



GCSE

3420UA0-1

MONDAY, 17 JUNE 2024 – MORNING

PHYSICS – Unit 1:
Electricity, Energy and Waves

HIGHER TIER

1 hour 45 minutes plus your additional time allowance

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

A separate Data Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

Write your name, centre number and candidate number in the spaces provided on the front cover.

Answer ALL questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional pages 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.

(Turn over)

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	

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 cm³

volume of water and object = 25 cm³

Use the results to answer the following questions.

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

volume = _____ cm³

- (ii) Use an equation from the separate data booklet to calculate the density of the object.
[2 marks]**

density = _____ g/cm³

(Turn over)

1 (a)(iii)

The teacher said the object was made from one of the materials in TABLE 1 in the separate diagram booklet.

Ffion thought the object was made of aluminium.

Use the data in the table to explain whether you agree with Ffion. [2 marks]

- 1 (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 marks]**

8

2 BLOCK DIAGRAM 2.1 in the separate diagram booklet 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 marks]

2 (a)(ii)

Neve says that fossil fuel power stations are about 35% efficient.

Jacob says they are less than 30% efficient.

Use the information in

SANKEY DIAGRAM 2.2 in the separate diagram booklet and an equation from the separate data booklet to explain whether you agree with Neve or Jacob. [3 marks]

Space for calculation.

(Turn over)

**2 (b) Power stations are connected to the National Grid.
The power demand on a particular day is shown in GRAPH 2.3 in the separate diagram booklet.**

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

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

peak power demand = _____ GW

2 (b)(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 GRAPH 2.3.

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 marks]

continue your answer on the next page

(Turn over)

10

12

(Turn over)

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

(a) nature [2 marks]

(b) speed [1 mark]

(c) ability to penetrate different materials [1 mark]

4

(Turn over)

- 4** The apparatus used by a group of students to determine the specific heat capacity of copper is shown in **DIAGRAM 4** in the separate diagram booklet.

- (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 the separate data booklet to calculate the specific heat capacity of copper. [3 marks]

specific heat capacity = _____ J/kg °C

(Turn over)

4 (a)(ii)

The true value of the specific heat capacity of copper is $385 \text{ J/kg } ^\circ\text{C}$.

Comment on the accuracy of the group's value. [2 marks]

(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 marks]

1.

2.

(Turn over)

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

9

- 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 marks]
(1 year = 365 days)**

time of use per day = _____ h

- 5 (b) A 3 m² 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 marks]

payback time = _____ years

8

(Turn over)

6 Describe how the current-voltage ($I-V$) characteristic of a filament lamp can be investigated using the circuit shown in DIAGRAM 6 in the separate diagram booklet. [6 marks QER]

[illegible]

6

- 7** **DIAGRAM 7.1** in the separate diagram booklet shows six resistors connected to a battery.

The resistor values are given in **TABLE 7.2** in the separate diagram booklet.

Use equations from the separate data booklet to answer the following questions:

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

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 marks]

total resistance of
the parallel combination = _____ Ω

(Turn over)

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

total resistance of circuit = _____ Ω

5

- 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 **TABLE 8** in the separate diagram booklet.
- (a)** Use an equation from the separate data booklet to **COMPLETE THE TABLE**. [4 marks]
Space for working.

- 8 (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 marks]**

Space for working.

8 (b)(ii)

**Suggest TWO advantages of sending signals by optical fibre from the UK to the USA.
[2 marks]**

1. _____

2. _____

**(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 marks]

1. _____

2. _____

- 9 Electromagnetic induction explains the operation of electric generators and transformers.**
- (a) DIAGRAM 9.1 in the separate diagram booklet 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 marks]**

9 (a)(ii)

The output from an a.c. generator is shown in **GRAPH 9.2** in the separate diagram booklet.

Three changes that could be made to a generator are listed in the first column of **TABLE 9.3** in the separate diagram booklet. Complete the table by placing **TWO** ticks (✓) in each row. [3 marks]

(b) DIAGRAM 9.4 in the separate diagram booklet 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 marks]

9 (b)(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 the separate data booklet to calculate the number of turns in the secondary coil, N_2 . [3 marks]

$N_2 =$ _____

11

(Turn over)

- 10 **DIAGRAM 10** shows a piston holding 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 the separate data booklet to calculate the pressure of the gas inside the cylinder. [2 marks]

pressure = _____ N/cm^2

10 (b) The temperature of the gas increases to 298 K and the gas is compressed so the volume becomes 75 cm³.

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

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

$T =$ _____ K

10 (b)(ii)

Use the equation:

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

to calculate the new gas pressure. [4 marks]

pressure = _____ N/cm²

7

END OF PAPER

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

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

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

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

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



GCSE

3420UA0-1

MONDAY, 17 JUNE 2024 – MORNING

PHYSICS – Unit 1:

Electricity, Energy and Waves

HIGHER TIER

1 hour 45 minutes plus your additional time allowance

DIAGRAM BOOKLET

This Diagram Booklet MUST be handed in to the invigilators and sent for marking.

