Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

S23-3420U10-1

3420U10-1

MONDAY, 19 JUNE 2023 – AFTERNOON

PHYSICS – Unit 1:
Electricity, Energy and Waves

FOUNDATION TIER

1 hour 45 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	12	
2.	7	
3.	4	
4.	4	
5.	12	
6.	9	
7.	12	
8.	7	
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 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 **5(c)**.

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Equations

current = $\frac{\text{voltage}}{\text{resistance}}$	$I = \frac{V}{R}$
total resistance in a series circuit	$R = R_1 + R_2$
energy transferred = power × time	$E = Pt$
power = voltage × current	$P = VI$
% efficiency = $\frac{\text{energy [or power] usefully transferred}}{\text{total energy [or power] supplied}} \times 100$	
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 = $\frac{\text{force}}{\text{area}}$	$p = \frac{F}{A}$
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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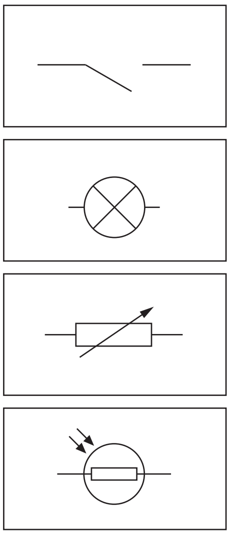
Answer **all** questions.

1. Students are investigating the properties of series and parallel circuits.

(a) **Draw a straight line** linking the circuit symbol on the left with the name of the component on the right. [3]



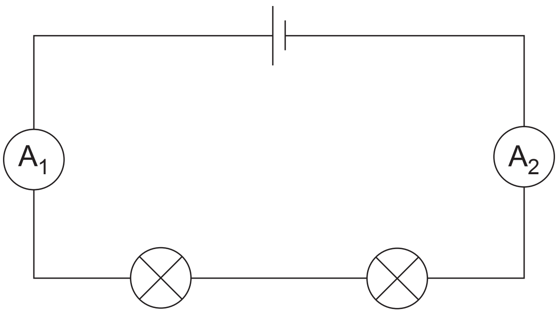
lamp

switch

variable resistor

LDR

(b) The students set up the following circuit and measure the current in different places.



(i) Underline words or phrases from the brackets to correctly complete the following sentences. [2]

The circuit is a (**double** / **series** / **parallel**) circuit.

The current reading on ammeter A_2 is (**less than** / **the same as** / **more than**) the reading on ammeter A_1.

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(ii) The battery voltage in the circuit is 3 V and the current through the lamps is 0.25 A.

I. Use the equation:

$$\text{power} = \text{voltage} \times \text{current}$$

to calculate the power of the circuit. [2]

power = ... W

II. Use the equation:

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

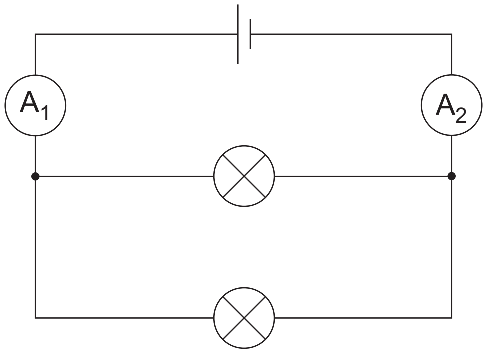
to calculate the resistance of the circuit. [2]

resistance = ...

III. **Circle** the correct unit for resistance. [1]

J Ω kg

(c) The students now use the **same** components to make the following circuit.



The students notice that the lamps are **brighter**.

Select words or phrases from the box to correctly complete the sentences below.
You may use each word once, more than once or not at all. [2]

increases	decreases	stays the same

The lamps are brighter because the resistance of the circuit ....

so the current through each lamp ....

