wjec cbac

GCSE

3420UA0-1

MONDAY, 19 JUNE 2023 – AFTERNOON

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 ______________________

PJ/DJ*(Y21-3420UA0-1) MLP

ADDITIONAL MATERIALS

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

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram 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 3.

(Turn over)

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	7	
2.	13	
3.	6	
4.	11	
5.	7	
6.	11	
7.	14	
8.	11	
Total	80	

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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 parellel 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 $v = \lambda f$

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

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

p = pressure
V = volume
T = kelvin temperature

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

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 $Q = mL$

(Turn over)

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

Answer ALL questions.

1 **TABLE 1.1 in the separate diagram booklet 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.**

(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 marks]**

(Turn over)

1 (a)(ii)

The energy sources for different types of power station are FOSSIL FUEL, NUCLEAR and HYDROELECTRIC.

COMPLETE TABLE 1.2 in the separate diagram booklet for the energy sources for types A, B, C and D. [3 marks]

Each energy source may be used once, more than once, or not at all.

1 (b) **Use the information below and an equation from pages 3 to 5 to calculate the % efficiency of a TYPE B power station. [2 marks]**

Input energy = 200 000 MJ

Heat energy produced = 30 000 MJ

Electrical energy produced = 170 000 MJ

% efficiency = ________

7

2 **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 DIAGRAM 2.1 in the separate diagram booklet to show the water waves in shallow water. [3 marks]**

(Turn over)

2 (b) The depth of the shallow water can be changed by using glass blocks of different thicknesses.

Look at DIAGRAM 2.2 in the separate diagram booklet. Regions A and B are both 15 cm long.

(i) I. How many waves are shown in REGION A? [1 mark]

____

II. Calculate the wavelength of the waves in REGION A. [1 mark]

wavelength = ____________ cm

(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 marks]

____

____

____

____

____

(Turn over)

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.

TABLE 2.3 in the separate diagram booklet shows their results.

(i) COMPLETE TABLE 2.3. [1 mark]

(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 marks]

wavelength = ___________ cm

(Turn over)

2 (c)(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 marks]

Space for calculations.

____

____

____

13

3 A saucepan is used to heat water on a gas cooker.

Explain, IN TERMS OF PARTICLES, the processes of conduction through the metal base of the saucepan AND convection in the water. [6 marks QER]

continue answer on the next page

(Turn over)

6

4 One type of petrol car costs £12 500 to buy. The equivalent model as an electric car costs £24 500.

(a) The electric car travels 240 km on a full charge.
It takes 8 hours to fully charge the electric car battery.
A home charging point is rated at 7 kW.
Homes are charged 30 p for each kWh of electricity used.

Use the information above and equations from pages 3 to 5 to calculate the cost, IN £, to travel 240 km. [3 marks]

charging cost for 240 km = £ ____________

(Turn over)

4 (b) Fuel consumption for the petrol car is 15 km / l (kilometres per litre).

The cost of petrol is £1.60 per litre.

(i) Calculate the fuel cost if the petrol car is driven 240 km. [2 marks]

fuel cost for 240 km = £ ___________

(Turn over)

4 (b)(ii)

Both cars are driven 14 400 km per year.

I. Calculate the difference in running costs for one year. [2 marks]

difference in running costs per year = £ ____________

II. Calculate the payback time of the EXTRA COST if the electric car is bought instead of the petrol car. [2 marks]

payback time = __________ years

(Turn over)

4 (c) **It is often claimed that electric cars are environmentally friendly because they do not produce greenhouse gases when used. Explain whether you agree. [2 marks]**

11

5 **TABLE 5.1 in the separate diagram booklet gives examples of transverse and longitudinal waves.**

(a) **Describe the difference between transverse and longitudinal waves. [2 marks]**

(Turn over)

5 (b) Light waves can travel through an optical fibre in the way shown in DIAGRAM 5.2 in the separate diagram booklet.

(i) Name the effect where light changes direction as shown at point A. [1 mark]

____

____

(ii) Explain why light waves travel through the fibre as shown. [2 marks]

____

____

____

____

____

(Turn over)

5 (c) DIAGRAM 5.3 in the separate diagram booklet shows an S wave shadow zone.

Explain how this led to the development of a model for the structure of the Earth. [2 marks]

7

(Turn over)

6 **Kinetic theory is used to explain the behaviour of gases.**

(a) **Look at DIAGRAM 6.1 in the separate diagram booklet.**
A fixed mass of gas is kept at a constant temperature in a container.
Explain why the pressure increases when its volume is decreased. [3 marks]

(Turn over)

6 (b) Students are given data about the behaviour of a fixed mass of gas kept at CONSTANT PRESSURE. The volume of the gas changes with temperature as shown in TABLE 6.2 in the separate diagram booklet.

(i) Chris states that

$$\frac{\text{volume}}{\text{temperature}} = \text{constant}$$

when temperatures are measured in °C.
Explain whether the results agree. [2 marks]
Space for calculations.