Surname _____

First name(s) _____

Centre Number _____

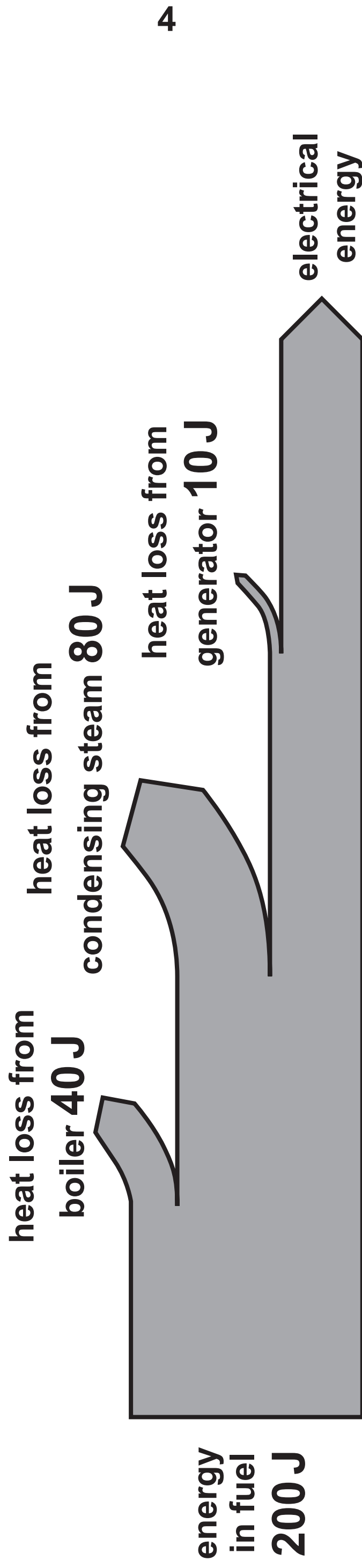
Candidate Number 0 _____

TABLE 1

Material	Density (g/cm³)
cork	0.2
magnesium	1.7
aluminium	2.7
steel	7.8
iron	7.8
copper	8.5
lead	11.3

BLOCK DIAGRAM 2.1

SANKEY DIAGRAM 2.2



GRAPH 2.3

Power demand (GW)

