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F

Wednesday 1 December 2021– Afternoon

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

J249/02 Paper 2 (Foundation 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

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 **28** 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 Estimate the reaction time of a student.

A 0.02 s

B 0.2 s

C 2 s

D 20 s

Your answer ☐ **[1]**

2 Which of the following is a renewable energy source?

A Coal

B Hydro-electricity

C Nuclear fuel

D Oil

Your answer ☐ **[1]**

3 Which factor can affect the **braking** distance of a car?

A Age of driver

B Consumption of alcohol

C Mass of car

D Tiredness

Your answer ☐ **[1]**

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4 A radioactive source has a count rate of 200 counts per minute (cpm).

The half-life of the radioactive source is 3 minutes.

What is the count rate of the radioactive source after 3 minutes?

A 0 cpm

B 100 cpm

C 200 cpm

D 400 cpm

Your answer ☐ **[1]**

5 The table shows the stopping distances for a car travelling at two different speeds.

Speed (miles per hour)	**Stopping distance (metres)**
30	23
70	96

The car now travels at 50 miles per hour.

Estimate the stopping distance.

A 28 m

B 53 m

C 73 m

D 88 m

Your answer ☐ **[1]**

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6 Water waves are made in a ripple tank.

A student counts 4 waves passing a point per second.

What has the student worked out?

A Amplitude

B Frequency

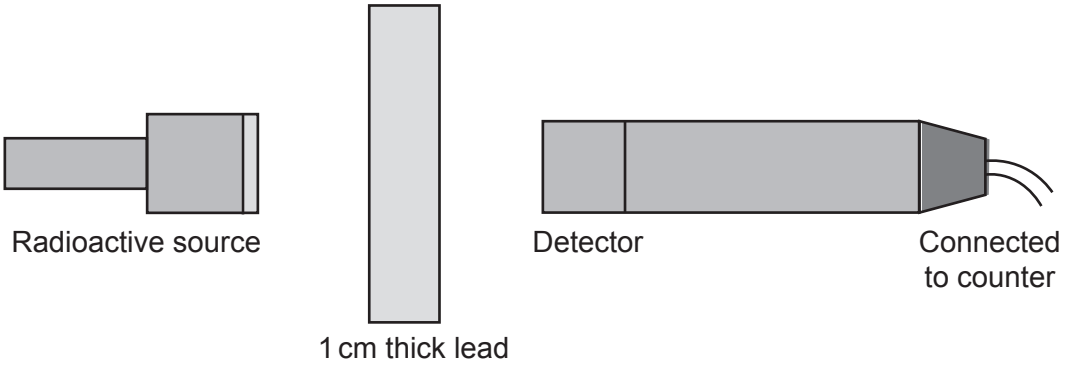
C Period

D Wave speed

Your answer ☐ **[1]**

7 A radioactive source produces gamma rays.

The diagram shows a detector and a piece of lead placed near the radioactive source.



The count rate is 1840 counts per minute (cpm) **without** the lead in place.

What could the count rate be **with** the lead in place?

A 0 cpm

B 160 cpm

C 1840 cpm

D 2530 cpm

Your answer ☐ **[1]**

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8 A force of 6 N moves through a distance of 3 m in the direction of the force.

Calculate the work done.

A 0.5 J

B 2 J

C 9 J

D 18 J

Your answer ☐ **[1]**

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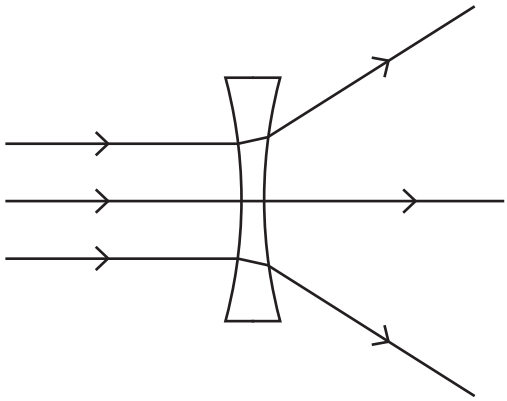
9 A student draws ray diagrams for some lenses.

