Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3420UA0-1

S24-3420UA0-1

MONDAY, 17 JUNE 2024 – 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.	**8**	
2.	**12**	
3.	**4**	
4.	**9**	
5.	**8**	
6.	**6**	
7.	**5**	
8.	**10**	
9.	**11**	
10.	**7**	
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 **6**.

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}
tera	T	multiply by 1 000 000 000 000	1×10^{12}

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Answer **all** questions.

1. (a) A group of students was asked to find the density of an object.
They made the following measurements.

mass of the object = 15 g
volume of water in measuring cylinder = 20 cm^3
volume of water and object = 25 cm^3

Use the results to answer the following questions.

(i) Calculate the volume of the object. [1]

volume = ... cm^3

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

density = ... g/cm^3

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(iii) The teacher said the object was made from one of the materials in the table below.

Material	Density (g/cm^3)
cork	0.2
magnesium	1.7
aluminium	2.7
steel	7.8
iron	7.8
copper	8.5
lead	11.3

Ffion thought the object was made of aluminium.
Use the data in the table to explain whether you agree with Ffion. [2]

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Examiner only

(b) The group is given a solid object that floats on water.
Describe how they would change the experiment to find the density of this object.
They still use the measuring cylinder partly filled with water. [3]

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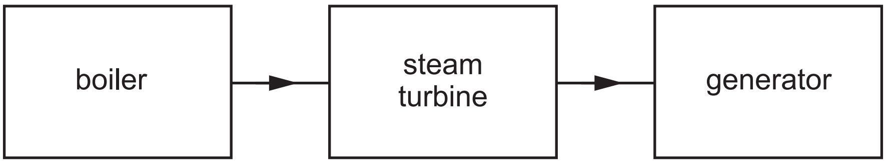
2. The block diagram below represents a fossil fuel power station.



(a) (i) Use the words in the block diagram to explain how electricity is generated in a fossil fuel power station. [3]

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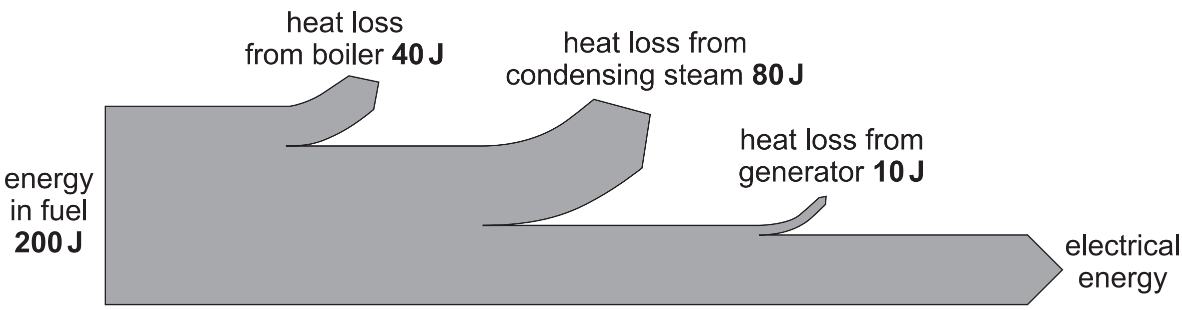
(ii) Neve says that fossil fuel power stations are about 35% efficient.
Jacob says they are less than 30% efficient.
Use the information in the Sankey diagram below and an equation from page 2 to explain whether you agree with Neve or Jacob. [3]



Space for calculation.

