Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8370765644

PHYSICS **5054/21**

Paper 2 Theory **May/June 2023**

1 hour 45 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.
- Take the weight of 1.0 kg to be 9.8 N (acceleration of free fall = 9.8 m / s^2).

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages.

DC (DE/JG) 316498/4

[Turn over

1 An aircraft pulls a glider along a runway as shown in Fig. 1.1.

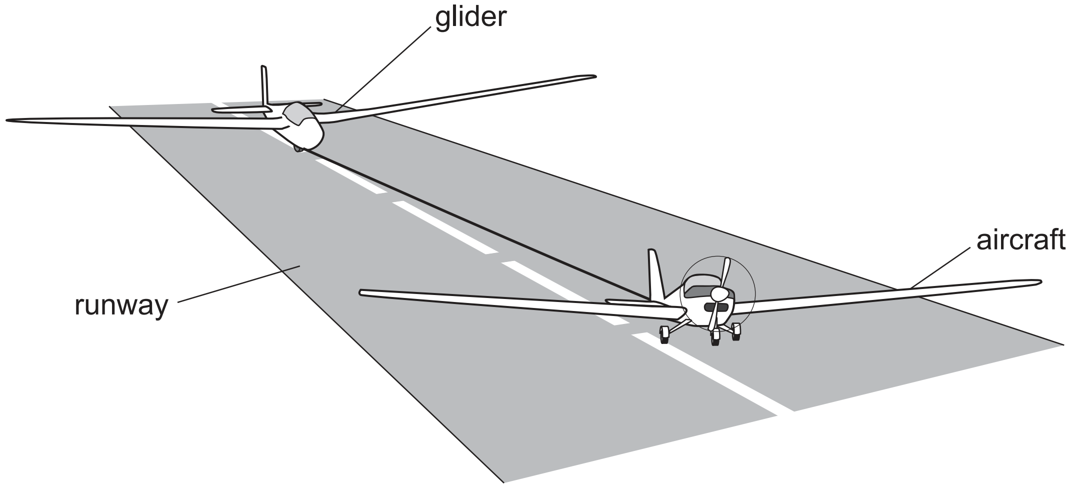

Fig. 1.1

Fig. 1.2 shows the speed of the glider during the first 12 s of the motion.

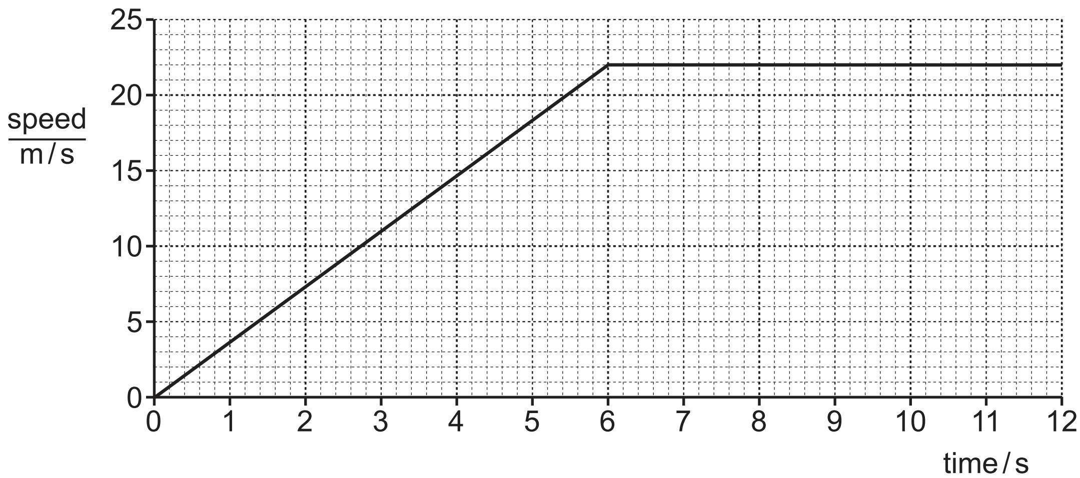

Fig. 1.2

(a) Describe the motion of the glider in the first 12 s.

