OCR
Oxford Cambridge and RSA

Thursday 25 May 2023 – Morning

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

J259/03 Breadth in physics (Higher Tier)

Time allowed: 1 hour 45 minutes

H

You must have:
- a ruler (cm/mm)
- the Equation Sheet for GCSE (9–1) Physics B (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 answers 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 **[ ]**.
- This document has **32** pages.

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

1 The picture shows a child on a slide. The child's hair is standing on end due to static electricity.

(a) Suggest what has happened to cause the child's hair to stand on end.

....

....

....

.... **[2]**

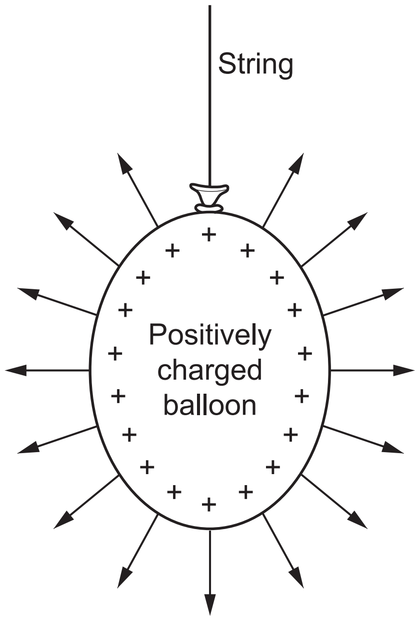
(b) Complete the sentence to explain static electricity.

Put a (ring) around the correct option.

Static electricity is the **sharing / storing / transfer** of electrons between insulators. **[1]**

(c) The diagram shows a positively charged balloon, hanging freely from a string.

There is an electric field around the balloon, as shown by the arrows.



(i) Explain what the direction and spacing of the arrows mean about the electric field.

Direction of arrows ....

....

Spacing of arrows ....

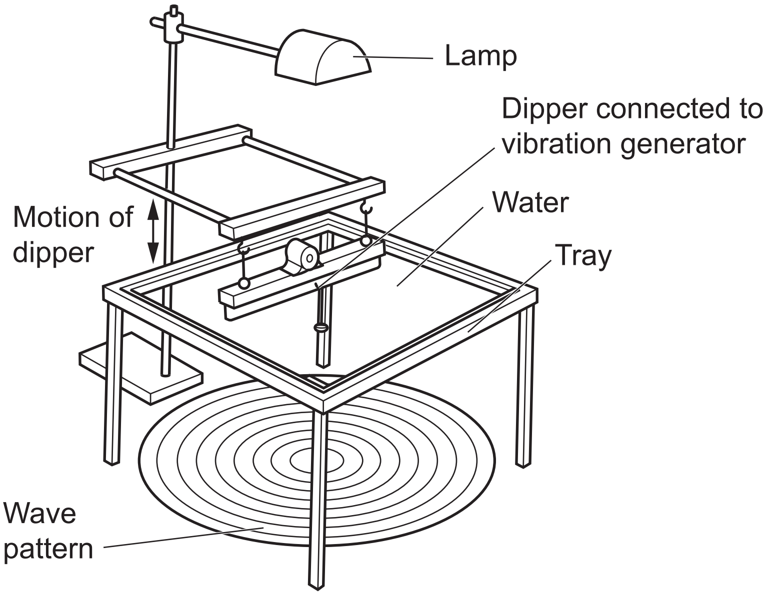
.... **[2]**

(ii) A second balloon is brought close to this balloon and the two balloons repel one another.

State the type of charge on the second balloon.

.... **[1]**

2 A student sets up a ripple tank, as shown in the diagram. The dipper dips up and down and sends circular water waves outwards.



(a) Which row gives the correct definitions of wavelength and frequency?

Tick (✓) **one** box.

Wavelength	**Frequency**	
The distance a wave travels in 1 second.	The number of waves in 1 second.	
The distance a wave travels in 1 second.	The time it takes for 1 wave to pass.	
The distance from peak to peak.	The number of waves in 1 second.	
The distance from peak to peak.	The time it takes for 1 wave to pass.	

[1]

(b) (i) The student takes a photograph of the wave pattern.

State **one** piece of equipment which needs to be included in the photograph to find the wavelength of the water waves.

.... **[1]**

(ii) The student then uses a smart phone to record a video of the movement of the water waves for a few seconds.

