OCR
Oxford Cambridge and RSA

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Thursday 23 June 2022 – Morning

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

J259/04

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 **20** pages.

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

Answer **all** the questions.

1 Layla is investigating how the pressure of a given mass of gas changes when the volume of the gas is increased.

She uses the apparatus shown in **Fig. 1.1**, and keeps the experiment at a constant temperature.

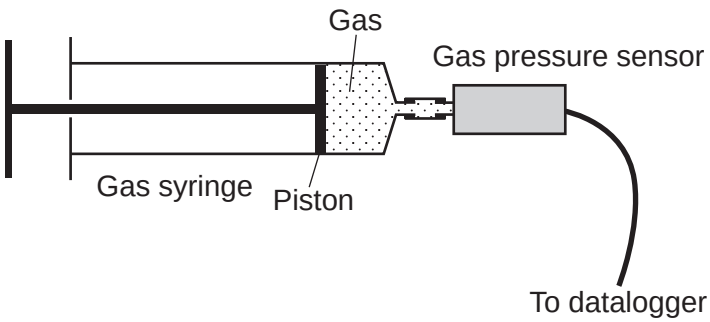

Fig. 1.1

(a) Explain why Layla needs to keep the temperature constant.

Use ideas from the particle model in your answer.

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

(b) **Fig. 1.2** shows a close-up image of the gas syringe and the path of a gas particle hitting the piston.

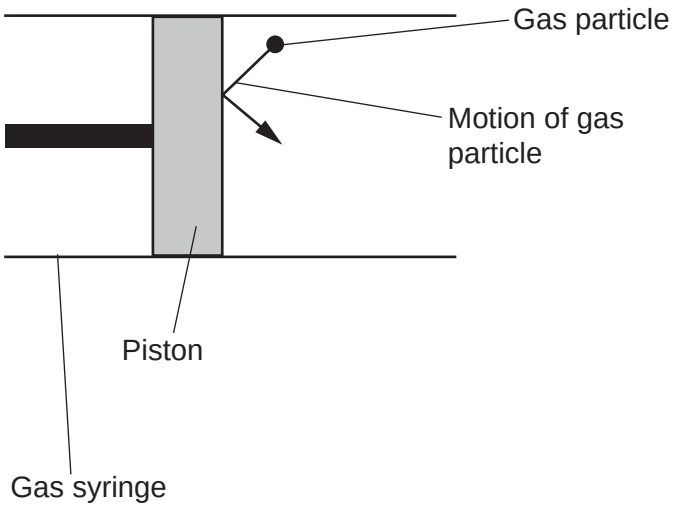

Fig. 1.2

Draw an arrow on **Fig. 1.2** to show the direction of the net force applied to the piston by the gas particle. **[1]**

(c) Layla moves the piston to increase the volume of the gas and records her results in the table.

Volume (cm^3)	**Pressure (N/cm^2)**
4.0	8.40
8.0	4.20
12.0	2.80
16.0	2.10
20.0	1.68

(i) Calculate the total force acting on the area of the piston when the volume of the gas is $8.0\,cm^3$.

The cross sectional area of the piston is $4\,cm^2$.

Use information from the table and the Data Sheet.

Force = ... N **[3]**

(ii) Calculate the constant for this given mass of gas.

Use the equation: pressure × volume = constant

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

Constant = ... Ncm **[3]**

(iii) Explain what conclusions Layla can make from the results in her table.

Use data from the table to support your answer.

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

2* The table shows the half-life and penetration power of some isotopes, A to E.

Isotope	Half-life	Penetration power
A	5 years	Reduced by thick lead
B	5 hours	Stopped by thin aluminium
C	2 minutes	Stopped by skin
D	6 hours	Reduced by thick lead
E	47 days	Stopped by thin aluminium

A medical tracer is injected into the body, for medical imaging purposes. A medical tracer contains a radioactive isotope that emits radiation. This radiation is detected from outside the body to produce an image.

Evaluate which isotope would be best suited to be used as a medical tracer.

Use your knowledge of the risks and benefits of using radioactive isotopes for medical imaging in your answer.