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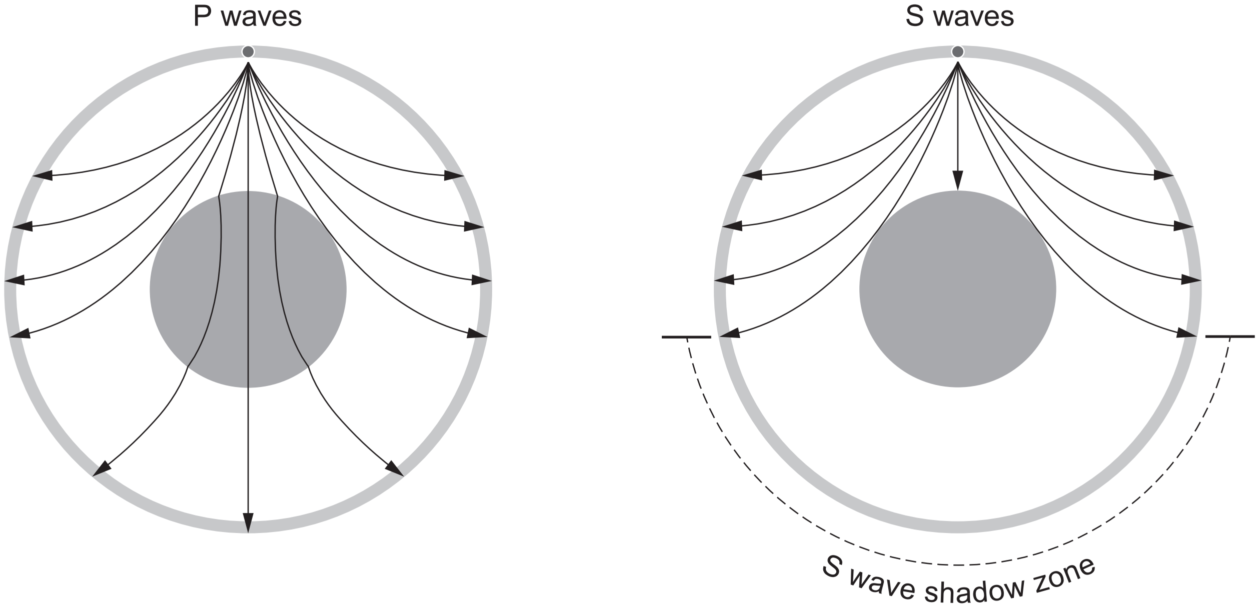
2. The diagram shows the path of seismic P and S waves through the Earth.



(a) (i) Underline the correct word in the bracket. [1]

The Earth has a liquid (**core** / **mantle** / **crust**).

(ii) Tick (✓) the **three** correct statements about P and S waves. [3]

P waves are transverse waves. ☐

P waves travel faster than S waves. ☐

S waves cannot travel in a liquid. ☐

P waves cannot travel in a solid. ☐

S waves are transverse waves. ☐

P waves cannot travel in a liquid. ☐

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(b) (i) P waves from an earthquake, which are travelling at a mean speed of 8000 m/s, reach a seismic monitoring station 500 s later.

Use the equation:

distance = speed × time

to calculate the distance travelled by the P waves to the monitoring station. [2]

distance = ... m

(ii) **A**, **B** and **C** are monitoring stations in Wales. They collect data from an earthquake.

The epicentre is located somewhere on the circles shown in the diagram below. **Mark with a cross (x)** the location of the epicentre. [1]

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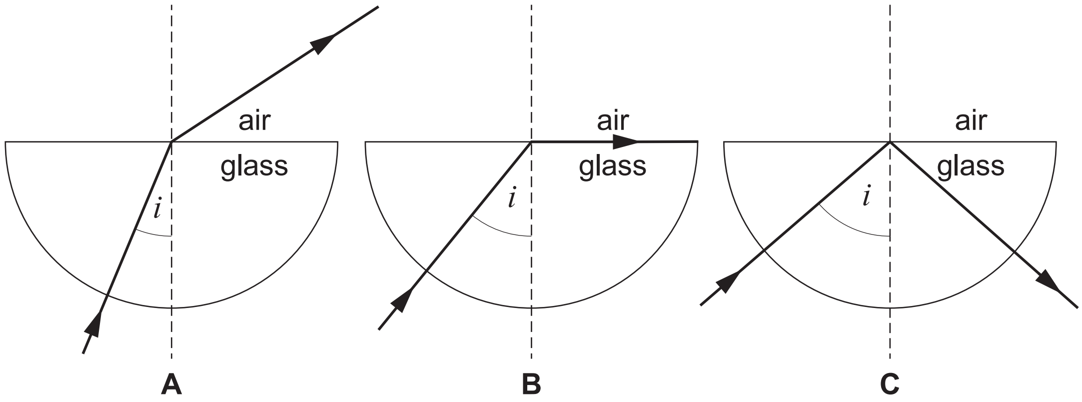
3. A class investigates the total internal reflection (TIR) of light in a glass block.