Describe how the student could use a video to find the frequency of the water waves.

....

....

....

.... **[2]**

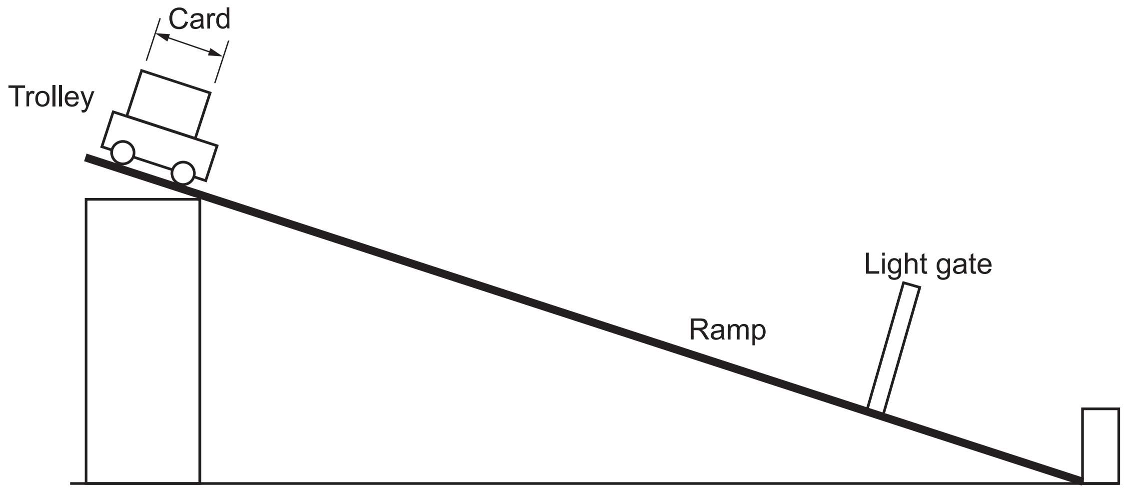
(iii) How can the student now calculate the speed of the water waves?

....

.... **[1]**

3 **Fig. 3.1** shows a trolley at the top of a ramp.

Fig. 3.1



(a) The trolley is released and accelerates down the ramp. When the trolley passes through the light gate, the instantaneous speed of the trolley is displayed.

Describe how the acceleration of the trolley down the ramp can be calculated using one light gate and a stopclock.

$$\text{Acceleration} = \frac{\text{change in speed}}{\text{time taken}}$$

....

....

....

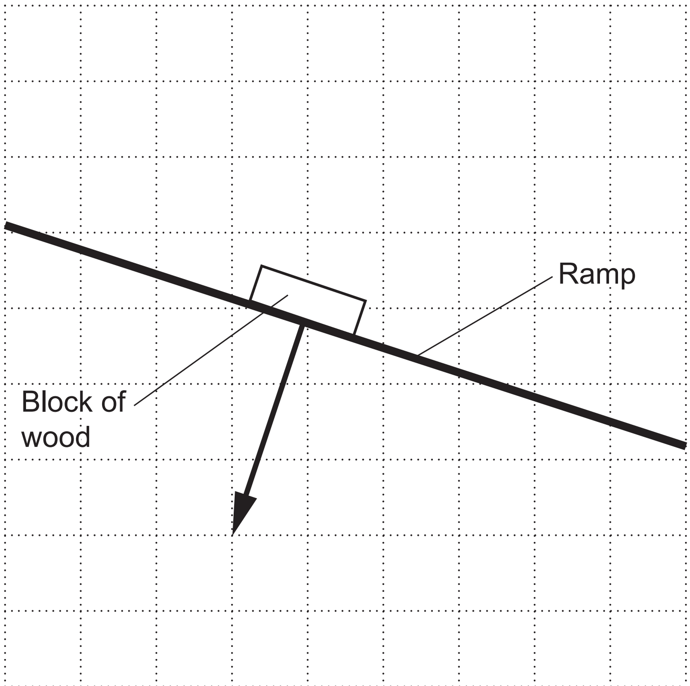
.... **[2]**

(b) A block of wood is placed on the ramp. It exerts a force of 3.2 N on the ramp, perpendicular to the surface of the ramp. This is shown as a vector on **Fig. 3.2**.

Draw **one** vector on **Fig. 3.2** to show the force the ramp exerts on the block of wood, to complete the interaction pair.

