CEDAR GIRLS' SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2025
SECONDARY FOUR

CANDIDATE NAME	
CLASS	INDEX NUMBER

PHYSICS

6091/02

Paper 2 Structured and Free Response

28 August 2025

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer all questions. Write your answers in the spaces provided.

Section B
Answer **one** question. Write your answers in the spaces provided.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use		
Section A		
1		**/ 7**
2		**/ 6**
3		**/ 7**
4		**/ 5**
5		**/ 7**
6		**/ 7**
7		**/ 7**
8		**/ 4**
9		**/ 10**
10		**/ 10**
Section B		
11		**/ 10**
12		**/ 10**
Deduction		
Total		**/ 80**

Section A

Answer **all** the questions in this section.

1 The resistive forces that act backwards on a car are air resistance and friction, as shown in Fig. 1.1.

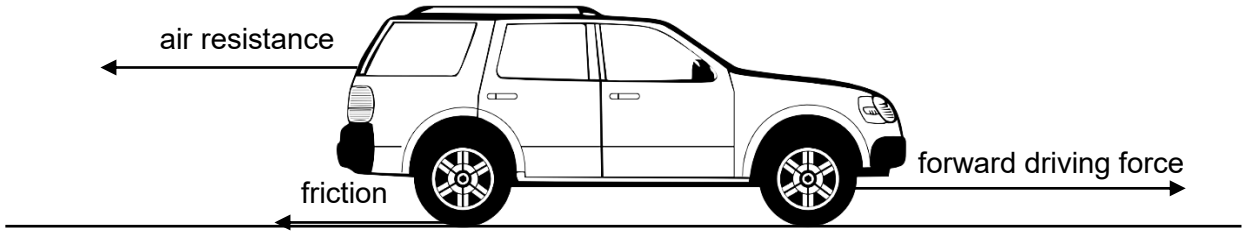

Fig. 1.1

Fig. 1.2 shows a graph of total resistive force that acts on the car against time *t*.

