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H

Monday 23 November 2020 – Morning

GCSE (9–1) Physics A (Gateway Science)

J249/04 Paper 4 (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (cm/mm)
- the Data Sheet for GCSE (9–1) Physics A (inside this document)

You can use:
- a scientific or graphical calculator
- an HB pencil

J249004

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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SECTION A

Answer **all** the questions.

You should spend a maximum of 30 minutes on this section.

Write your answer to each question in the box provided.

1 Four students measure the time it takes for a wave to travel the length of a ripple tank.

Each student collects three measurements of the time.

Student	Time taken (s)		
	1st measurement	**2nd measurement**	**3rd measurement**
A	2	2	1
B	2.1	2.1	2.4
C	2.1	2.0	2.2
D	2.11	2.49	2.23

Which student collected the **most** precise data?

Your answer ☐ **[1]**

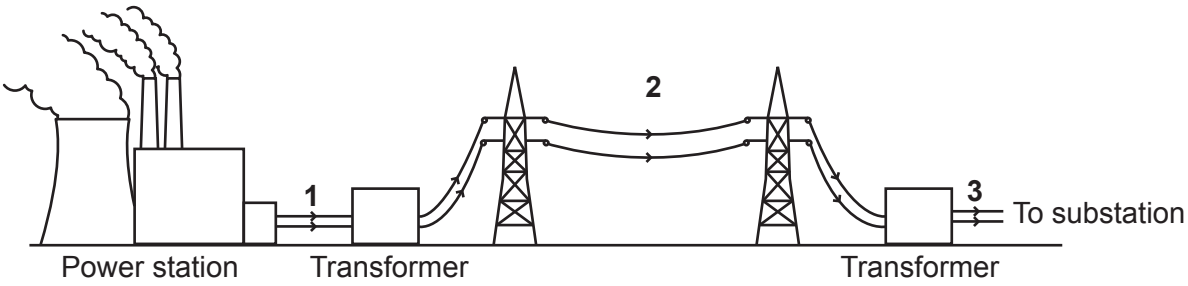
2 Which row in the table describes all electromagnetic waves?

	Type of wave	**Speed of wave in space**
A	Longitudinal	Changes with wavelength.
B	Longitudinal	Stays the same.
C	Transverse	Changes with wavelength.
D	Transverse	Stays the same.

Your answer ☐ **[1]**

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3 The diagram shows a simplified version of the national grid.



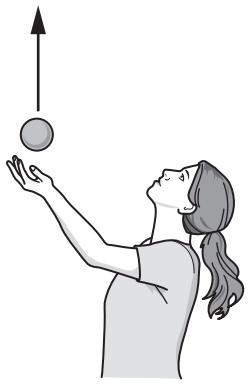
The potential difference (p.d.) is different at each point in the national grid.

Which row in the table is correct?

	p.d. at position 1 (V)	p.d. at position 2 (V)	p.d. at position 3 (V)
A	230	5000	11000
B	25000	450000	11000
C	450000	150	230
D	450000	5000	230

Your answer ☐ **[1]**

4 A ball is thrown vertically into the air.



Energy is transferred from a chemical store.

Where is the useful energy transferred to?

A A gravitational store and a thermal store only.

B A gravitational store only.

C A gravitational store and a chemical store only.

D A thermal store and a chemical store only.

Your answer ☐ **[1]**

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5 Electromagnetic waves can be ordered by frequency.

Which answer shows the waves in order of **increasing** frequency?

Low frequency ⟶ **High** frequency

A	Infra-red	Visible light	X-rays
B	Visible light	Infra-red	X-rays
C	Visible light	X-rays	Infra-red
D	X-rays	Visible light	Infra-red

Your answer ☐ **[1]**

6 Which statement about geostationary satellites is correct?

A They appear to be in a fixed position relative to a point on the Earth.

B They are in a polar orbit.

C They are positioned 400 km above the Earth's surface.

D They take 2 hours to orbit the Earth.

Your answer ☐ **[1]**

7 A car has a mass of 1000 kg and is travelling at a speed of 20 m / s.

Calculate the kinetic energy of the car.

A 10 000 J

B 20 000 J

C 200 000 J

D 400 000 J

Your answer ☐ **[1]**

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8 The maximum frequency of sound that a person can hear changes as they get older.

Which row in the table explains this change?