....

....

.... [2]

(b) In the first 6.0 s of the motion, there is a resultant force of 1800 N on the glider.

Using the increase in speed in the first 6.0 s, calculate the mass of the glider.

mass = ... kg [3]

(c) Determine the distance travelled by the glider in the first 6.0 s of its motion.

distance = ... m [2]

(d) The glider has no engine and stays in the air with the use of convection currents.

(i) State what is meant by a 'convection current'.

....

....

.... [1]

(ii) Suggest how the convection current that supports the glider is formed.

....

....

.... [1]

[Total: 9]

2 In a safety test, a car of mass 1100 kg travels at a speed of 10 m/s and collides with a stationary van of mass 3000 kg.

After the collision the car and the van move together with a velocity *v*.

Fig. 2.1 shows the car and van before and after the collision.

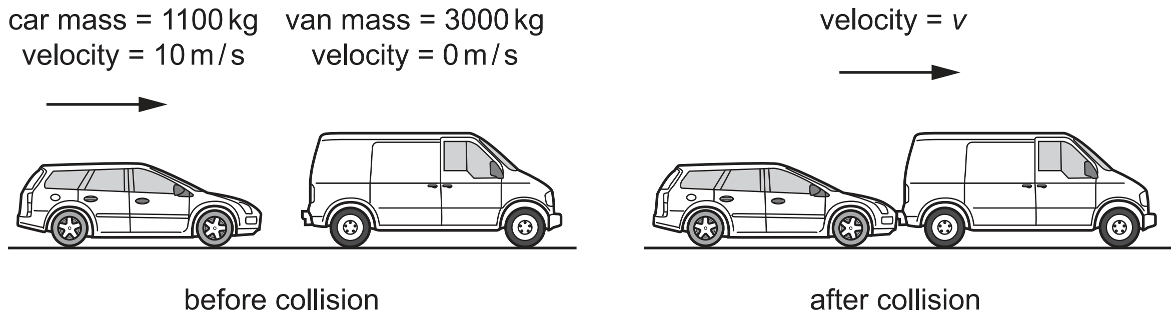

Fig. 2.1

The total momentum of the car and van is conserved during the collision.

(a) (i) Define 'momentum'.

....

.... [1]

(ii) State the unit of momentum.

.... [1]

(b) Calculate the velocity *v* of the car and van after the collision.

v = ... m/s [2]

(c) (i) Calculate the total kinetic energy of the car and van after the collision.

kinetic energy = ... J [2]

(ii) State the transfer of energy that occurs in the collision.

....

.... [1]

[Total: 7]

3 Fig. 3.1 shows a circuit containing three resistors, a 12 V power supply and an ammeter.

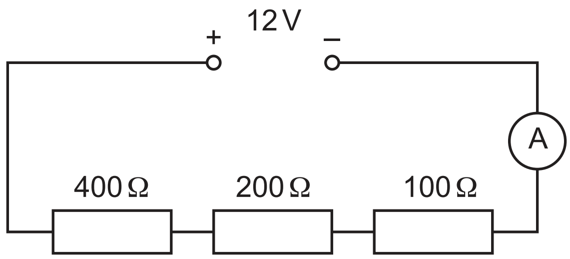

Fig. 3.1

(a) Calculate the current in the 400 Ω resistor.

current = ... A [2]

(b) Calculate the power produced in the 400 Ω resistor.

power = ... W [2]

(c) A student uses all of the components shown in Fig. 3.1 in another circuit.

She connects them so that there is the largest possible current in each resistor.

The current in one of the resistors is larger than the current in the other two resistors. The student connects the ammeter into the circuit to measure the current in this resistor.

Draw the circuit diagram of the arrangement. Label each resistor with the value of its resistance.