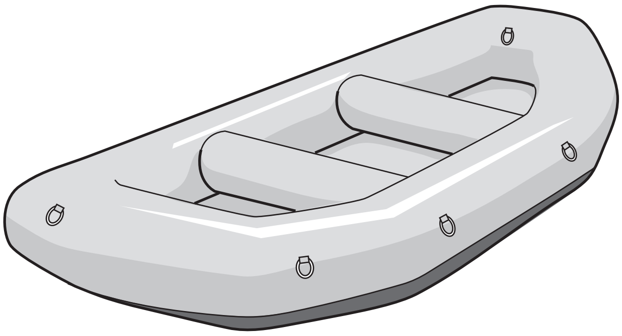
Use a ruler.

Fig. 3.2



[1]

4 This question is about an inflatable boat.



(a) Boats float because they are less dense than water.

Define density.

....

.... **[1]**

(b) The boat is inflated in the morning and then left out in the sun. The temperature of the air inside the boat rises to 50 °C.

- The volume and mass of the air inside the inflated boat are constant.
- The table contains data about the average speed of air molecules at different temperatures and pressures.

Temperature (°C)	Average speed of air molecules (m/s)	Pressure (Pa)
20	508	115 000
40	525	122 000
60	542	129 000

Explain why the boat feels firmer after being left out in the Sun.

Use the data in the table. You do not need to do any calculations.

....

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....

.... **[3]**

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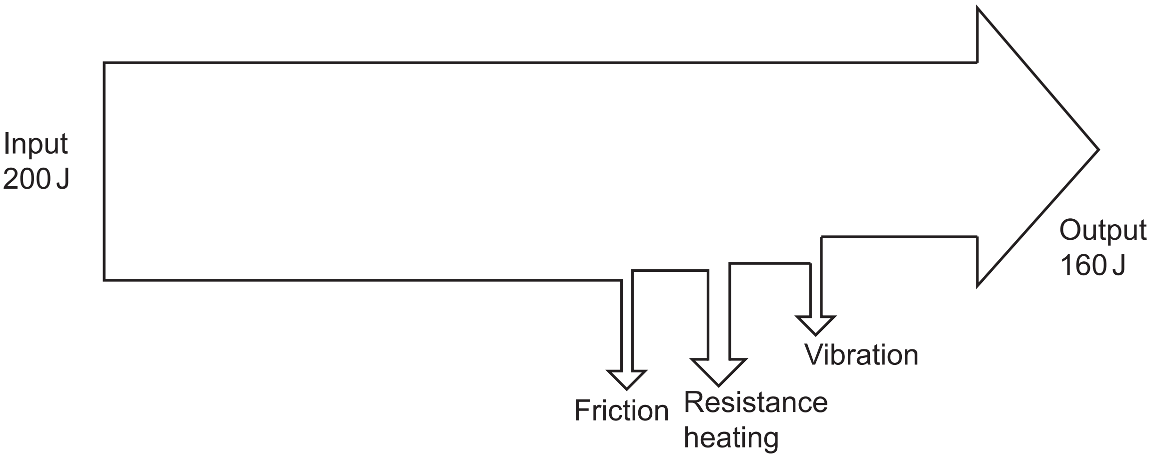
5 This question is about energy transfers in electric mixers.

The Sankey diagram shows the energy transferred when an electric hand mixer is in use for **one second**.



(a) **(i)** Describe how the Sankey diagram shows that all the energy transfers to and from the mixer are a closed system.

....

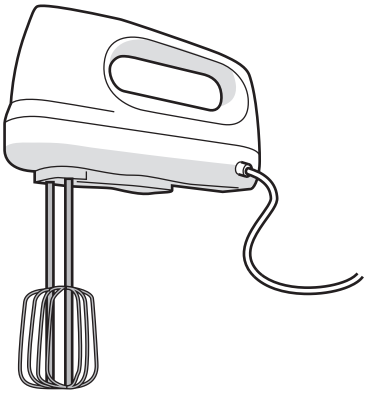
.... **[1]**

(ii) Calculate the power wasted when the mixer is in use.

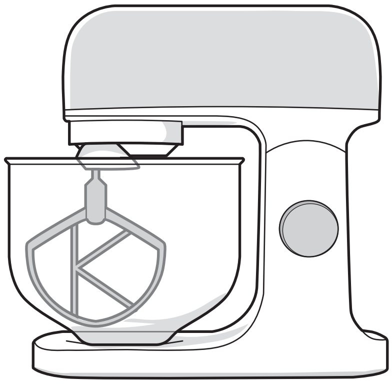
Power = ... W **[1]**

(b) A cook makes two cakes, using a different mixer for each one. The mixers and their power ratings are shown in the two images.