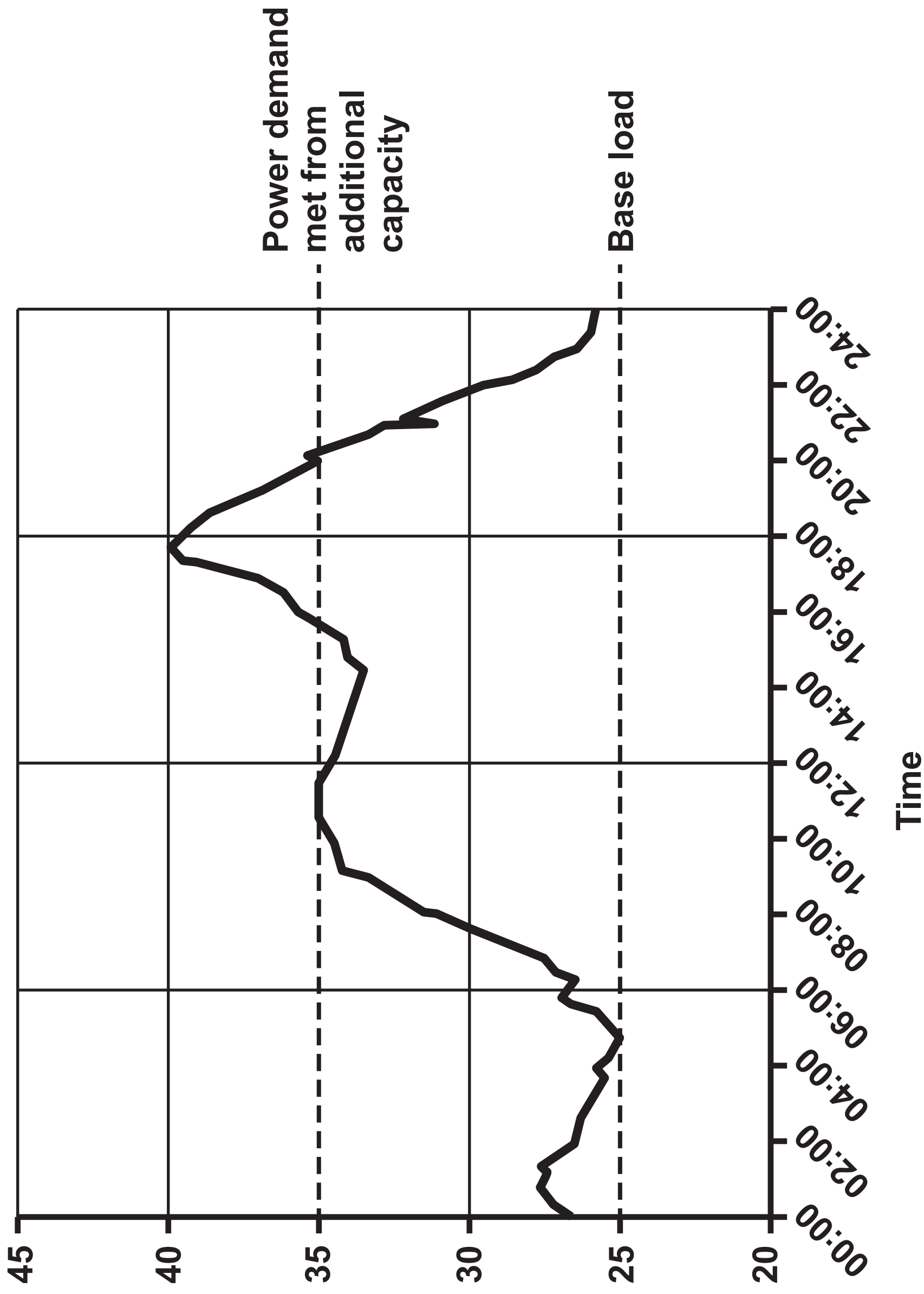


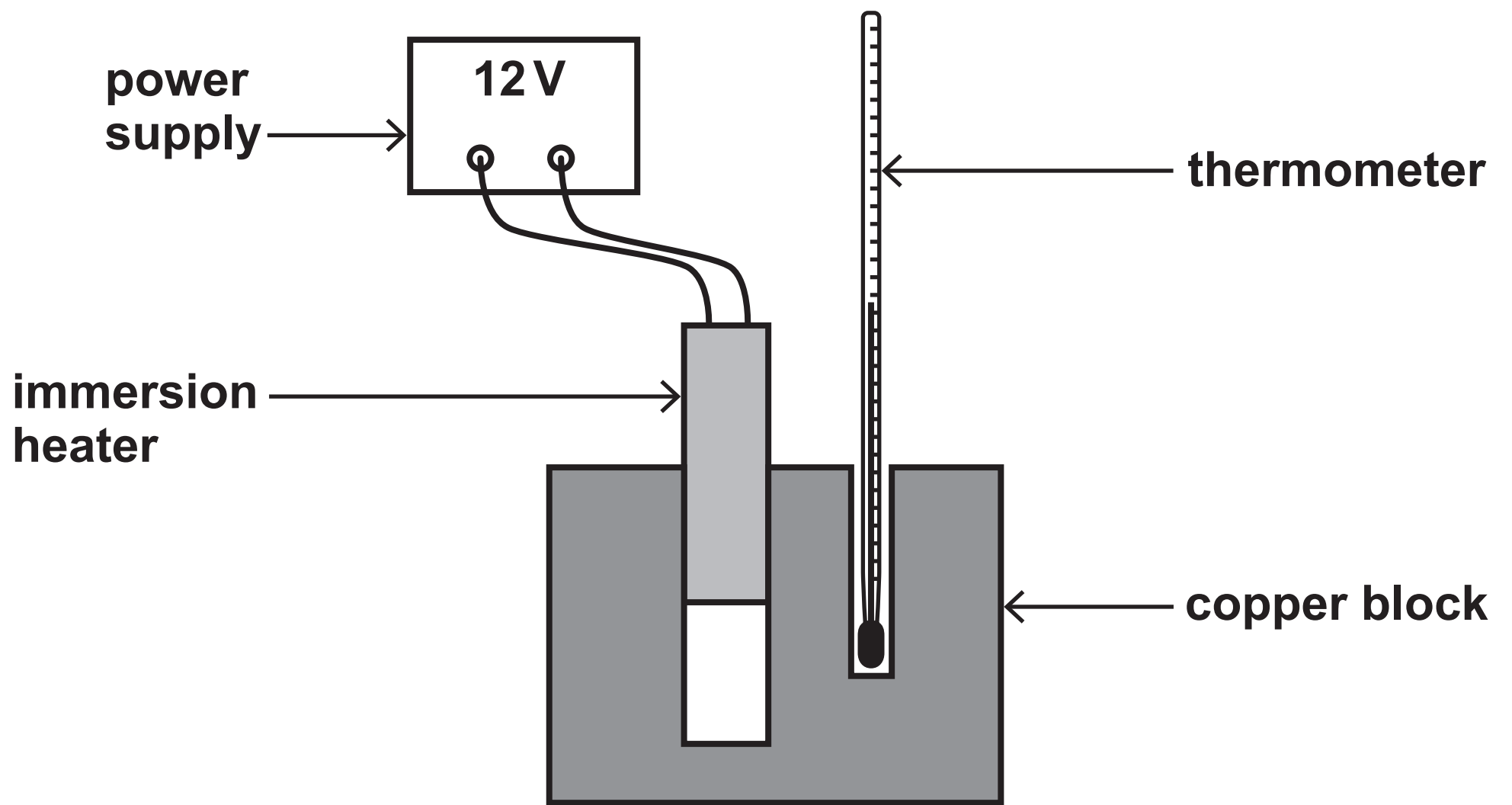
DIAGRAM 4

DIAGRAM 6

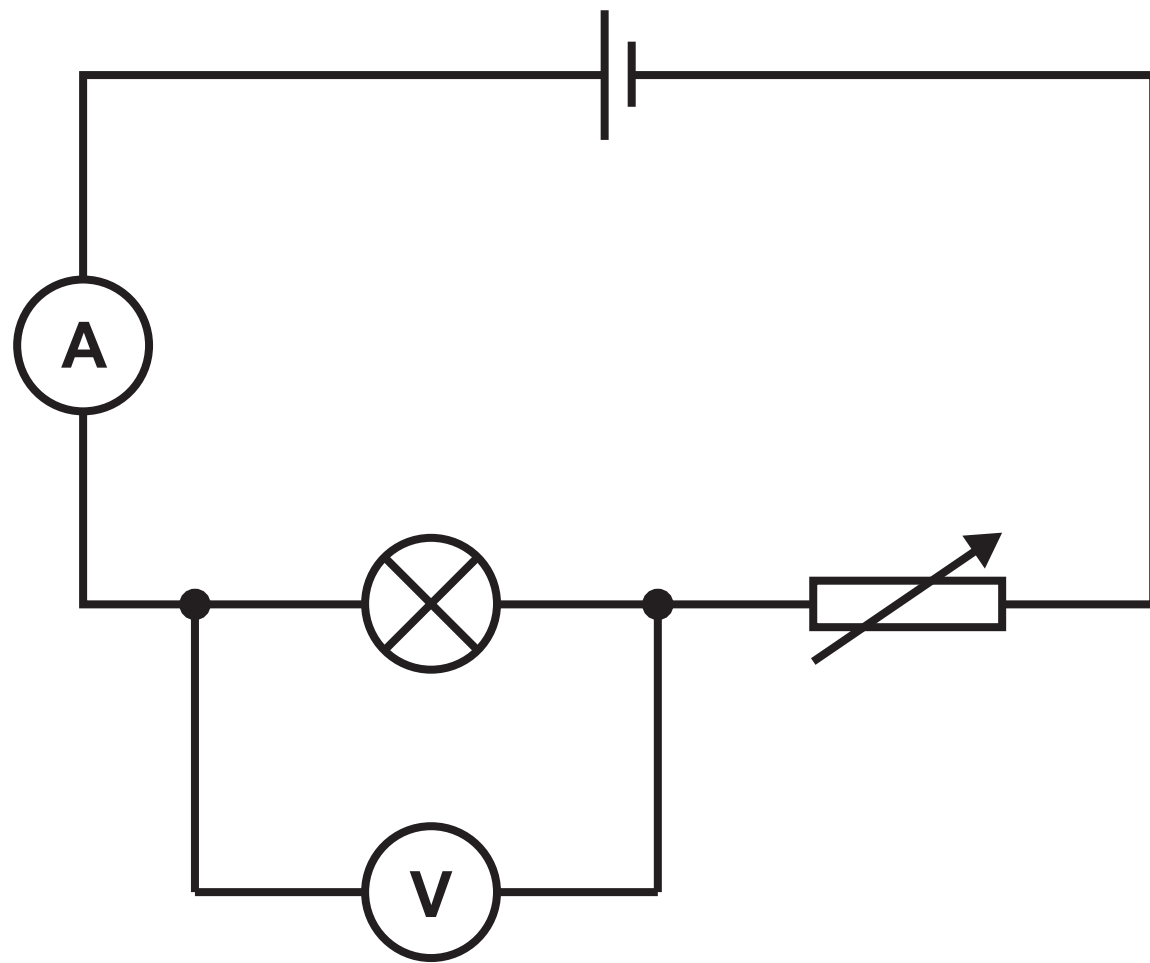