Which ray diagram is correct?

A



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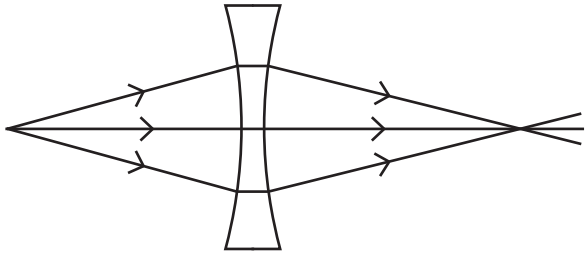

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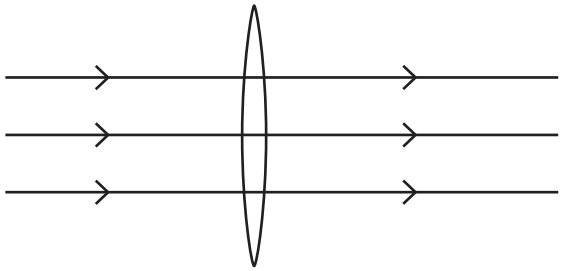

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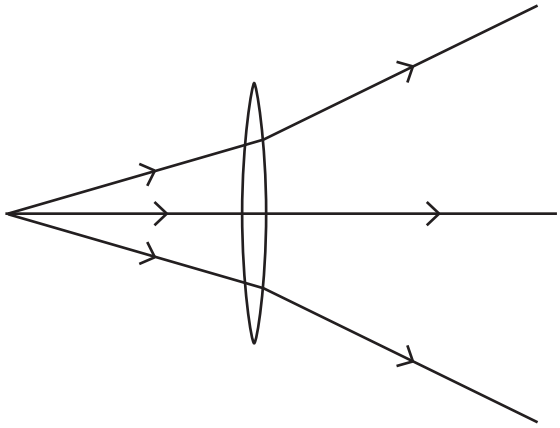

Your answer ☐ **[1]**

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10 A 3.0 kW oven is switched on for 1.5 hours.

Calculate the energy transferred by the oven.

Use the equation: energy transferred = power × time

A 2.0 J

B 2.0 kWh

C 4.5 J

D 4.5 kWh

Your answer ☐ **[1]**

11 A student calculates the change in the thermal energy of a 1 kg metal block.

The student heats the block and measures the change in temperature.

What other quantity is needed?

A Density of the metal

B Resistance of the metal block

C Specific heat capacity of the metal

D Volume of the metal block

Your answer ☐ **[1]**

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12 This question is about electricity at power stations and at homes.

Which row in the table is correct?

	Voltage at the power station (V)	**Voltage in the home (V)**
A	230	50
B	230	230
C	25 000	50
D	25 000	230

Your answer ☐ **[1]**

13 The table shows **two** uses of electromagnetic radiation.

Which row in the table is correct?

	Used for satellite communication	**Used for measuring temperature**
A	Microwaves	Infra red
B	Microwaves	Ultraviolet
C	Visible light	Infra red
D	Visible light	Ultraviolet

Your answer ☐ **[1]**

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14 Carbon-12 is an isotope of carbon.

Carbon-12 contains 6 protons and 6 neutrons.

Which atom **X** is also an isotope of carbon?

A $^{11}_{5}X$

B $^{12}_{5}X$

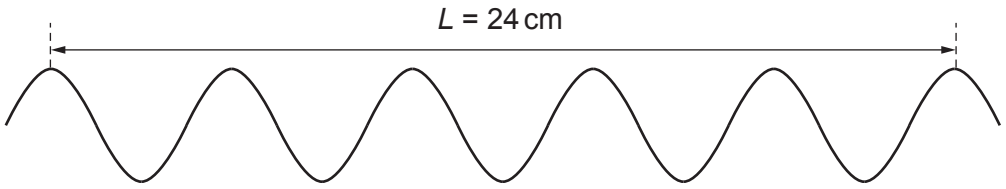
C $^{13}_{6}X$

D $^{13}_{7}X$

Your answer ☐ **[1]**

15 A student makes a wave in a ripple tank.

The student measures distance, *L*.