	Maximum frequency of sound a person can hear	What part of the ear is damaged?
A	Decreases with age	Cochlea
B	Decreases with age	Eardrum
C	Increases with age	Cochlea
D	Increases with age	Eardrum

Your answer ☐ **[1]**

9 Six wave peaks hit a wall in one minute.

Determine the frequency of the waves.

A 0.1 Hz

B 6 Hz

C 10 Hz

D 360 Hz

Your answer ☐ **[1]**

10 When an electron in an atom changes energy level, it emits electromagnetic radiation.

Which row in the table is correct?

	Energy level of the electron	Type of radiation emitted
A	Decreases	Almost any electromagnetic radiation.
B	Decreases	Visible light only.
C	Increases	Almost any electromagnetic radiation.
D	Increases	Visible light only.

Your answer ☐ **[1]**

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11 A car travels at a speed of 70 mph (miles per hour).

1 mile is approximately 1600 metres.

Convert 70 mph into m/s (metres per second).

A 2.6 m/s

B 31 m/s

C 112 m/s

D 160 m/s

Your answer ☐ **[1]**

12 The average temperature on the Earth has increased over the last century.

Which statement explains why?

A Radiation absorbed by the Earth has decreased.

B Radiation absorbed is less than radiation emitted.

C Radiation absorbed is greater than radiation emitted.

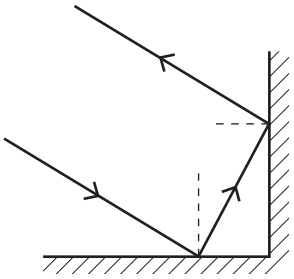
D Radiation emitted by the Earth has increased.

Your answer ☐ **[1]**

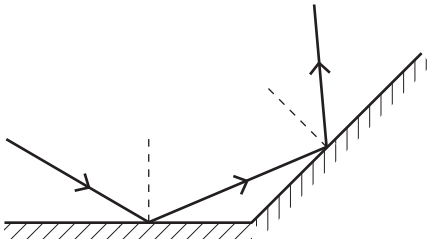
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13 Look at the diagrams of a light ray reflecting from two identical surfaces.

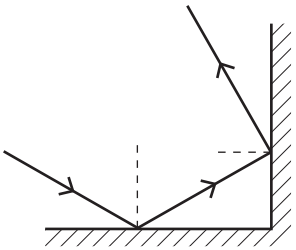
A



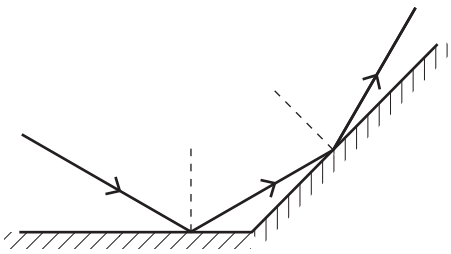
B



C



D



Which diagram is correct?

Your answer ☐ **[1]**

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14 Which statement about a star that explodes into a supernova is correct?

A The star has more mass than the sun.

B The star is older than the sun.

C The star will become a white dwarf.

D The star's core expands.

Your answer ☐ **[1]**

15 Which statement about nuclear **fusion** is correct?

A Energy is released because mass is converted to energy.

B Helium is converted into hydrogen.

C It is the main way in which nuclear power generates electricity.

D It is the splitting of a heavy nucleus into smaller nuclei.