DIAGRAM 7.1

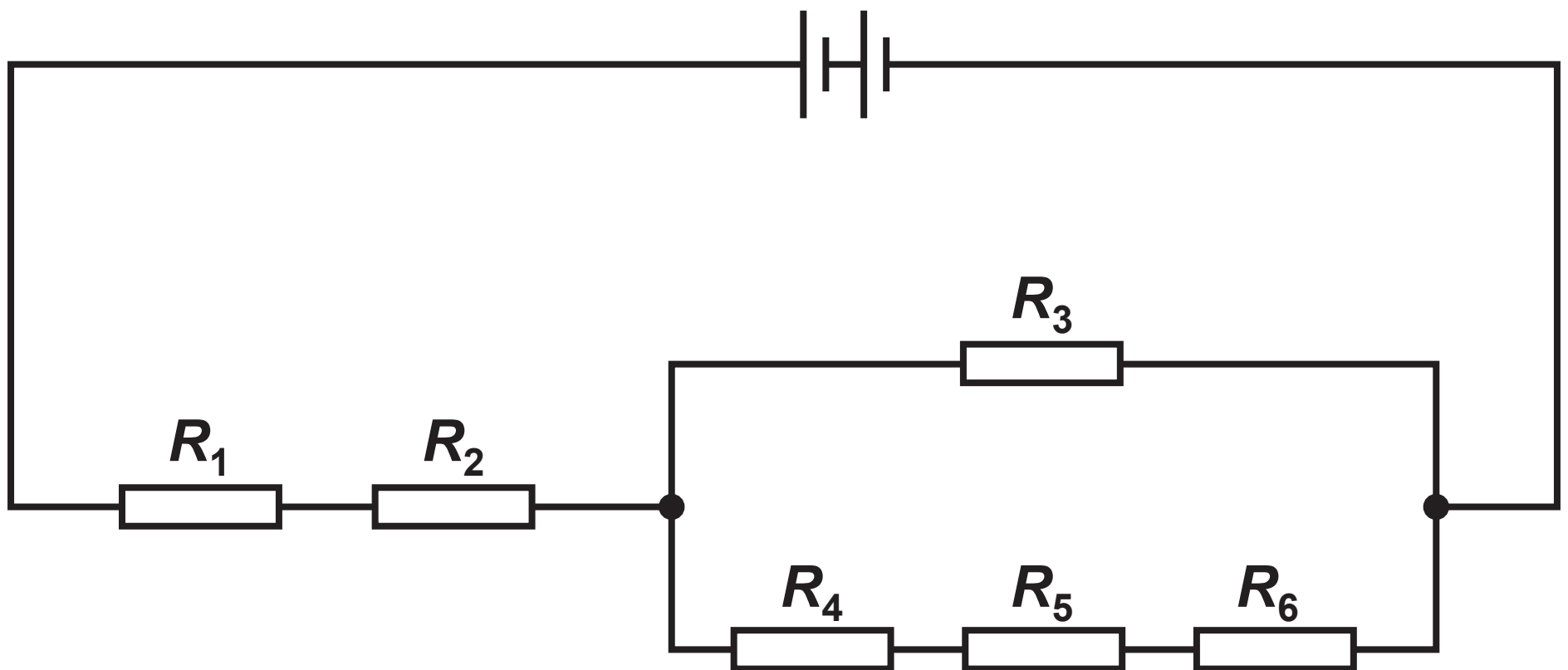


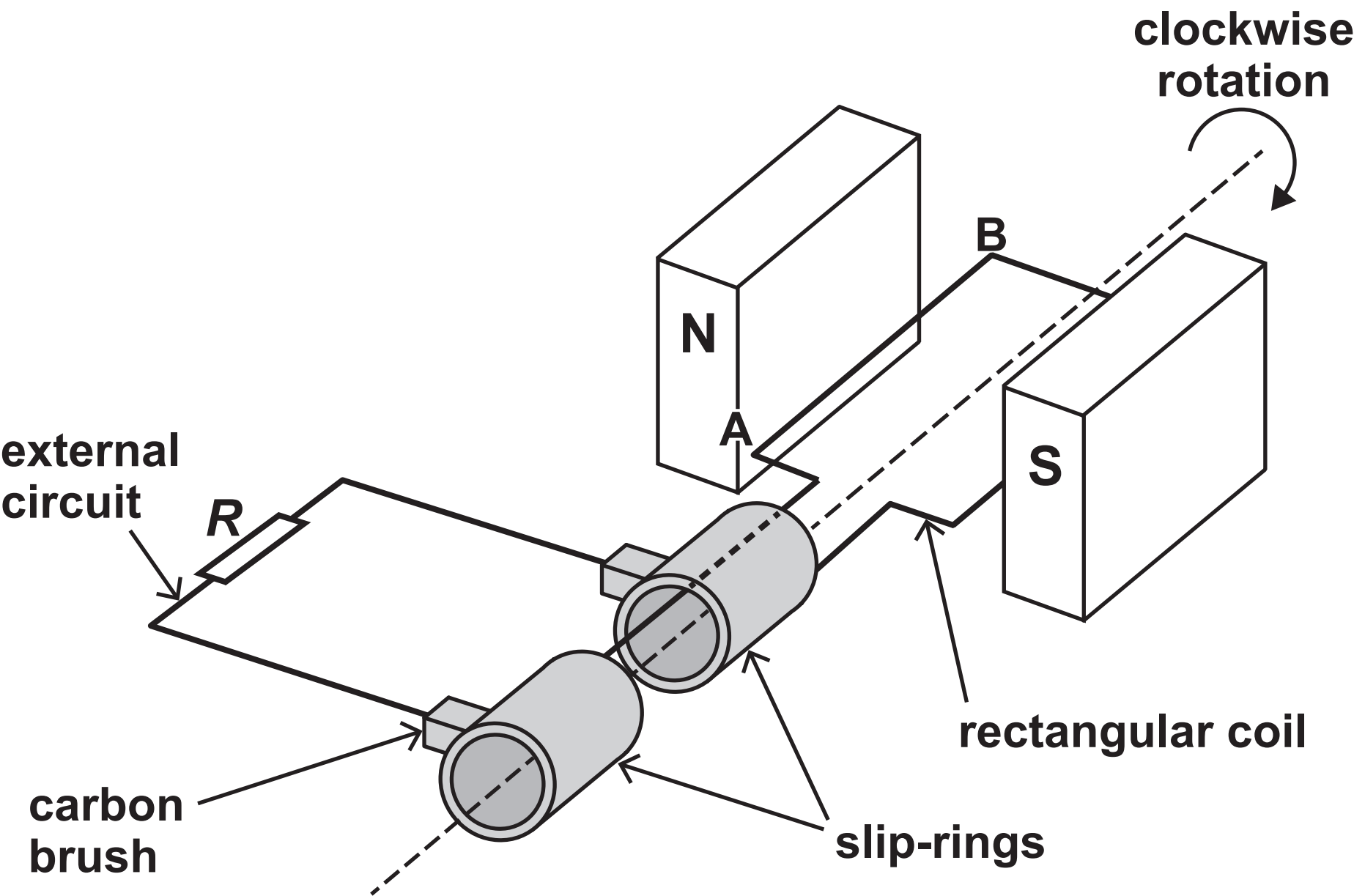
TABLE 7.2