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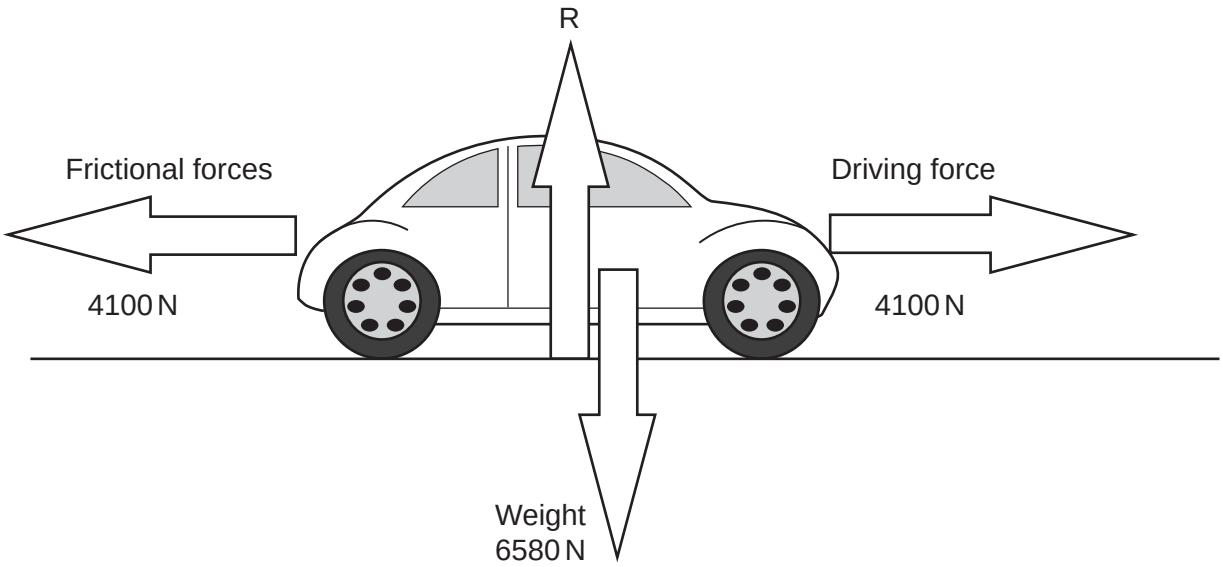
..... **[6]**

3 The diagram shows the forces acting on a car travelling at a constant speed in a straight line.



(a) **(i)** Calculate the mass of the car.
Use the Data Sheet.

Gravitational field strength = 10 N / kg

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

(ii) What is the magnitude of the total reaction force, R?

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

(iii) The driving force is increased to 4500 N and the car accelerates.

State the resultant force acting on the car as the car accelerates.

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

(b) Explain how the magnitude of the resultant force changes as the car accelerates to its maximum speed.

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

4 Li investigates the I-V characteristics of a diode using the circuit shown in **Fig. 4.1**.

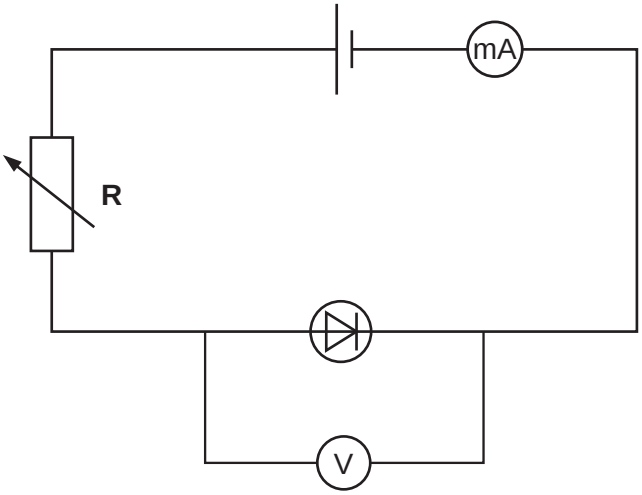

Fig. 4.1

(a) Li's results are shown **in Fig. 4.2**.