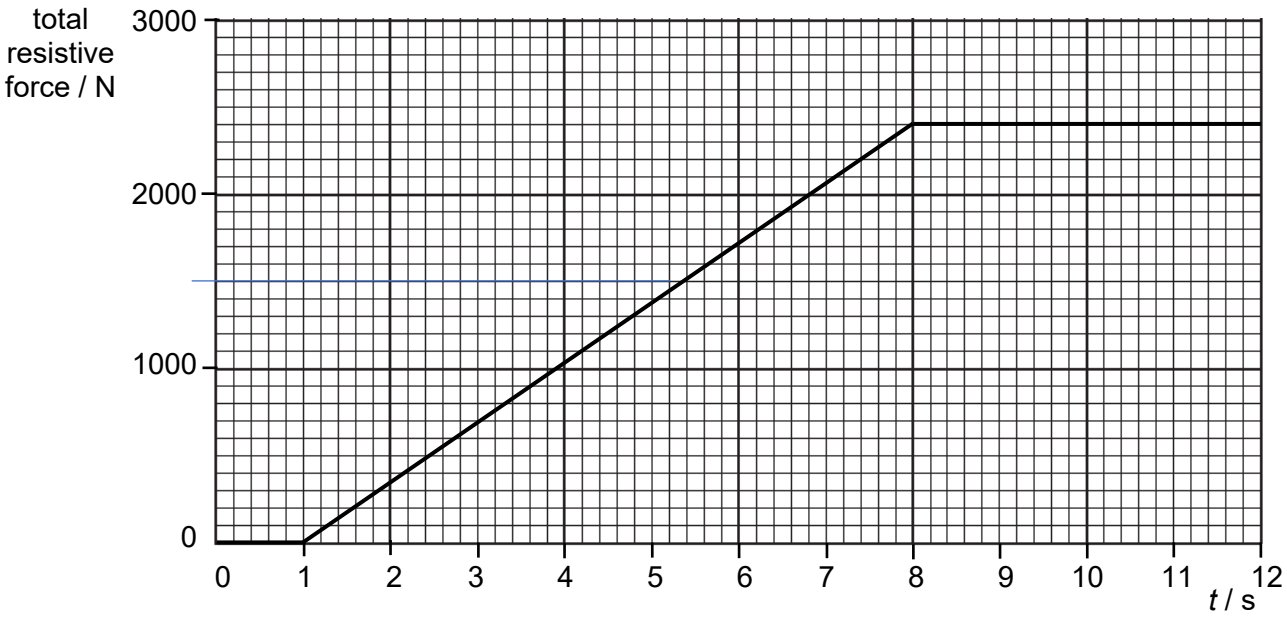

Fig. 1.2

The car is at rest at $t = 0$. The forward driving force acting on the car is zero until $t = 1.0$ s.

From $t = 1.0$ s until $t = 12$ s, the forward driving force has a constant value of 2400 N.

(a) (i) State the two time intervals when the resultant force acting on the car is zero.

..... [1]

(ii) Describe the motion of the car during these two intervals.

.....

……

……... [2]

(b) The car has a mass of 800 kg.

(i) Calculate the acceleration of the car at t = 3.0 s.

acceleration = …….. [2]

(ii) Calculate the value of t when the acceleration of the car is 0.50 m/s^2.

t = …….. [2]

[Total: 7]

2 Fig. 2.1 shows a barrier at the entrance to a car park. The wooden barrier arm has a weight of 60 N which acts through the centre of gravity at the position shown on Fig. 2.1.

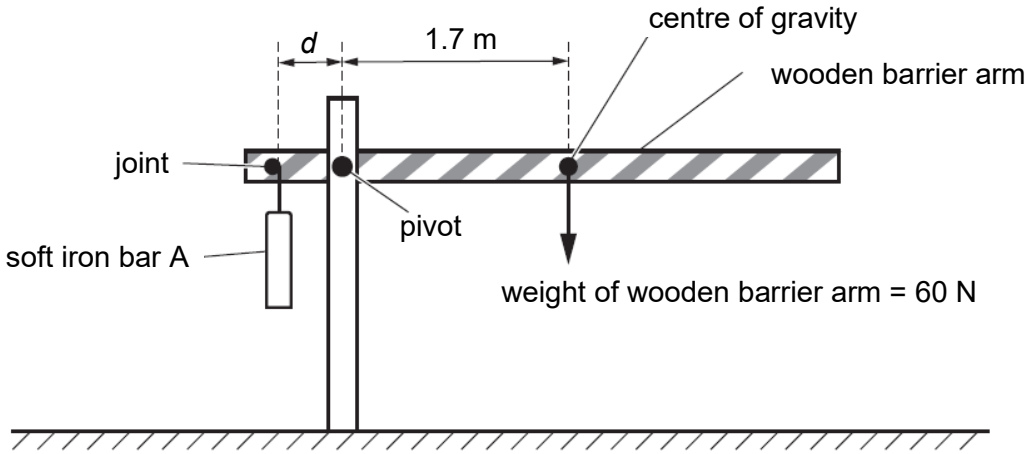

Fig. 2.1

(a) The wooden barrier arm is in equilibrium. The mass of the soft iron bar A is 23 kg.

The gravitational field strength is 10 N/kg.

Calculate *d*, the distance between the pivot and the joint holding the soft iron bar A.

d = ... [2]

(b) Fig. 2.2 shows a coil attached to a power supply placed below the soft iron bar A.

