Oxford Cambridge and RSA

Friday 16 June 2023 – 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 Equation Sheet for GCSE (9–1) Physics A (inside this document)

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

H

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 **32** pages.

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

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Section A

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

Write your answer to each question in the box provided.

1 A sound wave travels from air into water.

Which quantity stays the **same**?

A Amplitude

B Frequency

C Speed

D Wavelength

Your answer ☐ **[1]**

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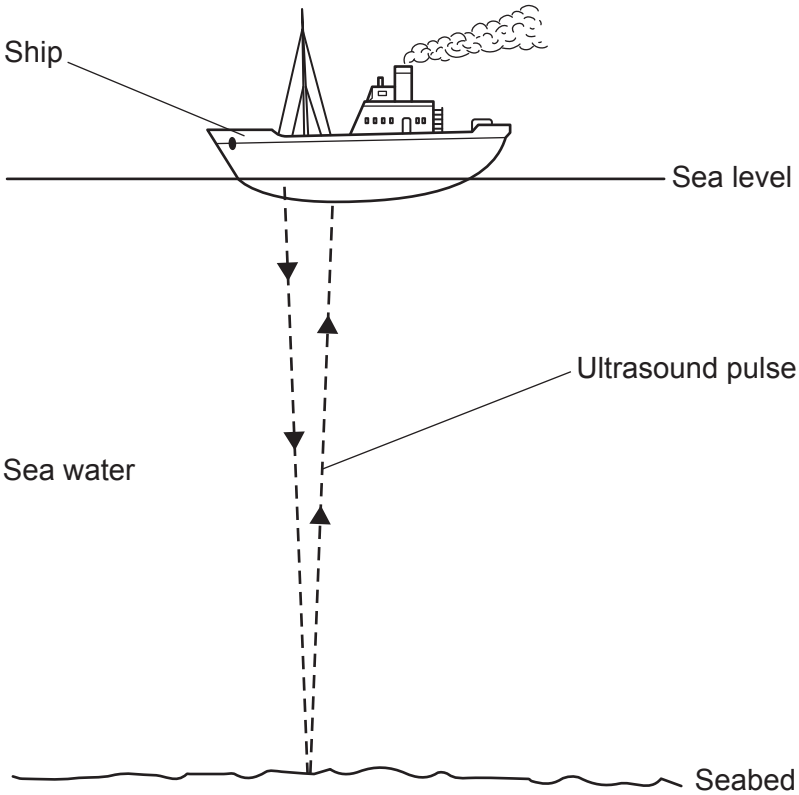
2 Ultrasound pulses can be used to measure the depth of the seabed.



The speed of ultrasound in sea water is 1500 m / s.

The seabed is 3600 m below sea level.

An ultrasound pulse is emitted from the ship.

How long is it before the ultrasound pulse **returns** to the ship?

Use the equation: distance travelled = speed × time

A 0.40 s

B 0.80 s

C 2.4 s

D 4.8 s

Your answer ☐ **[1]**

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3 A radioactive element emits gamma rays.

A teacher accidentally spills some of the radioactive element on their hands.

Which sentence describes what happens to the teacher?

A They are contaminated and irradiated.

B They are contaminated only.

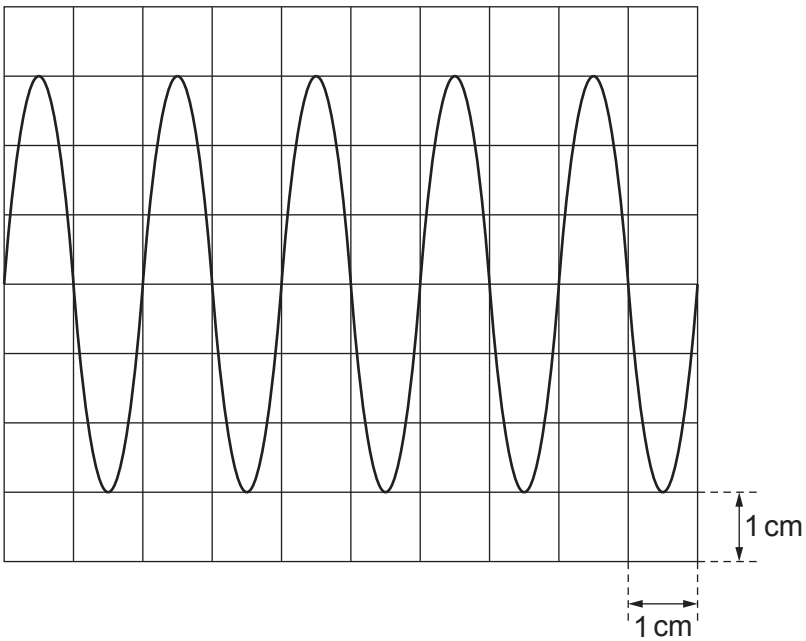
C They are irradiated only.

D They are not contaminated and not irradiated.

Your answer ☐ **[1]**

4 An oscilloscope is used to display a wave.

The diagram shows the screen of the oscilloscope.



The horizontal scale is 5 ms / cm.

What is the time period of the wave?

