OCR
Oxford Cambridge and RSA

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Wednesday 1 December 2021 – Afternoon

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

J259/04 Depth in physics (Higher Tier)

Time allowed: 1 hour 45 minutes

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

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

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J259904

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.

Answer **all** the questions.

1 Amir has bought an electric car.

(a) (i) The electric car has a power of 80 kW.

Define power, with reference to the energy store of the car's battery.

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(ii) Work is done when electric current passes from the battery to the motor, but some energy is wasted.

Describe how this energy is wasted and where this energy is transferred to.

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(b) 42 kWh of energy is stored in the fully charged battery.

(i) 1 kWh of electricity costs 16p.

Calculate the cost of fully charging the car, in £.

Cost = £ ..... **[2]**

(ii) Calculate the time taken, in hours, to fully charge the battery using a 7 kW charger.

Use the equation: power = energy ÷ time

Time = ... hours **[2]**

(iii) The manufacturer claims the car uses 1 kWh of energy to travel 6 km.

When the battery is fully charged Amir travels 220 km before the charge on the battery runs out.

Find out if the manufacturer's claim is correct.

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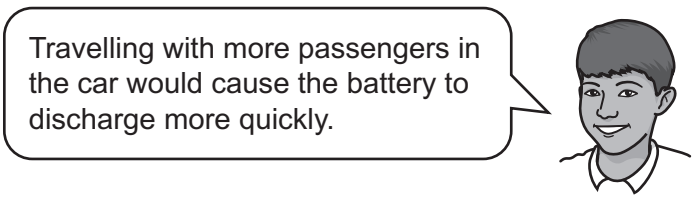
(c) Amir makes a hypothesis about the performance of the car's battery.



Amir has a small electrical motor and a trolley.

Outline an experiment that Amir could do in a school lab to investigate his hypothesis.

Include any additional equipment required in your answer.

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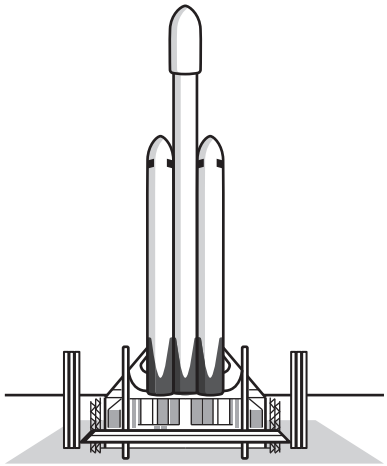
2* A space company is testing a rocket that may eventually take humans to Mars.



The mass of the rocket before lift-off is 1 420 000 kg including the fuel.
During lift-off the rocket's engines provide a maximum upward thrust of 23 000 000 N.

Explain how the forces and acceleration of the rocket change **before**, **during** and **after** lift-off.

Gravitational field strength = 10 N / kg

Use the equation: force = mass × acceleration

Use the equation: weight = mass × gravitational field strength

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3 Ling does an experiment to determine the I-V characteristics of an NTC thermistor. She builds the circuit in **Fig. 3.1**.

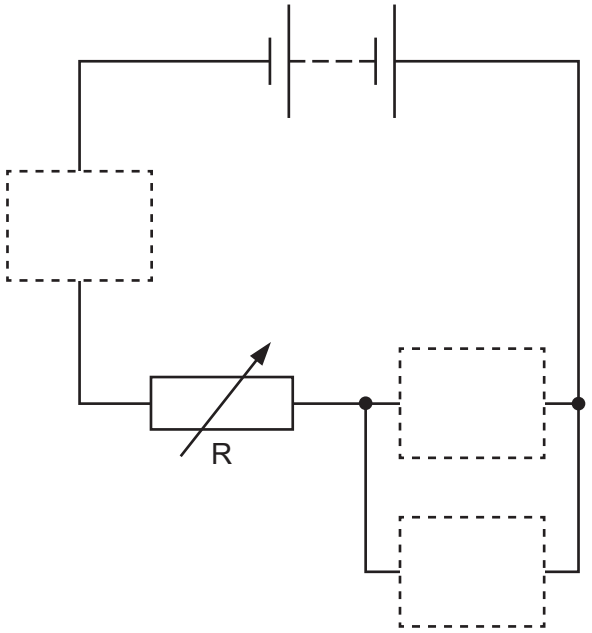

Fig. 3.1

(a) (i) Draw the correct circuit symbols inside the dotted boxes in **Fig. 3.1** to complete the circuit. **[2]**

(ii) Explain how the current changes when the temperature of the thermistor increases.