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 (3420UA0-1) **Turn over.**

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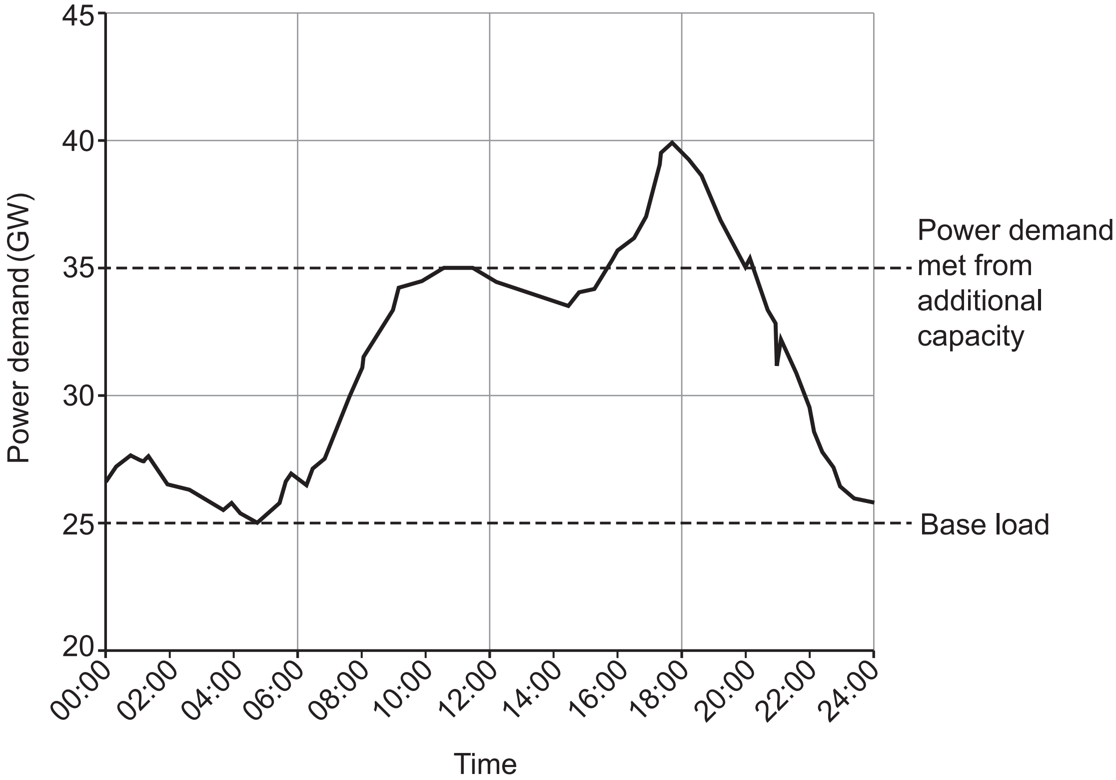
(b) Power stations are connected to the National Grid.
The power demand on a particular day is shown below.



(i) The graph shows that the base load is 25 GW. State what is meant by this. [1]

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(ii) State the peak power demand on the National Grid on the day shown in the graph. [1]

peak power demand = ... GW

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(iii) The Dinorwig power station is a pumped storage hydro-electric scheme.

Dinorwig has six 0.3 GW generators.
It is used to provide additional power once demand rises above 35 GW.
Once operating at maximum output, it can provide power for 6 hours before running out of water.

Rowan says that Dinorwig can provide power for the whole time that demand is over 35 GW.
However, he says that it will not be able to supply enough power to meet all the demand above 35 GW shown in the graph.
He also says that about 3 GW will need to be imported from overseas.

Explain whether you agree with Rowan.
Include data in your answer. [4]

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12

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3. Compare **P** and **S** seismic waves in terms of their:

(a) nature [2]

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(b) speed [1]

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(c) ability to penetrate different materials [1]

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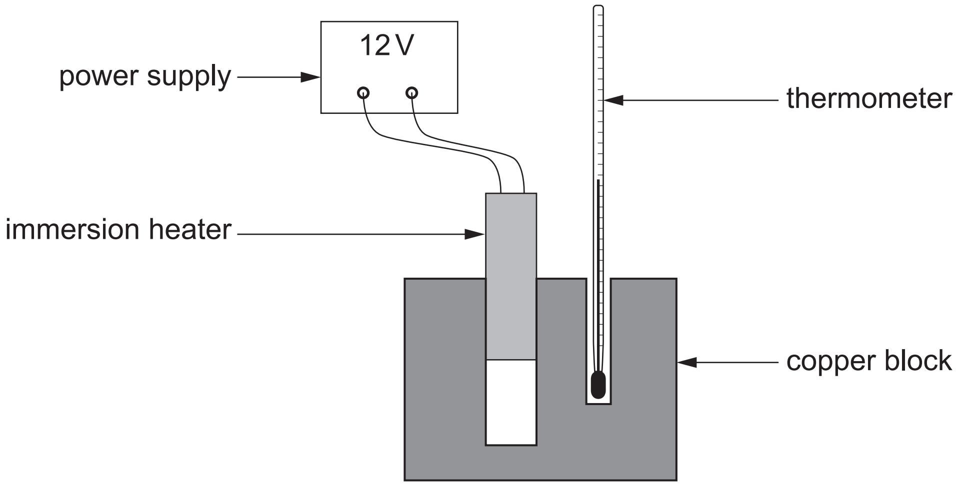
4. The apparatus used by a group of students to determine the specific heat capacity of copper is shown below.



