teacher demonstrates refraction using a ripple tank. The diagram below shows plane wavefronts travelling across a boundary between shallow and deep water. The frequency of the waves remains **constant** during refraction.



(a) Using a ruler, students measure the distance between wavefronts **A** and **B**. This measurement is the wavelength of the water waves in deep water. The distance between wavefronts **C** and **D** is measured to obtain their wavelength in the shallow water. The results are shown below.

	Deep water (**AB**)	Shallow water (**CD**)
Wavelength (mm)	10	5

(i) State how the measurement of wavelength could be improved. [1]

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(ii) The wavelength in the deep water is twice the wavelength in the shallow water. The teacher suggests, “the speed of the wavefronts in shallow water is double the speed of the wavefronts in the deep water.” Using information provided explain if the suggestion made by the teacher is correct. [2]

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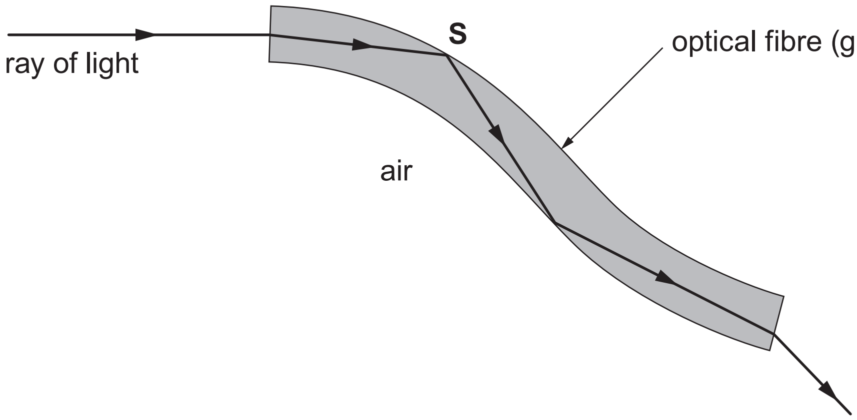
(b) An endoscope uses optical fibres. It can be used by doctors to produce medical images of a specific area inside a patient. A bundle of fibres is inserted into the body. Some of the fibres carry light into the body and others return the light reflected off internal surfaces. The diagram shows a ray of light passing through part of an optical fibre of an endoscope.



(i) State the name given to the change in direction of the signal at **S**. [1]

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(ii) State the **two** conditions needed for the ray of light to change direction at **S**. [2]

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(iii) Medical images can also be obtained from a computer tomography (CT) scan. This type of scan uses X-rays targeted at the patient from different positions outside the body. The information collected is processed by a computer to produce detailed 3D image segments of the patient.
Explain a disadvantage of using a CT scan to obtain medical information compared to using an endoscope. [2]

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3. The diagram shows the different waves that make up the electromagnetic (em) spectrum.

Gamma	X-rays	Ultraviolet	Visible light	Infra-red	Microwaves	Radio waves

(a) State in terms of **two** of their properties why they are arranged in this order from left to right. [2]

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(b) (i) State which em wave can be radiated as energy from the nuclei of radioactive materials. [1]

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(ii) State which em wave is used for satellite communications. [1]

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(c) The energy of X-rays ranges from 2.0×10^{-14} J to 2.1×10^{-17} J. Which em wave would have an energy of 1.5×10^{-12} J? [1]

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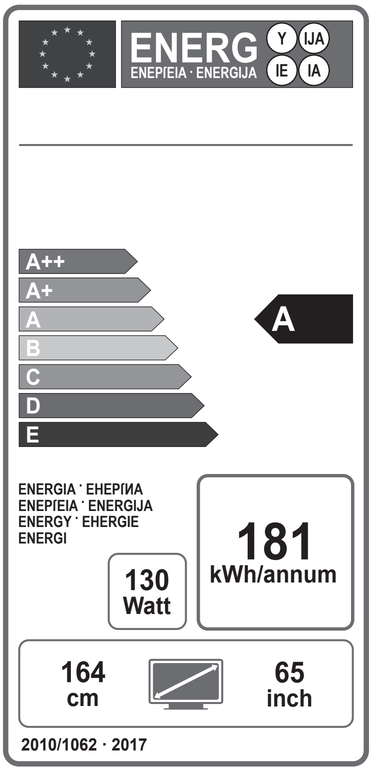
4. The following label is attached to a new TV.