200 W hand mixer



600 W stand mixer



Explain the difference in the energy stored in the cake mixtures and their surroundings when the cook uses the hand and stand mixers for the same amount of time.

....

....

....

.... **[2]**

(c) The hand mixer heats up when it is in use. This is caused by resistance as the current flows through the circuit in the hand mixer.

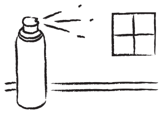
The resistance in the circuit is 40 Ω.

Calculate the power lost as heat when the current is 0.7 A.

Use the Equation Sheet.

Power = ... W **[3]**

6 **(a)** Ben records his observations from two wave demonstrations.



Sound Waves

When a can is sprayed, we hear it across the classroom 0.1 s later. We can smell it 30 s after it is sprayed.

Water Waves

When a coloured dye is thrown into a tank of water, it takes 1.5 s for the ripples to reach the end of the tank. It takes 50 s for the coloured dye to reach the end of the tank.

Explain how the demonstrations show that it is the wave and not the water or air itself that travels.

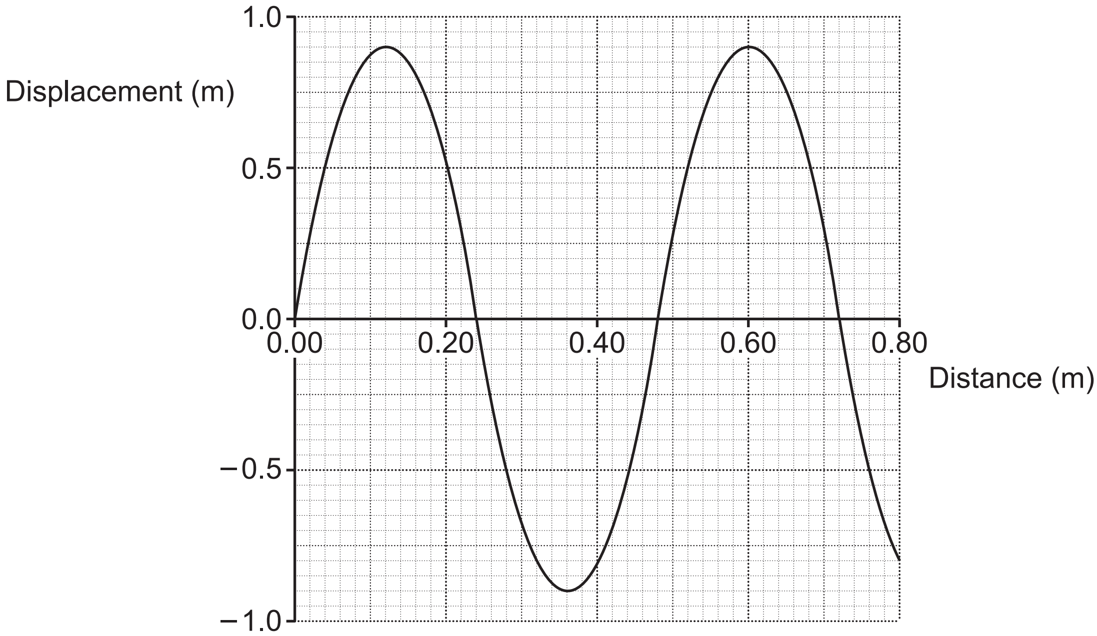
....

....

....

.... **[2]**

(b) A student makes waves on a rope. The graph shows information about these waves.



(i) State the amplitude of this wave.

Amplitude = ... m **[1]**

(ii) State the wavelength of this wave.

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

(iii) The student makes 10 waves in 20 seconds.

State the time period of this wave.

Time period = ... s **[1]**

(c) Describe how waves on a rope are an example of transverse waves.

....

....

....

.... **[2]**

7 **(a)** Electrical power is transmitted via the National Grid at 400 000 V a.c. (alternating current).

Electric train power lines need an a.c. electrical power supply of 25 000 V. A step-down transformer decreases the potential difference for the electric train power lines.

Information is shown about the primary coil and secondary coil of the step-down transformer.