(a) (i) The results from the experiment are given below.

Mass of the copper block = 0.5 kg
Temperature of the copper block at the start of the experiment = 19.5 °C
The energy supplied to the heater during the experiment = 5400 J
The temperature of the copper block after heating = 42.0 °C

Use an equation from page 2 to calculate the specific heat capacity of copper. [3]

specific heat capacity = ... J/kg °C

(ii) The true value of the specific heat capacity of copper is 385 J/kg °C.
Comment on the accuracy of the group's value. [2]

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Examiner only

(iii) State **two** improvements that could be made to this experiment that would lead to a more accurate value for the specific heat capacity of copper. [2]

1. ....

2. ....

(b) Explain what happens to the copper atoms when the block is heated. [2]

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9

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Turn over.

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5. A 30 kW gas boiler is used to provide heating and hot water in a house.

The energy released in one year by burning the gas is 22 000 kWh.

(a) Use the equation:

units used (kWh) = power (kW) × time (h)

to calculate the mean time of use **per day** of the gas boiler. [4]
(1 year = 365 days)

time of use per day = ... h

(b) A 3 m^2 solar water heating system costs £3600 and it is estimated to reduce gas consumption to 20 500 kWh per year.

Gas costs 12 p per kWh.

Use the equation:

cost = units used × cost per unit

to calculate the time to payback the cost of the solar water heating system. [4]

payback time = ... years

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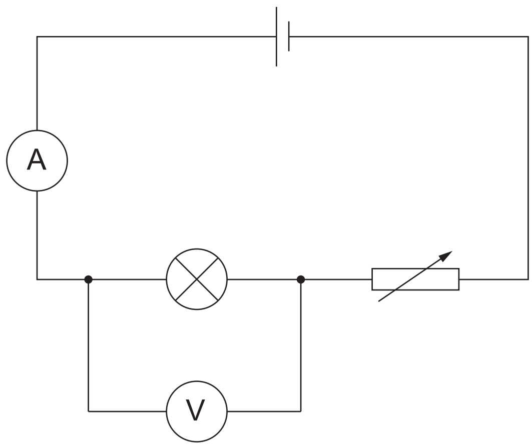
6. Describe how the current-voltage (I-V) characteristic of a filament lamp can be investigated using the following circuit. [6 QER]



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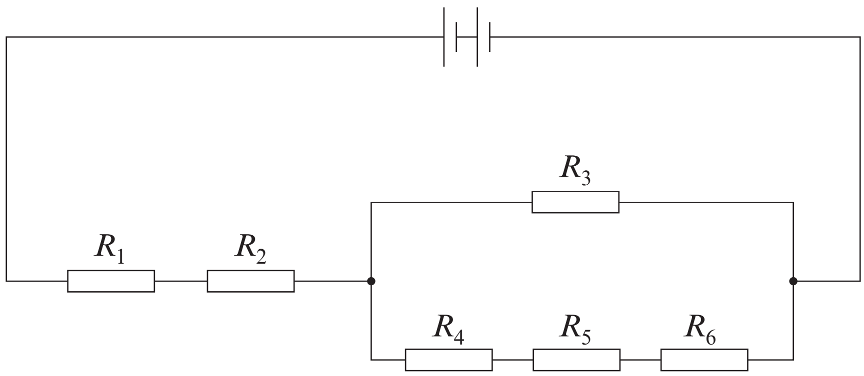
7. The diagram below shows six resistors connected to a battery.



The resistor values are given in the table below.

Resistor	R_1	R_2	R_3	R_4	R_5	R_6
Resistance (Ω)	60	80	300	160	120	170

Use equations on page 2 to answer the following questions:

(a) Calculate the total resistance of the series combination R_4, R_5 and R_6. [1]

total resistance of R_4, R_5 and R_6 = ... Ω

(b) Calculate the total resistance of R_3 combined in parallel with R_4, R_5 and R_6. [3]

total resistance of the parallel combination = ... Ω

(c) Calculate the total resistance of the circuit. [1]

total resistance of circuit = ... Ω

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8. The electromagnetic (em) spectrum consists of seven regions.
Two of these regions are infra-red and microwaves.
Some information about these regions is given in the table below.