(a) A few years ago the energy efficiency banding had a range from G up to A. Give a reason why additional coding, A+ and A++, has recently been added to the banding. [1]

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(b) The power of the TV is shown as 130 W. The TV manufacturer estimates that, on average, the TV will use 181 kWh per year. Using an equation from page 2, calculate the mean number of hours it is used per day. There are 365 days in a year. [4]

Mean number of hours used per day = ...

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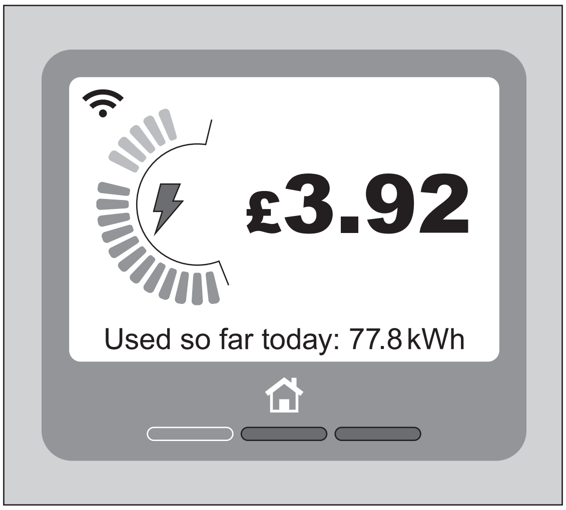
(c) Smart meters are a new kind of energy meter. As part of the government's plan to update the U.K.'s energy system they would like all homes to have Smart meters fitted by the end of 2020. Here is a screenshot of the Smart meter display used on a promotional leaflet.



Use an equation from page 2 to calculate the cost **in pence** of each kWh based on this display. [2]

Cost of kWh = ... p

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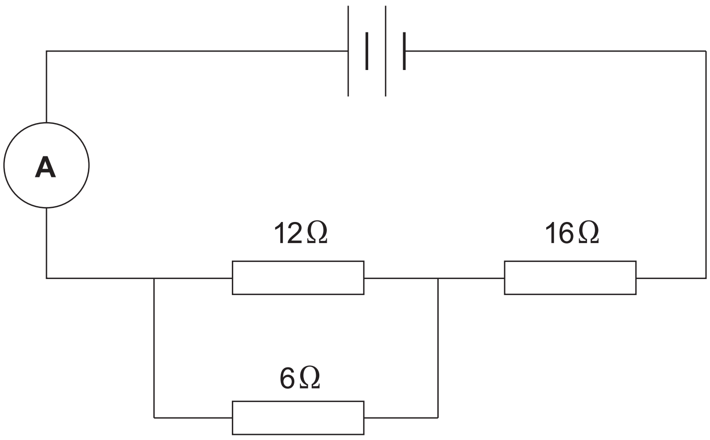
5. In an experiment a 16 Ω, 12 Ω and 6 Ω resistor are connected as shown.



(a) Use equations from page 2 to calculate the total resistance of the circuit. [3]

Total resistance = ... Ω

(b) A brand new battery is used in the circuit. The manufacturer states that the new battery can transfer a maximum of 75.6 kJ of energy. The current from the battery is measured as 1.5 A.

Use the equation:

$$P = I^2R$$

and another equation from page 2, to calculate the time **in minutes** the battery will last in this circuit. [4]

Time = ... minutes

7

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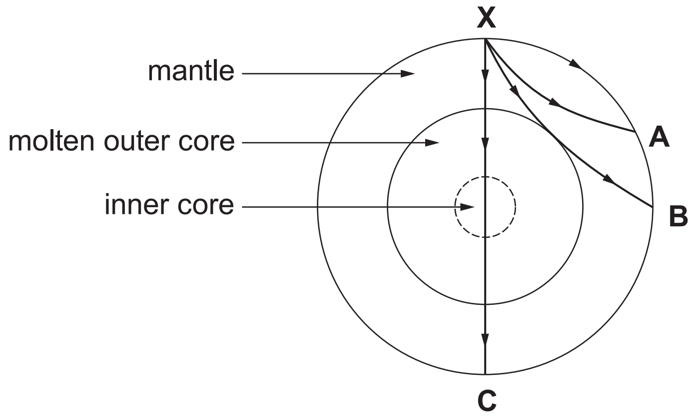
6. Earthquake monitoring stations can detect P and S waves from earthquakes. A seismic trace contains information about times of arrival for each wave type.