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

TABLE 8

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}

DIAGRAM 9.1



THIS IS A BLANK PAGE
TURN OVER

GRAPH 9.2
Output voltage

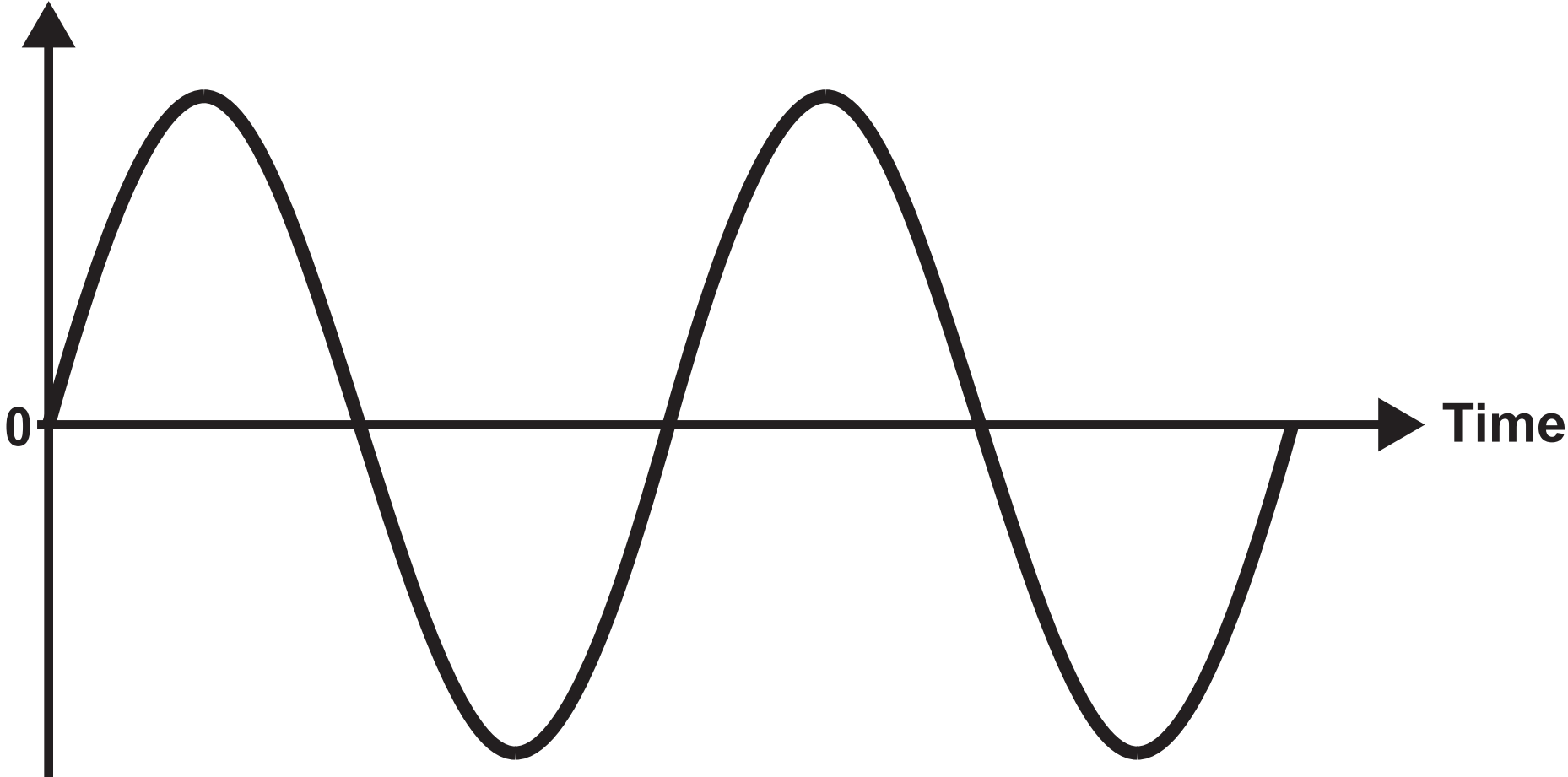


TABLE 9.3

