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GCSE (9–1) Physics B (Twenty First Century Science)

H

J259/03 Breadth in physics (Higher Tier)

Sample Question Paper

Date – Morning/Afternoon

Version 2

Time allowed: 1 hour 45 minutes

You must have:
- a ruler (in mm)
- the Data Sheet

You may use:
- a scientific or graphical calculator

First name									
Last name									
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **24** pages.

Answer **all** the questions.

1 **(a)** **(i)** Define density.

.....

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

(ii) A volume of air measuring 3.0 m^3 has a mass of 3.9 kg.
Calculate its density.

Density = ... kg/m^3 **[2]**

(b) Beth does an experiment to test the hypothesis '*the reason why a solid floats or sinks in a liquid depends upon both the density of the solid and the density of the liquid*'.

She was given blocks of rubber and wood and bottles of maple syrup and baby oil.

Material	**Density (g/cm^3)**
Rubber	1.52
Wood	0.85
Maple Syrup	1.37
Baby Oil	0.80

Material	**Floats in Maple Syrup**	**Floats in Baby Oil**
Rubber	No	No
Wood	Yes	No

Beth concludes that the density of both the solid and the liquid affects whether it floats or sinks.

Use the data to justify Beth's conclusion.

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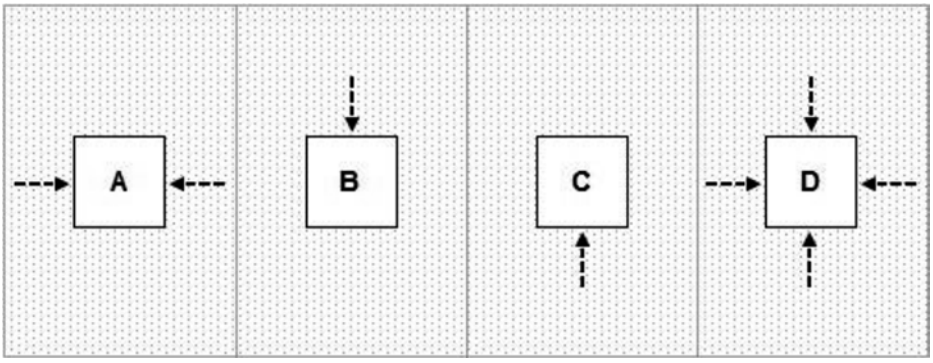
..... **[2]**

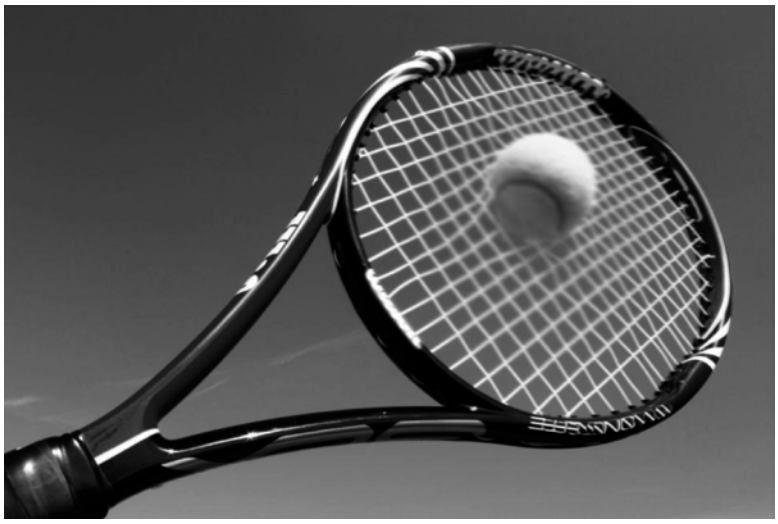
(c) A solid block is immersed in a liquid.

Which **one** of the diagrams (**A**, **B**, **C** or **D**), best shows the **direction** of all the force(s) on the solid caused by the liquid pressure?



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

2 This is a picture of a tennis ball being hit.



(a) The racket exerts an average force of 1000 N on the tennis ball.

Complete the following table to show whether each statement about the average force exerted by the tennis ball on the racket is **true** or **false**.

Put ticks (✓) in the correct boxes.

	True	**False**
The average force is a vector quantity		
The average force acts in the same direction as the ball is moving		
The average force equals 1000 N		
The average force depends upon the weight of the ball		

[2]

(b) The tennis ball has a mass of 0.06 kg.