They change the angle of incidence, i, of a ray of light and draw in the path of the ray out of the block.

Their results are shown in the three diagrams, **A**, **B** and **C** below.



(a) (i) State in which diagram, **A**, **B** or **C**, the angle of incidence is equal to the critical angle. [1]

Diagram ....

(ii) State which diagram, **A**, **B** or **C**, shows total internal reflection. [1]

Diagram ....

(b) Tick (✓) the box next to the condition required for total internal reflection to occur. [1]

Light must be travelling from a less dense to a more dense material. ☐

Light must be travelling from one material to a different material of equal density. ☐

Light must be travelling from a more dense to a less dense material. ☐

(c) State **one** use of total internal reflection. [1]

....

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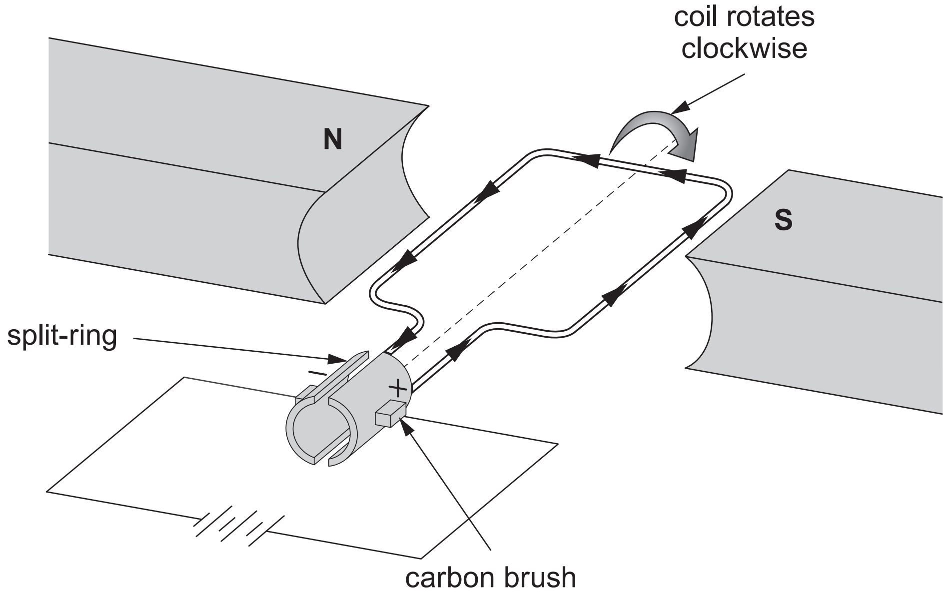
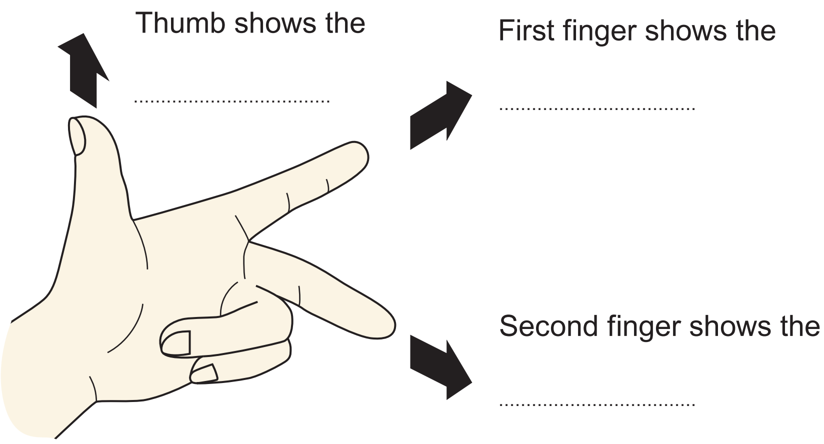
4. The diagram shows a simple d.c. motor.



The direction of the force on the coil is given by using Fleming's left-hand rule.

(a) **Complete** the labels on the diagram below using words from the box. [2]

CURRENT	**MAGNETIC FIELD**	**FORCE**



(b) State **two** ways of making the motor spin faster. [2]

1. ....

2. ....