6 (b)(ii)

The students plot a graph of the results in TABLE 6.2. Explain how they can use the graph to determine the value of absolute zero in °C. [2 marks]

(Turn over)

6 (c) **A balloon is filled to a volume of 2800 cm^3 at 7 °C (280 K).**
The balloon is heated to a temperature of 67 °C.
The pressure remains constant.

Use the equation:

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

to calculate the new volume of the balloon.
[4 marks]
[T (K) = θ (°C) + 273]

volume = ____________ cm^3

11

7 **Look at DIAGRAM 7.1 in the separate diagram booklet. The circuit is used to investigate how the resistance of a thermistor changes as temperature increases.**

(a) **ADD AN AMMETER AND A VOLTMETER to the diagram so the necessary measurements can be taken. [2 marks]**

(b) **On GRAPH 7.3 in the separate diagram booklet, PLOT THE RESULTS SHOWN in TABLE 7.2 and draw a curve of best fit. [2 marks]**

(c) **The resistance of the resistor, *R*, remains constant at 40 Ω.**

(i) **Calculate the voltage across the terminals AB when the temperature is 100 °C. [3 marks]**

voltage = ________ V

(Turn over)

7 (c)(ii)

Tom says as temperature increases the current increases.
Explain whether you agree. [2 marks]

____

____

____

____

____

(d) A lamp and a switch are now connected across the terminals AB, as shown in DIAGRAM 7.4 in the separate diagram booklet.

(i) The lamp has a power of 3 W at 12 V.
Use equations from pages 3 to 5 to calculate the resistance of the lamp at this power and voltage. [3 marks]

resistance = ____________ Ω

7 (d)(ii)

The switch, S, is now closed. Explain, without calculation, what happens to the total resistance of the circuit. [2 marks]

14

8 **Transformers are used to change the size of an a.c. voltage.**

(a) **Describe how the apparatus in DIAGRAM 8.1 in the separate diagram booklet is used to investigate the effect of the number of turns on the secondary coil on the output of a transformer. [4 marks]**

(Turn over)

8 (b) Explain why transformers only change a.c. voltages. [2 marks]

(c) Explain how step-up transformers increase the efficiency of the National Grid system. [2 marks]

(Turn over)

8 (d) A transformer is used to reduce the 230 V mains voltage to 11.5 V to run a television. The primary coil of the transformer has 600 turns. Use an equation from pages 3 to 5 to calculate the number of turns on the secondary coil. [3 marks]

number of turns = ______________

11

END OF PAPER

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

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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) ______________________________

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Candidate Number 0 ______________________________

PJ/DJ*(Y21-3420UA0-1) MLP

TABLE 1.1

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

TABLE 1.2

Type	Energy source
A	______________________
B	______________________
C	______________________
D	______________________