Draw a line of best fit for Li's results. **[1]**

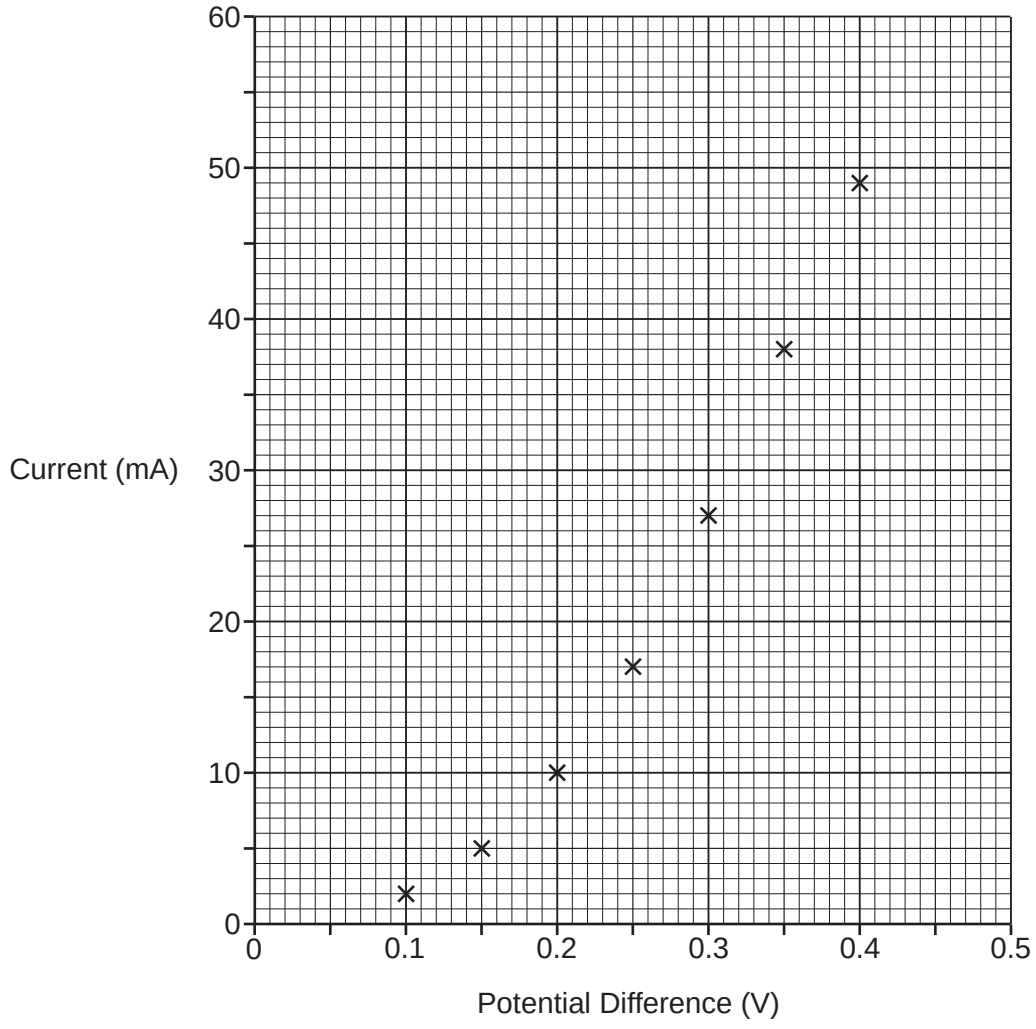

Fig. 4.2

(b) **(i)** Name the component, **R**, in **Fig. 4.1** and explain how it is used to produce the graph in **Fig. 4.2**.

Component **R** is .....

Explanation .....

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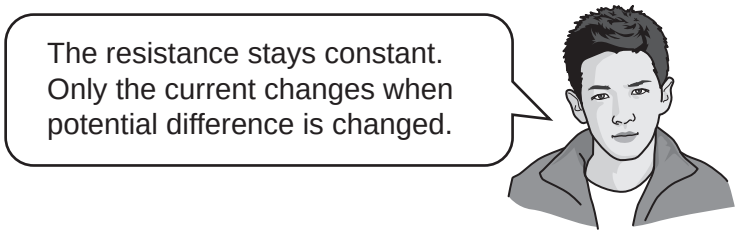
..... **[3]**

(ii) Calculate the resistance of the diode when the potential difference across it is 0.3 V, using **Fig. 4.2**.
Use the Data Sheet.

Resistance = ... Ω **[4]**

(c) Li makes this conclusion:



Explain why Li is wrong.

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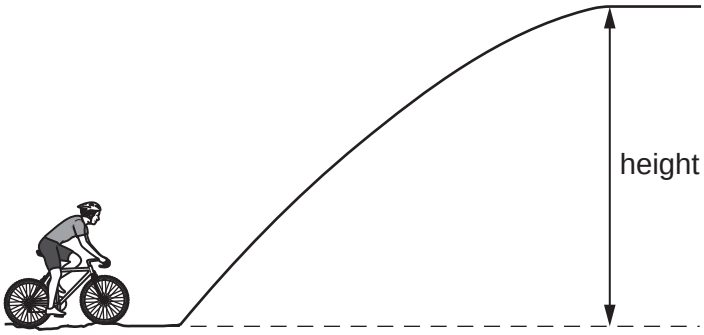
..... **[2]**

5 Alex is cycling up a hill as shown in the diagram.

The mass of Alex and the bicycle is 95 kg.



(a) (i) At the top of the hill, the gravitational potential energy store of Alex and the bicycle has increased by 7600 J.

Calculate the height at the top of the hill.

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

Gravitational field strength = 10 N / kg

Height = ... m **[2]**

(ii) Alex transfers 9000 J of energy to reach the top of the hill.

Explain why the amount of energy transferred by Alex is different to the increase in the gravitational potential energy store.

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

(iii) Calculate the efficiency of Alex to get to the top of the hill.

Use the equation: efficiency = useful energy transferred ÷ total energy transferred

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

(b) Alex goes back down the hill without pedalling.

Calculate the maximum speed that Alex can reach.

Assume that no energy is lost going back down the hill.

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

Give your answer to **1** decimal place.

Speed = ...m/s **[3]**

(c) Alex buys an electric bike which assists pedalling by supplying 11 A of current from a 24 V battery. It takes Alex 30 seconds to reach the top of the hill.