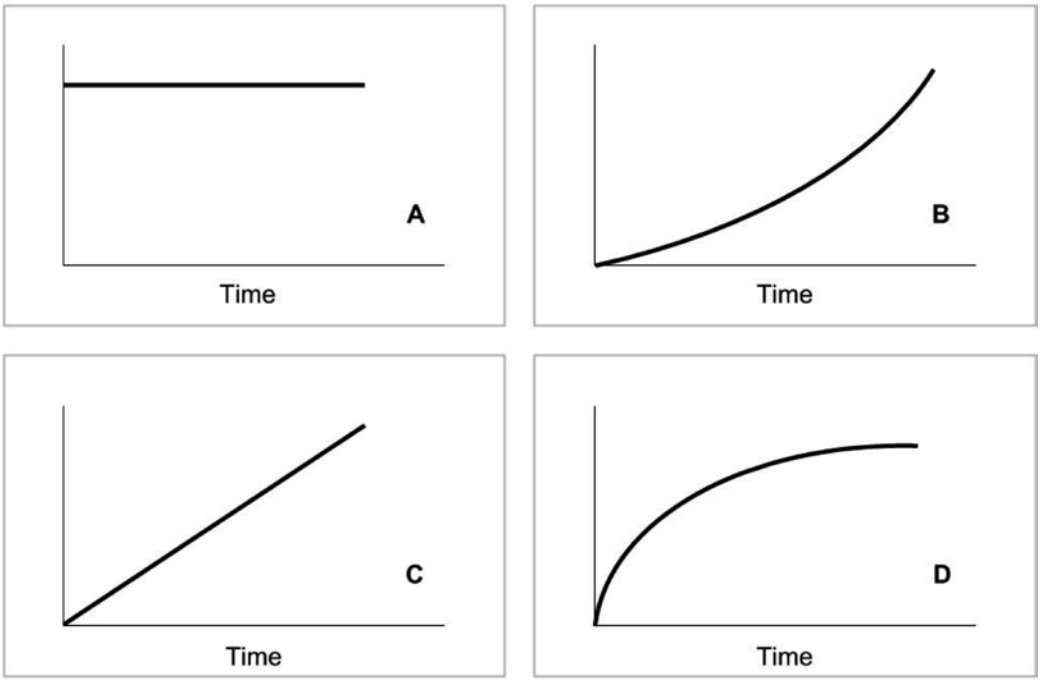
Calculate the momentum of the ball (in kg m/s) as soon as it leaves the racket at 50 m/s.

Momentum = ... kg m/s **[3]**

(c) Calculate the weight in newtons of the tennis ball. Gravitational field strength = 10 N/kg.

Weight = ...N **[3]**

3 **(a)** A coin is dropped to the floor.



(i) Which graph represents the distance–time graph of the coin dropping?

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

(ii) Which graph represents the speed–time graph of the coin dropping?

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

(b) The coin falls through a distance of 150 cm in a time of 0.8 seconds.

Calculate the average speed at which the coin falls.

Speed = distance ÷ time

Average speed = ... m/s **[3]**

(c) Explain the **difference** between vectors and scalars as it applies to velocity and speed.

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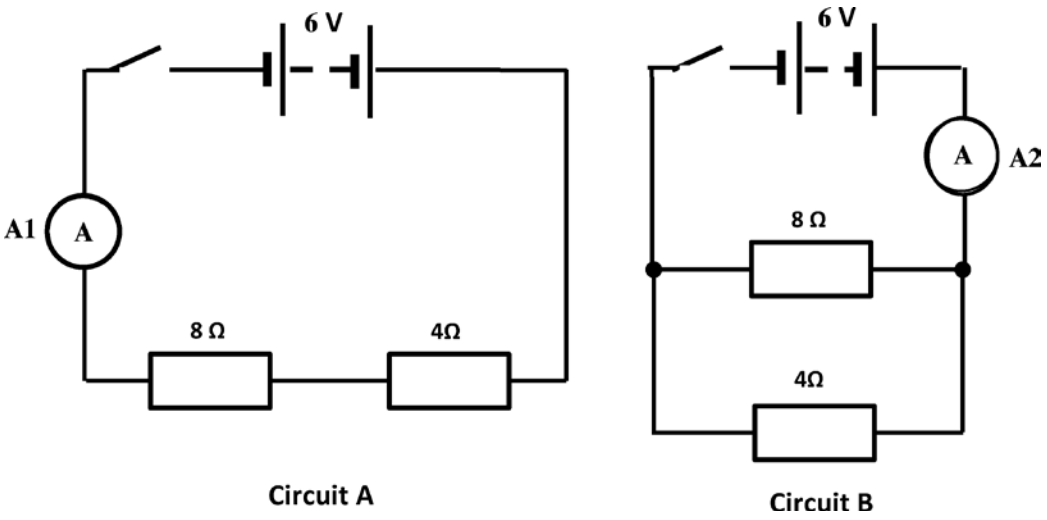
.....

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

4 Layla is comparing series and parallel circuits in an experiment.

Layla sets up the two circuits (**A** and **B**) below.



(a) Layla decides to check the battery voltage in the circuits.

Using the correct symbol add a meter to circuit **A** to show how she could do this. **[1]**

(b) Layla switches on both circuits.

Put a tick (✓) in the box next to the correct answer.

The p.d. across $\mathbf{A}_2$ is very large ☐

The p.d. across the 8 Ω resistor is the same in both circuits. ☐

The reading on $\mathbf{A}_1$ is less than the reading on $\mathbf{A}_2$. ☐

The total resistance in circuit **B** is 6 Ω. ☐ **[1]**

(c) Layla replaces the 4 Ω resistor with a 6 Ω resistor in each circuit.

Complete the table to show whether each statement is true for the two circuits.