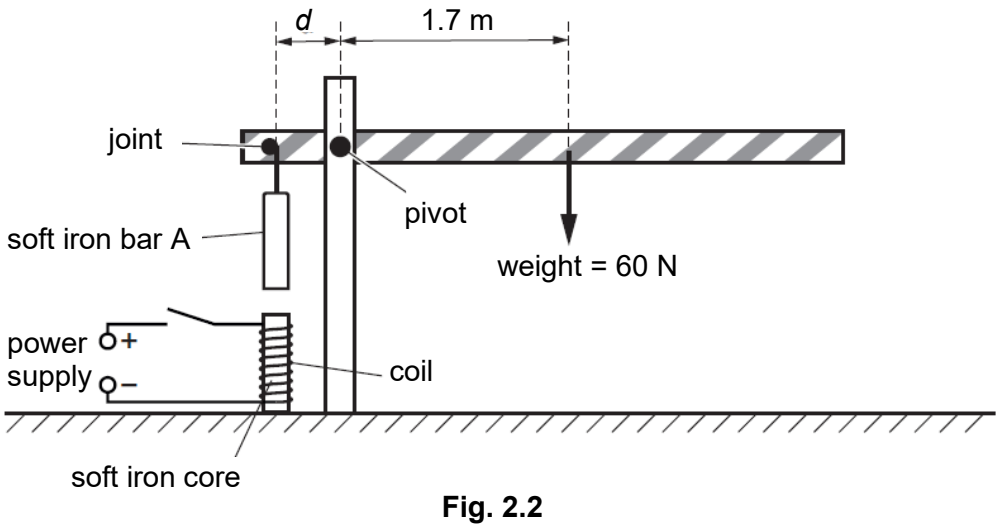

Fig. 2.2

(i) State and explain what happens to the wooden barrier arm when the switch in the coil circuit is closed.

…….....

…….....

.....

.....

..... [2]

(ii) A student suggests replacing the soft iron bar A with a steel bar of the same mass.

Explain why a steel bar is less effective than a soft iron bar in the barrier.

……

……..

……

……... [2]

[Total: 6]

3 At a sharp corner on a car racing circuit there is an escape lane as shown in Fig. 3.1.

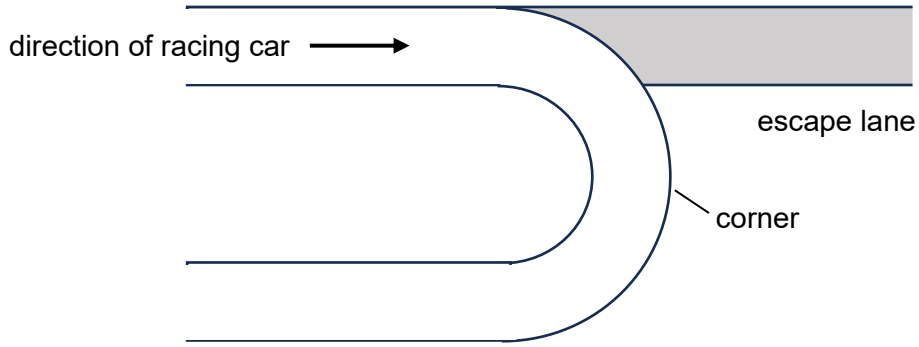

Fig. 3.1

The escape lane is a bed of small stones. The escape lane slopes upwards. A car of mass 700 kg approaches the escape lane at a speed of 40 m/s. The brakes fail and the car stops in the escape lane.

(a) Show that the energy in kinetic store of the car is 560 kJ when it approaches the escape lane.

[1]

(b) Describe what happens to the energy in kinetic store of the car as it stops.

……..

……..

……..

……..... [2]

(c) The car comes to rest 40 m along the escape lane, having risen through a vertical distance of 3.0 m. The gravitational field strength is 10 N/kg.

Calculate

(i) the change in energy in the gravitational potential store of the car when it stops in the escape lane,

change in energy = …….…….. [1]

(ii) the average frictional force exerted on the car in the escape lane.

force = …….…….. [2]

(d) The frictional force exerted on the car in the escape lane is not constant.

Suggest one factor, apart from the car's speed, that affects the value of the frictional force.

……..

…… [1]

[Total: 7]

4 A small aircraft takes off from the horizontal deck of a ship.

Before taking off, the aircraft is held in place by a holdback bar.

When the holdback bar is released, the aircraft is pulled along the deck by a steam-powered piston as shown in Fig. 4.1.