What is the wavelength of the wave?

A 2.4 cm

B 4.0 cm

C 4.8 cm

D 24 cm

Your answer ☐ **[1]**

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SECTION B

Answer **all** the questions.

16 This question is about the solar system.

(a) Describe how a planet's orbit is different compared to a moon's orbit.

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.....

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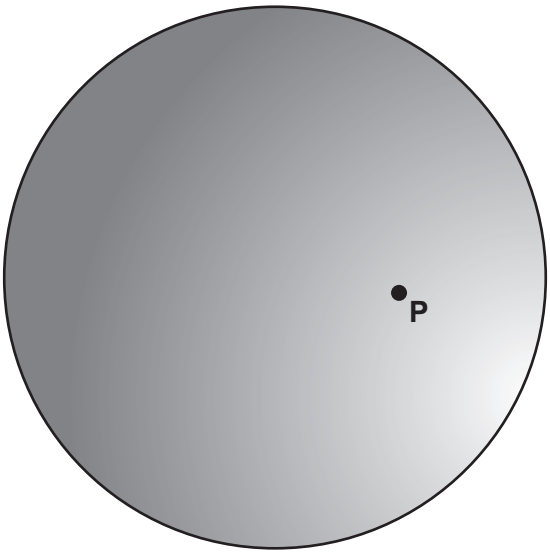
..... **[2]**

(b) The diagram shows the Sun.



Point **P** is inside the Sun.

(i) Draw an arrow at **P** to show the direction of the force of gravity at **P**.

Label the arrow **F**. **[1]**

(ii) Nuclear fusion reactions take place in the Sun. The energy released creates a force.

Draw an arrow at **P** to show the direction of this force.

Label the arrow **R**. **[1]**

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(iii) Explain why the size of the Sun does **not** change.

Write about force **F** and force **R** in your answer.

.....

.....

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

(iv) Complete the sentences using the words below.

You can use each word once, more than once, or not at all.

black hole **neutron star** **planetary nebula** **red giant**

red super giant **supernova** **white dwarf**

Towards the end of its life the Sun will expand.

The Sun becomes a ..... .

The Sun then gives off its outer layers of gas. This is called a

..... .

After this, the Sun will become a ..... .

[3]

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17 A 20 kg concrete block is lifted by a crane. The mass of **one** block is 20 kg.

(a) **(i)** Calculate the kinetic energy of the 20 kg block when it moves at 0.3 m / s.

Use the equation: kinetic energy = 0.5 × mass × (speed)^2

Kinetic energy = ... J **[2]**

(ii) The 20 kg block is lifted through a height of 16 m.

Calculate the gravitational potential energy gained by the 20 kg block.

Gravitational field strength is 10 N / kg.

Gravitational potential energy = ... J **[3]**

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(b) The crane lifts blocks through a different height using an electric motor:

- The gravitational potential energy gained by the blocks is 0.6 MJ.
- The input energy of the motor is 1.5 MJ.

(i) Calculate the efficiency of the motor.

Use the equation: efficiency = useful output energy transfer / input energy transfer

Efficiency = ... **[2]**

(ii) Explain why the efficiency of the motor is **not** 100%.

.....

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

(iii) The crane's lifting equipment contains moving parts. A workman suggests adding oil to these moving parts.

Explain how this will affect the efficiency.

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

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18 A musician plays a guitar.

This makes a sound wave in the air.

(a) The frequency of the sound wave is 440 Hz.

The speed of sound is 330 m / s.

Calculate the wavelength of the sound wave.

Use the equation: wave speed = frequency × wavelength

Wavelength = ... m **[3]**

(b) Explain how sound travels through the air from the guitar.

Write about air particles in your answer.

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

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(c) **Fig. 18.1** is a graph of a sound wave.