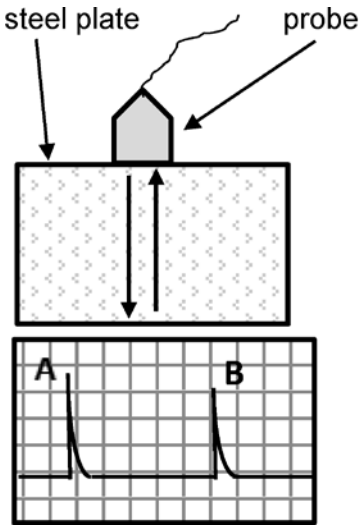
Put ticks (✓) in the correct boxes.

Statement	**True for circuit A**	**True for circuit B**	**True for both A and B**
The current from the battery decreases.			
Each unit of charge does less work on the 8 Ω resistor.			
The current in the 8 Ω resistor does **not** change.			

[3]

5 Ultrasonic testing is a technique widely used in industry to detect defects or flaws in many materials including metals and plastics.

The diagram shows ultrasound testing of a steel plate.



The probe sends out a sound wave into a sample of steel plate.

There are two signals displayed:

- one signal from the outgoing pulse (**A**)
- one signal due to an echo from the bottom surface (**B**).

For the sound waves,

- Frequency = 100 kHz
- Speed = 330 m/s

Calculate the wavelength of the sound waves.

Wavelength = ... m **[4]**

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TURN OVER FOR THE NEXT QUESTION

6 This question is about the magnetic effect of an electric current.

(a) **(i)** Which diagram (**A**, **B**, **C** or **D**) correctly shows the magnetic field caused by a wire conducting an electric current?

(The electric current is flowing **into the paper**.)

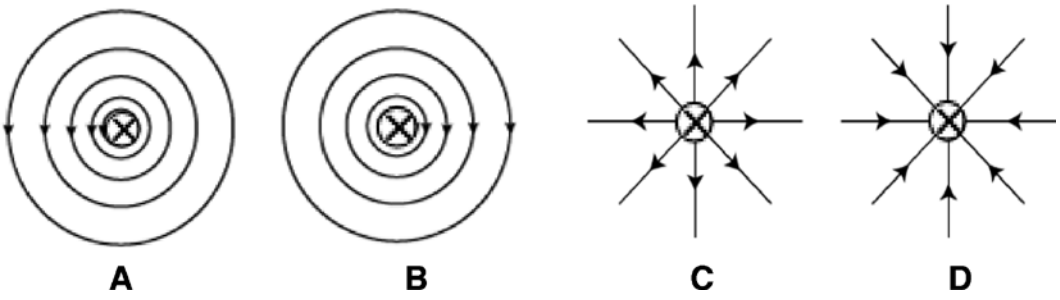
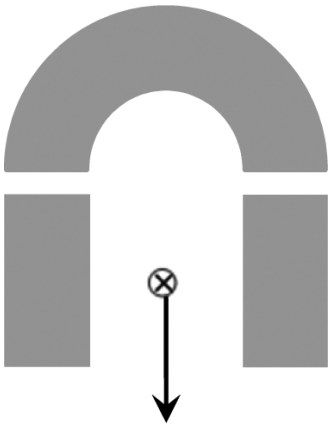


Diagram:..... **[1]**

A wire is placed between the North and South poles of a permanent magnet and at right angles to the magnetic field.

- The current is switched on (electric current flowing **into the paper**).
- This creates a force on the wire in the direction shown.



(ii) Complete the diagram by labelling the North and South poles of the permanent magnet N and S **and** sketching the resulting magnetic field between the poles. **[2]**

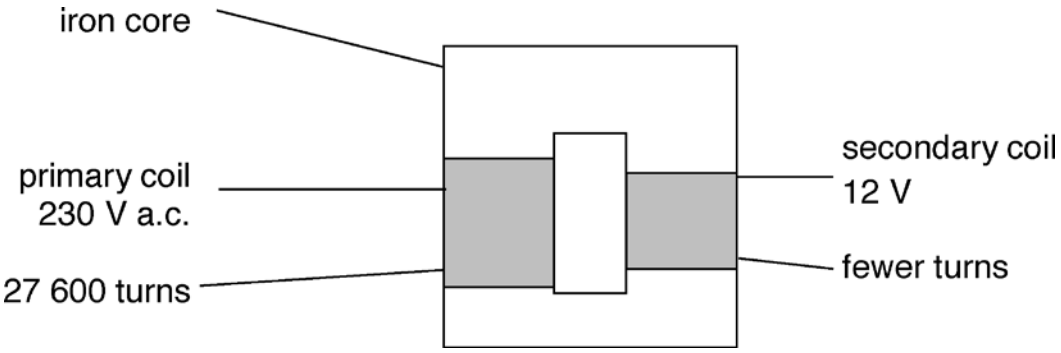
(iii) The current in the wire in **(ii)** is 0.2 A, and the magnetic flux density is 0.036 T.

The force experienced is 5.4×10^{-4} N.

Calculate the length of wire inside the magnetic field.

Length = ... m **[3]**

(b) This is a diagram of a simple transformer.



The secondary coil produces an output of 12 V.

Calculate the number of turns needed on the secondary coil.

Number of turns =..... **[2]**

(c) A National Grid transformer in a sub-station converts 30 000 V into 230 V to power a town.

The transformer is 99% efficient.

Using appropriate estimates, discuss the energy consequences **for the transformer sub-station** if the efficiency is less than 100%.