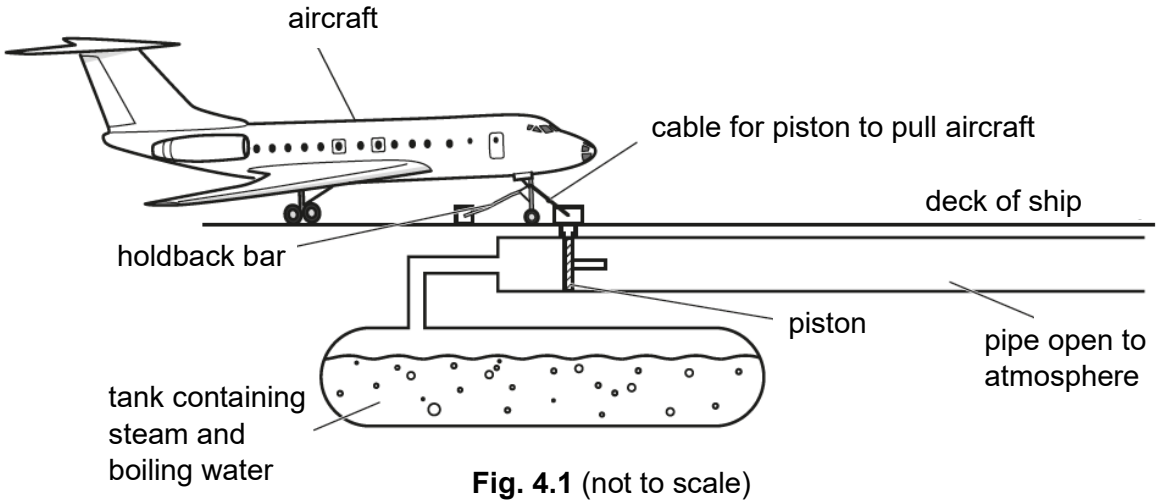

Fig. 4.1 (not to scale)

The steam exerts a high pressure on the piston.

(a) **(i)** Define *pressure*.

……

…….. [1]

(ii) Explain, using ideas about particles, how the steam creates a pressure on the piston.

……

……

…….. [2]

(b) When the pressure is high enough, the holdback bar is released. The steam pushes the piston along the pipe shown in Fig. 4.1.

The piston has a cross-sectional area of 0.30 m^2.

The pressure of the steam in the tank is 2.1×10^6 Pa and atmospheric pressure is 1.0×10^5 Pa.

Determine the resultant force on the piston caused by the pressure difference.

force = …….. [2]

[Total: 5]

5 Fig. 5.1 shows a connection to the internet made from a remote station A using a satellite above the Earth's surface.

Data is sent between stations A and B using an electromagnetic wave which travels to and from the satellite.

Station B is connected directly to the internet using optical fibre.

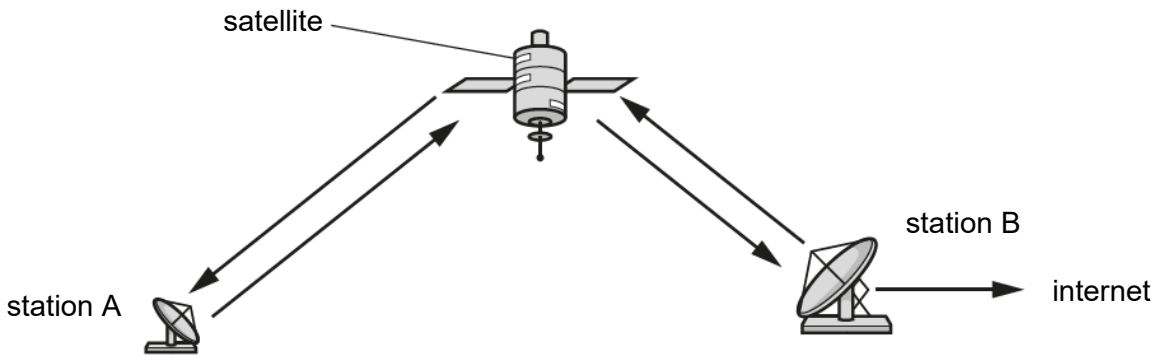

Fig. 5.1 (not to scale)

(a) State the type of electromagnetic (e.m.) wave used for this satellite data transmission.

……

…… [1]

(b) The frequency of this e.m. wave is 18 GHz.

Stations A and B are each 560 km from the satellite.

Calculate the number of wavelengths present in the e.m. wave as the data travels 560 km from A to the satellite.

number of wavelengths = …….. [2]

(c) The same data can be sent from A to B in a shorter time along the surface of the Earth using infrared waves and visible light to carry the information in optical fibres.