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(b) Ling plots a graph of her results, as shown in **Fig. 3.2**.

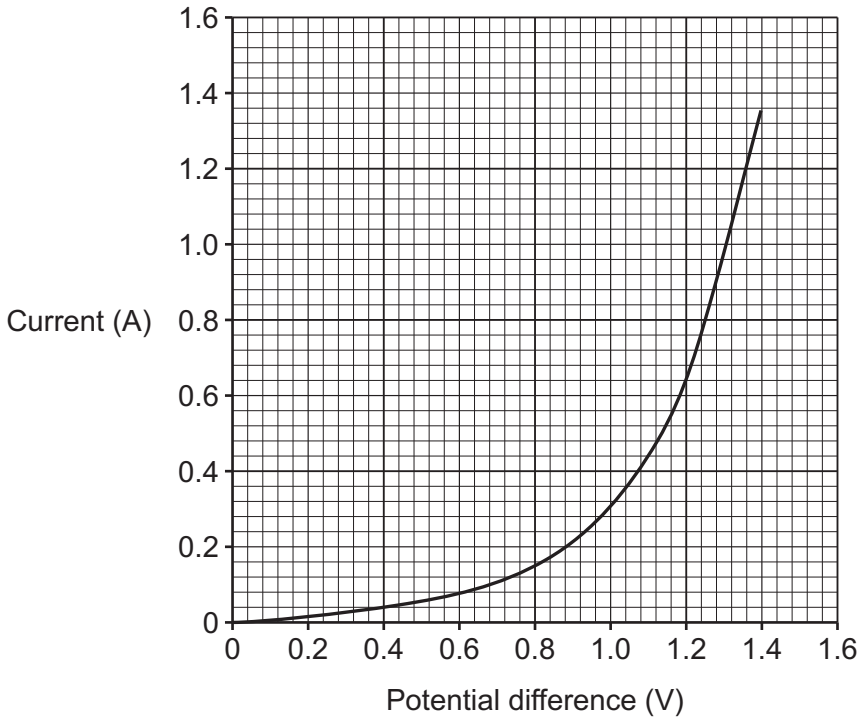


Fig. 3.2

Calculate the difference in the resistance of the thermistor when the potential difference is increased from 0.4 V to 1.2 V, using **Fig. 3.2**.