Primary coil	Secondary coil
400 000 V	25 000 V
.... A	1600 A

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

Use the Equation Sheet.

Current = ... A **[3]**

(ii) Explain why electrical power is transmitted at 400 000 V, and **not** 25 000 V.

....

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....

.... **[3]**

(iii) Each train runs from its own parallel loop of the circuit. One train draws a current of 200 A.

Calculate the maximum number of trains that could operate from this circuit.

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

(b) Houses in the UK are supplied with a.c. electricity at a much lower potential difference than electric train power lines.

(i) State the potential difference and frequency of the household a.c. electricity supply in the UK.

Potential difference = ... V

Frequency = ... Hz
[1]

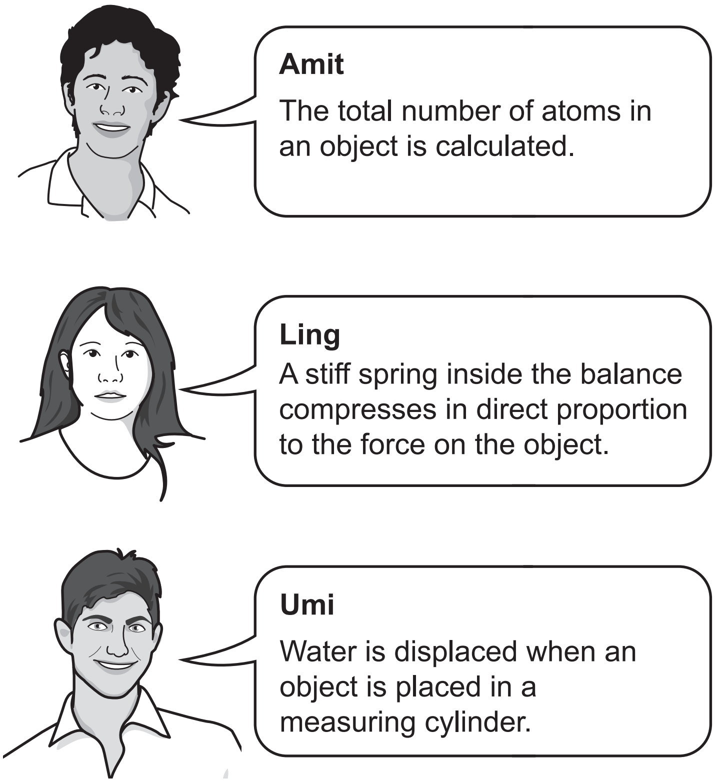
(ii) Laptops need a d.c. (direct current) electrical power supply.

Describe the difference between a.c. and d.c. electricity.

....

.... **[1]**

8 **(a)** Three students are talking about weight.



Who is describing how weight can be measured?

.... **[1]**

(b) Amit has a ball. The weight of the ball is 5.2 N.

Calculate the mass of the ball.

Gravitational field strength = 10 N / kg

Use the Equation Sheet.

Mass = ... kg **[3]**

(c) Amit kicks a ball which has a weight of 5.2 N into the air. It reaches a maximum vertical distance of 10 m and horizontal distance of 20 m.

How can the gravitational potential energy (J) of the ball at its maximum height be calculated?

Use the Equation Sheet to help you.

Tick (✓) **two** boxes.

5.2 × 10 × 10 = 520 Nm ☐

5.2 × 10 = 52 Nm ☐

5.2 × 20 = 104 Nm ☐

kg m is equivalent to J ☐

Nm is equivalent to J ☐

N / m^2 is equivalent to J ☐

[2]

9 This question is about atoms.

(a) What is the typical diameter of an atom?

Tick (✓) **one** box.

1×10^{3} m ☐

1×10^{-3} m ☐

1×10^{-6} m ☐

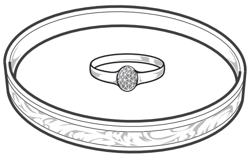
1×10^{-10} m ☐

[1]

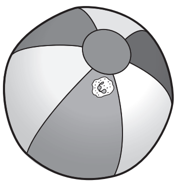
(b) Which example gives the best estimate for the ratio of the relative diameters of the atom and its nucleus?

The values in brackets are estimates for the diameters of the objects.

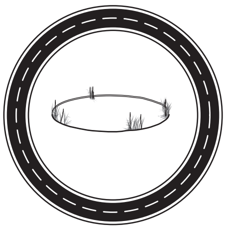
Tick (✓) **one** box.