[2]

[Total: 6]

4 **(a)** A student pushes a drawing pin into a wooden board, as shown in Fig. 4.1.

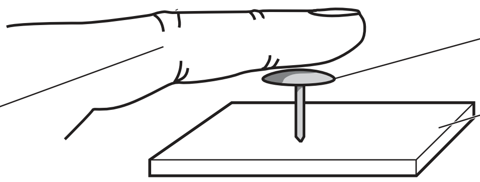

Fig. 4.1

The area of the pin in contact with the finger is $5.0 \times 10^{-5}\,m^2$. The student pushes downwards with a force of 26 N.

The mass of the drawing pin is very small.

(i) Calculate the pressure exerted by the finger on the drawing pin.

pressure = ... Pa [2]

(ii) Compare the force exerted by the finger on the drawing pin with the force exerted by the drawing pin on the wooden board.

....

.... [1]

(iii) Explain why the drawing pin goes into the wooden board but not into the finger.

....

....

....

.... [2]

(b) Fig. 4.2 shows water emerging from a plastic bag that contains a number of small holes.

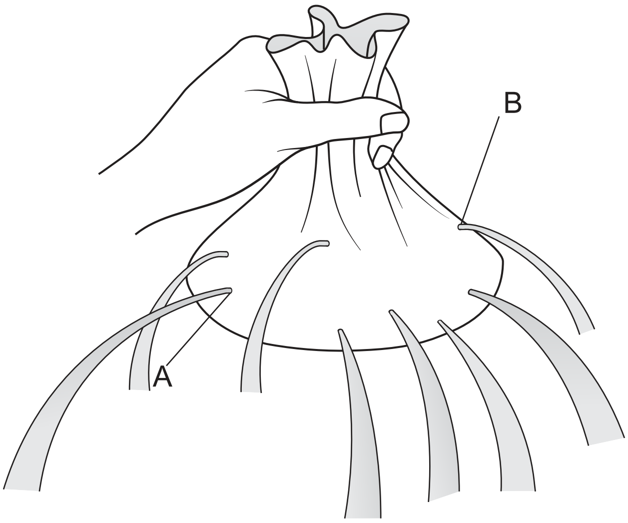

Fig. 4.2

(i) Explain why the water emerges from each hole in a direction at right angles to the surface of the bag.

....

....

....

.... [2]

(ii) The holes at A and B are the same size.

Explain why the water emerges faster from the hole at A than from the hole at B.

....

....

.... [1]

[Total: 8]

5 Fig. 5.1 shows the particles (molecules) in a sample of liquid water.

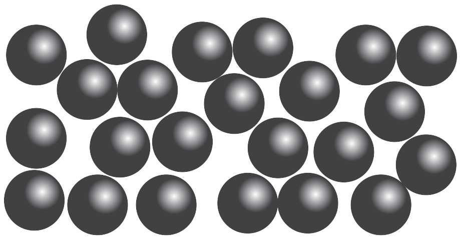

Fig. 5.1

(a) Explain, using ideas about particles, why liquids expand more than solids for the same temperature rise.

....

....

....

.... [2]

(b) The boiling point of water is 100 °C.

(i) State the boiling point of water on the Kelvin scale of temperature.

boiling point = ... K [1]

(ii) The temperature remains constant as water turns from liquid to gas at the boiling point.

Explain, in terms of particles, why energy must be provided even though the temperature stays constant.

....

.... [1]

(c) An electric heater is used to heat a sample of metal, as shown in Fig. 5.2. There is no thermal energy transferred from the metal to the surroundings during the heating.