(i) Suggest one other advantage of using optical fibres to connect stations A and B directly.

……

…….. [1]

(ii) The critical angle of the glass in an optical fibre is 45°.

Calculate the refractive index of the glass.

refractive index = …….…….. [2]

(iii) Fig. 5.2 shows an optical fibre made of the glass described in **(ii).**

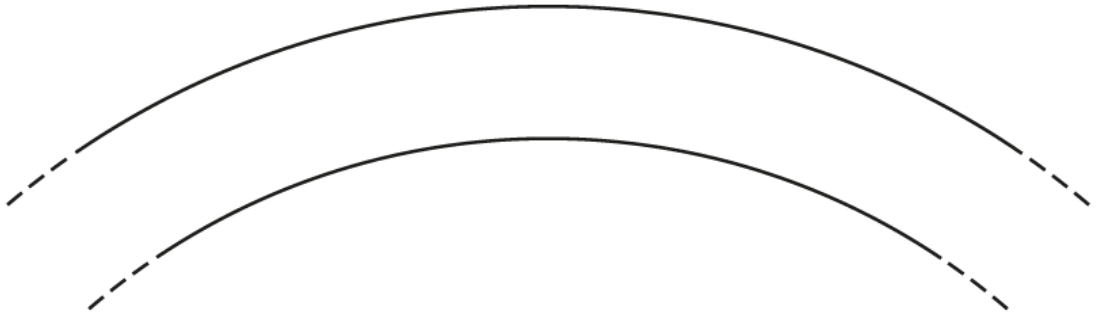

Fig. 5.2

On Fig. 5.2, draw accurately a ray of light in the fibre undergoing total internal reflection. [1]

[Total: 7]

6 A filament lamp is placed above a shiny metal surface, as shown in Fig. 6.1.

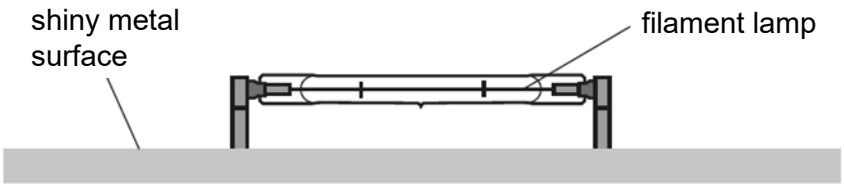

Fig. 6.1

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

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

……..

…… [1]

(b) The student considers replacing the filament lamp shown in Fig. 6.1 with an LED of the same brightness.

Data about the filament lamp and a suitable LED are shown in Table 6.1.

Table 6.1

	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 6.1, 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. 6.1.

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 to the earth wire.

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

……

……

……

…….. [2]

[Total: 7]

7 Fig. 7.1 shows a wireless charging plate used to charge the battery in a mobile phone. The coil of wire is part of an electric circuit.

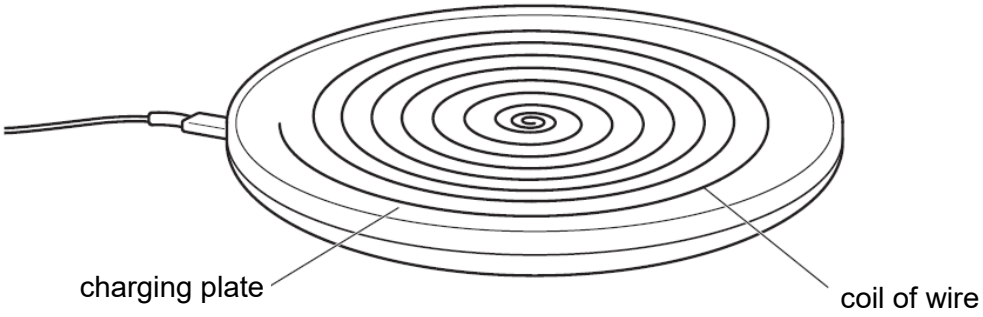

Fig. 7.1

The charging plate is connected to a 240 V a.c. power supply. The power supply is turned on.