(a) The diagram shows some paths taken by seismic waves travelling from an earthquake at **X**. There are three seismic monitoring stations: **A**, **B** and **C**.



Compare the seismic traces obtained at **A**, **B** and **C**, explaining any similarities **and** any differences. [6 QER]

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(b) S waves are transverse waves and P waves are longitudinal waves. Describe the difference between transverse and longitudinal waves. [2]

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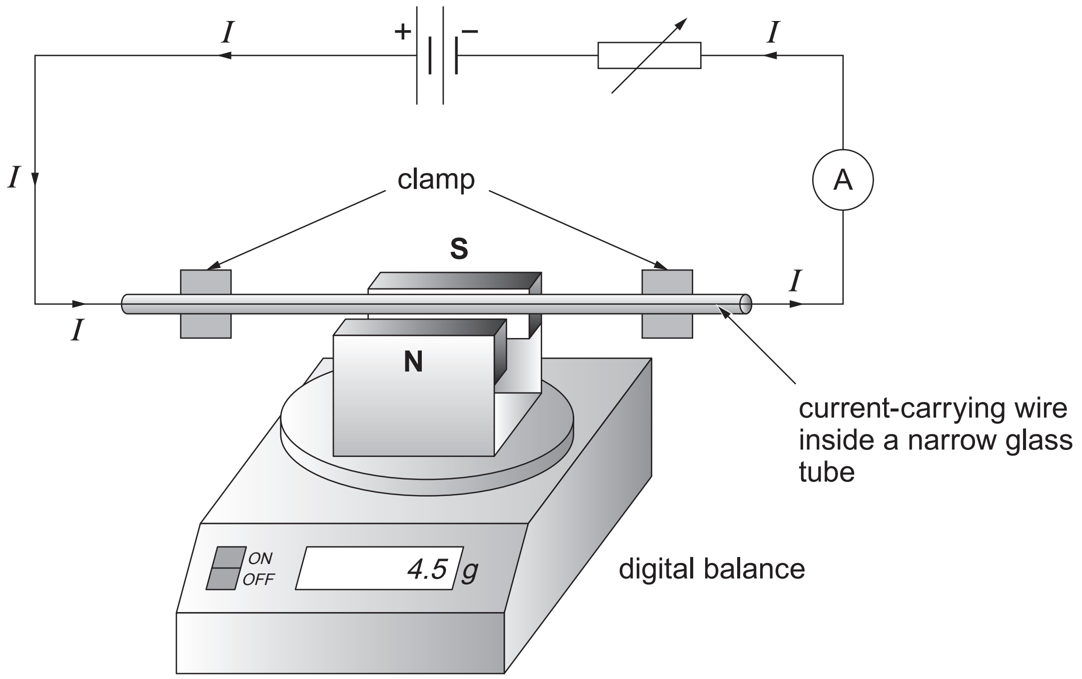
7. Apparatus is set up in a laboratory to investigate the force exerted by a current-carrying wire when it is placed in a uniform magnetic field. A magnet is placed on a digital balance and a current-carrying wire is placed between its magnetic poles.