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

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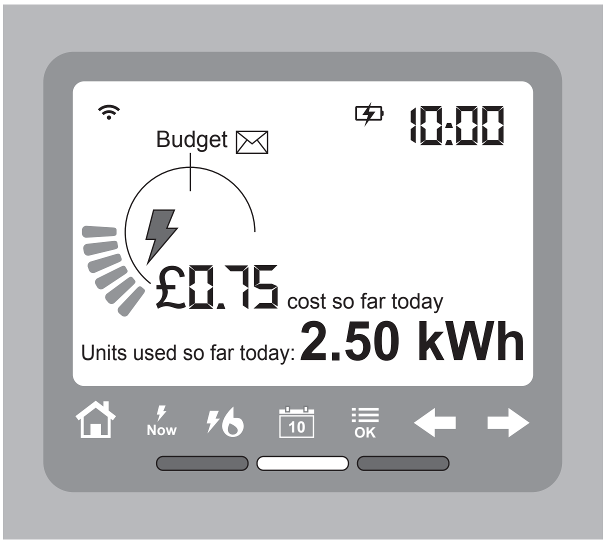
5. Smart meters are fitted into some houses to measure how much electricity is used. Householders can monitor and try to reduce their electricity use.
The diagram of the smart meter below shows the units used in **10 hours** from midnight to 10.00 am.



(a) (i) Use the equation:

$$\text{mean power (kW)} = \frac{\text{units used (kWh)}}{\text{time (h)}}$$

and information from the diagram to calculate the mean power of the appliances used in the 10 hours. [2]

mean power = ... kW

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(ii) I. State the cost of the electricity used in 10 hours in pence (p). [1]

cost = ... p

II. Use the equation:

$$\text{cost of 1 unit (p)} = \frac{\text{cost (p)}}{\text{units used (kWh)}}$$

to calculate the cost of 1 unit of electricity. [2]

cost of 1 unit = ... p

(b) Give **one** reason, **other than** to save money, why householders should be encouraged to reduce their electricity use. [1]

....

....

(c) Describe the function of an **earth wire**, a **fuse** and a **residual current circuit breaker (rccb)**.

Include in your answer:
- what they are each used to protect
- the fault that causes each of them to work. [6 QER]

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6. A teacher demonstrates heat transfer by infra-red radiation.

Experiment 1

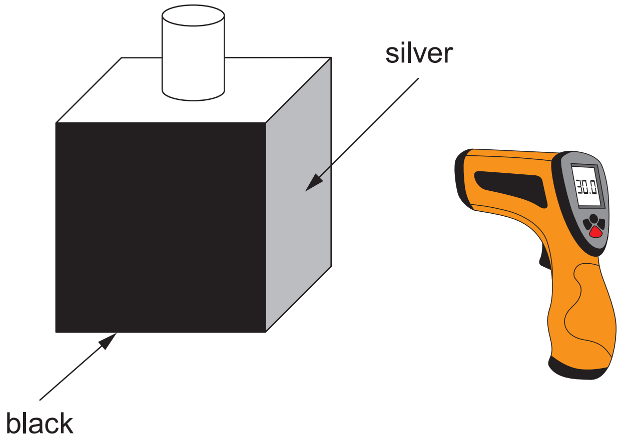
The teacher places a heater in between a black surface and a silver surface.

After a few minutes the temperature of each surface is recorded using an infra-red thermometer.

Experiment 2

The teacher fills the container with boiling water.

The infra-red thermometer is then used to take readings next to the side of the container which is black and the side which is silver.



Examiner only

The following results were obtained.

	Temperature (°C)	
	Black surface	Silver surface
Experiment 1	46	32

	Temperature (°C)	
	Black surface	Silver surface
Experiment 2	90	65

(a) Use the data to complete the following sentences.

(i) The .... surface is the better emitter of heat

as shown by the results for **Experiment** .... because ....

.... [2]

(ii) The .... surface is the better absorber of heat

as shown by the results for **Experiment** .... because ....

.... [2]

Examiner only

(b) Silver coating can be put on the outside of windows to help to keep houses cool in summer and warm in winter.

State why the silver coating helps to keep the house warm in the winter. [1]

....

....

(c) A family consider different methods of reducing their energy bills.
Data about these methods are given in the table below.

Method	Cost (£)	Yearly savings (£)
Cavity wall insulation	640	160
Loft insulation	480	160
Silver coating	500	25

(i) Calculate the payback time for the silver coating. [2]

payback time = ... years

 (3420U10-1)

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(ii) The family can only choose to fit one of the items.
Ieuan suggests that it is better to fit cavity wall insulation than loft insulation.
Use data from the table to explain whether you agree. [2]
Space for calculations.