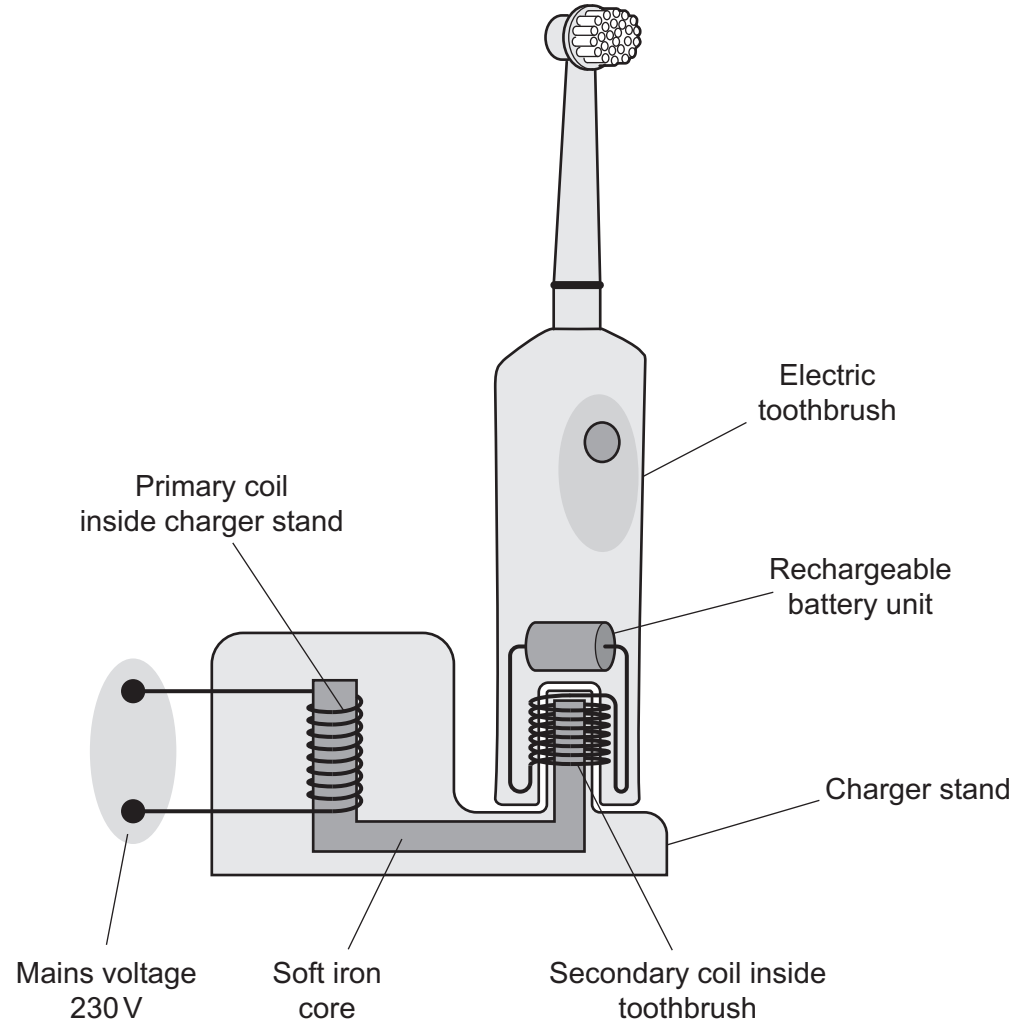
Give the **unit** of resistance.

Use the equation: potential difference = current × resistance

Difference in resistance = ... unit ..... **[4]**

4 Sam has an electric toothbrush.

The diagram shows the inside of the charger stand and electric toothbrush.
There is a transformer in the charger stand that charges a rechargeable battery unit inside the toothbrush.



(a) When the charger stand is plugged in, the primary coil is connected directly to the mains voltage of 230 V.

The secondary coil inside the toothbrush sits over the iron core when the battery is charging.

(i) Explain how the battery inside the toothbrush can charge on the charger stand.

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(ii) When the battery is charging the current in the primary coil is 0.25A and the potential difference across the battery is 20 V.

Calculate the current in the secondary coil.

Use the Data Sheet.

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

(b) Calculate the ratio of the number of turns in the primary coil to the number of turns in the secondary coil.