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						

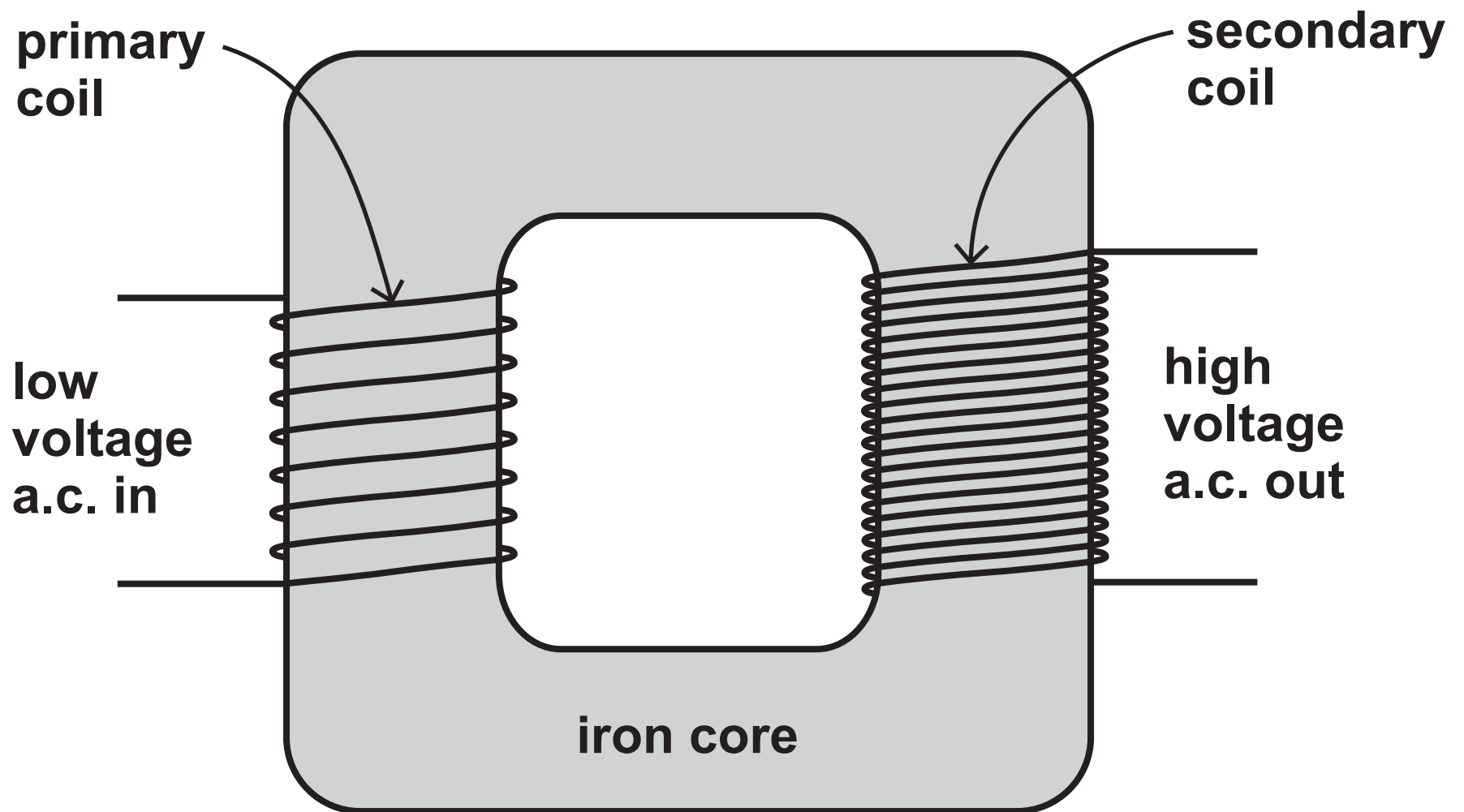
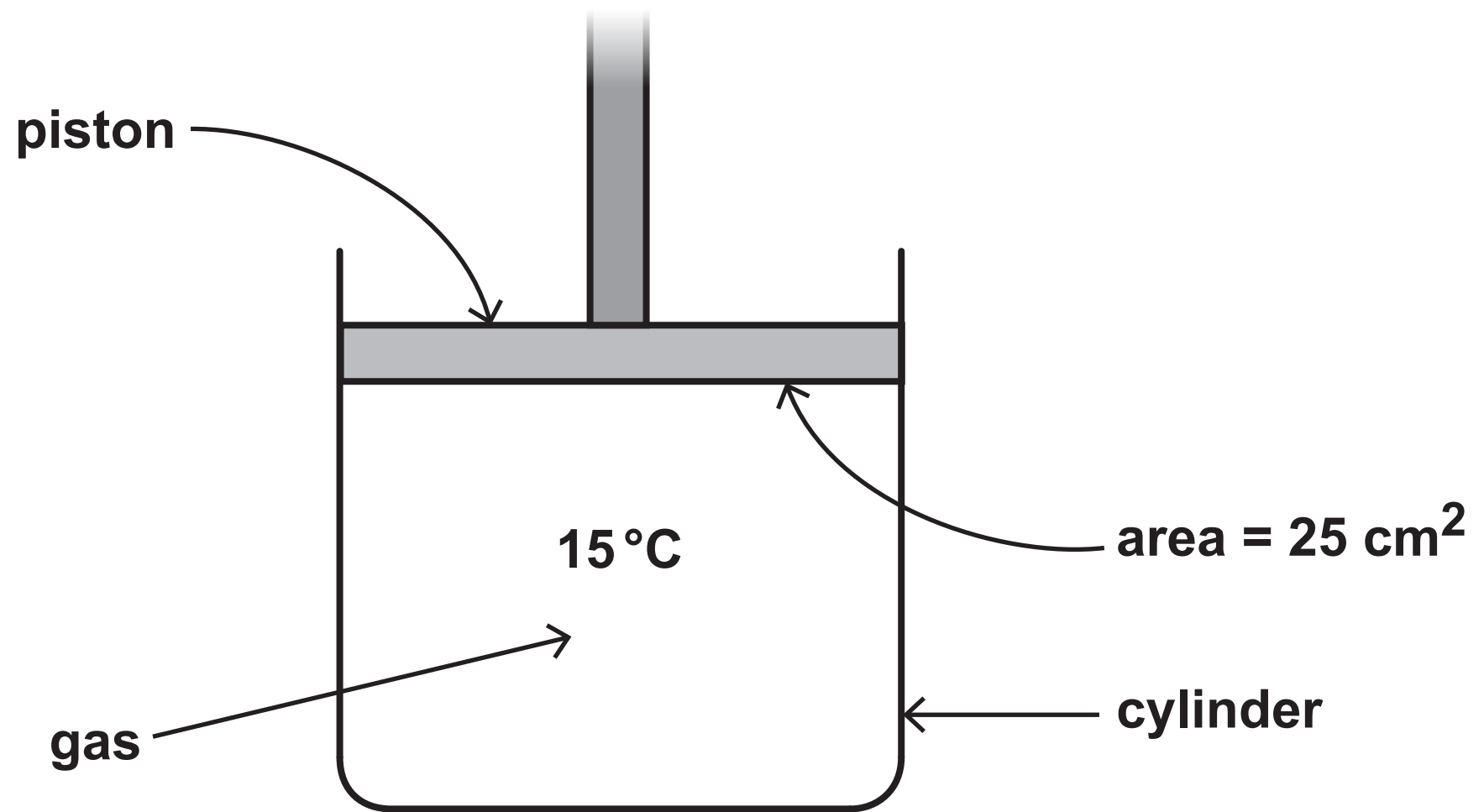
DIAGRAM 9.4