....

....

....

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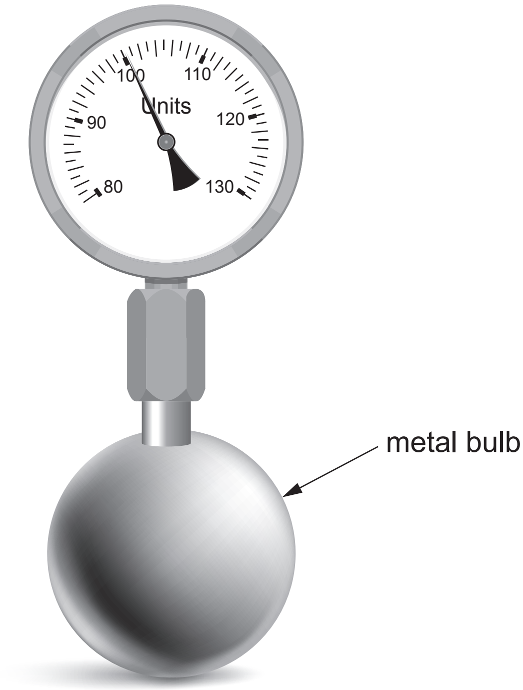
7. A teacher uses the apparatus shown below to demonstrate the link between the temperature and pressure of a gas.

The metal bulb, which is attached to a pressure gauge, contains a fixed volume of air.

The bulb is placed in a water bath and measurements of pressure for different temperatures are recorded.



(a) State the independent variable in this experiment. [1]

....

The following results were obtained.

Temperature (°C)	Pressure (units)
0	94
20	100
40	106
60	112
80	118

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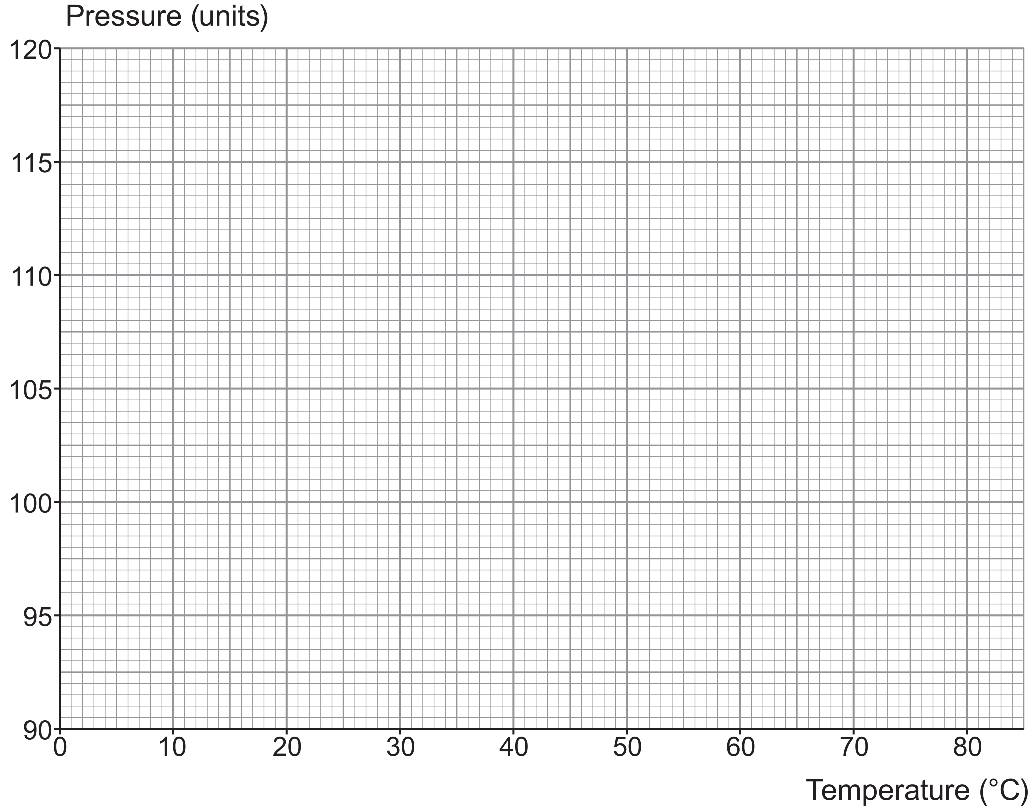
(b) (i) Plot the data on the grid below and draw a suitable line. [3]



(ii) Describe the relationship between the temperature and the pressure of the gas. [2]

....