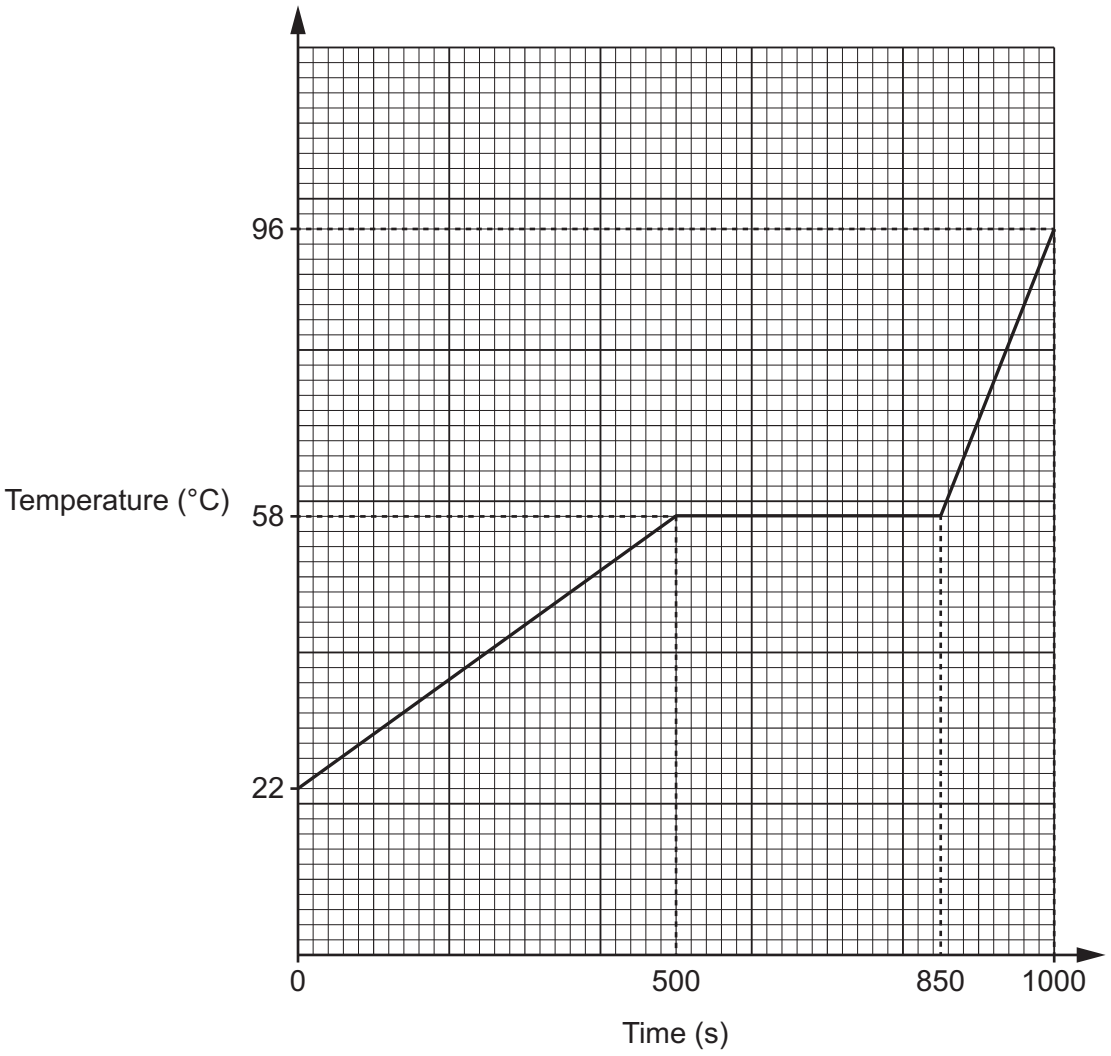
Use the Data Sheet.

Ratio = ... **[3]**

5 Ali is investigating the specific heat capacity of a type of wax.

He uses a 36 W heater to heat the solid wax from room temperature.
The mass of the wax is 0.2 kg.

He plots a graph of temperature against time as shown in the graph.



(a)* Explain how the specific heat capacity is different for solid wax and liquid wax, using the graph.

Use calculations and ideas from the particle model in your answer.

Use the Data Sheet.

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(b) When the wax is heated to a liquid its density changes.

Explain why.

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(c) Ali makes a candle that has an irregular shape.

(i) Describe how the volume of the irregularly shaped candle can be measured.

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

(ii) Ali makes measurements to find the volume and mass of the candle.
He writes down his results in the table.

Volume (m^3)	5.0×10^{-5}
Mass (kg)	4.3×10^{-2}

Calculate the density of the candle.

Give your answer in **standard form**.

Density = ... kg/m^3 **[4]**

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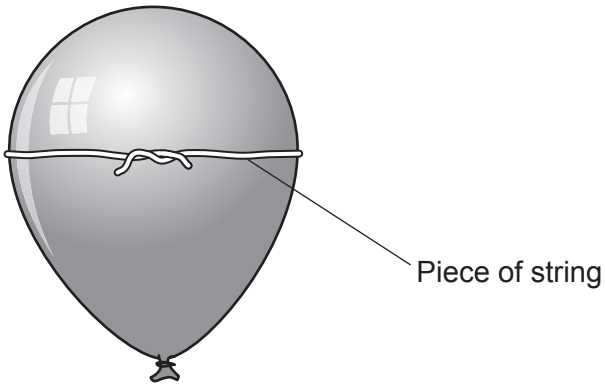
6 Nina and Mia investigate how the pressure of water affects the volume of the gas in a balloon.

They measure the circumference of an inflated balloon by wrapping a piece of string around it as shown, and using a metre rule to measure the length of the string.



They repeat this measurement when holding the balloon under different depths of water.
The water is at a constant temperature.

The table shows their results.