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

7 Two students are investigating springs and forces.

- They begin by comparing **three** different springs.
- They measure how much each spring stretched after attaching different weights.

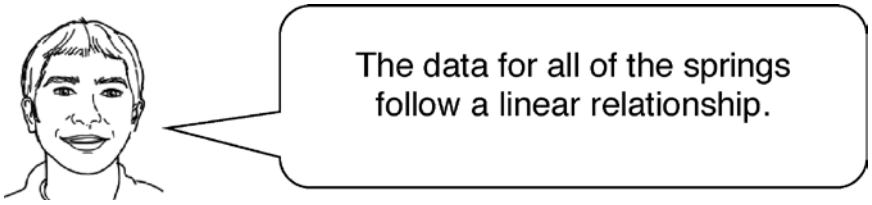
Here are their results:

SPRING A	
Force (N)	**Extension (cm)**
0.0	0.0
1.0	0.7
2.0	1.4
3.0	2.1
4.0	2.8
5.0	3.5

SPRING B	
Force (N)	**Extension (cm)**
0.0	0.0
1.0	0.6
2.0	1.0
3.0	1.6
4.0	2.4
5.0	3.8

SPRING C	
Force (N)	**Extension (cm)**
0.0	0.0
1.0	1.6
2.0	3.2
3.0	4.8
4.0	6.4
5.0	8.0

(a) One of the students makes a comment about the data.



Is this student correct?

Use your understanding of what is meant by a linear relationship to help explain your answer.

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

(b) The students plotted a force–extension graph in **Fig. 7.1** for **spring C**.

(Note that the extension of the spring is in metres).

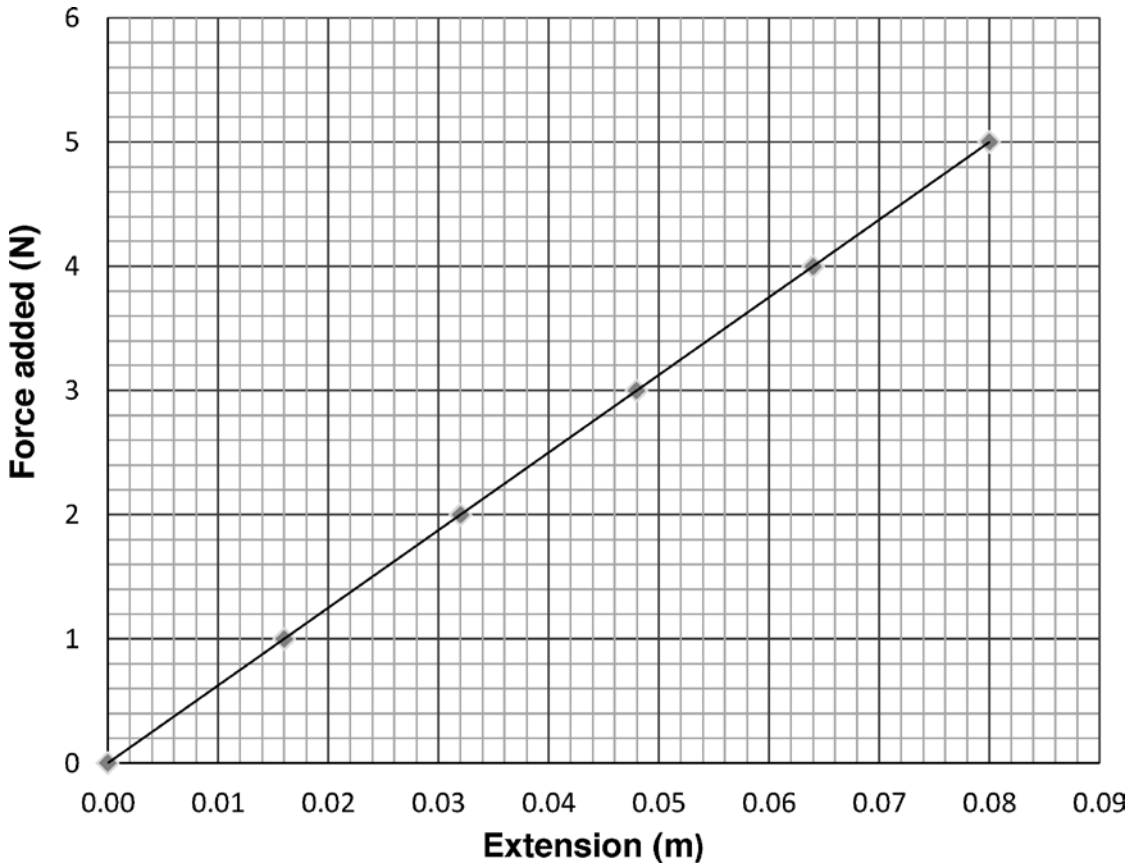

Fig 7.1

Use the graph to calculate the amount of work done (in joules) in stretching the spring over the first 8 cm (0.08 m).

Work done = ... J **[2]**

(c) When a rubber band is pulled, it stretches quite easily at the start and then becomes more difficult to stretch.

Sketch a curve on the graph in **Fig. 7.1** to show this behaviour. **[1]**

8 This question is about changing ideas about our Universe.

(a) In 1917, scientists suggested that the Universe was not changing in size.