DIAGRAM 2.1

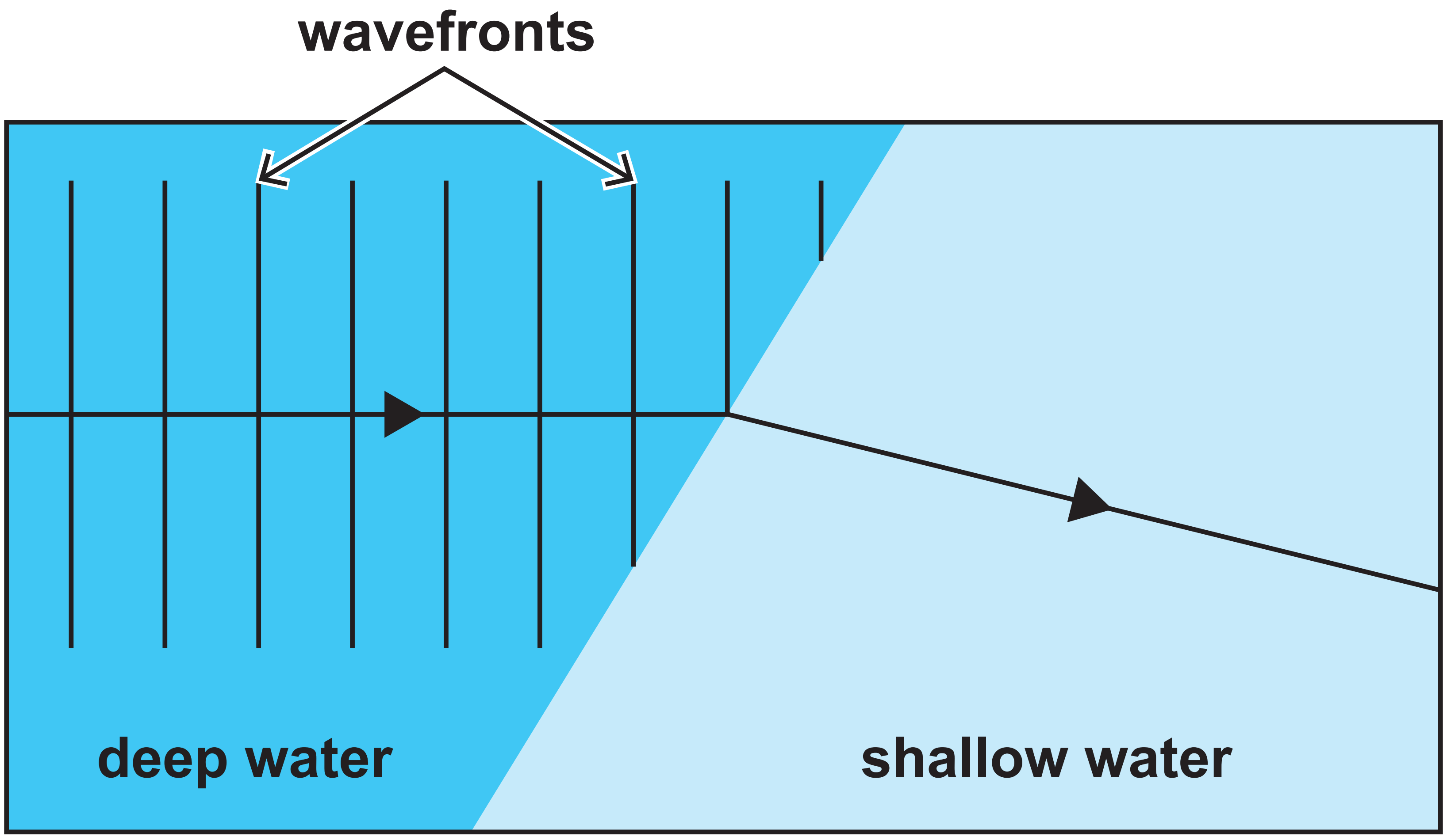

DIAGRAM 2.2

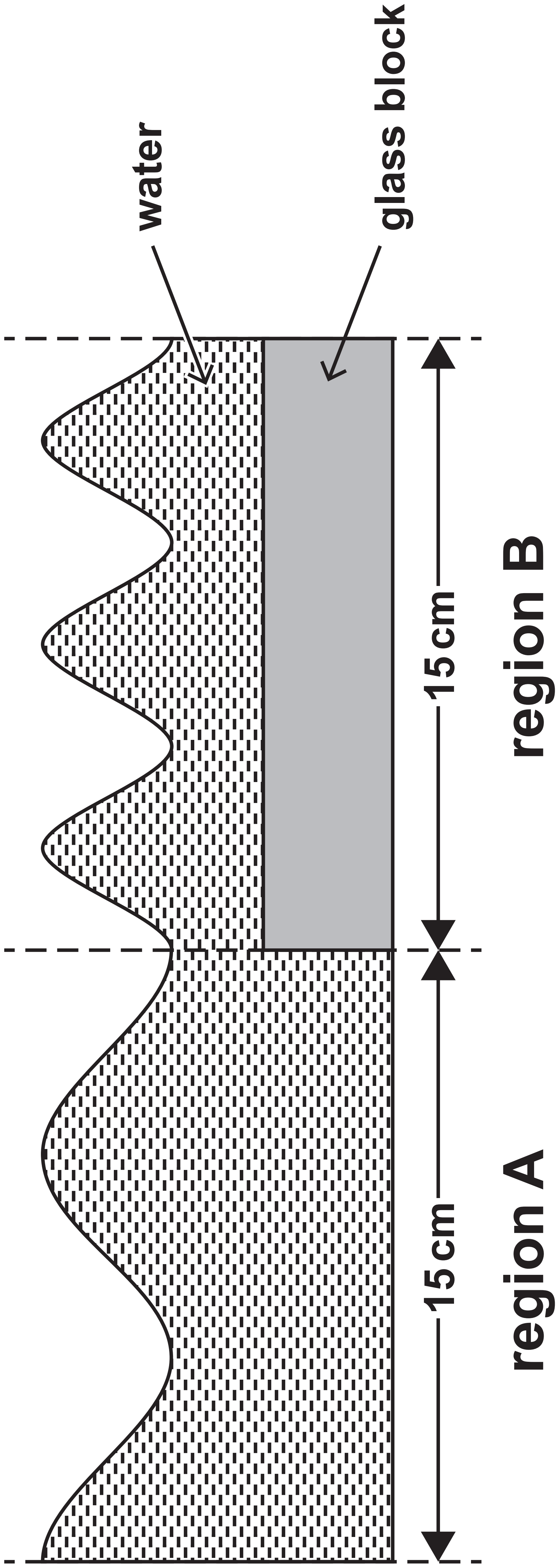

TABLE 2.3

Thickness of glass block (cm)	Depth of water (cm)	Wave speed (cm/s)
8	2	60
6	4	75
4	______________	82