A total of 9000 J of energy needs to be transferred by Alex and the battery to reach the top of the hill.

Calculate the energy supplied by the battery, and use this to calculate the energy that Alex needs to supply by pedalling.

Use the equations: power = current × potential difference **and** power = energy ÷ time

Energy supplied by Alex = ... J **[4]**

(d) Alex says 'If I cycle more slowly, I will use less power to reach the top of the hill'.

Explain why Alex is correct.

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

6 **(a)** Which ray diagram in **Fig. 6.1** shows how rays of light are refracted by a **concave** lens?

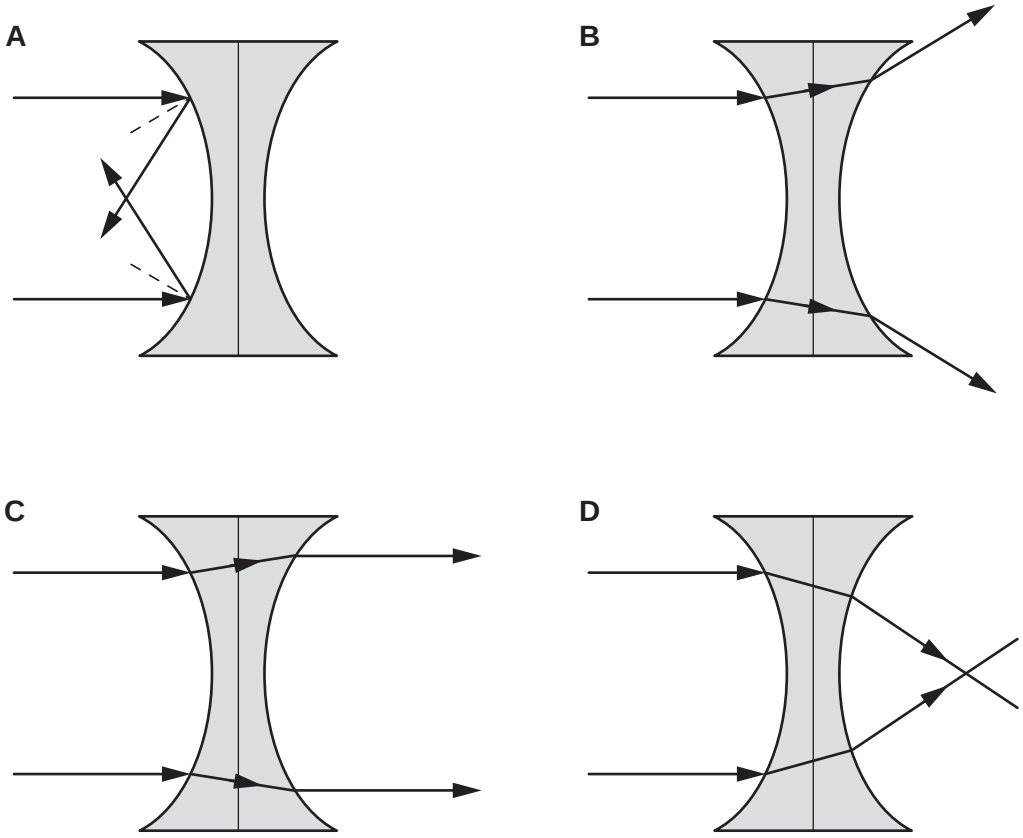

Fig. 6.1

Tick (✓) **one** box.

A ☐

B ☐

C ☐

D ☐

[1]

(b) Blue light is shone on to a **convex** lens.

Fig. 6.2 shows two parallel rays **A** and **B**. The path of ray **A** is drawn. Ray **B** is only partially drawn.

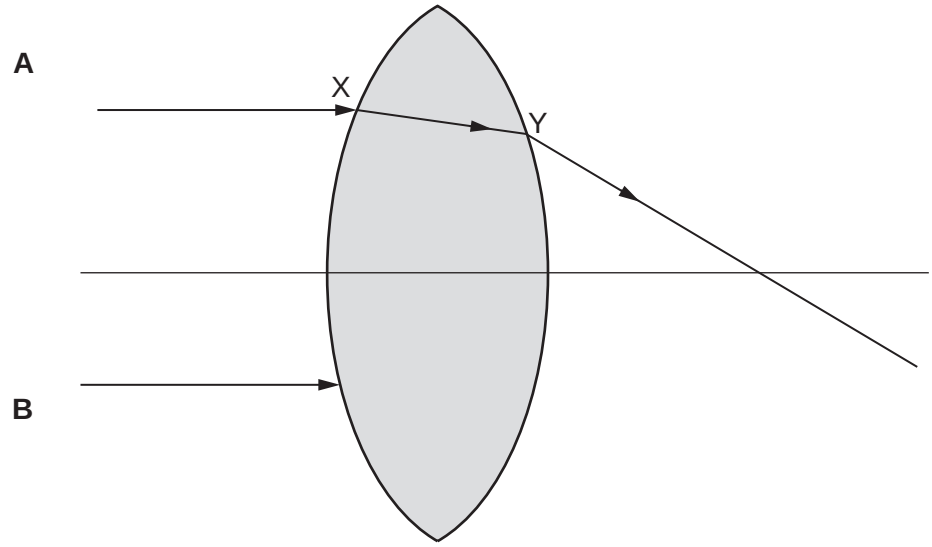

Fig. 6.2

(i) Complete the path of ray **B**. **[2]**

(ii) Ray **A** enters the lens at point X and leaves the lens at point Y.