Depth of water (m)	**Circumference of balloon (cm)**			
	Attempt 1	**Attempt 2**	**Attempt 3**	**Mean**
0.2	27	33	30	30
0.4	25	29	30	28
0.6	31	25	22	26
0.8	19	21	29	23

(a) (i) Nina makes a conclusion.

Nina

The results in the table show that the circumference is inversely proportional to the depth.

Circumference $\propto \frac{1}{\text{depth}}$

Is Nina correct?

Yes ☐

No ☐

Explain your answer, using information from the table.

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(ii) Nina and Mia's measurements were not accurate as it was difficult to measure the circumference of the balloon under water.

Suggest an alternative method to investigate the effect of pressure on the volume of a gas.

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

(b) (i) Calculate the pressure of water at a depth of 0.8 m.

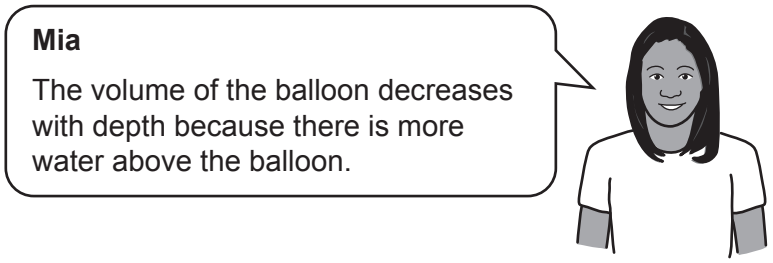
Use the equation: pressure = density × gravitational field strength × depth

Density of water = 1000 kg / m^3

Gravitational field strength = 10 N / kg

Pressure = ... N / m^2 **[2]**

(ii) Mia makes a conclusion about the volume of the balloon.



Explain why the volume of the balloon decreases with increasing depth of water.

Use ideas about the forces acting on the balloon in your answer.

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(c) Explain why the atmosphere of the Earth can be compared to a body of water.

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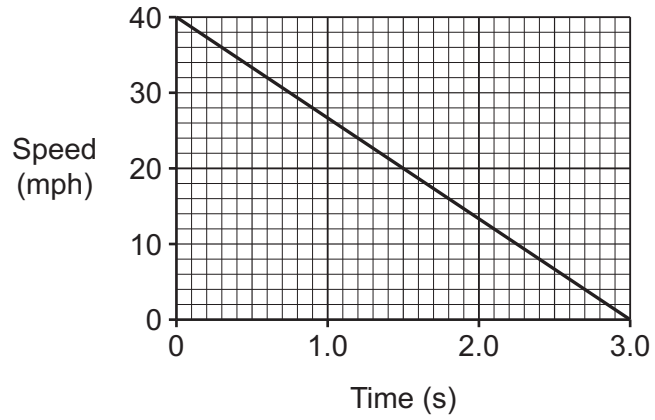
7 Ben drives a car along a straight road at 40 mph.

The graph shows how long it takes the car to stop from 40 mph when the brakes are applied.



(a) Ben sees an obstacle in the road and puts his foot on the brakes until the car stops.

(i) Calculate the resultant force on the car as it slows from 40 mph to 0 mph.

Use the data sheet and the graph.

The change in momentum of the car is 21 600 kg m / s

Resultant force = ... N **[3]**

(ii) The obstacle is 30.0 m away when Ben puts his foot on the brakes.

Determine if the car hits the obstacle.

Use the graph.

40 mph = 18 m / s

[3]

(b) (i) The speed limit on the road outside a school is 15 mph.

Explain why reducing the speed of cars is an important factor in reducing injuries on roads.

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(ii) Stopping distance is the sum of the thinking distance and the braking distance.

Ben

At 40 mph, my store of kinetic energy will be double compared to driving at 20 mph. Therefore, my total stopping distance will also be double.

Evaluate Ben's claim about his total stopping distance.

Use the equation: kinetic energy = 0.5 × mass × $(\text{speed})^2$

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8 The astronomer Edwin Hubble made observations that provide evidence for the Big Bang model of the Universe.

He used measurements of the wavelength of light observed from galaxies which were at different distances from Earth.

In 1929 Hubble used this data to produce the graph in **Fig. 8.1**.