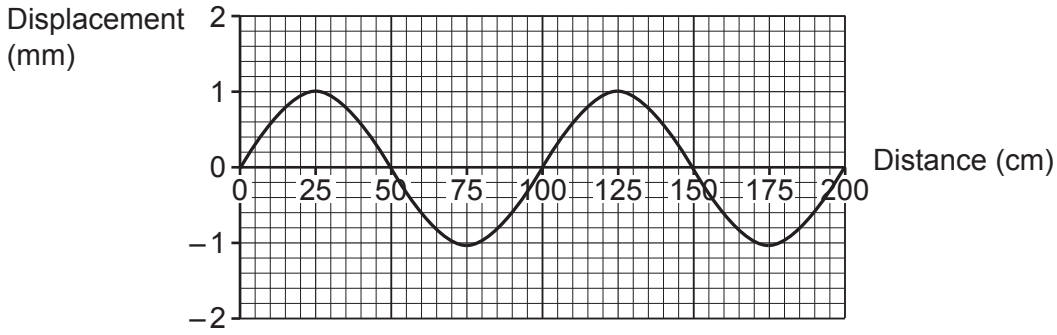

Fig. 18.1

Another sound wave has a **higher** frequency. The amplitude of the wave remains the **same**.

Draw this sound wave on **Fig. 18.2**.

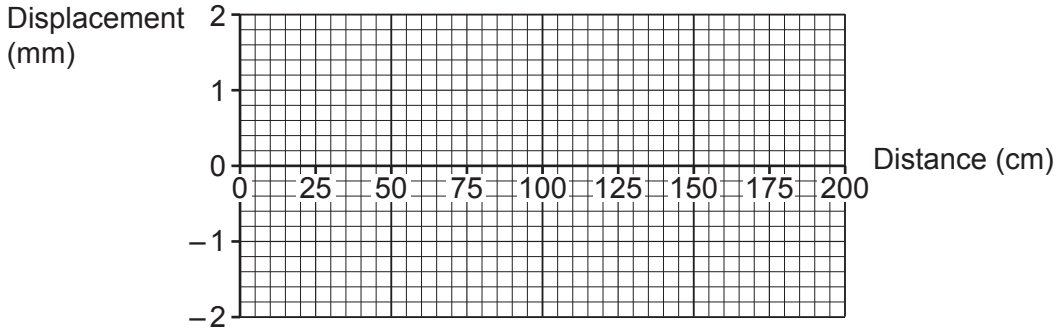

Fig. 18.2

[2]

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19 Plutonium-238 (Pu-238) is a radioactive element.

(a) This is the symbol for Pu-238:

$$^{238}_{94}Pu$$

Draw lines to connect each box with the correct answer.

Mass number	**94**
Number of protons	**144**
Number of neutrons	**238**

[2]

(b) **(i)** A scientist measures the activity of a sample of Pu-238.

The scientist takes five different measurements.

Table 19.1 shows their results:

Measurement	1	2	3	4	5
Activity (GBq)	227	235	234	227	232

Table 19.1

What is the **mode** of the activity?

Mode = ... GBq **[1]**

(ii) An alpha particle is emitted by Pu-238.

Complete the radioactive decay equation for Pu-238 decay.

$$^{238}_{94}Pu \rightarrow ^{234}_{\ldots\ldots}U + ^{\ldots\ldots}_{2}He$$

[2]

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(iii) A student says, 'Alpha radiation is safer than beta.'

Do you agree with this student?

Tick (✓) **one** box.

Yes ☐

No ☐

Explain your answer.

.....

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

(c) A scientist is using a radioactive element. The scientist accidently touches the radioactive element and becomes **contaminated**.

The scientist stops using the radioactive element.

Explain why the scientist is still at risk.