Bracelet (10 cm) and ring (2 cm) ☐



Beachball (0.5 m) and white blood cell (1.2×10^{-5} m) ☐



Racetrack (200 m) and pond (2 m) ☐

[1]

(c) Ideas about the model of the atom have developed over the last 200 years.

Write the numbers **2**, **3** and **4** to show the correct historical order.

The earliest idea has been labelled as 1.

Tiny nucleus with the negative charges in different energy levels around it ....

Negative charges in a ball of positive charge ....

Spherical atom, the same all the way through .....1.....

Tiny nucleus containing almost all the mass and all the positive charge ....

[1]

10 Some atoms have unstable nuclei.

An unstable sulfur nucleus changes into a chlorine nucleus by beta decay.

(a) **(i)** Complete the balanced nuclear equation.

$$^{35}_{16}\text{S} \rightarrow\ ^{35}_{\square}\text{C}l +\ ^{\square}_{\square}e$$

[2]

(ii) Compare and contrast the composition of the sulfur and chlorine nuclei to explain where the beta particle has come from.

....

....

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....

....

.... **[3]**

(b) The masses of 16 chlorine atoms are shown in the table.

Atom	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Nuclear mass	35	35	35	37	35	37	37	37	35	35	35	35	37	35	35	35

(i) Explain how chlorine nuclei can have differing nuclear masses.

....

....

....

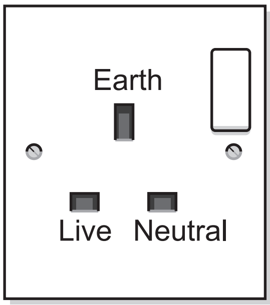
.... **[2]**

(ii) Calculate the **mean** nuclear mass.

Mean nuclear mass = ... **[2]**

11 (a) **Fig. 11.1** shows a UK 3-pin plug socket.

Fig. 11.1



Complete the table by:

- writing **live**, **neutral** and **earth** in the Pin column next to their correct functions
- writing the potential difference (p.d.) compared to earth for each pin.

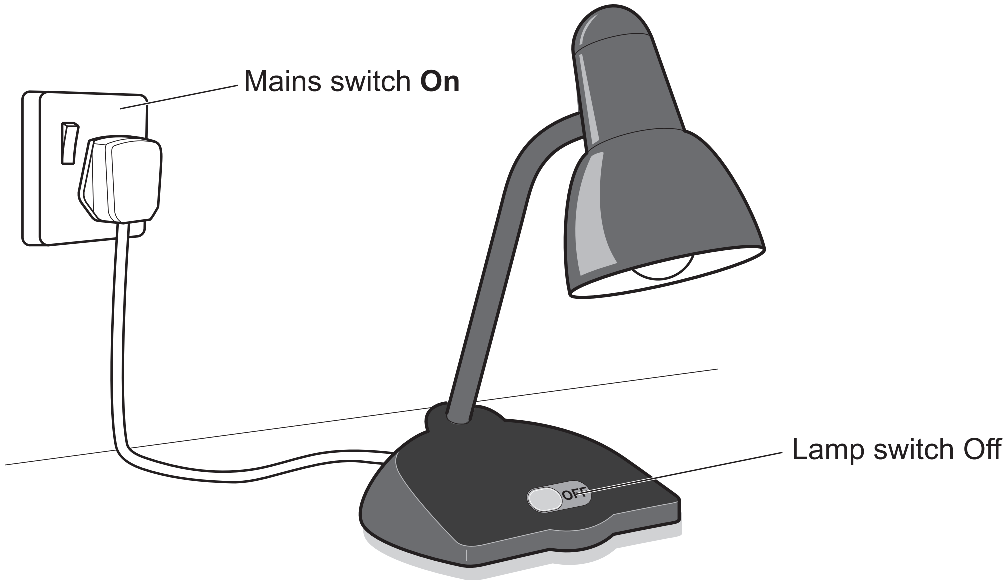
Function	**Pin**	**p.d. compared to earth (V)**
Returns current to the supply	....	....
Safety	....	0
Conducts current from the supply	....	....

[2]

(b) **Fig. 11.2** shows a broken desk light plugged into the wall, with the lamp switch off.

Inside the light, the live wire is touching the metal case.

Fig. 11.2



Explain why a person can get a shock if they touch the metal case, even though the lamp switch is off.