A 5 ms

B 10 ms

C 15 ms

D 30 ms

Your answer ☐ **[1]**

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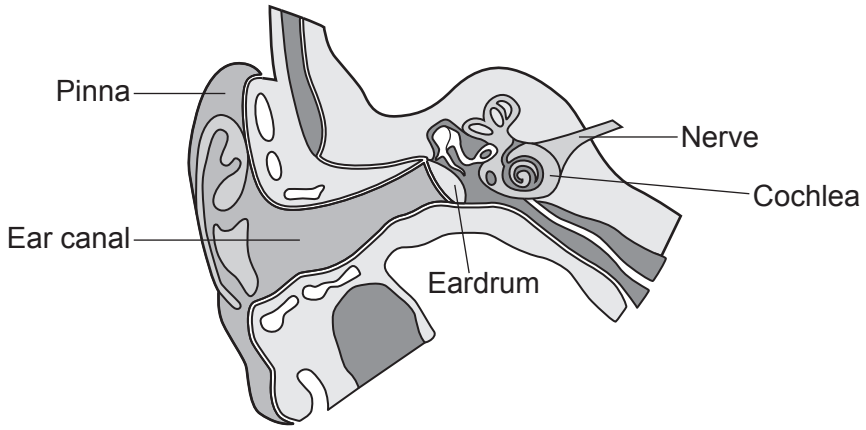
5 Which diagram shows the parts of the ear with the correct labels?

A



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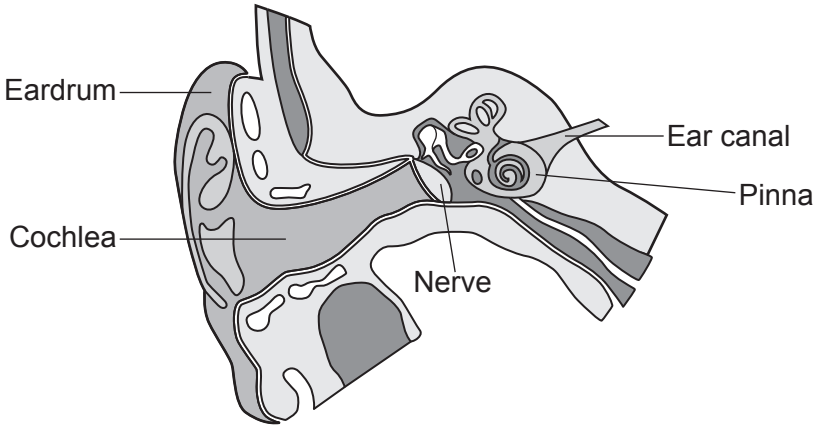

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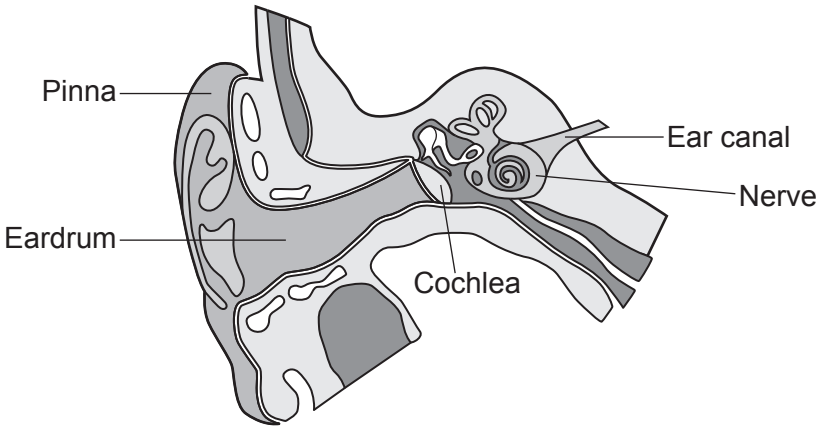

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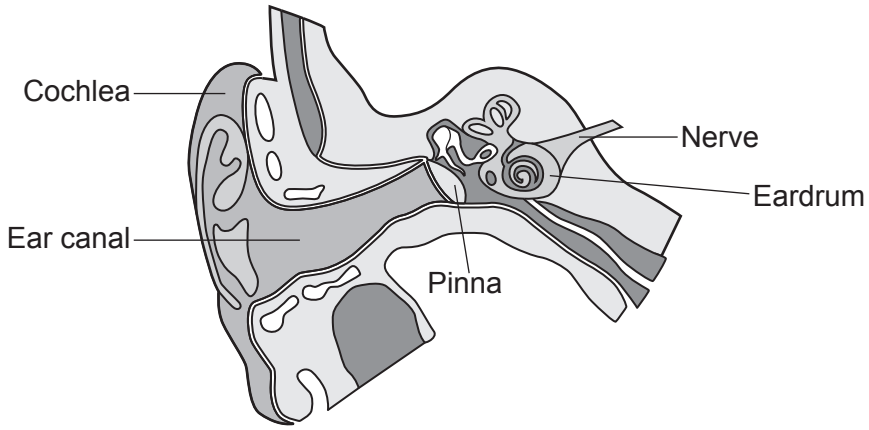

Your answer ☐ **[1]**

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6 Which sentence about P seismic waves is correct?

A P waves are slower than S waves.

B P waves are transverse.

C P waves can travel through solids and liquids.

D P waves can travel through solids but not liquids.

Your answer ☐ **[1]**

7 A teacher plugs an electric kettle into the domestic electricity supply.

The kettle has a power rating of 2300 W.

What is the current in the kettle?

Use the Equation Sheet.