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

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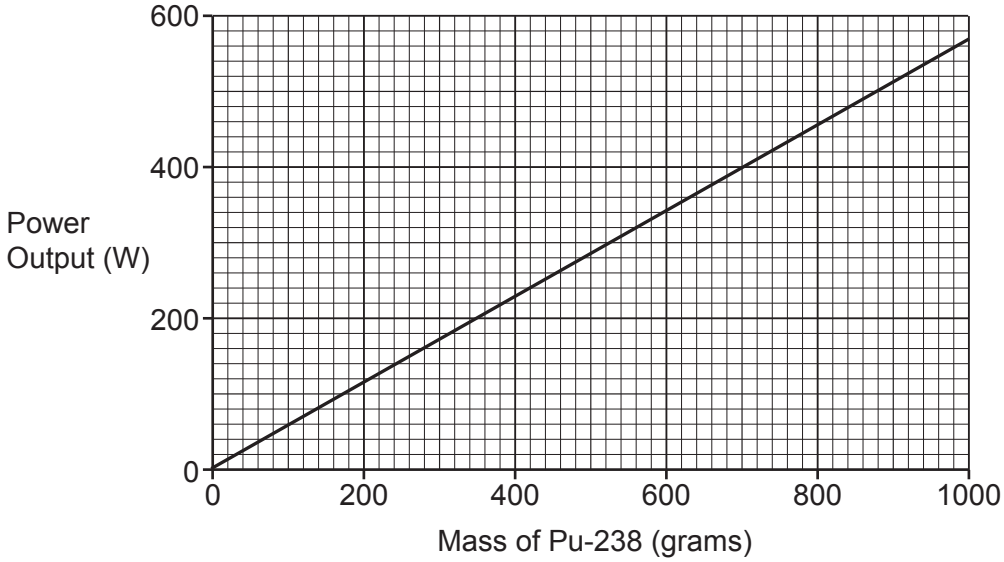
(d) Pu-238 can be used to generate electricity.

(i) The power output generated increases with the mass of Pu-238.

This is a graph of power output against mass of Pu-238:



Use the graph to find the mass of Pu-238 needed for a power output of 460 W.

Mass = ... grams **[1]**

(ii) Pu-238 was used to generate electricity on a probe that went to Neptune.

The half-life of Pu-238 is 88 years.

Suggest why Pu-238 was used on the probe that went to Neptune.

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

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20 A group of students compare the power of three kettles **A**, **B** and **C** using this method:

- They pour water in each kettle.
- They plug the kettles in and switch the kettles on.
- They measure the temperature of the water every 20 s.
- They calculate the change in thermal energy of the water every 20 s.

(a) Each kettle has the **same** efficiency and is used for the **same** time.

Describe **one other** factor the students should control in their method.

.....

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

(b)* The students test the kettles using a valid method.

Fig. 20.1 shows how the change in thermal energy varies with time:

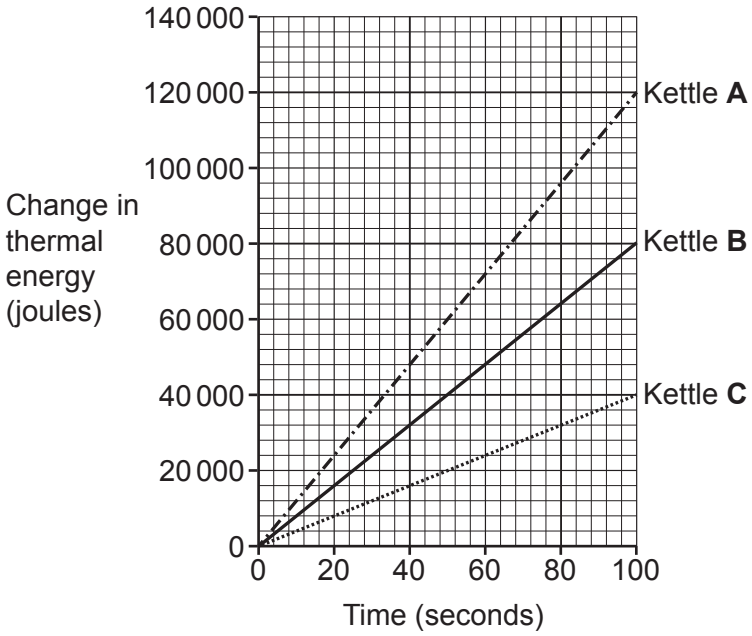

Fig. 20.1

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Each kettle has the **same** efficiency.