Your answer ☐ **[1]**

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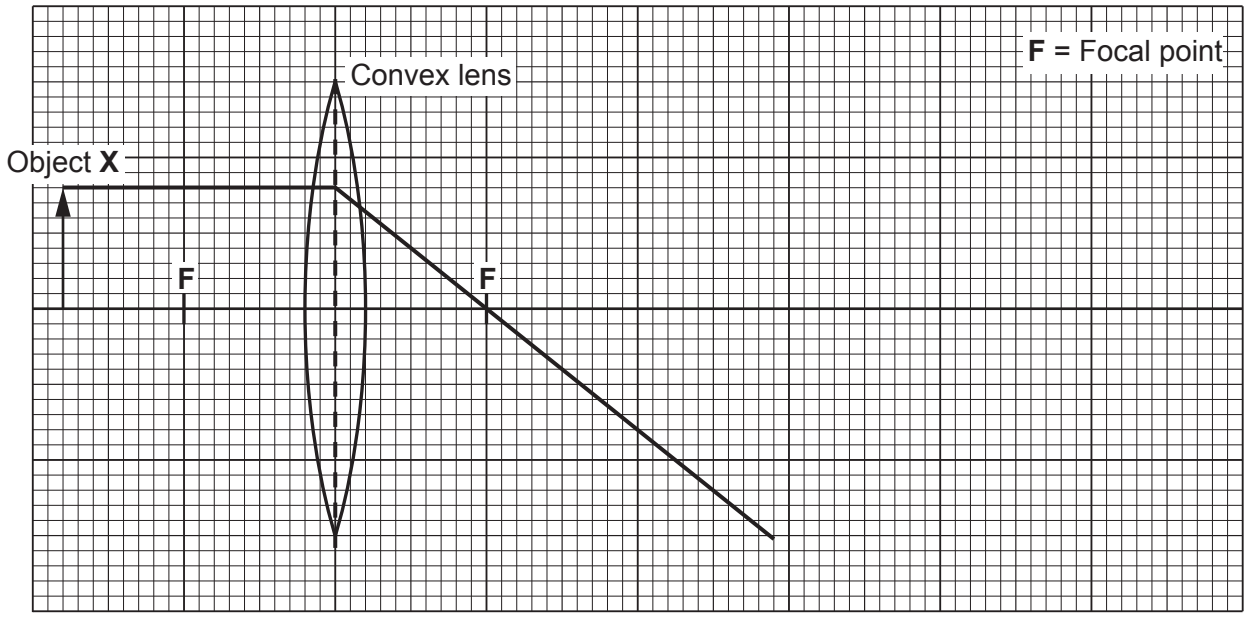
SECTION B

Answer **all** the questions.

16 A projector is used to create a larger image of an object.

(a) The diagram shows one light ray as it passes through the convex lens.

Draw **one** more ray on the diagram to show where the image is formed. Label the image **Y**.



[2]

(b) The projector contains a white light source.

Explain how this white light source can be used to get **red** light.

.....

..... **[2]**

(c) **(i)** The projector is connected to the mains power supply. The projector has an earth wire.

State the potential difference between the earth wire and the live wire in normal use.

Potential difference = ... V **[1]**

(ii) A projector with a plastic case does not need an earth wire.
A projector with a metal case needs an earth wire.

Explain why.

.....

.....

.....

..... **[2]**

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17 A student investigates the rate of cooling using a cardboard box to model the walls of a building.

She puts a beaker of hot water into the cardboard box. She measures the temperature of the water every two minutes.

She investigates how the rate of cooling changes with the thickness of the walls.

(a) Describe a method she can use to do this investigation.

.....

.....

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.....

.....

..... **[3]**

(b) Here are the results of one of her experiments.

Time (minutes)	Temperature of water (°C)
0	90
2	75
4	63
6	54
8	47
10	41
12	37

(i) Plot the results on the grid in **Fig. 17.1**.

Two of the points have been plotted for you. **[2]**

(ii) Draw a line of best fit on your graph. **[1]**

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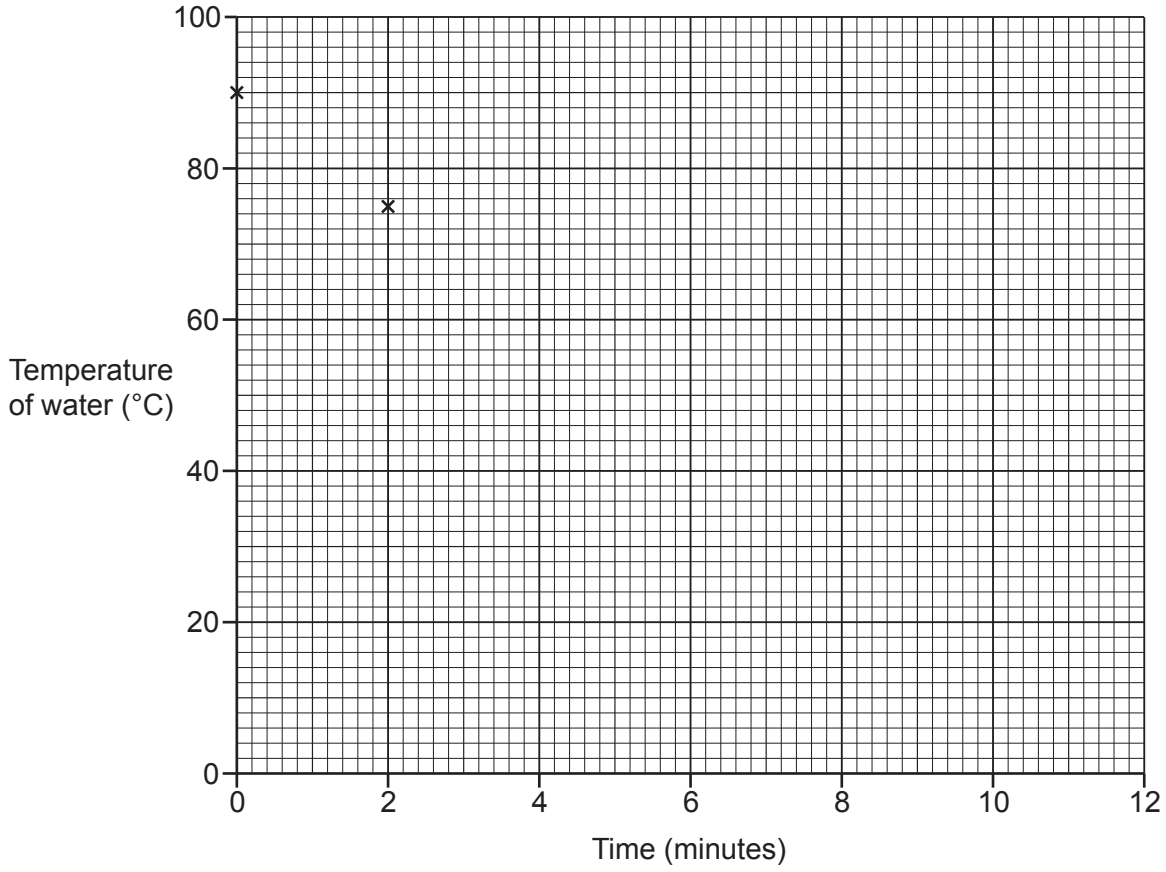