A 0.10 A

B 3 A

C 10 A

D 13 A

Your answer ☐ **[1]**

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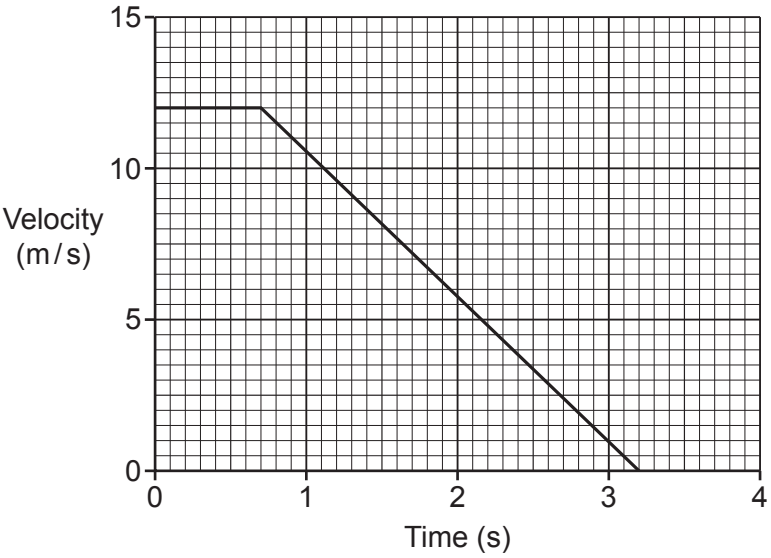
8 The velocity–time graph shows how the velocity of a car changes after the driver sees a hazard in the road.



What is the braking distance of the car?

A 8.4 m

B 15.0 m

C 17.5 m

D 23.4 m

Your answer ☐ **[1]**

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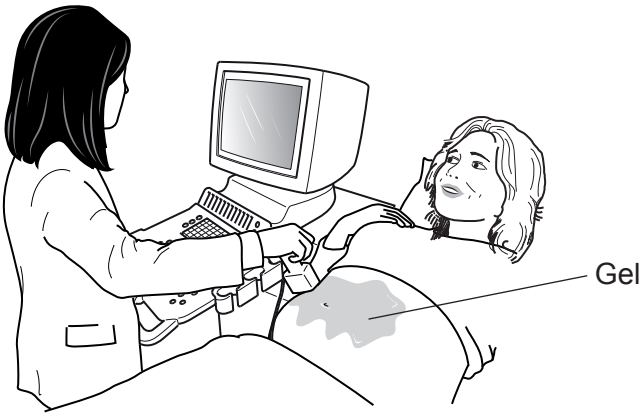
9 Ultrasound scans are used to take pictures of unborn babies.

Before the ultrasound scan, gel is placed on the skin.



Which sentence explains why the scan **only** works when the gel is used?

A The gel amplifies the ultrasound waves.

B The gel lubricates the skin.

C The gel reflects the ultrasound waves.

D The gel transmits the ultrasound waves.

Your answer ☐ **[1]**

10 The kinetic energy of a car is 180 kJ when its speed is 20 m / s.

What is the mass of the car?

Use the Equation Sheet.

A 225 kg

B 450 kg

C 900 kg

D 18 000 kg

Your answer ☐ **[1]**

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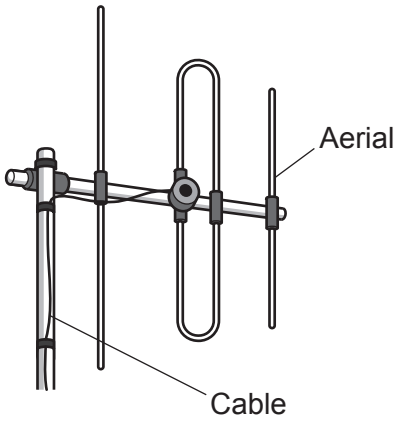
11 A radio aerial receives radio signals.

The aerial is connected to a radio receiver using a cable.



How does the radio signal travel through the cable?

A As a light wave

B As a radio wave

C As a sound oscillation

D As an electrical oscillation

Your answer ☐ **[1]**

12 A coal fired power station has an efficiency of 0.4.

What is the input energy needed to obtain a useful output energy of 500 MJ?

Use the equation: efficiency = $\frac{\text{useful output energy transfer}}{\text{input energy transfer}}$

A 200 MJ

B 500 MJ

C 540 MJ

D 1250 MJ

Your answer ☐ **[1]**

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13 0.090 J of energy is transferred when stretching a spring.

The spring constant of the spring is 50 N / m.

What is the extension of the spring?

Use the Equation Sheet.

A 0.0036 m

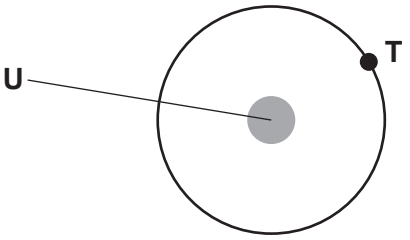
B 0.030 m

C 0.060 m

D 0.084 m

Your answer ☐ **[1]**

14 Object **T** moves at a constant speed in a circular orbit around object **U**.



Why does the velocity of **T** change?

A The force of gravity is at right angles to the velocity of **T**.

B The forces acting on **T** are balanced.

C The force of **U** on **T** equals the force of **T** on **U**.

D The forces acting on **U** are balanced.

Your answer ☐ **[1]**

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15 A vehicle is travelling at 30 m / s.

The vehicle travels 75 m while decelerating to a stop.

What is the deceleration of the vehicle?

Use the Equation Sheet.