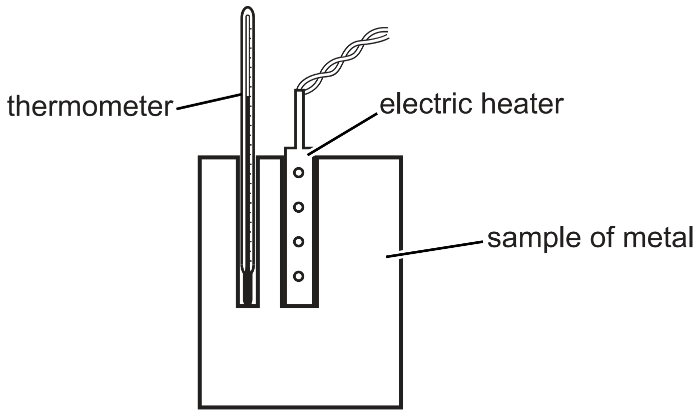

Fig. 5.2

The metal has a mass of 200 g and is initially at 15 °C.

The heater is switched on for 2.0 minutes and then switched off. The maximum temperature reached by the metal is 40 °C.

The power of the heater is 20 W.

Calculate the specific heat capacity of the metal.

Show your working.

specific heat capacity = ... J /(g °C) [3]

[Total: 7]

6 The virtual reality headset in Fig. 6.1 contains a display and a lens, as shown in Fig. 6.2.

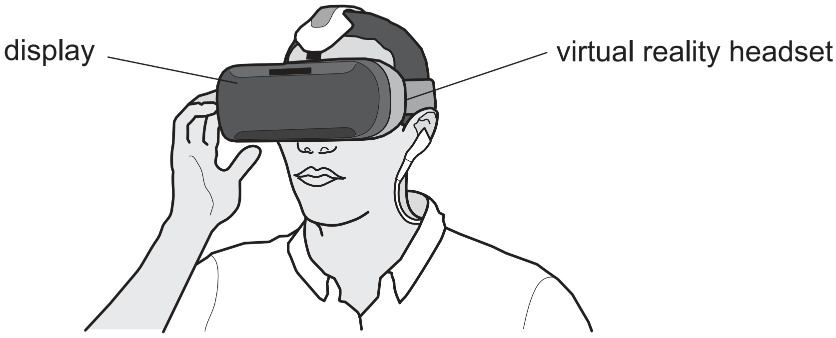

Fig. 6.1

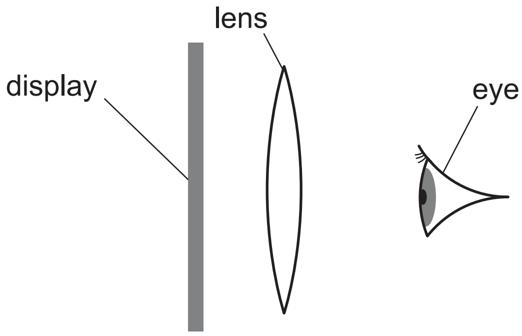

Fig. 6.2 (not to scale)

The display is the object for the lens.

The lens acts as a magnifying glass and forms a virtual image of the display.

(a) **(i)** Describe where the display must be positioned relative to the focal length of the lens for the lens to act as a magnifying glass for the image on the display.

....

.... [1]

(ii) Explain how a virtual image is formed.

....

....

.... [1]

(b) An arrow on the display is 3.4 cm from the lens. The virtual image of the arrow is 22 cm from the lens.

Fig. 6.3 shows the arrow O, the lens L and the virtual image of the arrow I, drawn on a grid with a scale of 1:2.