....

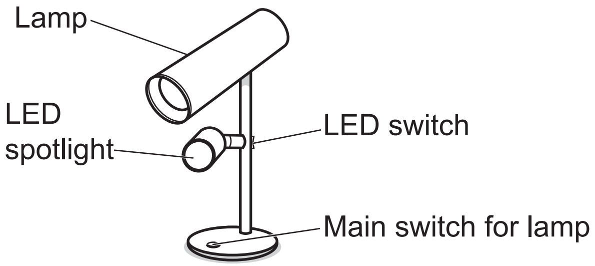
....

....

.... **[2]**

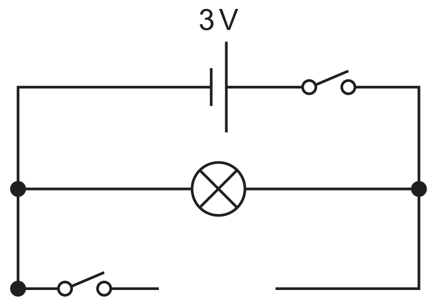
(c) **Fig. 11.3** shows a different desk light that runs on batteries. It has a lamp and an additional LED spotlight that can be switched on and off.

Fig. 11.3



(i) Complete the circuit diagram in **Fig. 11.4** by drawing the LED (light emitting diode) symbol in the gap.

Fig. 11.4



[1]

(ii) When the lamp is switched on, a current of 0.015 A flows through it.

Calculate the charge that flows through the lamp in 50 minutes.

Use the equation: charge = current × time

Charge = ... C **[3]**

(iii) The LED has a resistance of 50 Ω.

Calculate the **total** current flowing through the cell when both switches are closed.

Use the equation: potential difference = current × resistance

Current = ... A **[3]**

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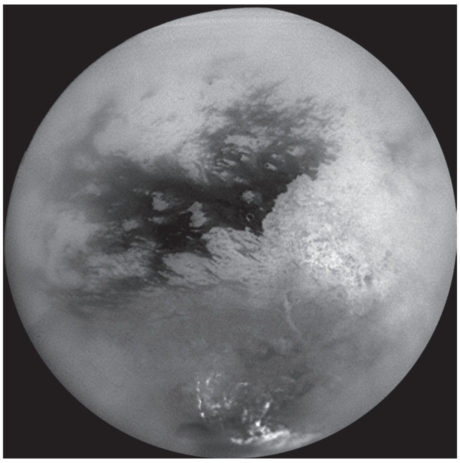
12 This question is about methane on the surface of Saturn's largest moon, Titan.

Methane is found as a solid, liquid, and a gas on Titan.



(a) The table shows the densities of methane as a solid, liquid and a gas at –182 °C, and 150 kPa, the typical conditions on the surface of Titan.

Density of methane (g / cm^3)		
Solid	Liquid	Gas
0.45	0.42	7.2×10^{-4}

Explain why the density of solid and liquid methane are similar.

Use the particle model in your answer.

....

....

....

.... **[2]**

(b) A 100 g puddle of liquid methane evaporates on Titan.

(i) What mass of methane gas has been added to the atmosphere on Titan?

Explain your answer using the particle model.

....

....

....

.... **[2]**

(ii) A different puddle of liquid methane freezes.

- The mass of the puddle is 90 g.
- The volume of the puddle when it is solid is 200 cm^3.

Calculate the change in volume of the puddle as it freezes.

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

Use the table and the Equation Sheet.

Change in volume = ... cm^3 **[4]**

(c) Explain how the volume and pressure of methane in a container changes when it has been compressed.

The temperature of the methane remains constant.

....

....

....