TABLE **5.1**

Transverse waves	Longitudinal waves
light	sound
S waves	P waves

DIAGRAM **5.2**

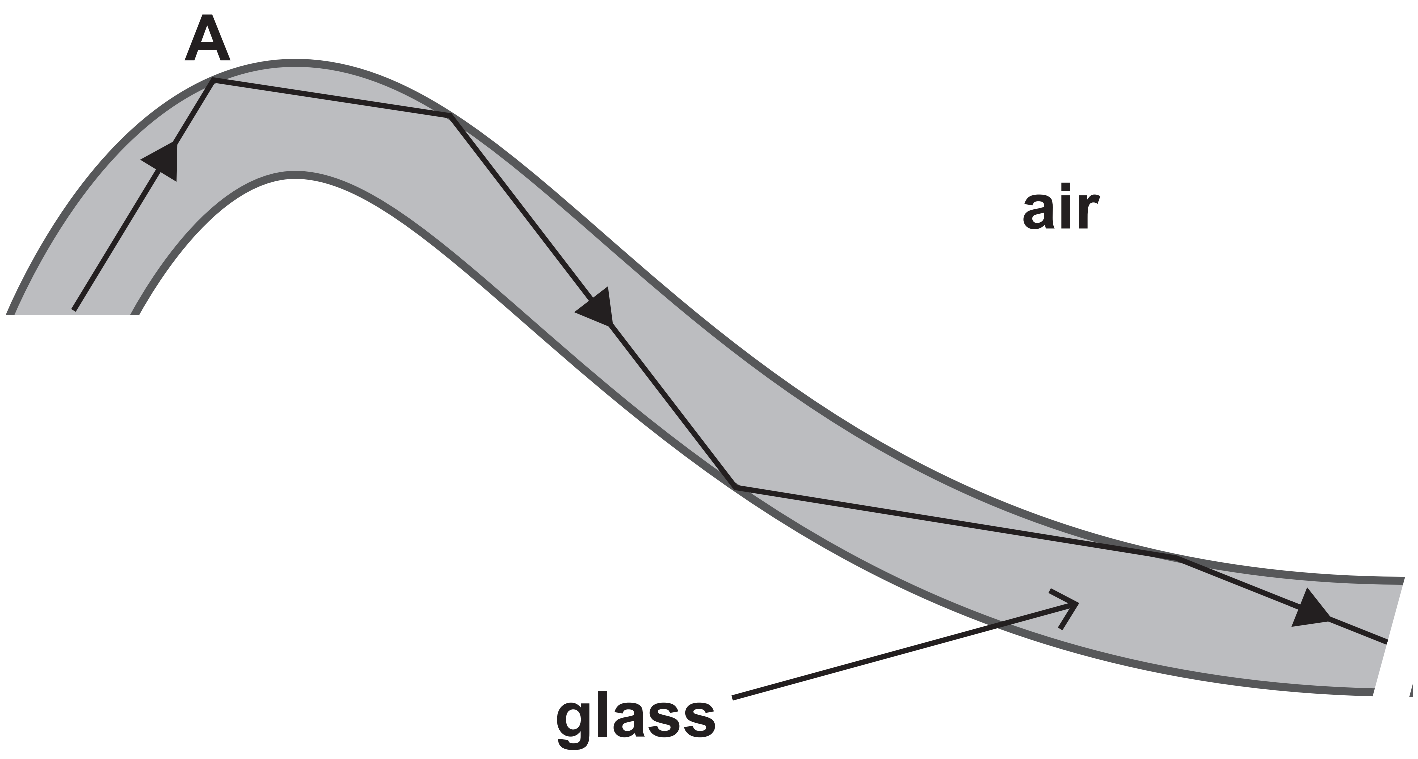

DIAGRAM 5.3

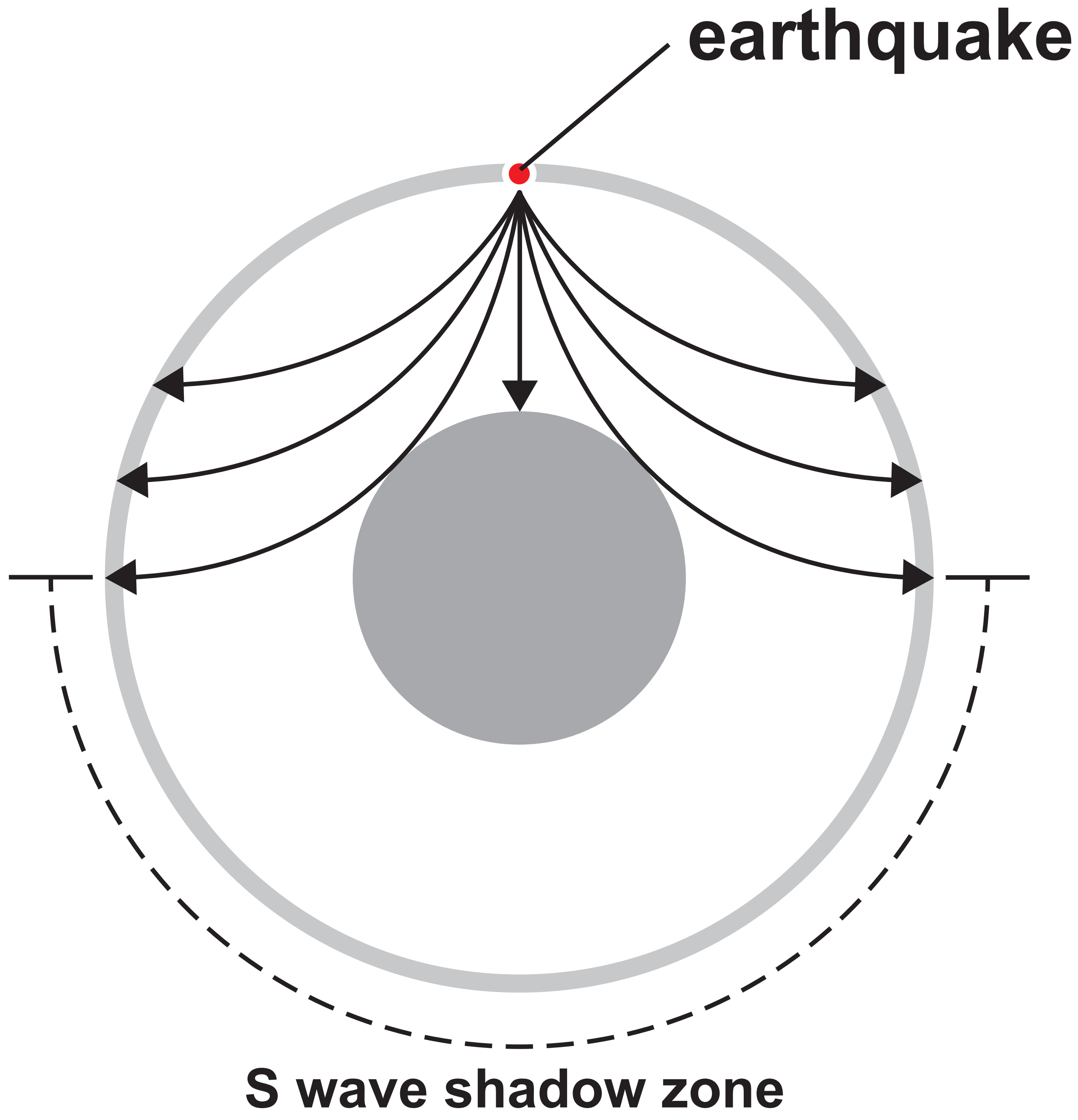