Fig. 17.1

(iii) Describe how the temperature of the water changes with time.
Use data from the graph **Fig. 17.1** in your answer.

.....

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..... **[2]**

(iv) The thickness of the cardboard box is doubled. Everything else stays the same.

Sketch a line on the graph in **Fig. 17.1** to suggest what these new results may look like.
Label your line **Z**. **[1]**

(v) Suggest **one** way to improve the investigation.

.....

..... **[1]**

(c) Explain why the rate of cooling of a metal box is different to a cardboard box.
Assume the thickness of the walls is the same in both boxes.

.....

..... **[1]**

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18* The UK generates some of its electrical power from wind turbines.

Fig. 18.1 shows the total electrical power generated by wind turbines in the UK.

The graph is for a single day in December which had very strong winds.

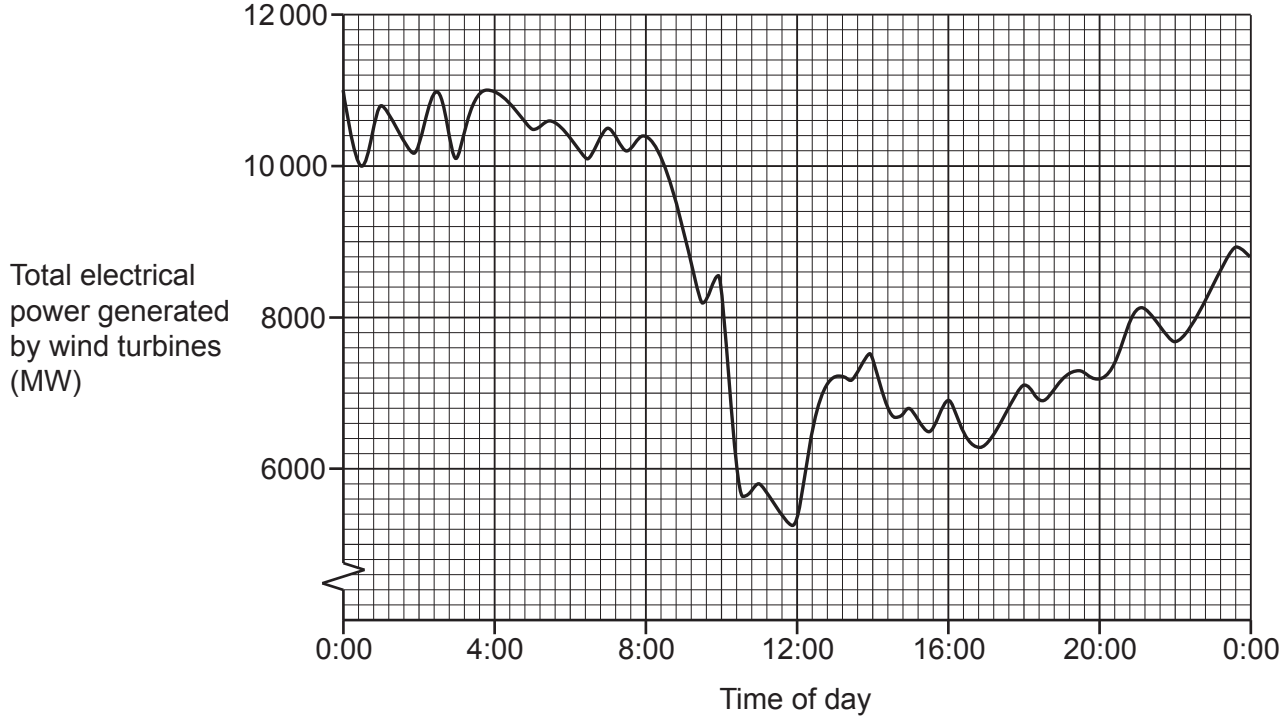


Fig. 18.1

Fig. 18.2 shows the total demand for electrical power in the UK on the same day.

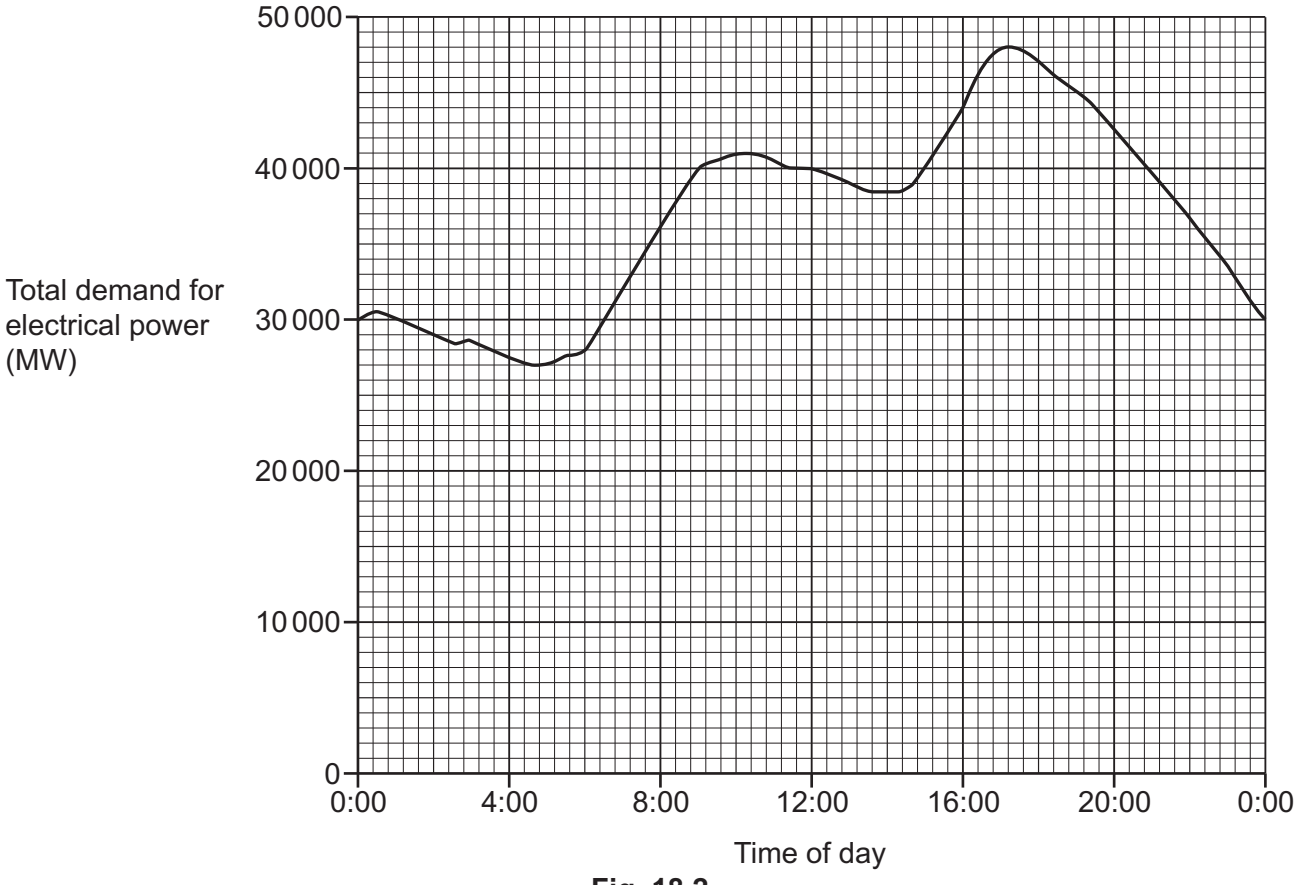


Fig. 18.2

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Some experts believe the UK should generate most of its electrical power from wind.