(a) A mobile phone is placed on the charging plate as shown in Fig. 7.2. The coil in the mobile phone is part of a separate circuit that charges the battery.

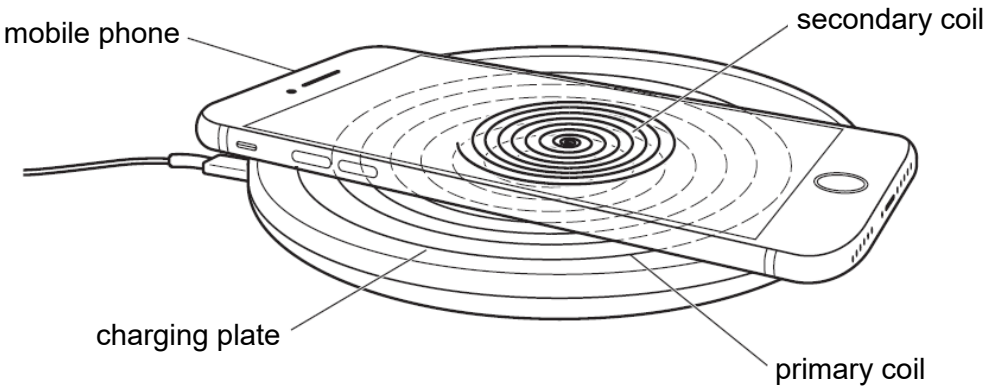

Fig. 7.2

The coil in the charging plate and the coil in the mobile phone act like a transformer.

(i) Explain why there is a current in the secondary coil shown in Fig. 7.2.

……

……

……

……[2]

(ii) Suggest why the transformer made from the charging plate and mobile phone is not 100% efficient.

……

……[1]

(b) The primary coil in the charging plate has 1000 turns while the secondary coil in the mobile phone has 50 turns.

Calculate the voltage across the coil in the mobile phone.

voltage = …….. [2]

(c) The mobile phone battery can be recharged using this charging plate and stores 22 kJ of energy when fully recharged. The current in the secondary coil is 0.65 A.

Calculate the time taken to fully recharge a completely uncharged battery.

time = …….. [2]

[Total: 7]

8 **(a)** Carbon-14 ($^{14}_{6}C$) is a radioactive isotope of carbon. Carbon-12 ($^{12}_{6}C$) is not radioactive.

All living organisms contain both carbon-12 atoms and carbon-14 atoms. The ratio of carbon-14 to carbon-12 is $1 : 1 \times 10^{12}$.

Carbon-14 has a half-life of 5700 years.

(i) When an organism dies, no new carbon is absorbed. The amount of carbon-12 in the dead organism remains fixed.

Describe how the amount of carbon-14 in the dead organism decreases with time.

……

……

…….…… [1]

(ii) A sample of wood contains carbon-14 and carbon-12 atoms in the ratio $1 : 4 \times 10^{12}$.

Calculate the number of years elapsed since the tree died.

number of years = …… [2]

(b) Other radioactive isotopes have different half-lives.

Suggest one reason why radioactive isotopes with a short half-life is more suitable to be administered into a patient's body during diagnostic imaging.

.....

..... [1]

[Total: 4]

9 A Cedarian carried out an experiment to investigate the terminal velocity of a falling object. Two metal balls X and Y are released from rest and allowed to fall through a tall cylinder of glycerin (a thick liquid).

The metal balls are both spherical. Table 9.1 shows the properties of the two balls.

Table 9.1

	radius / cm	density / kg m^{-3}
Ball X	7.5	7800
Ball Y	7.5	11 300

The distance fallen from a fixed point was recorded at equal time intervals for each ball as shown in Table 9.2.

Table 9.2

	Ball X	Ball Y
time / s	distance fallen / cm	distance fallen / cm
0.0	0	0
0.5	2.0	3.0
1.0	3.9	6.5
1.5	5.6	10.2
2.0	7.0	13.8
2.5	8.0	17.1
3.0	9.0	20.1

(a) Explain how the data in Table 9.2 can be used to determine whether the balls have reached terminal velocity.

…….

…….