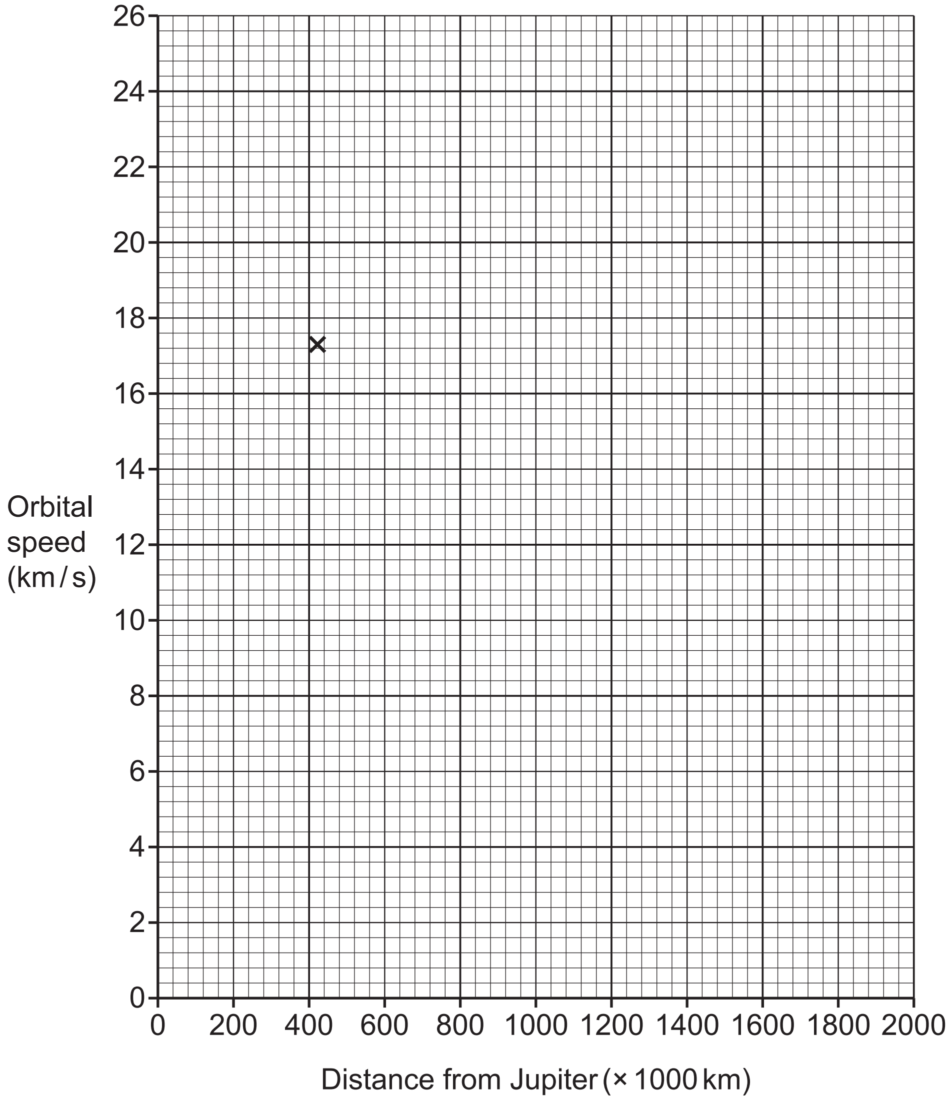
.... **[2]**

13 This question is about the motions of objects in the solar system.

(a) **(i)** The table shows data about four moons of Jupiter.

Moon Name	**Distance from Jupiter (× 1000 km)**	**Orbital speed (km/s)**
Thebe	222	23.9
Io	420	17.3
Europa	670	13.7
Callisto	1880	8.2

- Plot the data on the axes. One point has been plotted for you.
- Draw a line of best fit.



[2]

(ii) Another moon called Ganymede orbits 1 070 000 km from Jupiter.

Predict the orbital speed of Ganymede.

Use the graph.

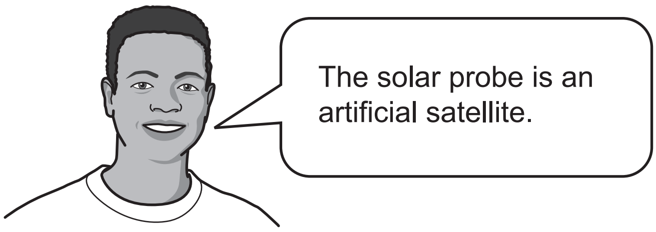
Orbital speed = ... km/s **[1]**

(iii) Describe the relationship shown by the graph.

....

.... **[1]**

(b) (i) Scientists have sent a solar probe to the Sun to collect data on its activity.
Leo says:



What is an artificial satellite?

....

.... **[1]**

(ii) The solar probe will reach a speed of 190 km/s, with a momentum of 9.5×10^6 kg m/s.

Calculate the mass of the solar probe.

Use the Equation Sheet.

Mass = ... kg **[4]**

END OF QUESTION PAPER

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).