Evaluate the advantages and disadvantages of this idea.

Use the graphs in **Fig. 18.1** and **Fig. 18.2** and your own ideas about wind turbines to support your answer.

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..... **[6]**

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19 Ultrasound waves can be used to create an image of part of the inside of a body.

(a) Ultrasound waves have a higher frequency than ripples on the surface of water.

Describe **another** difference between ultrasound waves and ripples on the surface of water.

Explain your answer.

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..... **[2]**

(b) The graph in **Fig. 19.1** shows how displacement of the ultrasound wave varies with distance.

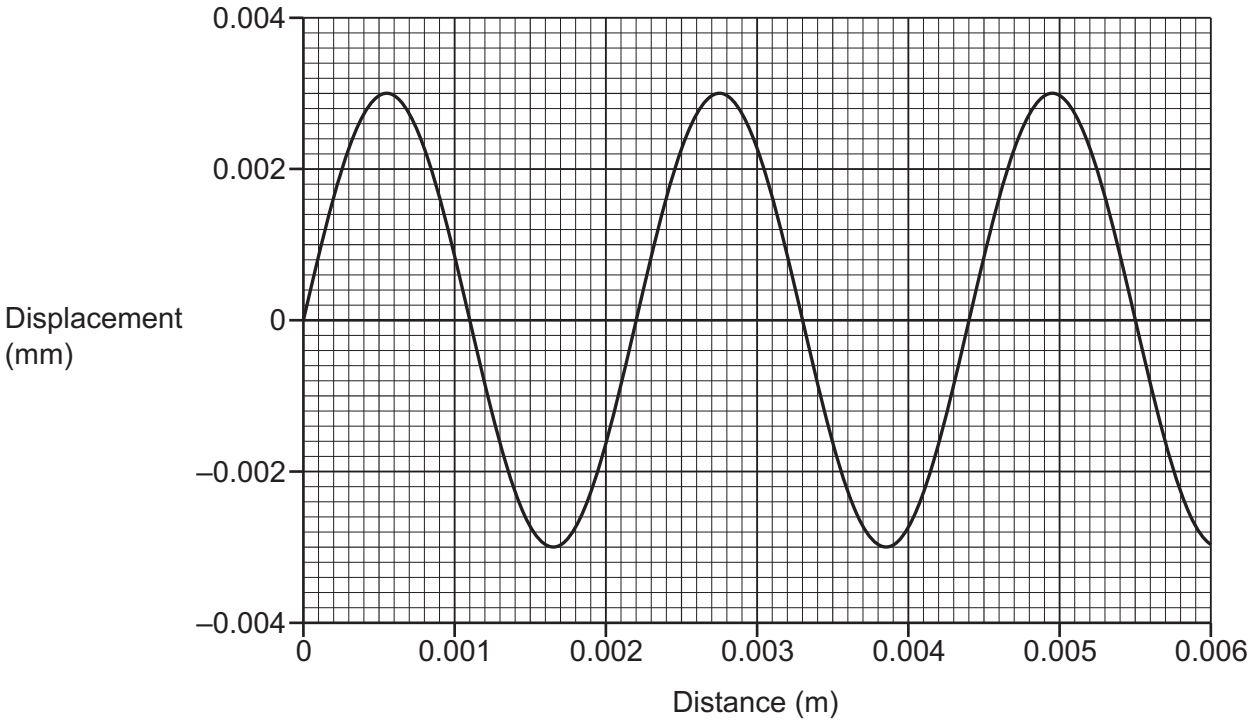


Fig. 19.1

(i) Use the graph in **Fig. 19.1** to determine the wavelength of the ultrasound wave.

Wavelength = ... m **[1]**

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(ii) The speed of ultrasound waves in **(b)(i)** is 4500 m / s.

Calculate the frequency of the ultrasound wave in **Fig. 19.1**.

Use the equation: wave speed = frequency × wavelength

Give your answer in **standard form** and to **2** significant figures.