DIAGRAM 10





GCSE

3420UA0-1

MONDAY, 17 JUNE 2024 – MORNING

PHYSICS – Unit 1:

Electricity, Energy and Waves

HIGHER TIER

Data Booklet

Equations and SI multipliers

THIS IS A BLANK PAGE
TURN OVER

EQUATIONS

$$\text{current} = \frac{\text{voltage}}{\text{resistance}} \quad I = \frac{V}{R}$$

$$\text{total resistance in a series circuit} \quad R = R_1 + R_2$$

$$\text{total resistance in a parallel circuit} \quad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\text{energy transferred} = \text{power} \times \text{time} \quad E = Pt$$

$$\text{power} = \text{voltage} \times \text{current} \quad P = VI$$

$$\text{power} = \text{current}^2 \times \text{resistance} \quad P = I^2R$$

$$\% \text{ efficiency} = \frac{\text{energy [or power] usefully transferred}}{\text{total energy [or power] supplied}} \times 100$$

$$\text{density} = \frac{\text{mass}}{\text{volume}} \quad \rho = \frac{m}{V}$$

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

$$\text{cost} = \text{units used} \times \text{cost per unit}$$

$$\text{wave speed} = \text{wavelength} \times \text{frequency} \quad v = \lambda f$$

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{pressure} = \frac{\text{force}}{\text{area}} \quad p = \frac{F}{A}$$

$$\begin{aligned} p &= \text{pressure} \\ V &= \text{volume} \\ T &= \text{kelvin temperature} \end{aligned} \quad \frac{pV}{T} = \text{constant}$$

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

$$\begin{aligned} \text{change in} & & & & & & \\ \text{thermal} & = \text{mass} \times & \text{specific} & \times & \text{change in} & & \Delta Q = mc\Delta\theta \\ \text{energy} & & \text{heat} & & \text{temperature} & & \\ & & \text{capacity} & & & & \end{aligned}$$

$$\begin{aligned} \text{thermal energy for} & & & & & & \\ \text{a change of state} & = \text{mass} \times & \text{specific} & & & & Q = mL \\ & & & \text{latent heat} & & & \end{aligned}$$

$$\begin{aligned} \text{force on a} & & & & & & \\ \text{conductor} & & & & & & \\ \text{(at right angles} & = & \text{magnetic} & \times & \text{current} \times \text{length} & & F = BIl \\ \text{to a magnetic} & & \text{field} & & & & \\ \text{field) carrying a} & & \text{strength} & & & & \\ \text{current} & & & & & & \end{aligned}$$

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
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}