A 2.5 m / s^2

B 6.0 m / s^2

C 12 m / s^2

D 24 m / s^2

Your answer ☐ **[1]**

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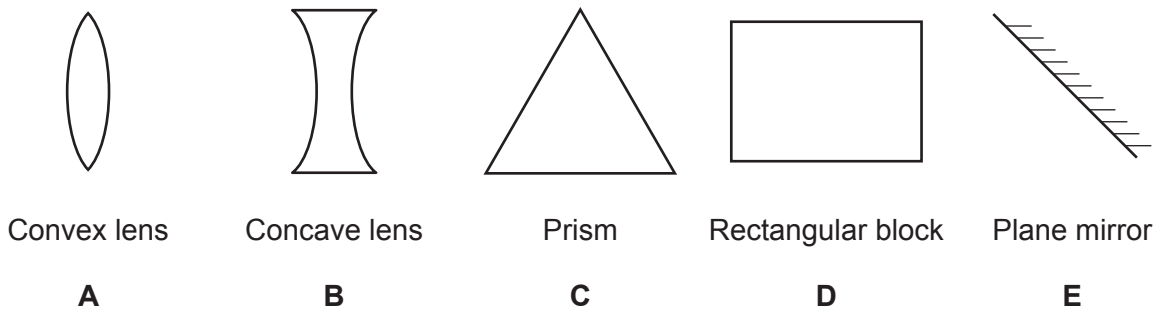
Section B

16 (a) A student shines three parallel rays of red light at different glass objects. **Fig. 16.1** shows the glass objects.

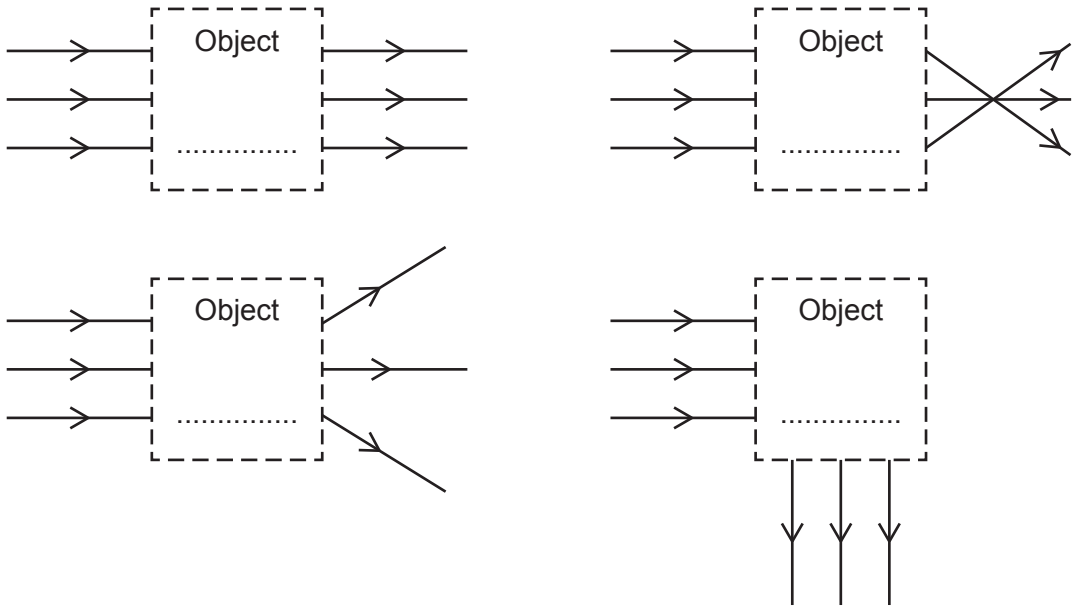
Fig. 16.1



The student draws ray diagrams to show what happens to the three parallel rays of red light.

Write **one** letter in each box in **Fig. 16.2** to identify which glass object produces that ray diagram.

Fig. 16.2



[4]

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(b) The wavelength of red light in glass is 4.33×10^{-7} m.

The speed of red light in glass is 2.0×10^{8} m/s.

Calculate the frequency of the red light in glass.

Use the equation: wave speed = frequency × wavelength

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

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

(c) A football player wears a red shirt with a white number 3 on the back.

(i) What is the colour of the shirt and the number when viewed under **blue** light?

Colour of shirt .....

Colour of number ..... **[1]**

(ii) Another football player says, 'Under **red** light, I cannot read the number on the shirt.'

Explain why.

.....

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

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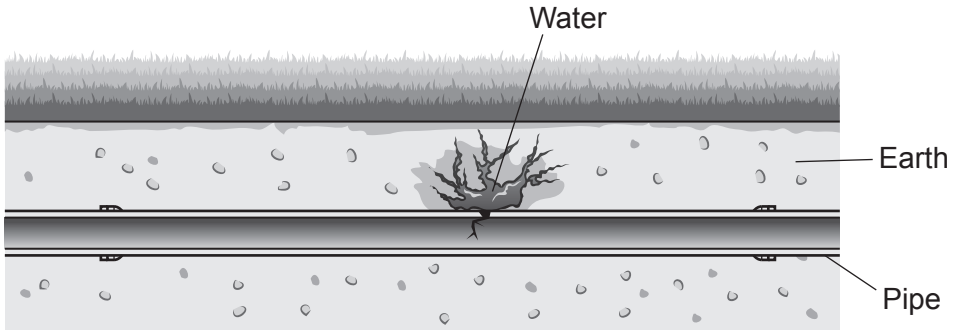
17 An underground water pipe has a leak, as shown in the diagram.



A tracer called sodium-24 is used to detect leaks in underground pipes.

(a) **(i)** Sodium-24 has a half-life of 15 hours.

Give **two** reasons why this is useful.

1 .....

.....

2 .....

.....

[2]

(ii) Sodium-24 emits beta and gamma radiation.

Explain why this makes sodium-24 a good tracer.

.....

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

(iii) Sodium-24 decays to form a stable isotope.

Explain why this is important.

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

(b) The tracer is monitored using a gamma radiation detector.

How is the location of the leak found?

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

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(c) A 12 mg mass of sodium-24 is added to water.

The half-life of sodium-24 is 15 hours.

What mass of sodium-24 remains in the water after 30 hours?

Mass remaining = ... mg **[2]**

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18 **(a)** Polonium-210 is a radioactive material which emits alpha particles.

(i) Complete **Table 18.1** to show the composition of an **alpha particle**.