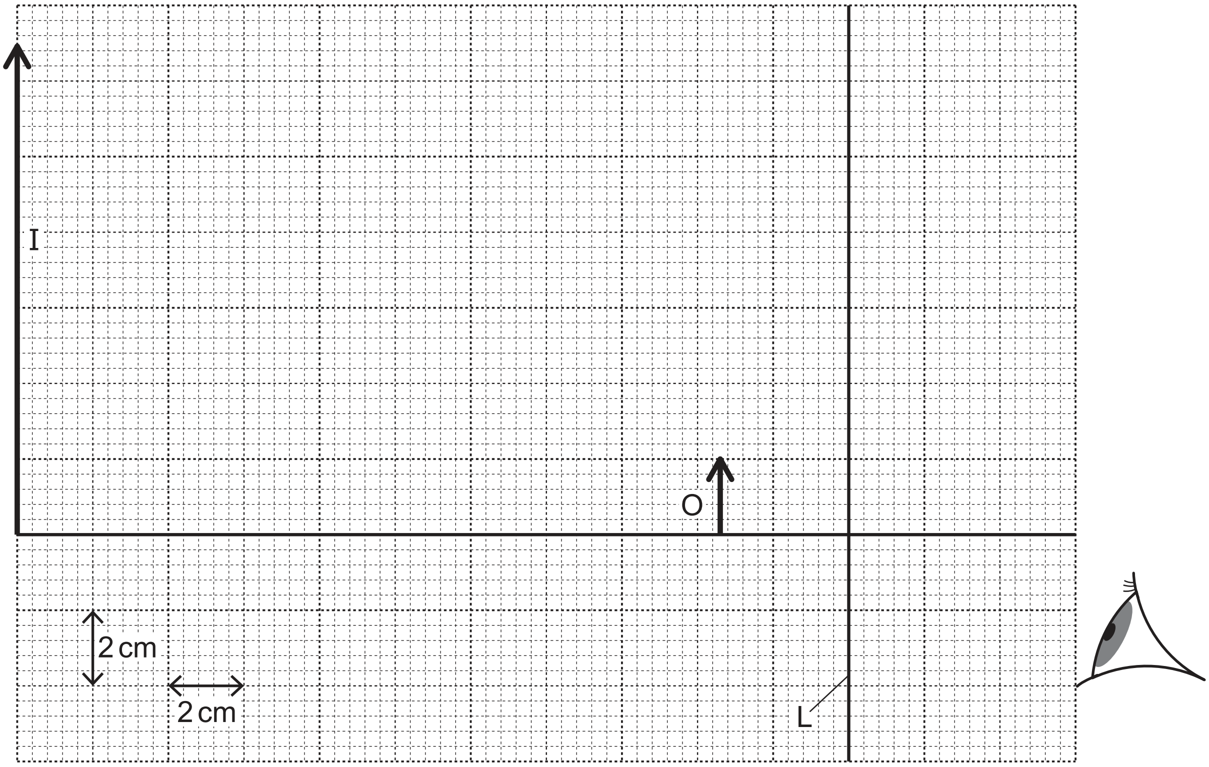

Fig. 6.3 (scale: 1 cm represents 2 cm)

(i) On Fig. 6.3, draw a ray diagram to show the formation of the virtual image I. [3]

(ii) Determine the focal length of the lens.

focal length = ... cm [1]

[Total: 6]

7 A water wave in a ripple tank diffracts as it passes through the gap in a barrier.

Fig. 7.1 shows a drawing made by a student of the crests in the pattern.

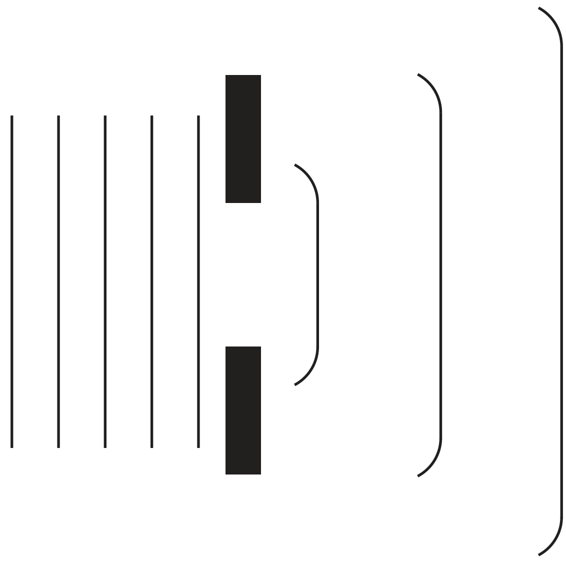

Fig. 7.1

(a) State **one** way in which the student's drawing of the crests is wrong.