(a) To prevent the current-carrying wire moving during the experiment it is contained in a narrow glass tube that is clamped. A pupil predicts that the current-carrying wire would move upwards if it had **not** been contained in the narrow glass tube.
Explain whether the pupil is correct. [3]

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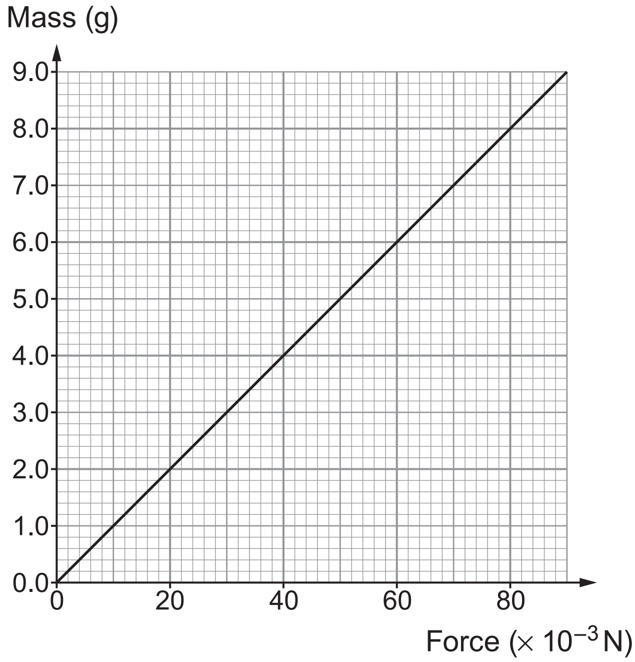
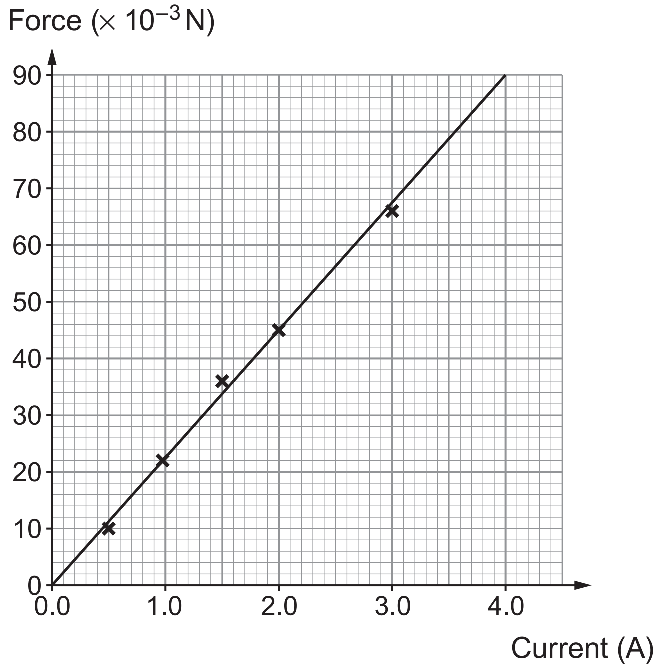
(b) When **no** current flows through the wire the digital balance is adjusted to read zero. The mass reading displayed on the digital balance is converted to a force, in newtons, using **Graph 1**.

Graph 1



The current through the wire is varied and the readings of force calculated. The data is plotted on the grid below and a best fit straight line is drawn.

Graph 2



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(i) During the experiment a reading of **4.0 g** is displayed on the digital balance. Use the graphs opposite to complete the table. [2]

Mass (g)	Force (N)	Current (A)
4.0	....	....

(ii) Describe the relationship between current and force. [2]

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(iii) A student correctly states that the line on **Graph 2** must obey the equation of a straight line: $y = mx + c$. Comparing this with $F = BIl$ and, given that force is plotted on the y-axis, identify the **quantities** that represent the gradient and the intercept. [2]

Gradient = ...

Intercept = ...