Explain the effect that gravity would have in a Universe that is **not** changing in size.

.....

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

(b) About this time, Edwin Hubble noticed **red-shifts** in the light from the galaxies.

This provided evidence that galaxies were moving away from each other at high speeds.

(i) Explain what is meant by red-shift and how this shows that galaxies are moving away from each other.

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

The graphs in **Fig. 8.1** show how the speed that galaxies are moving away from us is linked to their distance from us.

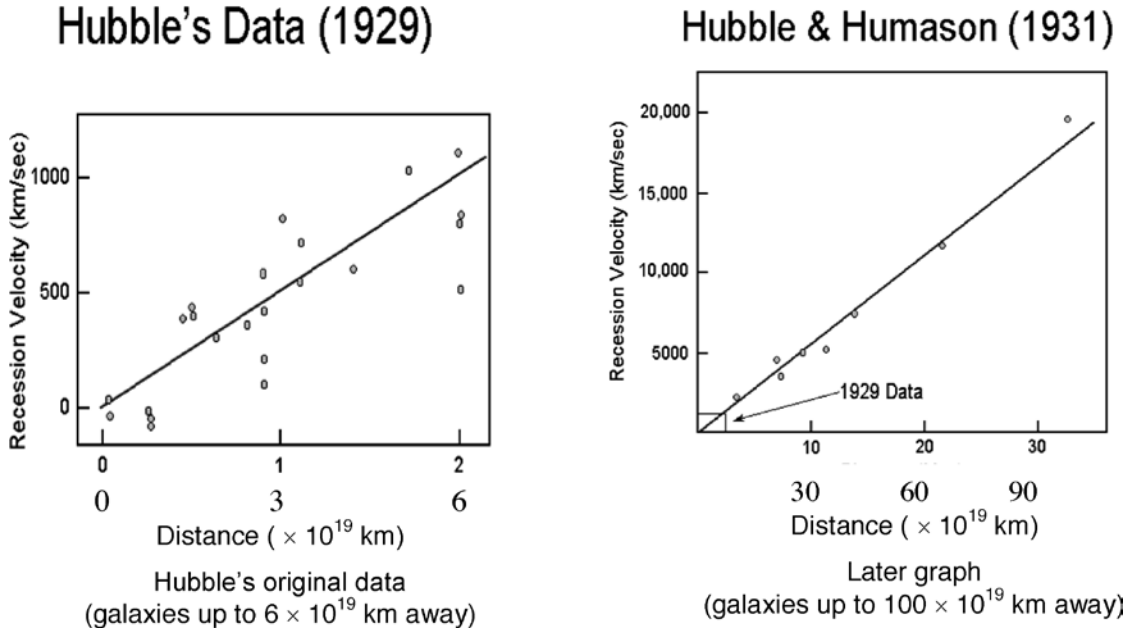

Fig. 8.1

(ii) Describe the trend shown in **Fig. 8.1** and explain how the data provides evidence which leads to the Big Bang model of the Universe.

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

(iii) From the graphs in **Fig. 8.1**, astronomers can work out the age of the Universe.

Explain how the data can be used to calculate the age of the Universe.

Assume that the speeds of the galaxies have remained reasonably constant over time.

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

(iv) Suggest **two** reasons why present day estimations of the age of the Universe are more valid than Hubble's initial values.

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

9 **(a)** Nuclear medicine uses radioactive isotopes as tracers and to help diagnose and treat different types of cancer.

Some details about four radioactive isotopes of iodine are shown in **Table 9.1**.

Isotope	Radiation emitted	Half-life
Iodine–123	gamma	13 hours
Iodine–128	beta	25 minutes
Iodine–129	Beta and gamma	15.7 million years
Iodine–131	Beta and gamma	8 days

Table 9.1

(i) Iodine–123 is widely used as a **tracer**.

Explain why iodine–123 is the most suitable iodine isotope for use as a tracer, from the four isotopes listed in **Table 9.1**.

Explain in terms of:

- the radiation emitted
- the half-life.