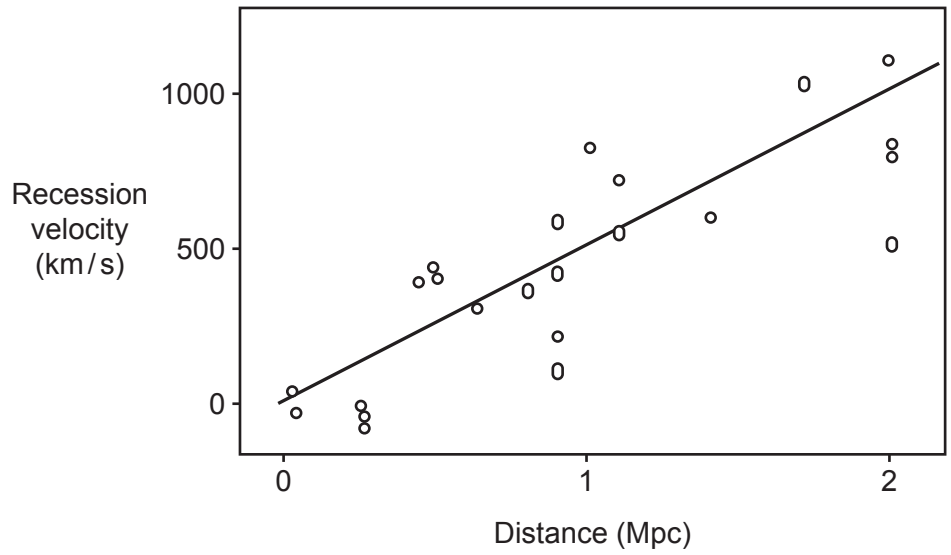

Fig. 8.1

Recession velocity is the speed at which the galaxy is moving away from the Earth.

(a) Each point on the graph in **Fig. 8.1** indicates the position of a galaxy at a different distance from Earth.

Explain how **Fig. 8.1** provides evidence for the Big Bang model.

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(b) **Fig. 8.2** shows the results of more recent observations. These observations are the result of more sophisticated telescope design.

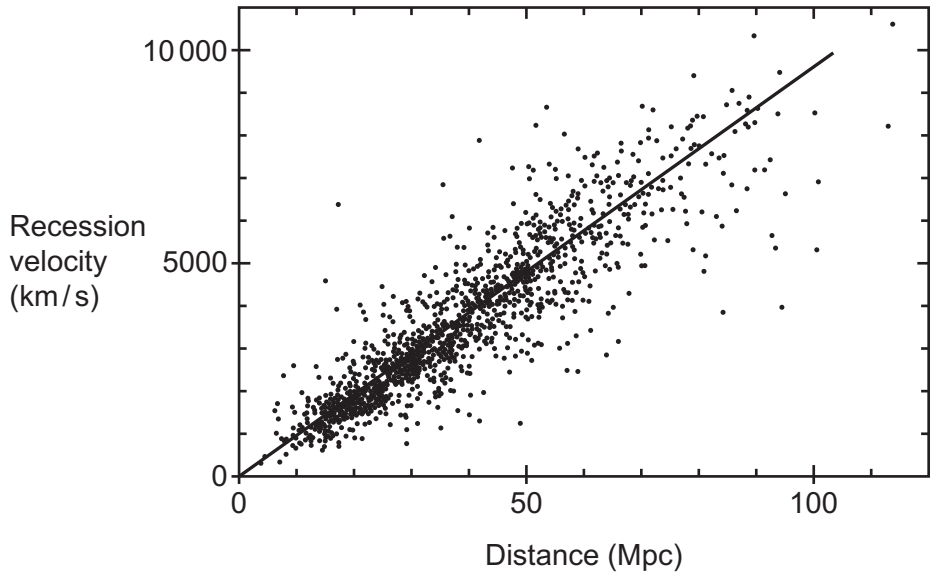

Fig. 8.2

(i) Describe **two** changes to telescopes that have helped to improve the observations of galaxies since 1929.

1. .....

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2. .....

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[2]

(ii) Give **one** reason why the data shown in **Fig. 8.2** has increased confidence in the Big Bang model.

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

9 **Fig. 9.1** shows an alternating current (a.c.) generator being used to power a bulb.