…….

…… [2]

(b) Explain why the balls will eventually reach terminal velocity as they fall through glycerin.

……..

……..

……..

…… [2]

(c) **(i)** Explain why, despite both balls having the same size, one ball reaches terminal velocity first.

……

……

……

……

…… [2]

(ii) State which ball will reach terminal velocity first.

…… [1]

(iii) Estimate the terminal velocity of this ball.

terminal velocity = …….. [2]

(iv) On Fig. 9.1, sketch the velocity-time graph of this ball for 3.0 s.

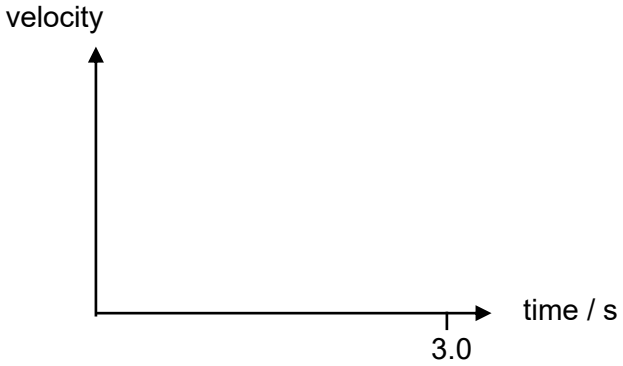

Fig. 9.1

[1]

[Total: 10]

10 **(a)** Fig. 10.1 shows a simple direct current (d.c.) motor.

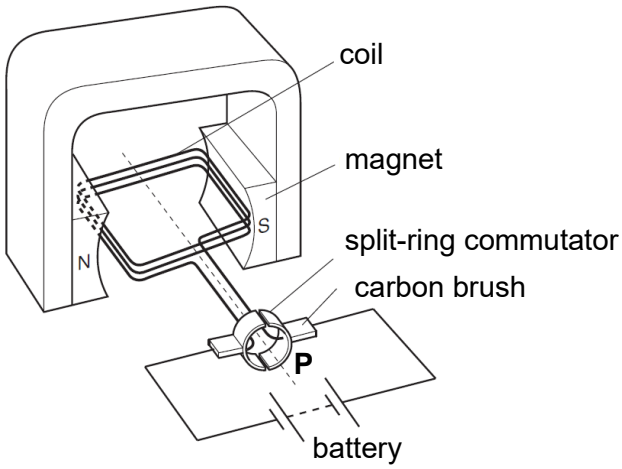

Fig. 10.1

(i) Explain the purpose of the split-ring commutator.

……

……

……

..... [2]

(ii) State the direction of rotation of the coil when viewed from the position **P**.

……..... [1]

(iii) Explain your answer to **(a)(ii)**.

……

……

..... [1]

(b) Fig. 10.2 shows a drone that uses lightweight brushless d.c. motors to rapidly spin propellers, generating lift and allowing precise control for hovering, ascending, and directional movement.

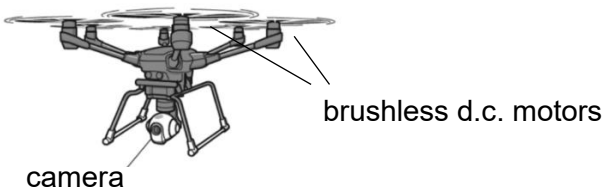

Fig. 10.2

A brushless d.c. motor uses fixed coils to create a rotating magnetic field, which causes surrounding permanent magnets to spin. It has no brushes and split-ring commutator.

(i) Suggest one advantage of using brushless d.c. motors in the drone.

…… [1]

(ii) For the drone to land safely, it needs to lose its lift. This can be achieved by reducing the speed of the brushless d.c. motors.

Suggest one way to reduce the speed of the motors.

……

…….. [1]

(c) The drone has two identical lamps that are connected to a 12 V battery as shown in Fig. 10.3.