DIAGRAM 6.1

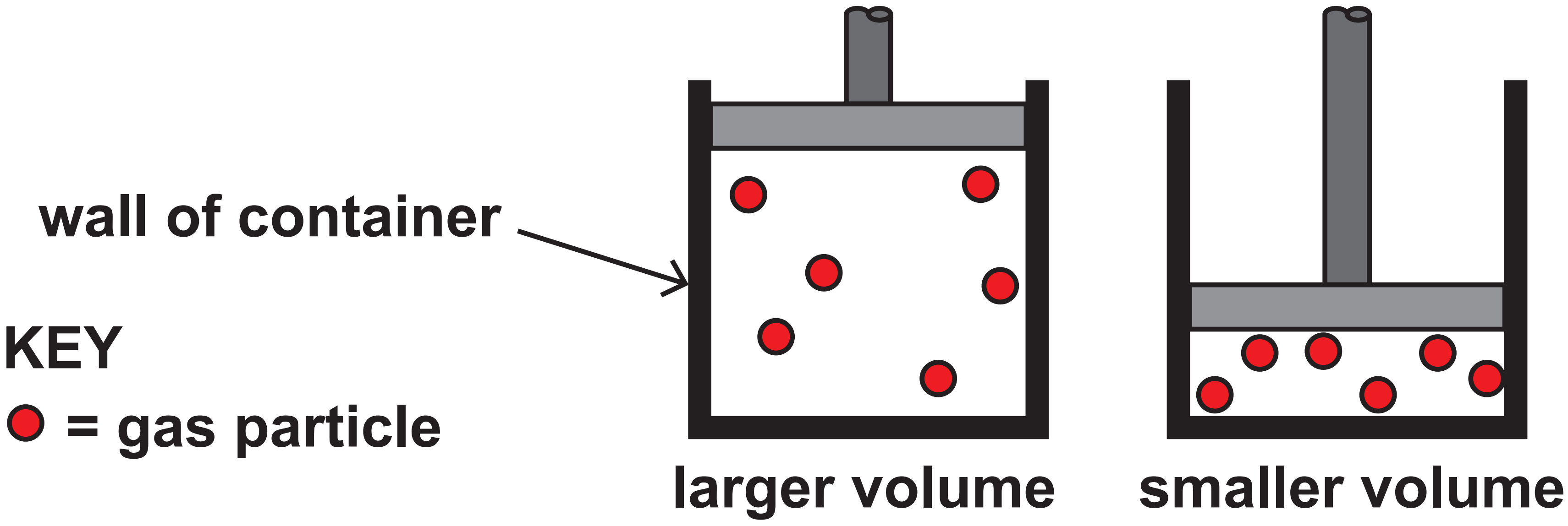

TABLE 6.2

Temperature (°C)	Volume (cm^3)
−223	20
−173	40
−73	80

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