(iv) The length of wire contained in the magnetic field, B, is 5.0 cm. Use information from **Graph 2** to calculate the magnetic field strength of the magnet used in the experiment. [3]

Magnetic field strength, B = ... T

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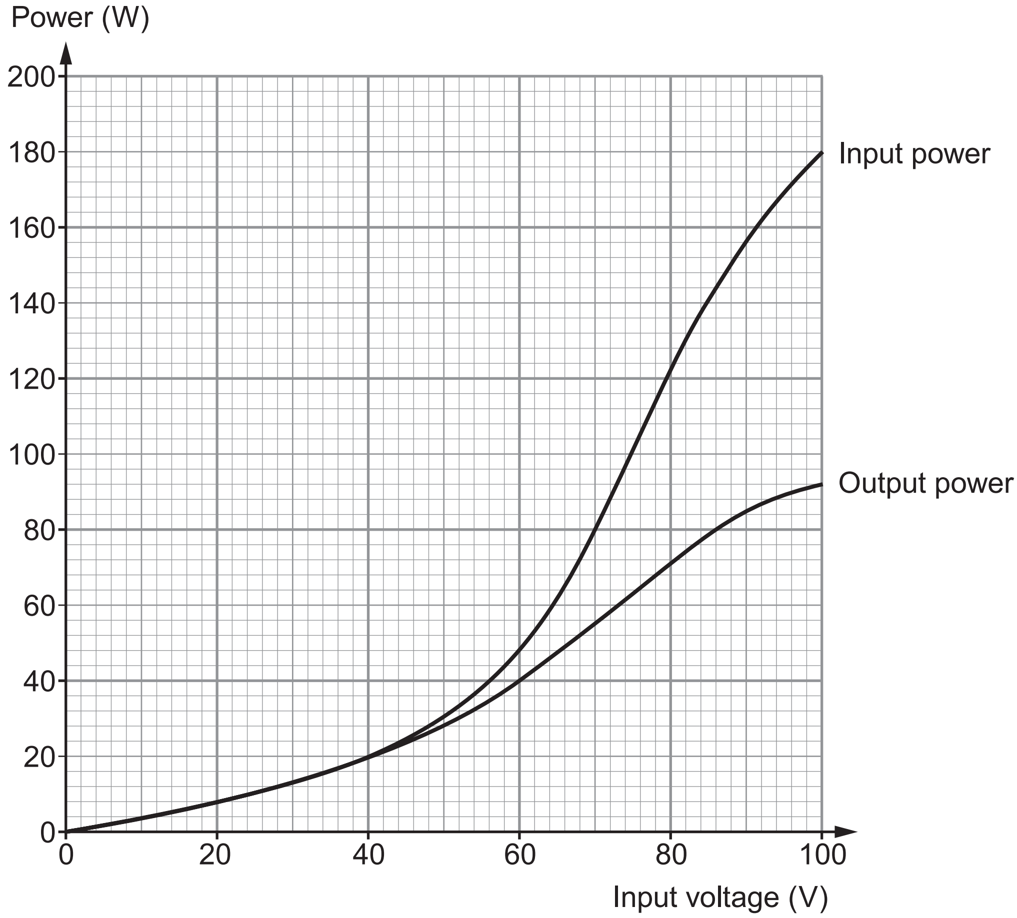
8. Abigail carries out an investigation to compare the input power and output power of a transformer. Data is collected at different input voltages and displayed on a graph.



(a) Abigail concludes that as the input voltage increases the transformer becomes less efficient. Use information on the graph to explain whether you agree or disagree with her. [2]

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(b) Use an equation from page 2 to calculate the current supplied to the **input coil** of the transformer at 100 V. [2]

Current = ... A

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(c) Explain the purpose of the laminations in the soft iron core in a transformer. [2]

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(d) Explain the advantage of using high voltages for the transmission of electricity in the National Grid. [2]