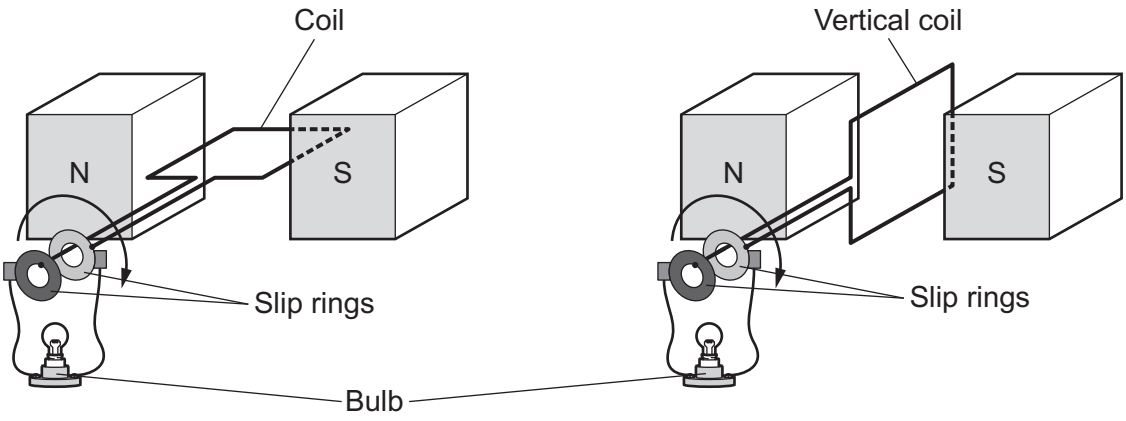

Fig. 9.1

When the coil rotates an alternating potential difference is induced across the ends of the coil as shown in **Fig. 9.2**.

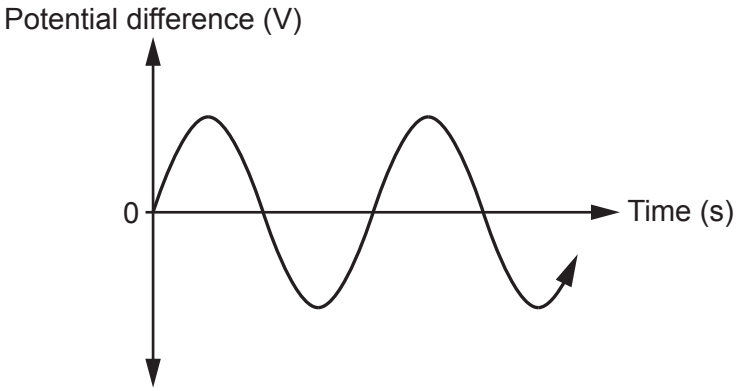

Fig. 9.2

(a) The bulb flashes on and off.
As the coil passes through the vertical position the bulb is off.

Explain why.

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(b) The coil is rotated at a faster speed.

Suggest **two** changes this will have on the bulb.