Table 18.1

Number of protons	.....
Number of neutrons	.....
Number of electrons	.....

[2]

(ii) A person swallows a small amount of polonium-210. Doctors examine the person using a Geiger-Müller tube outside the body.

Explain why the doctors do **not** detect the polonium-210 inside the body.

.....

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

(b) Polonium-210, $^{210}_{84}Po$, can be made in a nuclear reactor in two steps.

(i) In the first step, bismuth-209, $^{209}_{83}Bi$ is bombarded with neutrons to make $^{210}_{83}Bi$.

State the name given to these different forms of the element bismuth.

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

(ii) In the second step, $^{210}_{83}Bi$ decays to form $^{210}_{84}Po$.

Complete the **balanced nuclear** equation for this decay.

$$^{210}_{83}Bi \rightarrow {}^{210}_{84}Po + \text{.....}$$

[2]

(c) 1 μg of polonium-210 is enough to kill a human being.
210 g of polonium-210 has an activity of 3.57×10^{16} Bq.

Calculate the activity of a sample of 1 μg of polonium-210.

Give your answer in **standard form**.

Activity = ... Bq **[3]**

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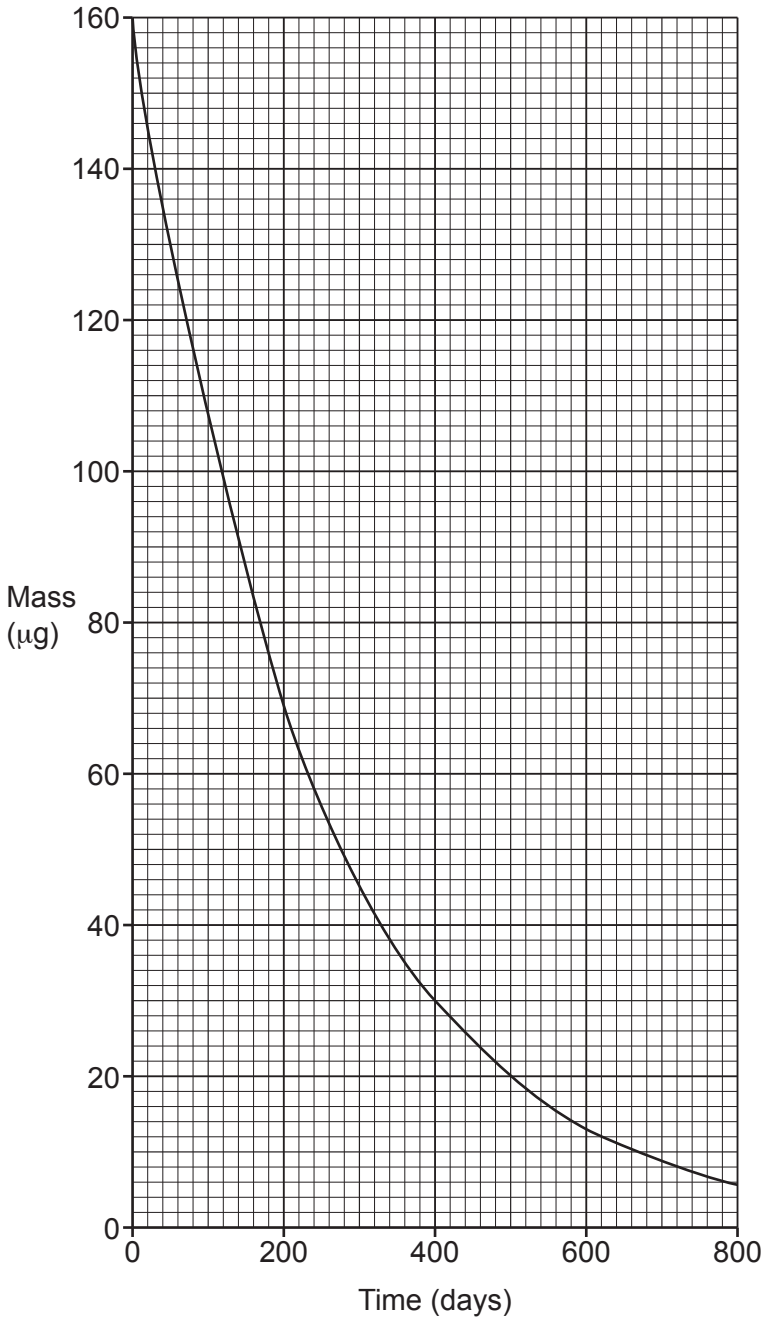
(d) The graph shows how the mass of a sample of polonium-210 changes with time.



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(i) Use the graph to complete **Table 18.2**. Two answers have been filled in for you.

Table 18.2

Time (days)	Mass (μg)
0	160
200	.....
400	30
600	.....

[1]

(ii) A teacher explains half-life and radioactive decay to their class.

The teacher says,
'For equal time periods, the ratio:

$$\frac{\text{mass at the start of the time period}}{\text{mass at the end of that time period}}$$

is constant.'

Use this ratio and your answers in **Table 18.2** to determine if the teacher is correct for the sample of polonium-210.

.....