....

.... [1]

(b) The gap in the barrier is now made smaller than the wavelength, as shown in Fig. 7.2.

Complete Fig. 7.2 with at least three crests to show the new diffraction pattern.

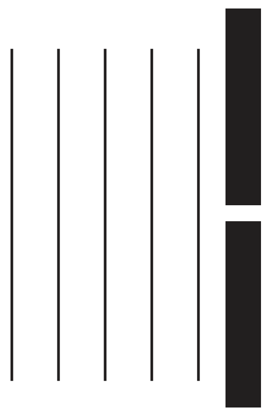

Fig. 7.2

[2]

(c) In one part of the ripple tank, the water wave has a speed of 6.0 cm / s and a wavelength of 2.0 cm.

The wave then passes into a shallower region of the tank.

The speed of the wave in the shallow region is 4.0 cm / s.

(i) Define the term 'wavelength'.

....

.... [1]

(ii) Calculate the frequency of the wave.

frequency = ... Hz [2]

(iii) Calculate the wavelength of the wave in the shallow part of the tank.

wavelength = ... cm [1]

[Total: 7]

8 A filament lamp is arranged above a shiny metal surface, as shown in Fig. 8.1.

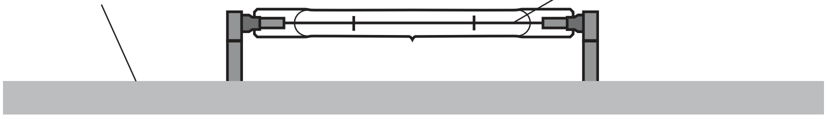

Fig. 8.1

A student reads in a textbook that a light-emitting diode (LED) is more efficient than a filament lamp.

(a) **(i)** State what is meant by 'efficiency'.

....

....

.... [1]

(ii) Suggest why the efficiency of a filament lamp is very low.

....

....

.... [1]

(b) The student considers replacing the filament lamp shown in Fig. 8.1 with an LED of the same brightness.

Data about the filament lamp and a suitable LED are shown in Table 8.1.

Table 8.1

	input power / W	energy efficiency
filament lamp	120	6.2%
LED	15	–

The LED emits the same amount of visible light as the filament lamp.

Using this information and the data in Table 8.1, determine the efficiency of the LED.

efficiency = ... % [2]

(c) The filament lamp is connected to the live and neutral wires in the mains supply.

The earth wire in the mains supply is connected to the shiny metal surface shown in Fig. 8.1.

There is a fuse in the live wire.

By accident, the live wire touches the shiny metal surface.

(i) Describe what then happens.

....

....

....

.... [2]

(ii) In another similar lamp, the fuse is wrongly connected into the earth wire.

Explain why a person is **not** protected when the live wire touches the shiny metal surface.

....

....

....

.... [2]

[Total: 8]