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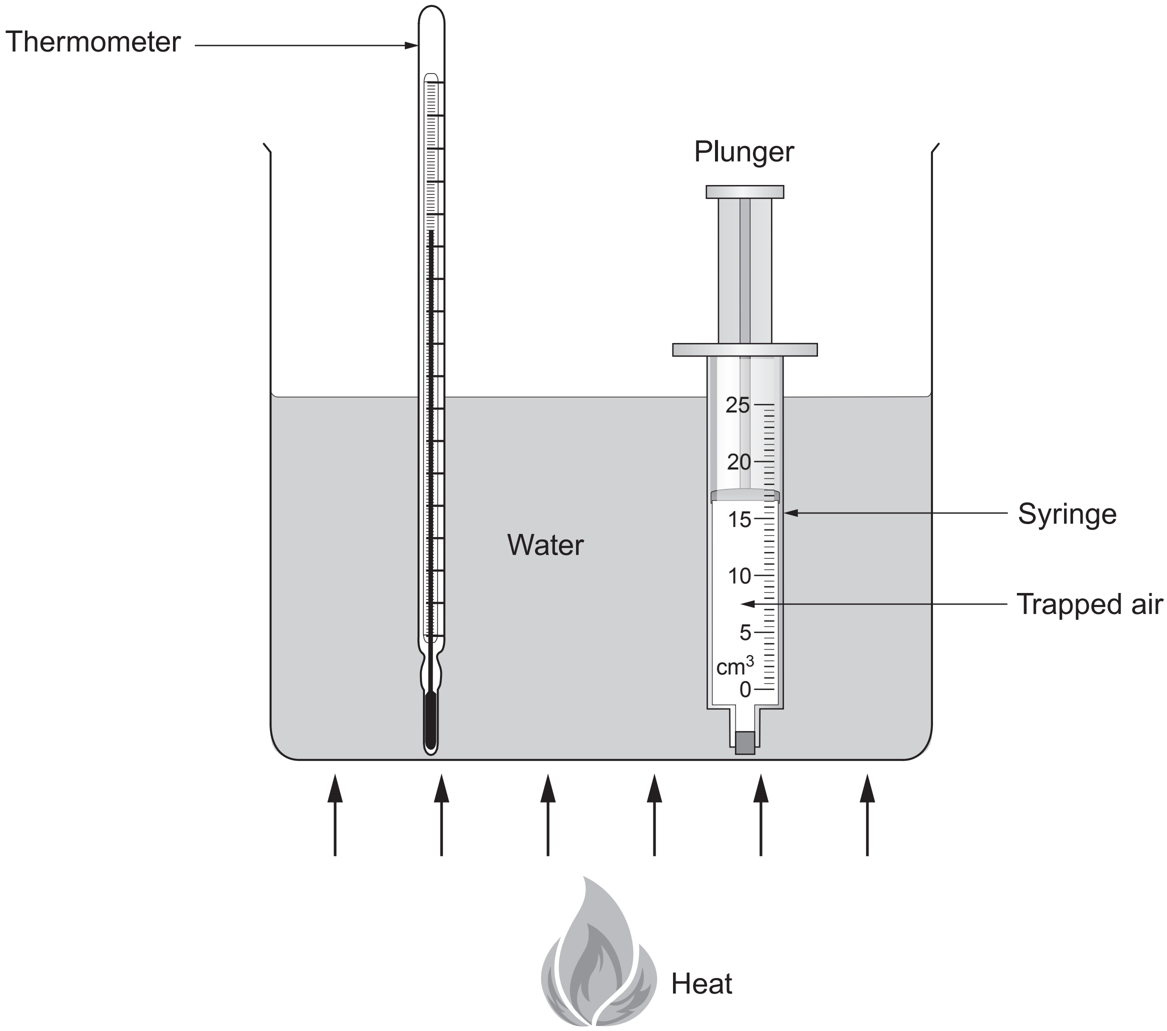
9. In a class experiment the volume of a fixed mass of air changes when it is heated.



The air is trapped in a syringe which has been sealed at one end but the plunger at the other end is free to move in or out. The maximum volume the syringe can measure is 25.0 cm^3. The volume of trapped air in the syringe is measured as the temperature of the water is increased. The results are shown in the table below.

Temperature (°C)	Volume of trapped air (cm^3)
10	19.5
30	21.0
50	22.5
60	23.0
80	24.5