Explain why ray **A** changes direction at the points X and Y.

Use ideas about wave speed and wavelength in your answer.

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

(c) Red light has a longer wavelength than blue light.

Explain how the path of ray **A** in **Fig. 6.2** would be different if red light was used.

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

7* Edwin Hubble studied the visible light spectrum of distant galaxies and compared them to the spectrum of our Sun.

Fig. 7.1 shows the visible light spectrum of our Sun, and the visible light spectrum of two galaxies, Galaxy X and Galaxy Y.

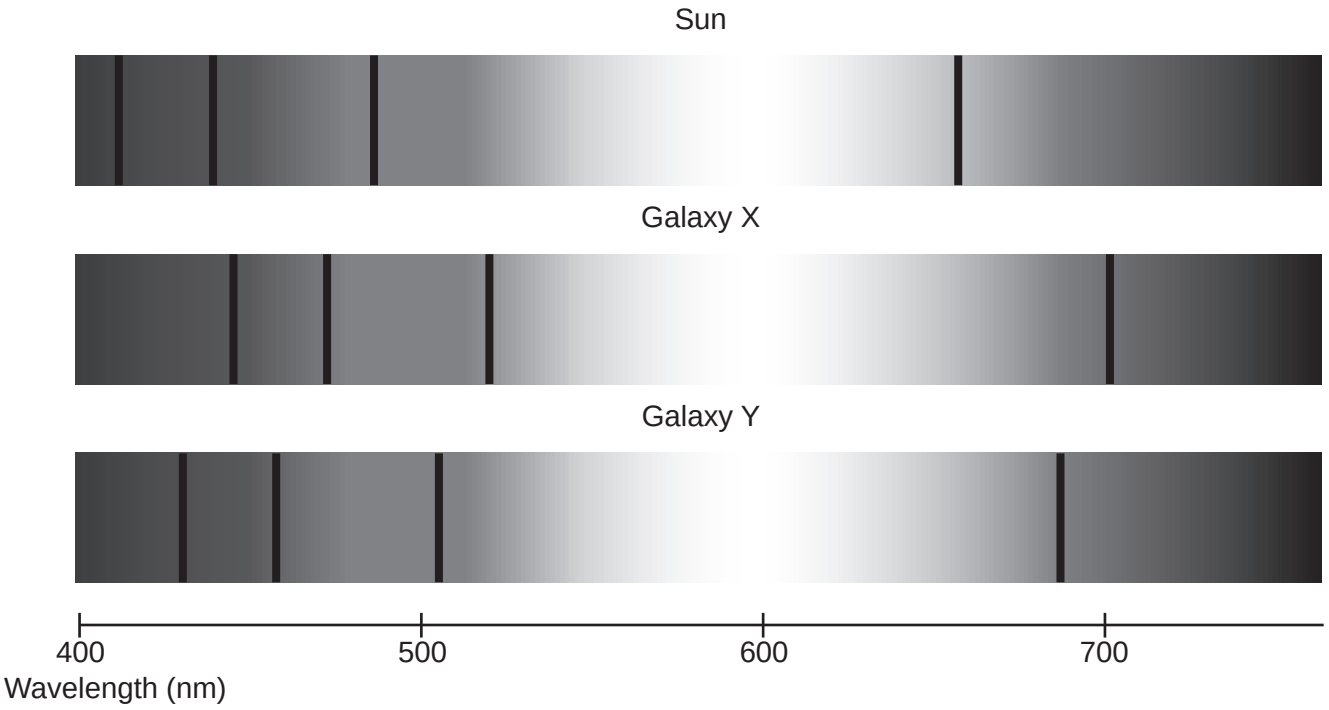

Fig. 7.1

Hubble used his observations to produce the graph shown in **Fig. 7.2**. The graph includes the two galaxies, Galaxy X and Galaxy Y.