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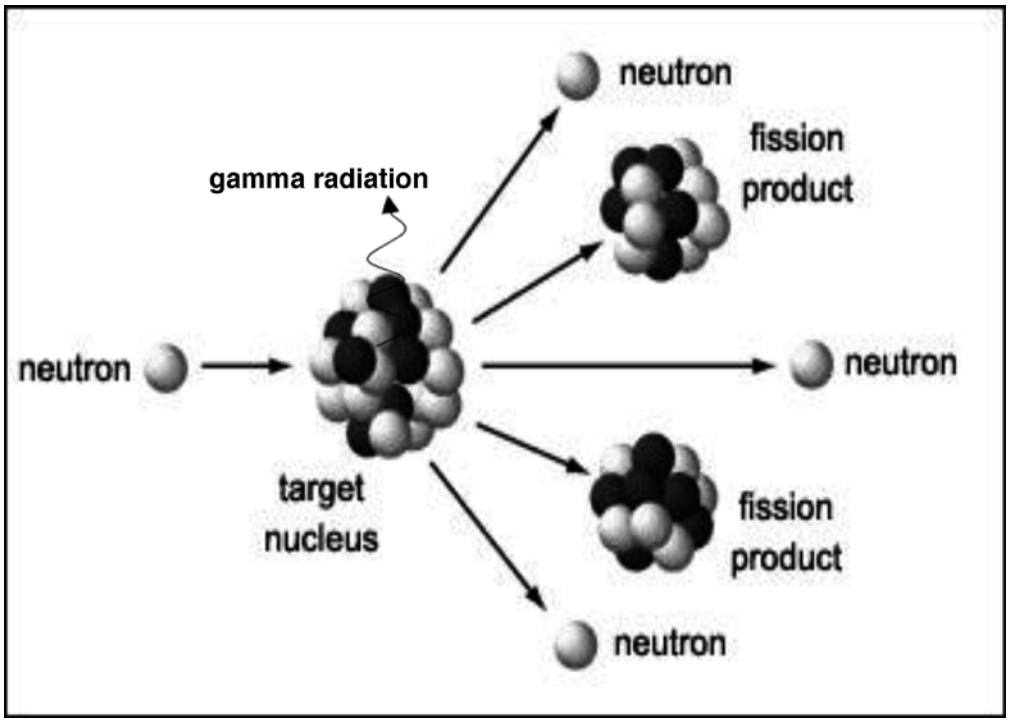
..... **[2]**

(ii) Iodine–129 and iodine–131 are both produced by the fission of uranium atoms during the operation of nuclear reactors.

Here is a diagram of a fission reaction.



How is the energy released in this reaction carried away from the target nucleus after fission?

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

(b) Describe the process of Nuclear **Fusion**.

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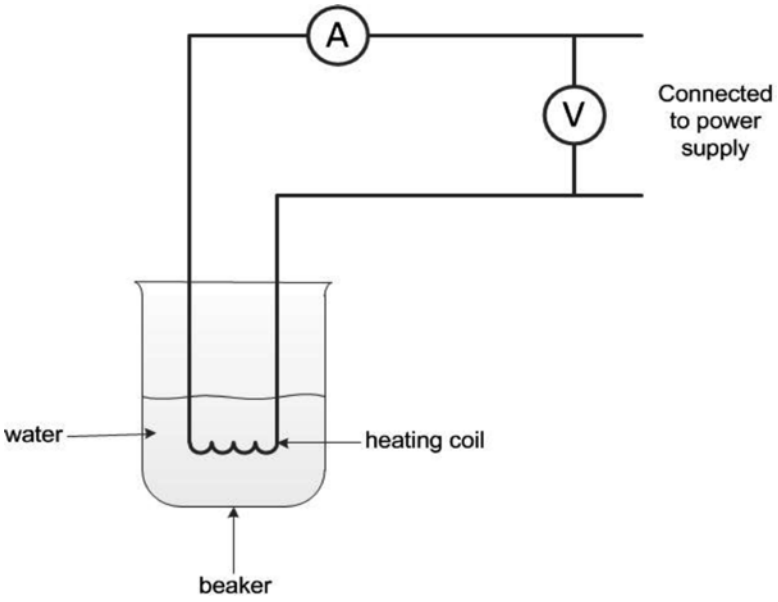
..... **[2]**

10 Jack uses the equipment below.



From the results, he is able to calculate the specific heat capacity of water.

(a) (i) State **one** safety issue Jack needs to consider in a risk assessment and explain what he can do to prevent this issue.

.....

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

(ii) Jack uses a mass of water of 0.10 kg.

He obtains a temperature change of 30°C.

He calculates the change in thermal energy to be 12 900 J.

Calculate the specific heat capacity of water

Specific heat capacity = ... J/kg°C **[3]**

(iii) State and explain how Jack could improve the experiment to get a more accurate result.

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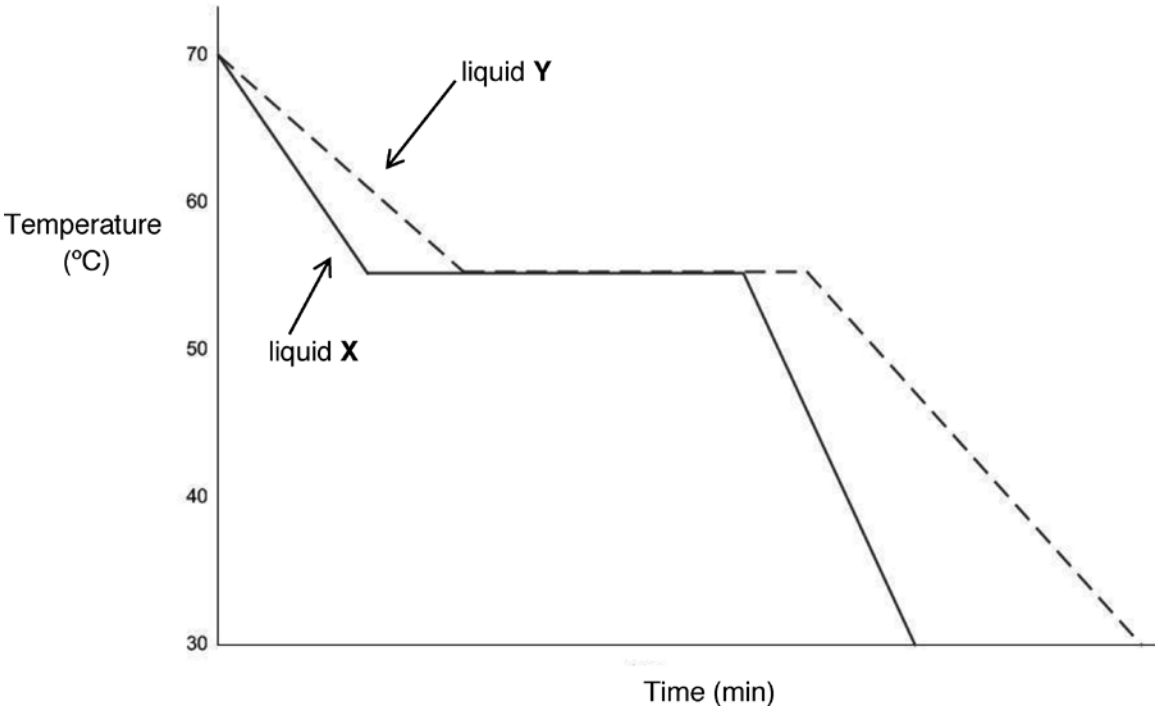
..... **[2]**