DIAGRAM 7.1

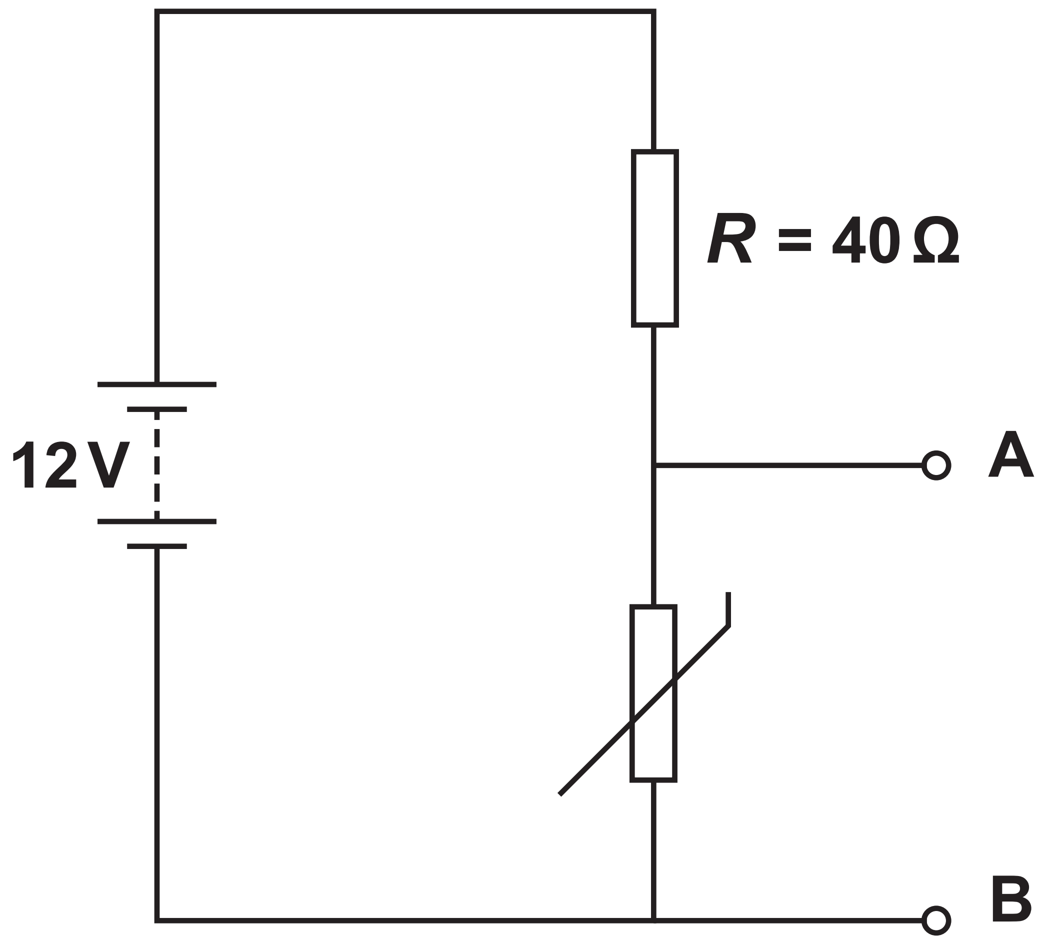


TABLE 7.2

Temperature (°C)	Resistance of thermistor (Ω)
0	120
25	92
50	70
75	52
100	40
125	30