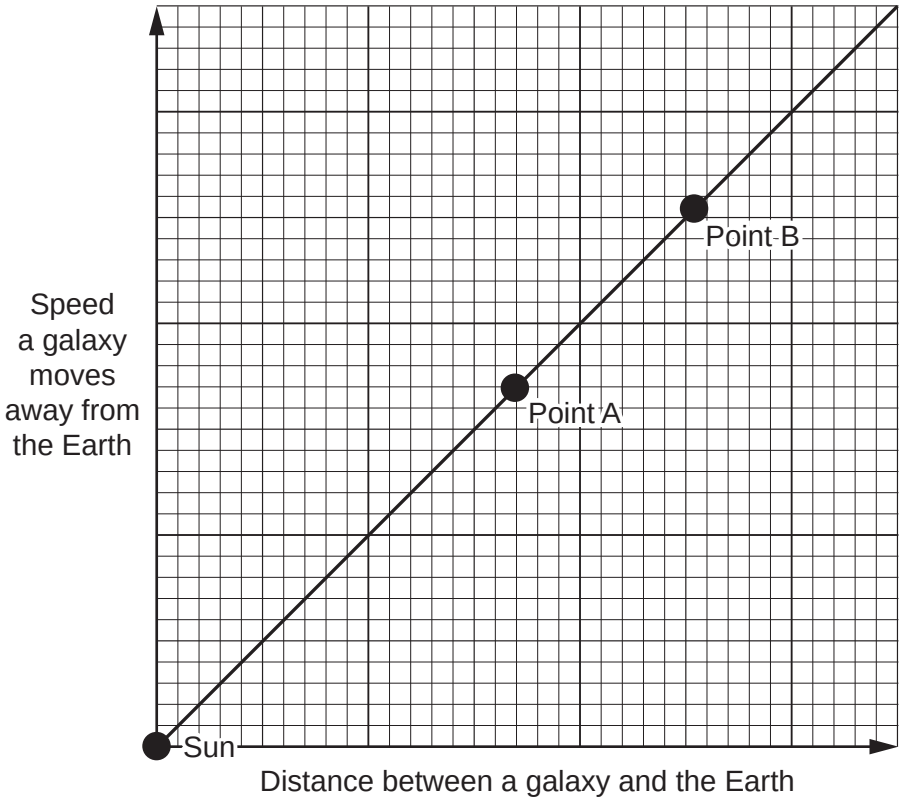

Fig. 7.2

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Explain how the evidence in **Fig. 7.1** and **Fig. 7.2** leads to the 'Big Bang' model of the universe.

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8 **Fig. 8.1** shows an alternating current (a.c.) generator.

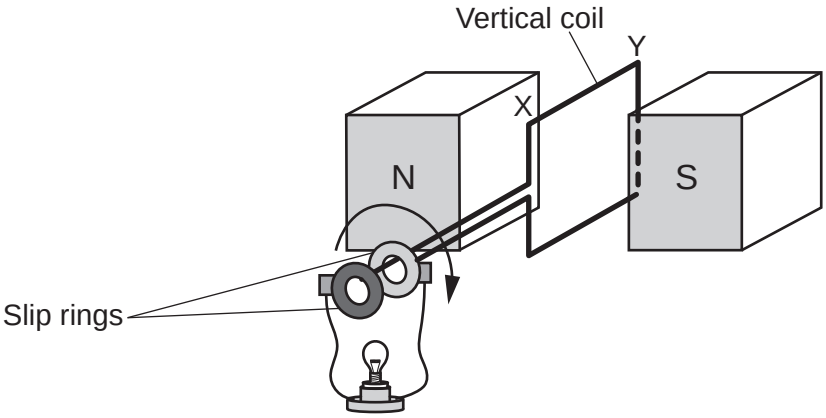

Fig. 8.1

Fig. 8.2 shows the potential difference generated across the bulb as the coil rotates.

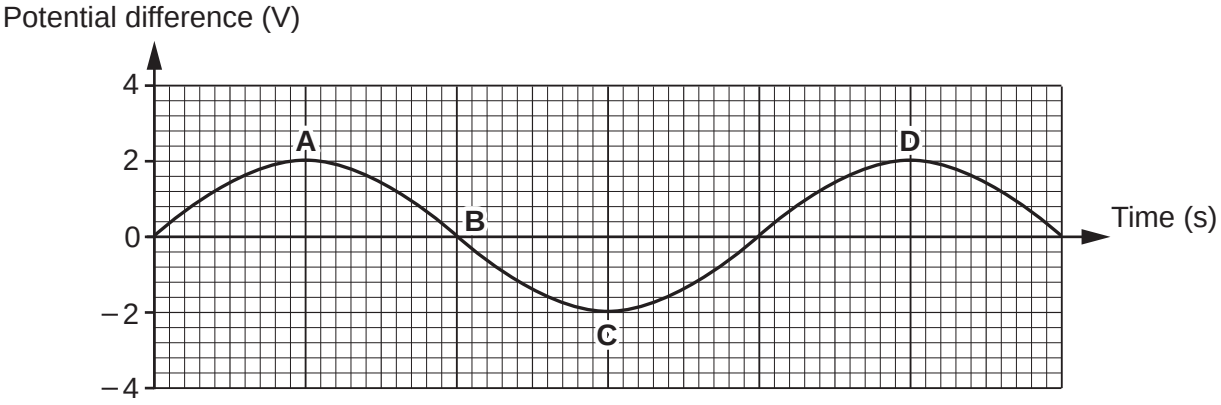

Fig. 8.2

(a) Which letter in **Fig. 8.2**, **A**, **B**, **C**, or **D**, shows the potential difference when the coil is in the vertical position shown in **Fig. 8.1**?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

D ☐

[1]

(b) Explain the change in potential difference during one complete revolution of the coil, using **Fig. 8.2**.