Frequency = ... Hz **[4]**

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(c) Doctors can use an ultrasound scan to measure the size of a person's kidney.

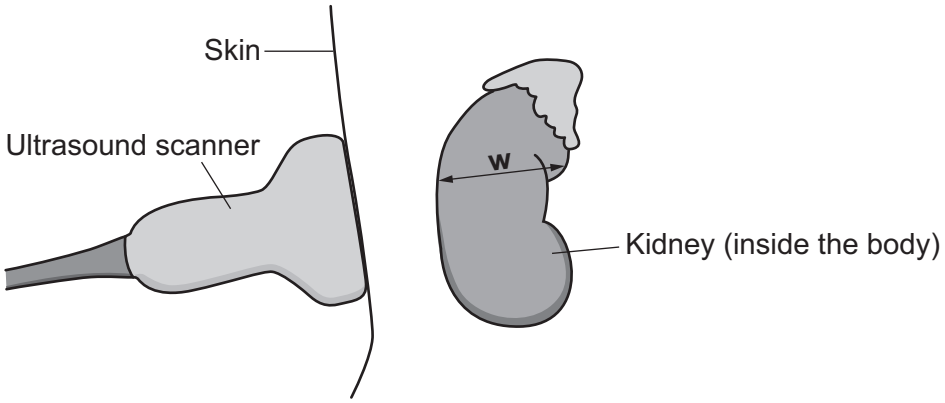


Fig. 19.2

Complete the sentences using the words below.

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

Increases **Decreases** **Stays the same**

The ultrasound scanner is made from a solid ceramic material.

As the wave enters the body, the speed ..... .

As the wave enters the body, the frequency ..... .

[2]

(d) **(i)** Explain what happens to the ultrasound wave when it reaches the kidney.

.....

.....

.....

..... **[2]**

(ii) **Fig. 19.2** shows the thickness of the kidney, **w**.

Explain how ultrasound waves are used to measure **w**.

.....

.....

..... **[2]**

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(e) A doctor uses an ultrasound scan instead of X-rays to measure the kidneys.

Explain why.

.....

..... **[1]**

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20 Americium-241 is a radioactive source that is used in smoke detectors.

(a) This is the symbol for americium-241:

$^{241}_{95}Am$

Describe the structure of an americium-241 **nucleus**.

.....

.....

..... **[2]**

(b) Americium-241 decays by emitting alpha radiation to form neptunium (Np).

Complete the balanced symbol equation for the decay.

$$^{241}_{95}Am \longrightarrow {}^{.....}_{.....}Np + {}^{4}_{2}{}^{.....}$$

[3]

(c) When smoke enters a detector:

- The smoke particles absorb the emitted alpha radiation.
- The alarm sounds.

Explain why beta and gamma sources are **not** suitable for use in a smoke detector.

.....

..... **[1]**

(d) The half-life of americium-241 is 432 years.

(i) Explain what is meant by **half-life**.

.....

..... **[1]**

(ii) Explain why the half-life of americium-241 is suitable for a smoke detector.

.....

..... **[1]**

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(iii) The table shows some data for two radioactive sources.

Source	Half-life (years)	Radiation emitted
Americium-241 (Am-241)	432	Alpha
Thorium-228 (Th-228)	2	Alpha

Both sources start with the same number of radioactive nuclei.

Which source is a greater health risk? Explain your answer.

.....

.....

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..... **[2]**

(e) Read the information below about smoke detectors.

In smoke detectors, fine particles of americium-241 are rolled into a metallic foil. The americium-241 cannot be inhaled or move around.

The amount of radiation emitted is very small compared with the natural radioactivity in $1\,m^3$ of soil.

Americium-241 also emits a small amount of gamma rays.

A scientist says, '**There is no risk from the disposal of smoke detectors in household waste.**'

Do you agree with this statement? Give **two** reasons for your answer.

Yes ☐

No ☐

1 .....

.....

2 .....

.....

[2]

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21 (a) This question is about an electric kettle.

(i) An electric kettle is filled with water, connected to the mains and switched on.

The electricity for the kettle is generated in a coal-fired power station.

Describe the energy transfer that occurs when the kettle is switched on.

Include ideas about energy stores in your answer.

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.....

..... **[2]**

(ii) The mains supply has a potential difference of 230 V.

The kettle has a current of 5.0 A. The kettle is switched on for 2.0 minutes.

Calculate the total energy transferred to the kettle in 2.0 minutes.

Total energy transferred = ... J **[4]**

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(b) (i) **Table 21.1** gives some information about a different kettle.