....

Examiner only

(iii) I. Use information from the graph or the table to determine the decrease in pressure for every **10 °C** decrease in temperature. [2]

decrease in pressure = ... units

II. Use your answer to part I. above to determine the pressure of the gas at −10 °C. [1]

pressure = ... units

(iv) State the value of absolute zero in °C. [1]

absolute zero = ... °C

(c) The specific heat capacity of air, c, at constant volume is 720 J/kg °C.

Use the equation:

heat energy supplied = mass × specific heat capacity × change in temperature

$$Q = mc\Delta\theta$$

to calculate the heat energy required to raise the temperature of 0.05 kg of air **from** 20 °C **to** 60 °C. [2]

heat energy = ... J

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8. 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	[redacted]	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]

....

....

....

Examiner only

(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 = ...

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

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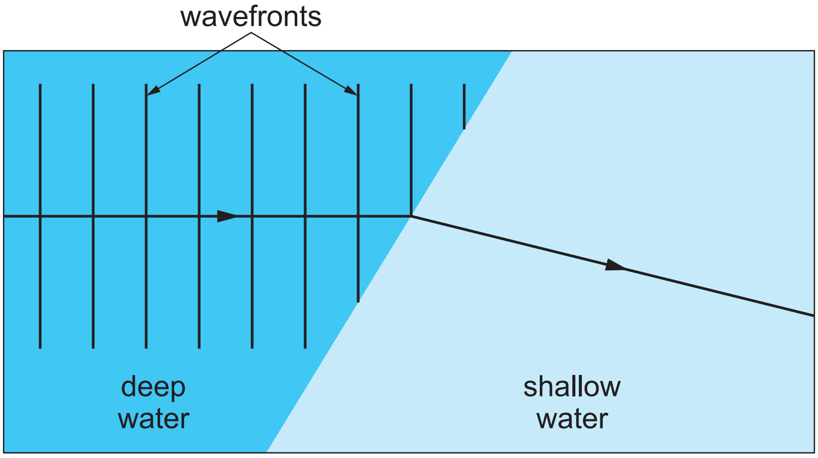
9. Water waves refract when they travel from deep water to shallow water.

Refraction happens because the speed of the wave changes.

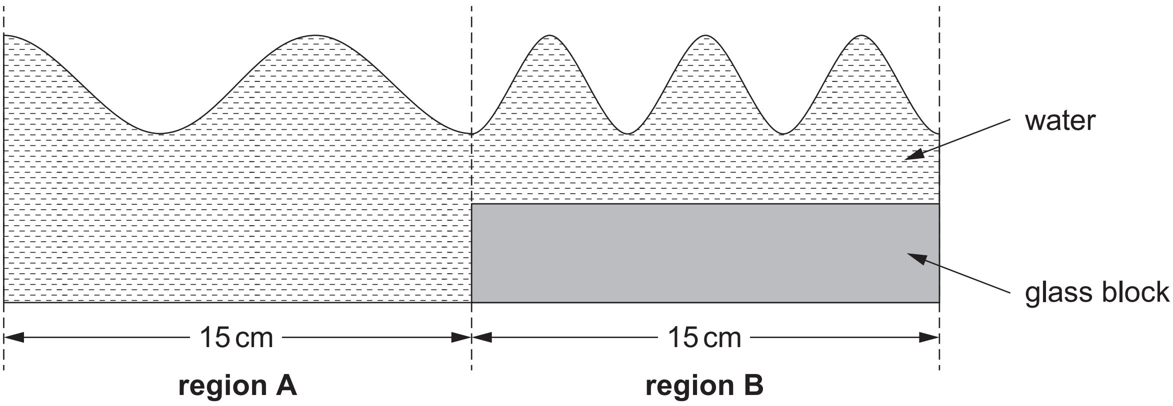
The wavelength also changes because the frequency is constant.

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

 (3420U10-1)

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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]

....

....

....

(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

TURN OVER FOR THE LAST PART OF THE QUESTION

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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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END OF PAPER

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

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