Use data from **Fig. 20.1** to:

- Describe in detail how the change in thermal energy varies with time.
- Compare the **power** of the kettles.

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

(c) How is energy transferred from the power station to the kettle?

In your answer write about:

- How electricity is distributed.
- The type of voltage used.

.....

.....

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

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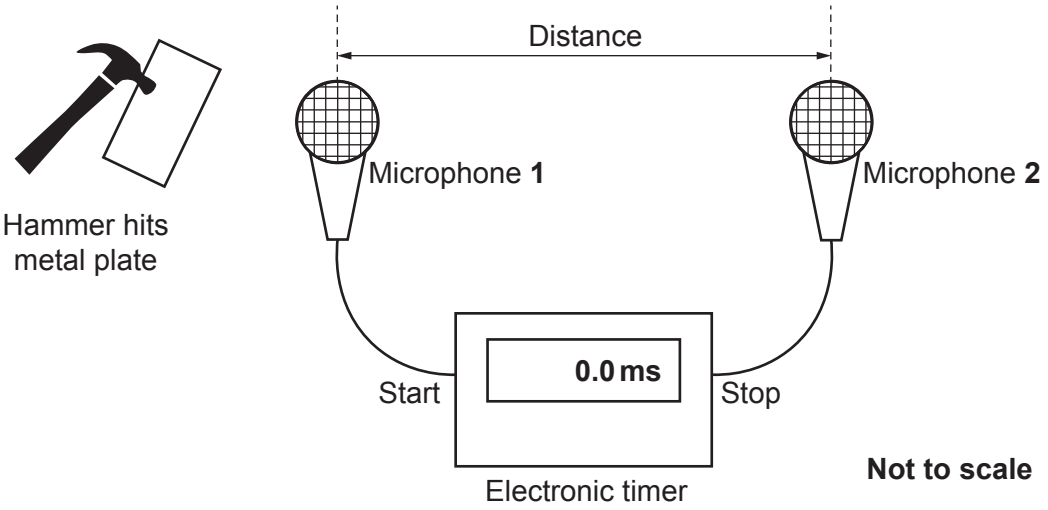
21 A student measures the speed of sound.

They use this equipment:



This is the student's method:

- A sound is created when the hammer hits the metal plate.
- When the sound reaches microphone **1**, the electronic timer starts.
- When the sound reaches microphone **2**, the electronic timer stops.
- This process is repeated several times.

(a) They record the time displayed on the timer in a table:

Measurement	Time (ms)
1	6.7
2	6.3
3	6.7
4	6.6

Calculate the mean time.

Give your answer to **2** significant figures.

Mean time = ... ms **[2]**

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(b) They do **not** place the hammer and plate **between** the two microphones.

Suggest **one** reason why.

.....

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

(c) Another student repeats the same experiment.

These are the student's measurements:

- The distance between the microphones is 2.4 m.
- The mean time measured is 7.5 ms.

(i) Calculate the speed of sound.

Use the equation: distance travelled = speed × time

Speed of sound = ... m/s **[4]**

(ii) Describe how the student can measure the distance between the microphones.

.....

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

(iii) The student looks up the speed of sound on a reliable website. They find the value for the speed of sound is 330 m/s.

Suggest why this is different from your value calculated in **21(c)(i)**.

.....

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

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22 This question is about visible light.

(a) **(i)** State **one** change that happens to light when it travels from water into air.

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

(ii) Diagram in **Fig. 22.1** shows a ray of light from a fish in a container of water.

Complete the ray diagram in **Fig. 22.1** to show the path of the ray after it leaves the water.

Include a normal line in your diagram.