GRAPH **7.3**

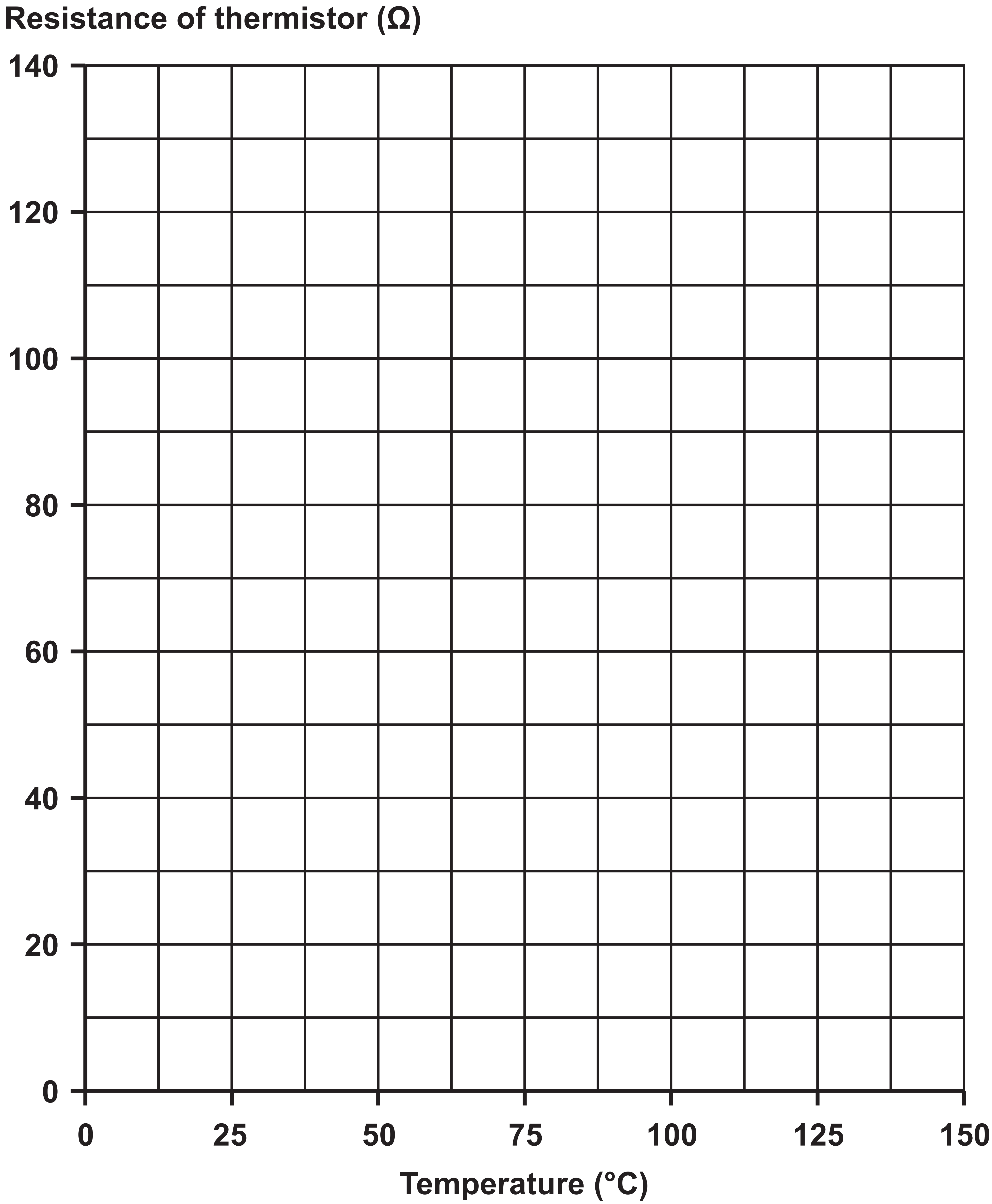

Resistance of thermistor (Ω)
140
120
100
80
60
40
20
0
0
25
50
75
100
125
150
Temperature (°C)