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

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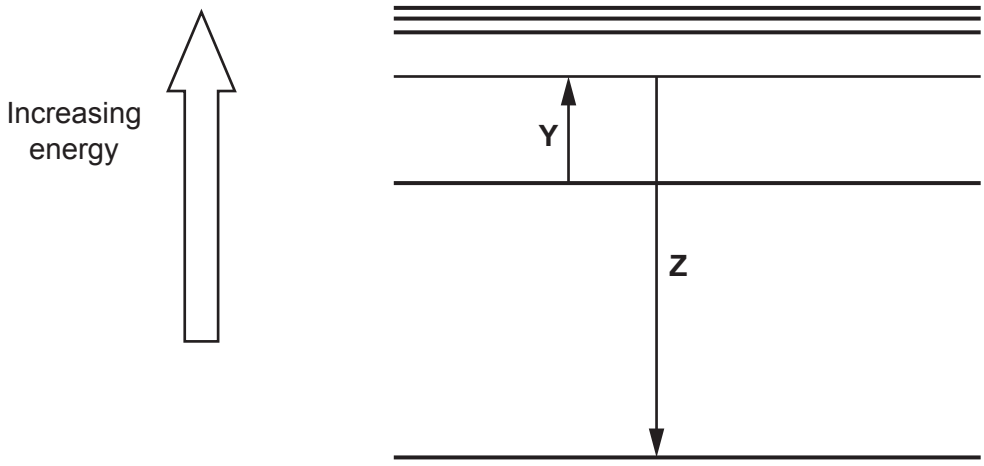
19 **(a)** Atoms can emit or absorb electromagnetic radiation when electrons move between energy levels.

The diagram shows electron transitions **Y** and **Z** between energy levels in an atom.



(i) Draw an arrow on the diagram showing the transition of an electron in the **lowest** energy level when it is lost from the atom. **[2]**

(ii) Complete each sentence about the electron transitions in the diagram.

Use the words in the list.

absorbed	**emitted**	**excited**	**ionised**
higher than	**lower than**	**the same as**	

When an electron is ....., as shown by arrow **Y**, electromagnetic radiation is ..... by the atom.

The frequency of electromagnetic radiation involved in transition **Z** is ..... the frequency of the electromagnetic radiation involved in transition **Y**.

[2]

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(b) Line spectra give astronomers information about the motion of distant galaxies.

The table gives the wavelength of a line in the spectrum of hydrogen observed in a laboratory on the Earth.

The table also gives the wavelength of the **same** line in the spectrum of hydrogen observed from galaxy **A** and galaxy **B**.

Source	Wavelength of line (nm)
Laboratory on the Earth	656
Galaxy **A**	712
Galaxy **B**	739

Explain how the data in the table can be used to compare the motion of galaxy **A** with galaxy **B**.

.....

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..... **[4]**

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20 **(a)** The Sun is a star.

Describe how the Sun was formed.

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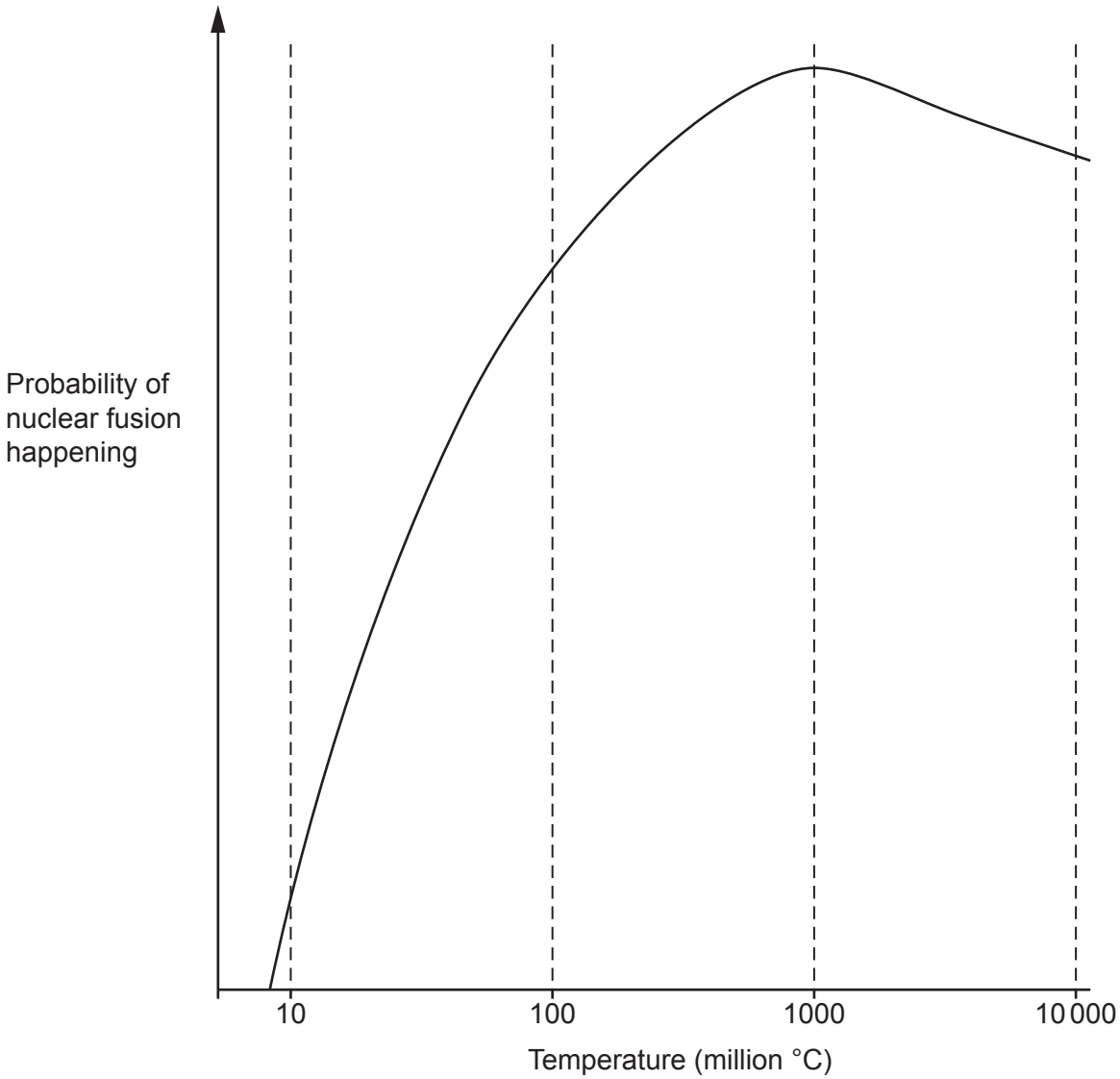
..... **[3]**

(b)* Nuclear power stations use nuclear fission rather than nuclear fusion to generate energy.