Energy transferred to the kettle	525 000 J
Mass of water	1.2 kg
Starting temperature of water	25 °C
Final temperature of water	100 °C
Specific heat capacity of water	4200 J / kg °C

Table 21.1

Calculate the efficiency of the kettle described in **Table 21.1**.

Give your answer as a percentage.

Use an equation from the data sheet.

Efficiency = ... % **[5]**

(ii) Explain why the efficiency of the kettle is less than 100%.

.....

..... **[1]**

(c) The water can also be heated using a 12 V heater.

A transformer is used to change a 120 V supply into 12 V.
The current in the secondary coil is 9.0 A.

Calculate the current in the primary coil.

Use an equation from the data sheet.

Current = ... A **[2]**

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22 Edwin Hubble discovered that all distant galaxies were moving away from the Earth.

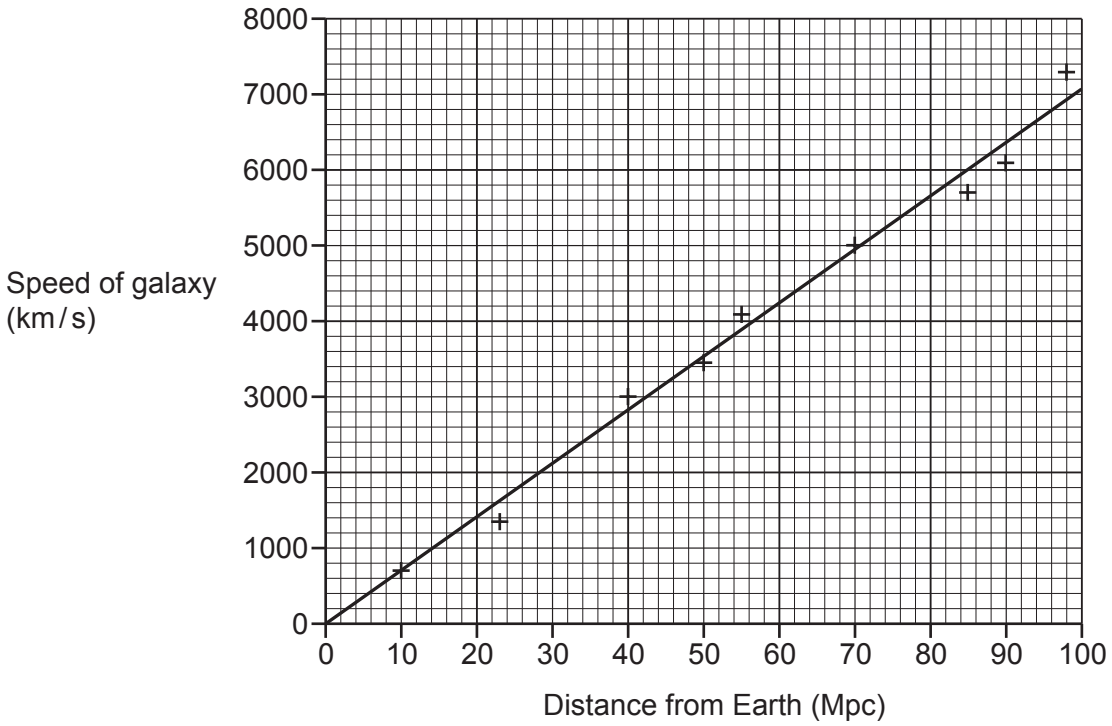
(a) Explain how he could tell that all distant galaxies were moving away from the Earth.

.....

.....

..... **[2]**

(b) This graph shows how the speed of a galaxy changes with distance from the Earth.



(i) Use data from the graph to show that the speed of the galaxy is proportional to the distance from the Earth.

.....

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.....

..... **[2]**

(ii) Explain how data from the graph provides evidence for the Big-Bang.

.....

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..... **[1]**

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(c) Before Edwin Hubble could publish his results, his work was peer reviewed.

Suggest why peer review is important.

.....

..... **[1]**

(d) The parsec (pc) is a unit used for measuring large distances in the Universe.

(i) A galaxy is at a distance of 82 Mpc from the Earth.

Use the graph to determine the speed of this galaxy.

Give your answer in metres per second (m/s).

Speed = ... m/s **[2]**

(ii) Calculate the time it takes for the galaxy to travel 2.53×10^{24} m.

Use your answer to **22(d)(i)** to help you.

Time = ... s **[3]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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