(b) Jack then does another experiment.

- He fills two beakers with equal masses of liquids **X** and **Y,** at the same temperature.
- The liquids are left and their temperatures are monitored throughout the experiment.

A graph of the temperature of the liquids with time is shown below.



Use the graph to compare what happens to liquids **X** and **Y** at 55°C.

Suggest what is happening to the liquids at this temperature.

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

(c) Jack concludes that liquids **X** and **Y** are the same substance.

State what evidence there is to support this?

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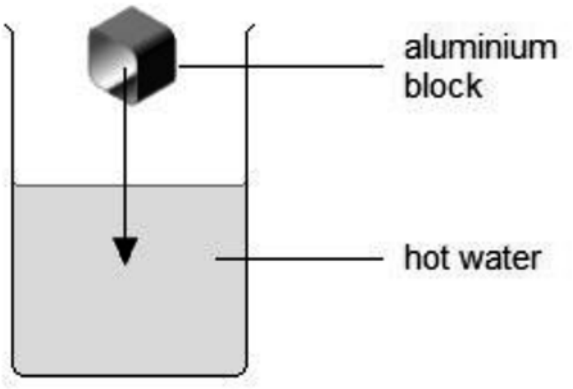
..... **[1]**

(d) A beaker contains hot water.

Jack wants to calculate the thermal energy lost by the hot water when he puts a cold aluminium block into it.



What information will he need to make this calculation?

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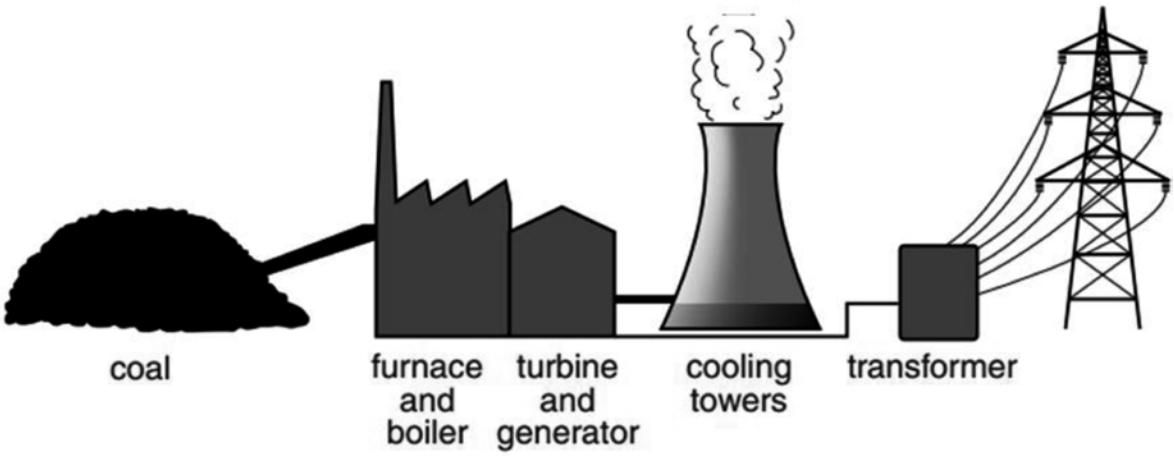
..... **[3]**

11 **(a)** In a coal-burning power station, large amounts of heat energy are needed to convert water into steam. The steam then drives the turbine to generate energy.



(i) Name an energy resource which does **not** need a furnace or boiler, as it can drive the turbine directly when generating electricity.

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

(ii) Write down **one** advantage and **one** disadvantage that the method of generating electricity in **(i)** has over a coal-burning power station.

Advantage: .....

.....

Disadvantage: .....

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

(b) Some coal-burning power stations can use some of their waste energy to heat local houses and industries. However, the efficiency of these Combined Heat and Power stations is less than from a typical coal-burning power station.