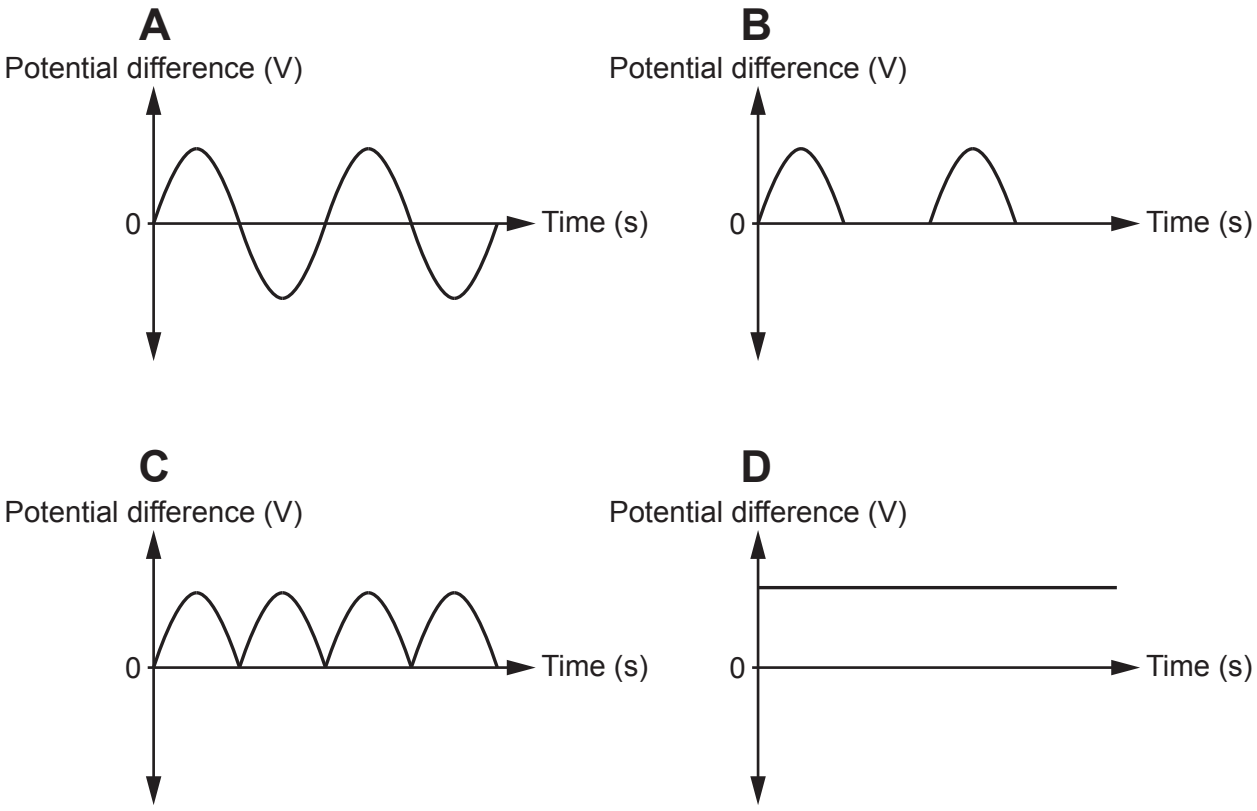
1. .....

2. .....

[2]

(c) The slip rings shown in **Fig. 9.1** are replaced by a split-ring commutator.

Which graph **A**, **B**, **C** or **D** shows the potential difference that will now be generated across the bulb?



Tick (✓) **one** box.

A ☐

B ☐

C ☐

D ☐

[1]

(d) A moving coil microphone can be made by attaching a diaphragm to a coil which is in the field of a permanent magnet, as shown in **Fig. 9.3**.

The microphone produces a changing current when a soundwave is incident on the diaphragm.

The coil is connected to a zero centre ammeter, which can show zero, positive, or negative current flowing.

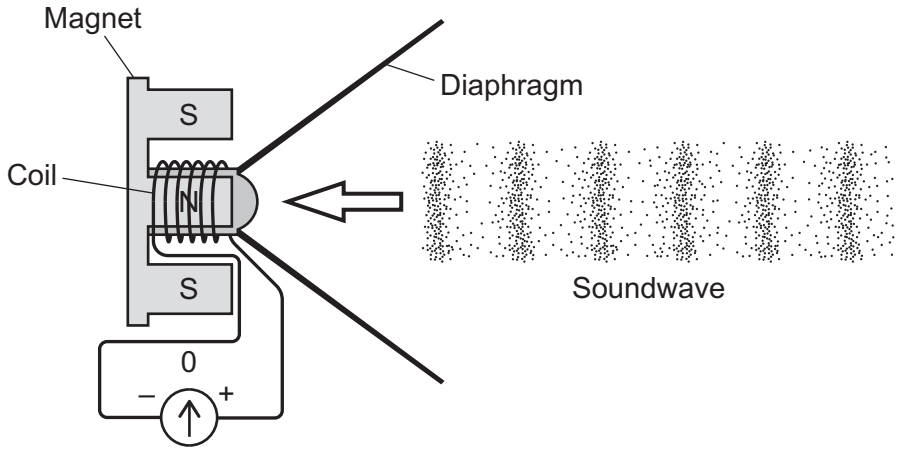


Fig. 9.3

(i) Describe the motion of the particles in a soundwave.

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(ii) When the soundwave has a high frequency the changing current that is produced also has a high frequency.

Explain how the microphone produces a current from a soundwave with a high frequency.

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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).

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