9 Fig. 9.1 shows a simple a.c. generator.

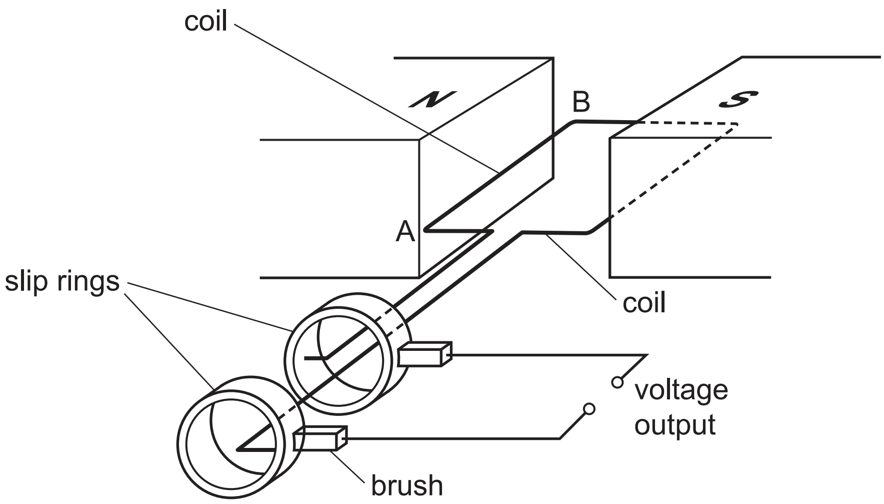

Fig. 9.1

(a) Explain why there is a voltage induced in the coil when the coil is turned.

....

....

....

.... [2]

(b) In Fig. 9.1 the coil is horizontal, with side AB on the left. The output voltage is +6.0 V.

On Fig. 9.2 draw a line from each of the shaded boxes to one of the circled voltages to show the voltage output when the coil is in different positions.

One line has been drawn for you.

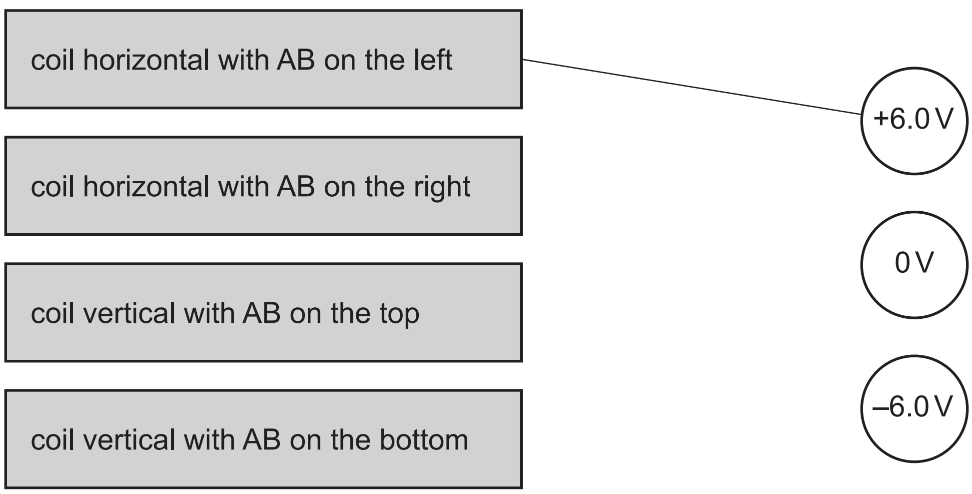

Fig. 9.2

[2]

(c) Both an a.c. generator and a d.c. motor contain a coil and brushes.

(i) Fig. 9.1 shows how the brushes are connected to the coil in an a.c. generator.

Draw a diagram to show how the brushes are connected to the coil in a d.c. motor.

[2]

(ii) State why there are forces on the sides of the coil in a d.c. motor.

....

.... [1]

[Total: 7]

10 Carbon-14 is an isotope of carbon. It undergoes radioactive decay with a half-life of 6000 years. The age of a sample of wood is found using the carbon-14 that it contains.

(a) Describe what happens during radioactive decay.

....

....

....[2]

(b) The count rate of the carbon-14 in the sample of wood is initially 1600 counts / minute.

On Fig. 10.1 draw a graph to show how the count rate will vary over the next 24 000 years.

The initial count rate is already marked with an **x**.