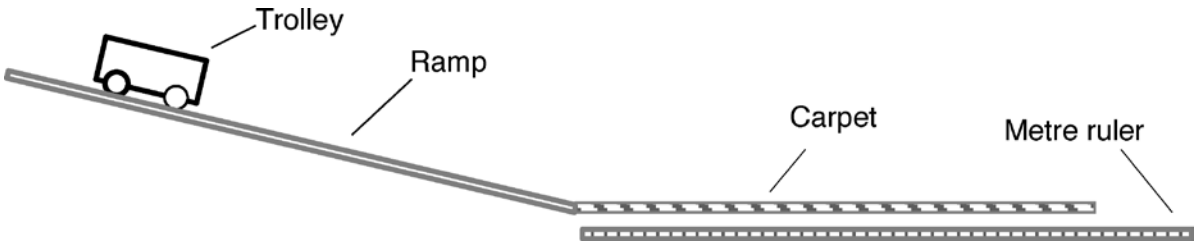
Select **one** answer below to give a location where this process would be useful.

Place a tick (✓) in the correct box.

Town **A**: small population far from power station	
Town **B**: large population close to power station	
Town **C**: large population far from power station	
Town **D**: small population close to power station	

[1]

12 A group of students are designing an experiment to investigate the relationship between stopping distance and speed.



The apparatus

- The trolley has a mass of 200 g and is placed on a gently sloping ramp.
- The thick carpet is used to slow down the trolley.
- The metre ruler is used to measure the stopping distance.

(a) How could the student calculate the 'top speed' of the trolley at the bottom of the ramp, just before it reaches the carpet?

Name the additional apparatus required and explain how it should be used.

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

The procedure

- The trolley is released and allowed to run freely down the slope.
- The distance it takes for the trolley to come to rest is measured.

The experiment is repeated by releasing the trolley from different positions up the ramp. This changes the 'top speed'.

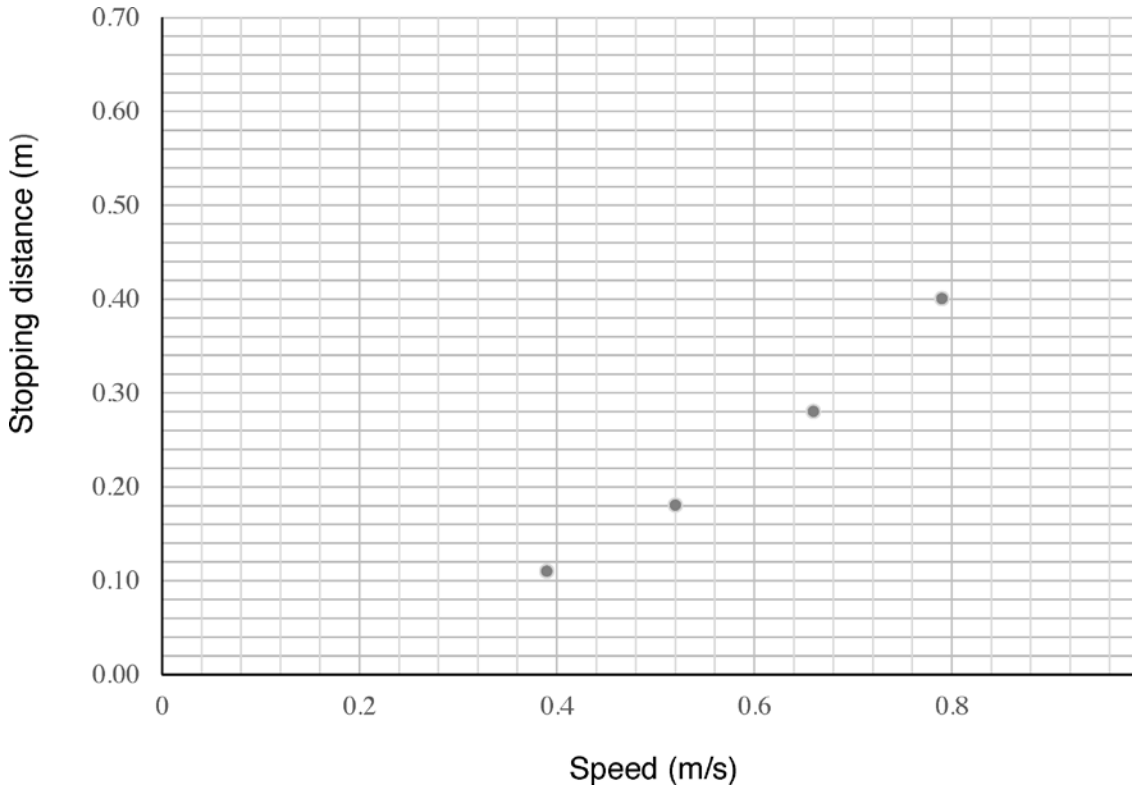
The results

The speed and stopping distance are shown in the table.

Speed (m/s)	Stopping distance (m)
0.52	0.18
0.39	0.11
0.66	0.28
0.79	0.40
0.82	0.44
0.94	0.62

(b) A graph is plotted from the results.

Complete the plotting of the points below and draw a smooth curve of best fit.



[2]

(c) Describe the pattern shown on the graph.

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

(d) Describe and explain how this graph would differ if the trolley had an 800 g mass placed on top of it.

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

END OF QUESTION PAPER