Property	Infra-red	Microwaves
Wave speed in space (m/s)	....	....
Typical wavelength (m)	7.5×10^{-7}	....
Typical frequency (Hz)	4.0×10^{14}	3.0×10^{10}

(a) Use an equation from page 2 to **complete the table**. [4]
Space for working.

(b) Communication between the UK and USA can be made by optical fibres or by geostationary satellites.
An infra-red signal sent by optical fibre travels 9000 km and a microwave signal sent by satellite travels 72 000 km.

The speed of the microwave signal through space is 1.5 times the speed of the infra-red signal through glass.

(i) Compare these methods in terms of time delay between sending a signal from the UK and receiving the signal in the USA. [2]
Space for working.

....

....

(ii) Suggest **two** advantages of sending signals by optical fibre from the UK to the USA. [2]

1. ....

2. ....

Examiner only

(iii) A geostationary satellite stays directly above the same point on the Earth. It orbits in the same direction as the Earth spins.

State the **two** other conditions needed to achieve geostationary orbit. [2]

1. ....

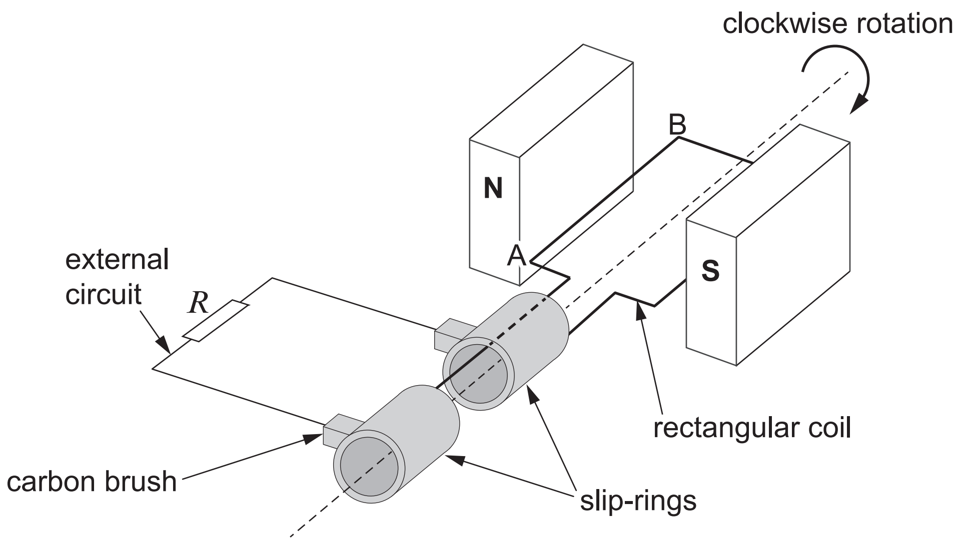
2. ....

10

Examiner only

9. Electromagnetic induction explains the operation of electric generators and transformers.

(a) The diagram shows an a.c. generator.



(i) Explain how Fleming's right hand rule is used to determine the direction of the induced current in the side labelled AB **and** state this direction. [3]

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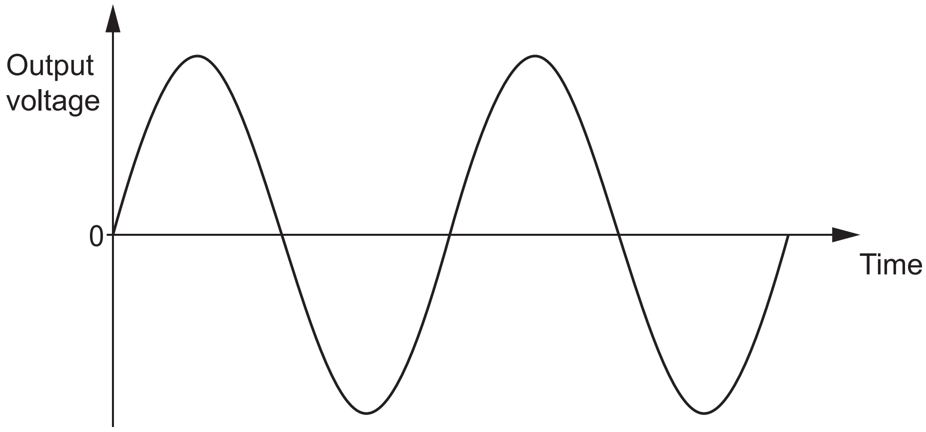
(ii) The output from an a.c. generator is shown in the graph below.