DIAGRAM 7.4

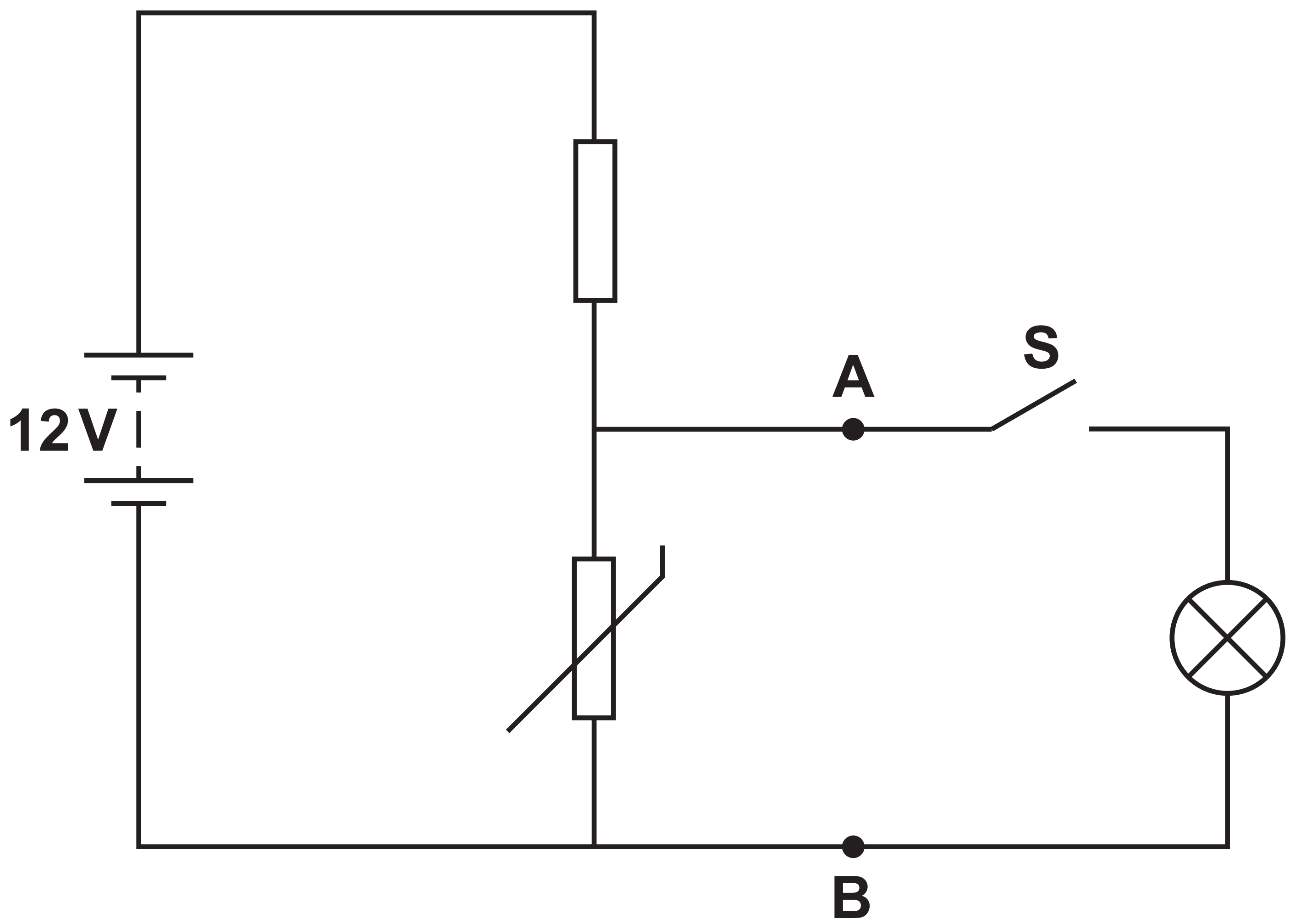
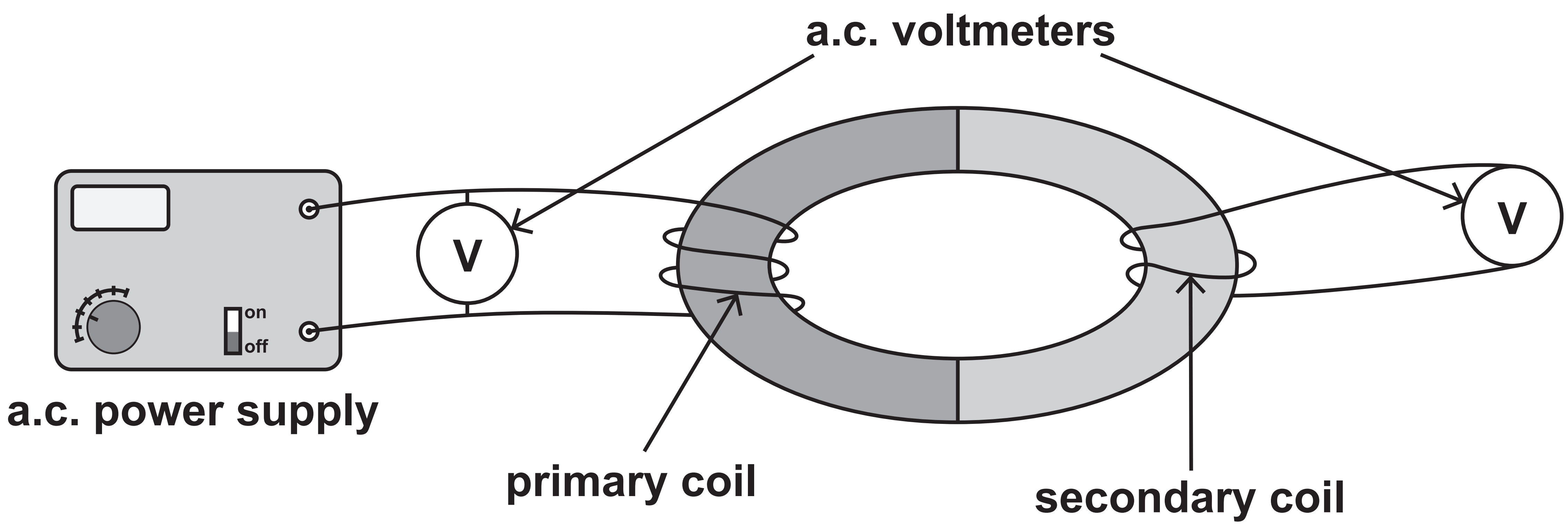


DIAGRAM 8.1


a.c. voltmeters
V
V
on
off
a.c. power supply
primary coil
secondary coil