Include the side of the coil labelled XY **in Fig. 8.1** in your answer.

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

(c) **(i)** What change could be made to the generator in **Fig. 8.1** to change it into a direct current (d.c) generator?

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(ii) Draw the potential difference output for a **direct** current generator rotated at the same speed, on **Fig. 8.3**.

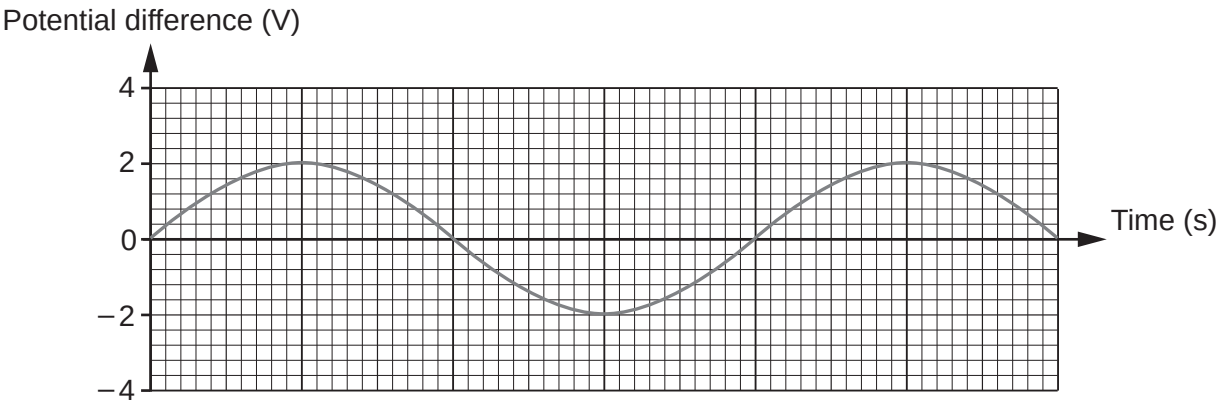
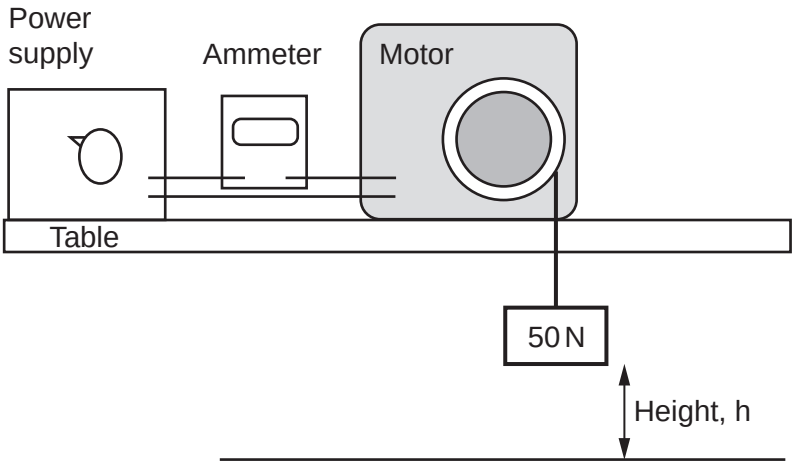


Fig. 8.3

[2]

9 Kai uses the apparatus shown in the diagram to investigate the efficiency of an electric motor.



When Kai switches on the power supply the motor lifts the 50 N weight. He records the current on the ammeter and measures the height reached by the weight in 10 s.

Kai adjusts the power supply and repeats his measurements. He records his results in the table.