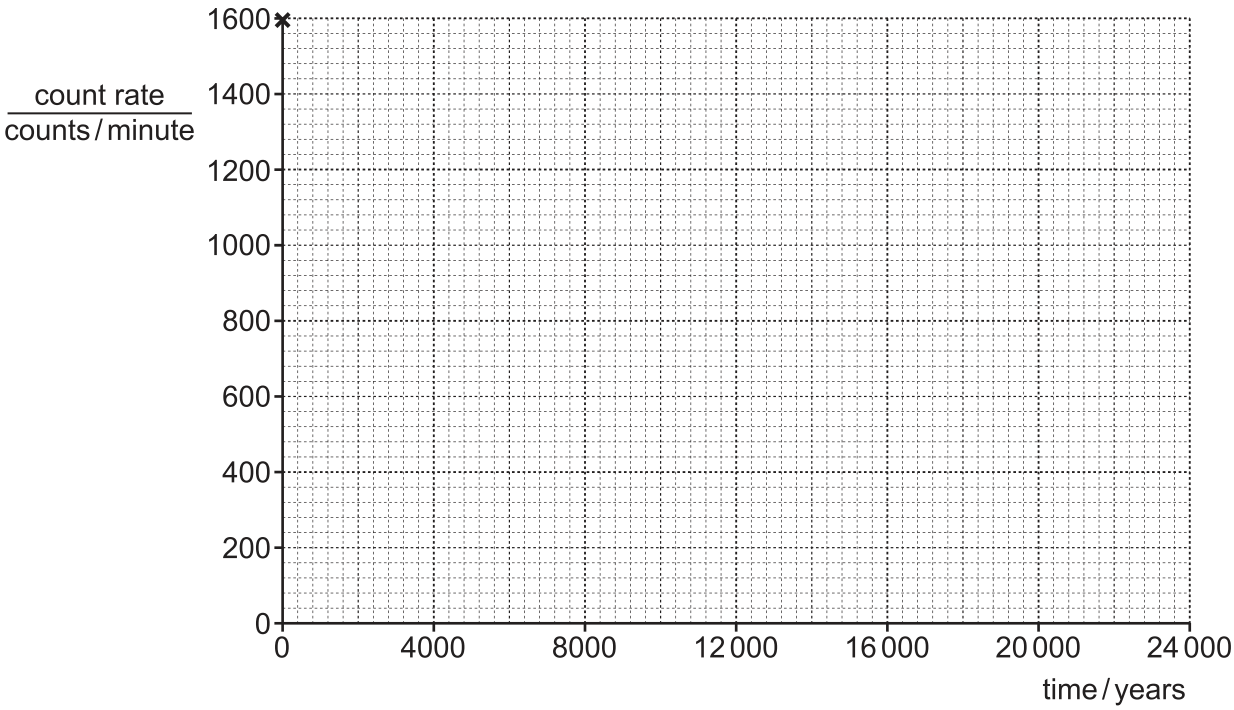

Fig. 10.1

[2]

(c) Name the apparatus used to measure the radiation from the sample of wood and describe how it is used to measure the count rate.

apparatus used ....

how the apparatus is used ....

....

.... [2]

(d) Describe how the count rate from a sample of wood is used to find its age.

....

....

....

....

....

.... [2]

[Total: 8]

Question 11 begins over the page

11 Table 11.1 shows details about eight planets in the solar system, their average distance from the Sun, their orbital period and their average surface temperature.

Table 11.1

planet	distance from the Sun / km	orbital period / s	average surface temperature / °C
....	5.8×10^7	7.6×10^6	167
Venus	1.1×10^8	1.9×10^7	464
Earth	1.5×10^8	3.2×10^7	15
Mars	2.3×10^8	5.9×10^7	−65
....	7.8×10^8	3.7×10^8	−110
Saturn	1.4×10^9	9.3×10^8	−140
....	2.9×10^9	2.6×10^9	−195
Neptune	4.5×10^9	5.2×10^9	−200

(a) Complete Table 11.1 by adding the names of the three planets that are not given. [2]

(b) Calculate the orbital speed of Mars as it travels around the Sun.

orbital speed = ... km / s [2]

(c) Describe the relationship between the distance of a planet from the Sun and its orbital period.

....

.... [1]

(d) Describe the relationship between the distance from the Sun and the average surface temperature of a planet.

In your description, include any anomalies.

....

....

.... [2]

[Total: 7]