This graph shows how the probability of a nuclear fusion reaction changes with temperature.



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Compare the processes of fission and fusion.

Explain why power stations only use nuclear fission at present.

Use the graph, and your scientific knowledge.

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

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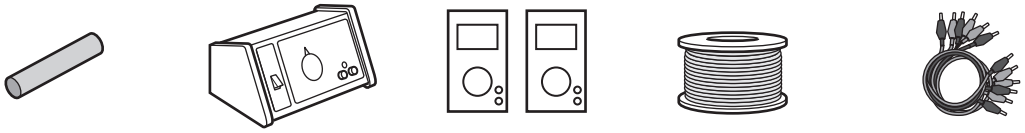
21 **(a)** A student investigates how the potential difference across the secondary coil of a transformer changes with the number of turns on the secondary coil.

The diagram shows the student's equipment.



Soft iron rod | a.c. power supply | Voltmeters | Insulated wire | Connecting wires

Describe a method that the student uses to obtain valid results.

You can include a labelled diagram to support your answer.

.....

.....

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.....

.....

..... **[4]**

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(b) A transformer is used to change the potential difference (p.d.) of a supply.

The table shows the data for this transformer.

Number of turns on the primary coil	3540
Number of turns on the secondary coil	300
p.d. across primary coil	230 V
Current in secondary coil	4.62 A

(i) Calculate the p.d. across the secondary coil of the transformer.

Use the Equation Sheet.

p.d. across the secondary coil = ... V **[3]**

(ii) Calculate the current in the primary coil of the transformer.

Use the Equation Sheet.

Current in primary coil = ... A **[3]**

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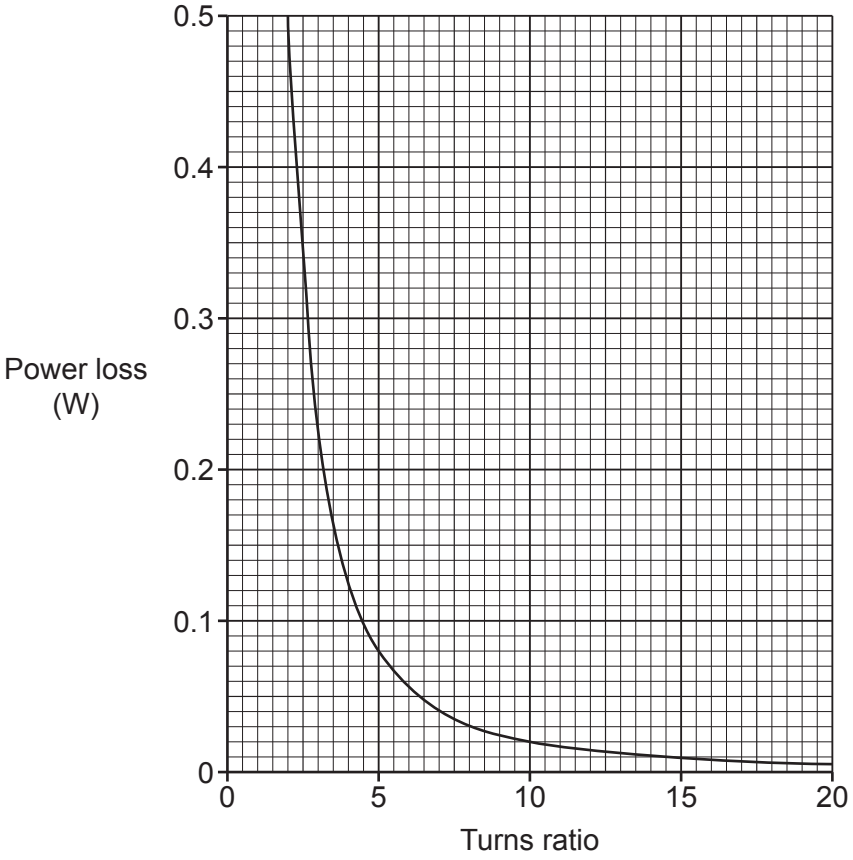
(c) A teacher calculates power losses in a model power line.

The teacher changes the 'turns ratio' of a step-up transformer using the equation:

$$\text{turns ratio} = \frac{\text{number of turns in secondary coil}}{\text{number of turns in primary coil}}$$

The graph shows how power loss in the power line changes with the turns ratio.



(i) A student says, 'As the turns ratio doubles, the power loss halves.'

Use data from the graph to explain why the student is **incorrect**.

.....

.....

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

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(ii) Explain why step-up transformers are used in the national grid.

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

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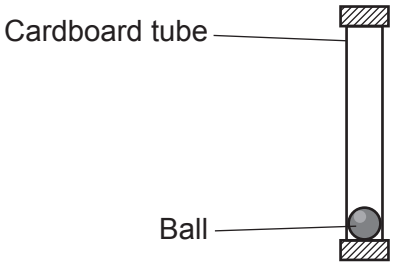
22 (a) **Fig. 22.1** shows a sealed cardboard tube containing a ball.