Current (A)	Height reached by 50 N weight (m)	Power output (W)
0.0	0.0	0.0
0.5	1.24	6.2
1.0	1.90	9.5
1.5	2.24	11.2
2.0	2.30	

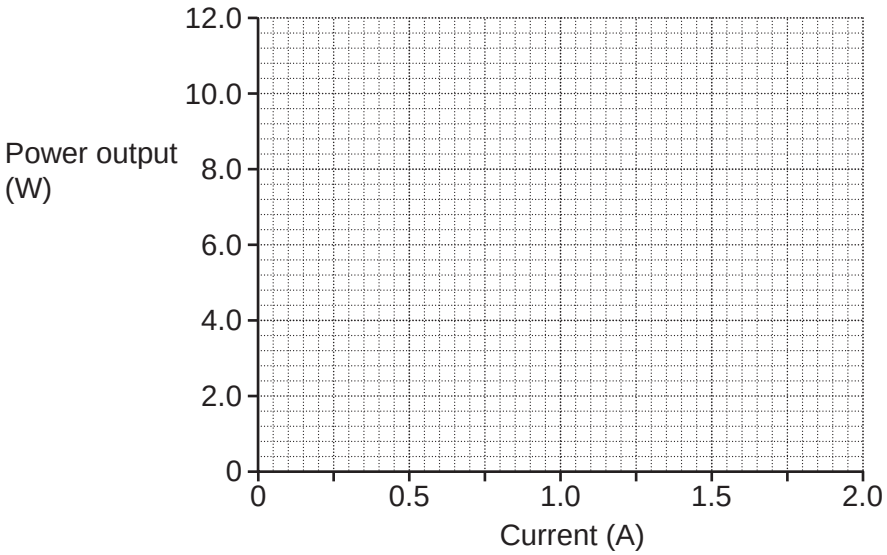
(a) (i) Calculate the power output when the current is 2.0 A.

Use the equation: power = work done ÷ time

Use the Data Sheet.

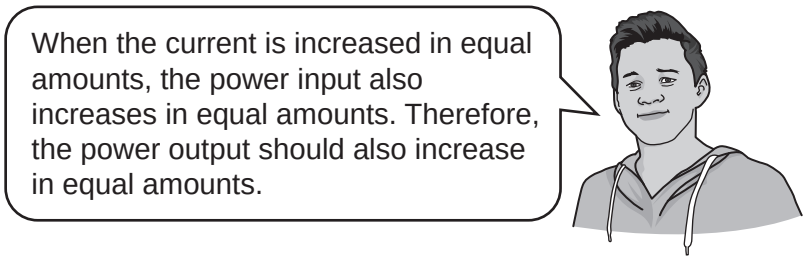
Power output = ... W **[3]**

(ii) Plot the power output against the current on the graph.



[2]

(b) Kai made a hypothesis before recording his results.



What other quantity would need to be measured to confirm this hypothesis?

Explain your answer.

Quantity .....

Explanation .....

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[2]

(c) Write a conclusion that Kai can make about the electric motor.

Use data from the graph to support your answer.

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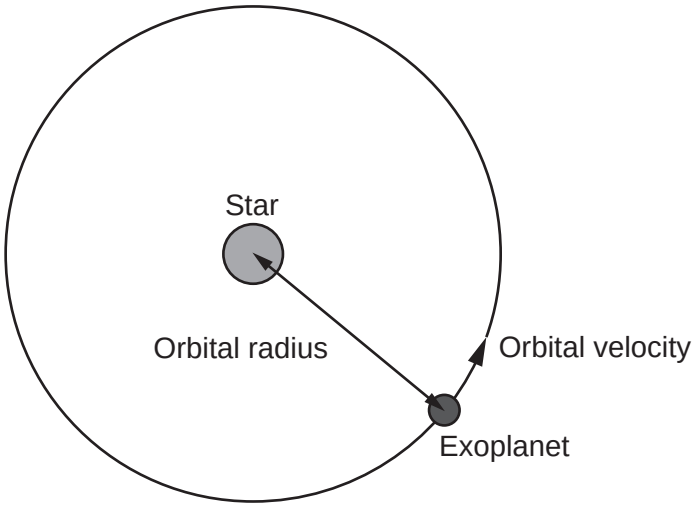
..... **[2]**

10 Exoplanets are planets that orbit stars outside our Solar System. The table shows details on some exoplanets that could sustain life.

Exoplanet	Star	Mass of star compared to the Sun	Orbital period (days)	Orbital radius ($\times 10^9$ m)	Orbital velocity (m / s)
Gilese 667 c	Gilese 667	3.8	28	225	5.8×10^5
Kepler 452 b	Kepler 452	1.2	384	225	4.2×10^4
Earth	Sun	1	365	150	3×10^4

(a) The force needed to keep an object moving in a circle depends on the speed of the object and the radius of the circle. The greater the speed and/or the smaller the radius, the greater the force needed.

The diagram shows an exoplanet orbiting a star.



Explain why Gilese 667 c has a higher orbital velocity than Kepler 452 b.
Use the idea that the weight of an object is proportional to its mass.

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

(b) Another exoplanet is discovered in orbit around a star.

The star has the same mass as Kepler 452. The orbital velocity of the planet is approximately the same as the Earth's orbital velocity.

What is the possible range of values for the orbital radius of this exoplanet?

Explain your answer.

Orbital radius is **between** ..... $\times 10^9$ m **and** ..... $\times 10^9$ m

Explanation.....

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[3]

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).