Three changes that could be made to a generator are listed in the first column of the table below.
Complete the table by placing **two** ticks (✓) in each row. [3]

Change	Effect on voltage			Effect on time for 1 cycle		
	Decreases	Stays the same	Increases	Decreases	Stays the same	Increases
Weaker magnets						
Coil spins faster						
More turns in the coil						

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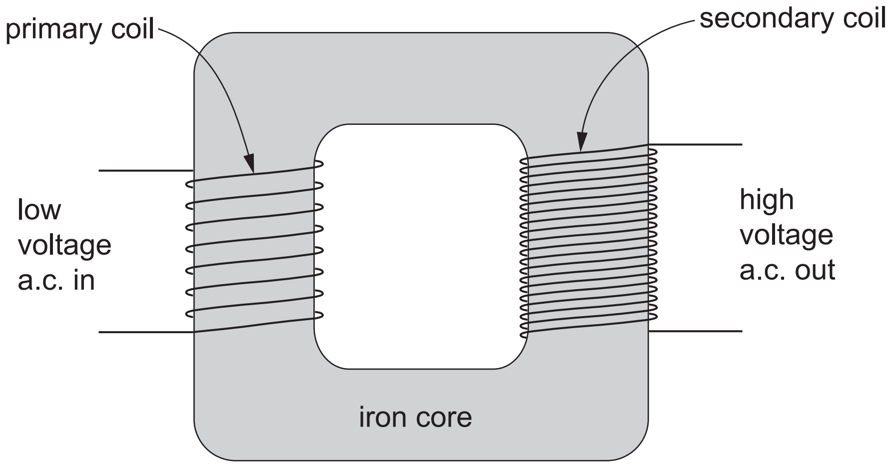
(b) The diagram shows a step-up transformer used in the National Grid.



(i) Explain how an alternating voltage applied to the primary coil produces an alternating voltage across the secondary coil. [2]

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(ii) A transformer increases voltage from 25 000 V to 400 000 V.
The primary coil contains 600 turns of wire.
Use an equation from page 2 to calculate the number of turns in the secondary coil, N_2. [3]

N_2 = ...

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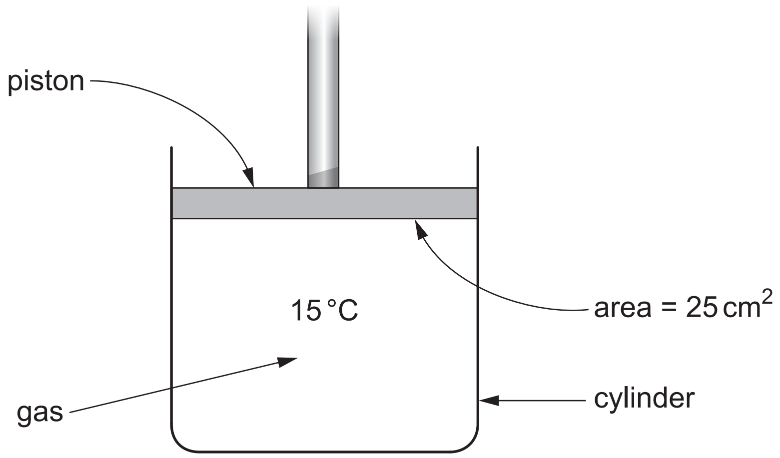
10. A piston holds 125 cm^3 of gas in a cylinder at a temperature of 15 °C.
The surface area of the lower surface of the piston is 25 cm^2.
The gas exerts a force of 250 N on this surface.



Use the information above to answer the following questions.

(a) Use an equation from page 2 to calculate the pressure of the gas inside the cylinder. [2]

pressure = ... N/cm^2

(b) The temperature of the gas increases to 298 K and the gas is compressed so the volume becomes 75 cm^3.

(i) Convert **15 °C** into K.
Use the equation: [1]

$$T/\text{K} = \theta/°\text{C} + 273$$

T = ... K

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(ii) Use the equation:

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

to calculate the new gas pressure. [4]

pressure = ... N/cm^2

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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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