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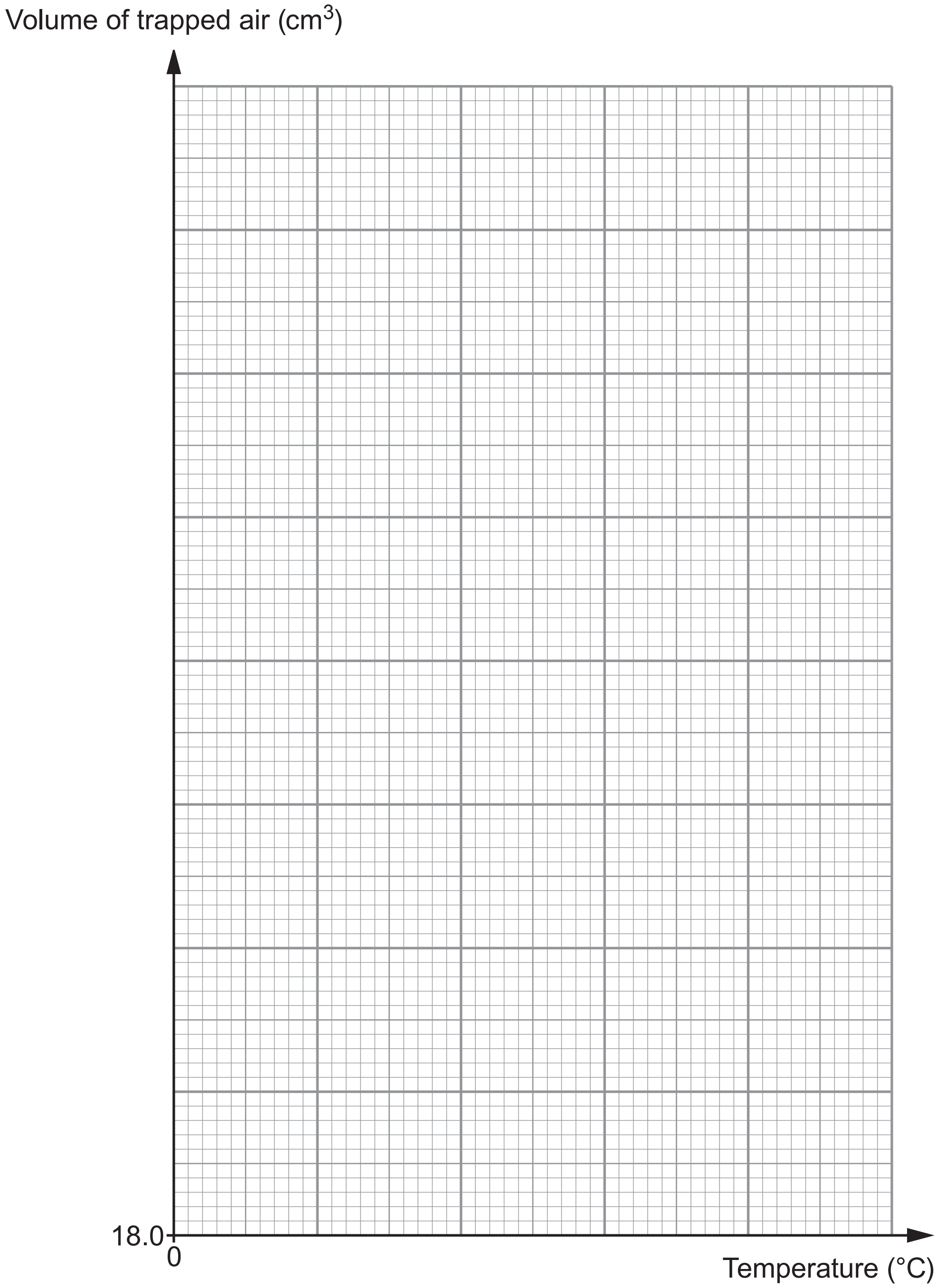
(a) Plot the data on the grid below and draw a suitable line.
(Note that the scale on the volume axis does not start at zero.) [3]



(b) Explain, using your graph, whether the students can take a volume reading from the syringe at 100 °C. [2]

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(c) Explain how, if at all, the density of the trapped air changes as it is heated. [2]

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(d) Explain, in terms of the motion of molecules, why the volume of the trapped air increases as the temperature increases. [2]

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(e) The data in the table shows when the temperature increases from 10 °C to 60 °C the volume of trapped air increases from 19.5 cm^3 to 23.0 cm^3. Using only this information, calculate the temperature, in °C, at which the volume of the trapped air is zero. [3]

Temperature = ... °C

(f) State the name given to the temperature when the volume is zero. [1]

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

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