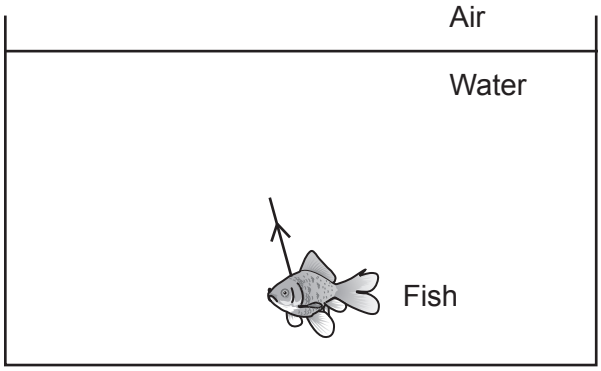

Fig. 22.1

[3]

(b) Diagram in **Fig. 22.2** shows three incident rays hitting the surface of the fish. Light is scattered from the surface of the fish.

Complete the diagram in **Fig. 22.2** to show the scattered rays.

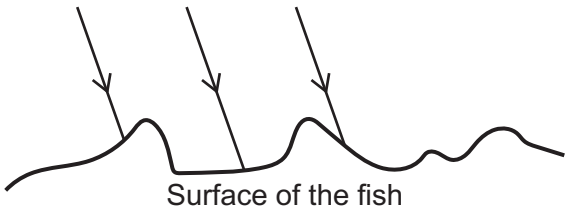

Fig. 22.2

[1]

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(c) The fish appears red under white light.

Explain why the fish appears black under green light.

.....

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

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23 A solar cell changes light into electricity. Solar panels contain solar cells.

(a) A student investigates a solar cell:

- They change the intensity of the light.
- They measure the potential difference across the solar cell.

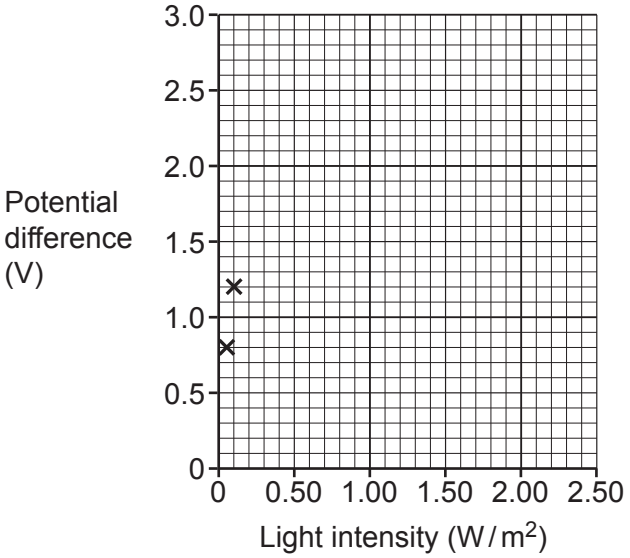
(i) **Table 23.1** shows the student's results:

Light intensity (W/m^2)	Potential difference (V)
0.05	0.8
0.10	1.2
0.20	1.5
0.40	1.8
0.80	2.2
1.60	2.5

Table 23.1

Plot a graph of the results from **Table 23.1**. Two results have already been plotted for you.

Draw a line of best fit. **[3]**



(ii) The light intensity is changed to $2.00\,W/m^2$.

Use your graph to predict the potential difference of the solar cell.

Show your working on the graph.

Potential difference = ... V **[2]**

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(iii) Suggest **one** way the student could improve their investigation.

.....

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

(b) **(i)** More people use solar panels to generate electricity compared to twenty years ago.

Suggest **two** reasons why.

1 .....

.....

2 .....

.....
[2]

(ii) A homeowner fits solar panels to the roof of their house.

Table 23.2 gives the energy values for the house for **one** day:

Area of one solar panel	1.6 m^2
Area of roof that can be used	24 m^2
Maximum energy output of one solar panel	26 MJ
Energy needed by all appliances in the house	364 MJ

Table 23.2

Explain whether the energy needed by all the appliances can be generated using **only** solar panels.

Use **Table 23.2** and your knowledge of solar panels to explain your answer.

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..... **[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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