Fig. 22.1



The cardboard tube is quickly turned upside down so that the ball falls the whole length of the tube.
Fig. 22.2 shows the energy stores of the ball at the **top** of the tube.

Complete **Fig. 22.3** to show the energy stores of the ball before it hits the **bottom** of the tube. **[3]**

Fig. 22.2

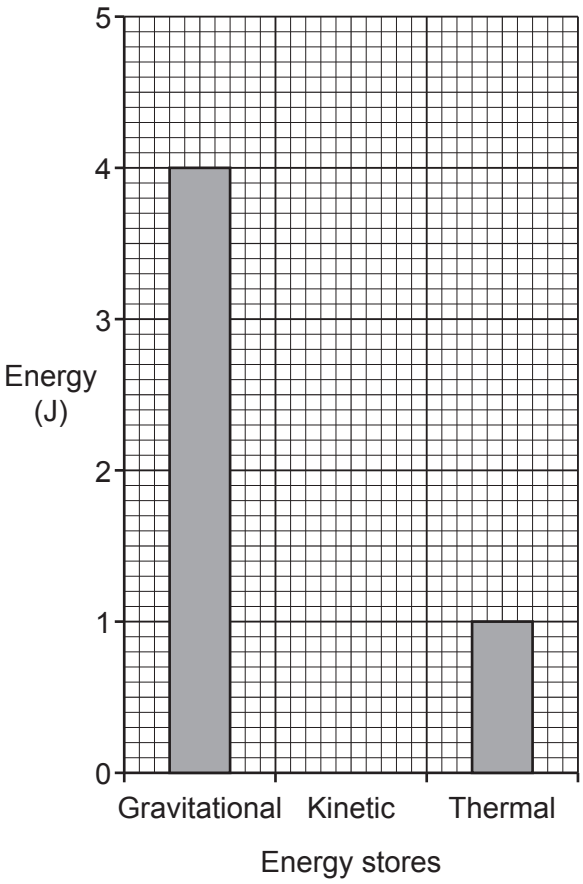
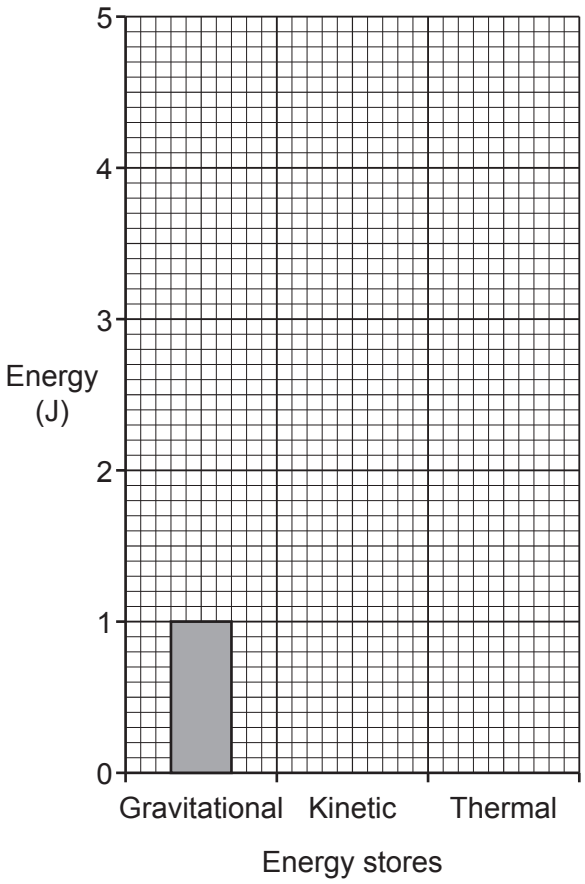


Fig. 22.3



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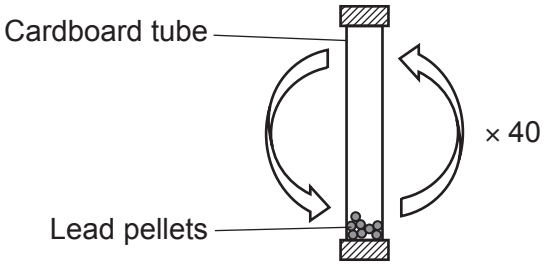
(b) Student **A** and student **B** determine the specific heat capacity of lead using this method.

- Measure the mass and initial temperature of small lead pellets.
- Place the pellets in a sealed cardboard tube.
- Quickly turn the tube upside down 40 times.
- Measure the final temperature of the lead pellets.

Fig. 22.4 shows a diagram of the equipment:

Fig. 22.4



(i) State **one** way to improve the experiment.

.....

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

(ii) Explain why the cardboard tube is turned upside down very quickly.

.....

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

(iii) **Student A** uses 0.030 kg of lead pellets and a 1.5 m long cardboard tube.

Calculate the change in potential energy of the pellets when the tube is turned upside down **once**.

Use the equation: potential energy = mass × height × gravitational field strength

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

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(iv) **Student B** repeats the experiment using a different tube.

The total change in potential energy of 0.030 kg of lead pellets for this tube is 21 J.
The temperature change of the lead pellets is 5 °C.

Calculate the specific heat capacity of lead. Include the correct unit.

Use the Equation Sheet.

Specific heat capacity = ... Unit ..... **[4]**

(v) Student **A** says, 'I think we should use a metal with a higher specific heat capacity. This will give us more accurate results.'

Student **B** says, 'I think we should turn the tube upside down 100 times. This will give us more accurate results.'

Explain why both student **A** and student **B** are **not** correct.

Student **A** .....

.....

.....

.....

Student **B** .....

.....

.....

.....

[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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