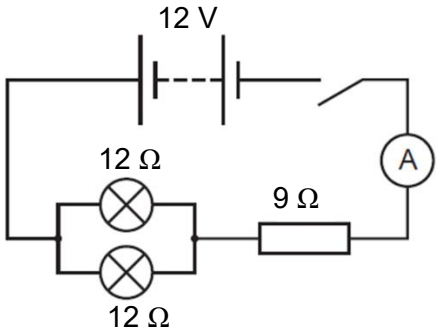

Fig. 10.3

(i) Assuming the ammeter is ideal, calculate its reading when the switch is closed.

ammeter reading =…….. [2]

(ii) Calculate the potential difference (p.d.) across each lamp.

p.d. =…….. [2]

[Total: 10]

Section B

Answer **one** question from this section.

11 A pan containing ice at –15 °C is placed on a gas heater as shown in Fig. 11.1.

Fig. 11.1

(a) Thermal conduction occurs in the metal from which the pan is made.

Using the kinetic particle model, describe the process of thermal conduction in a metal.

……..

……..

……..

……..

……..

…… [3]

(b) Fig. 11.2 shows how the temperature of the contents of the pan varies with time.

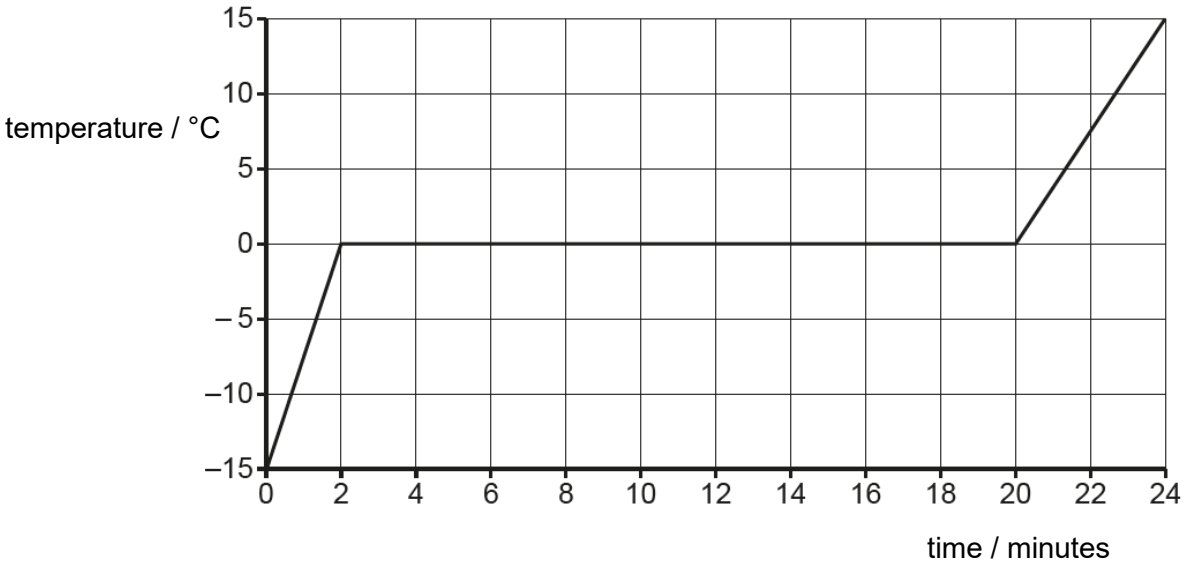

Fig. 11.2

(i) Explain why the temperature of the contents of the pan is constant between time = 2 min to 20 min.

……

……

……

…….. [2]

(ii) The initial mass of ice in the pan is 1.5 kg and the initial temperature is –15 °C.

The specific heat capacity of ice is 2100 J/(kg °C) and the specific latent heat of fusion of water is 334 000 J/kg.

Calculate the energy required to melt the ice completely.

energy = …….. [3]

(iii) All the energy transferred to the pan comes from the heater.

Using your answer to **(ii)** and Fig. 11.2, determine the power of the heater used to warm the ice.

power = …….. [1]

(iv) The graph in Fig. 11.2 has a smaller gradient after the ice has completely melted than when it is a solid.

Explain why.

……

……..… [1]

[Total: 10]

12 **(a)** In Fig. 12.1, A and B are two conductors mounted on insulating stands. A is positively charged and B is initially uncharged.

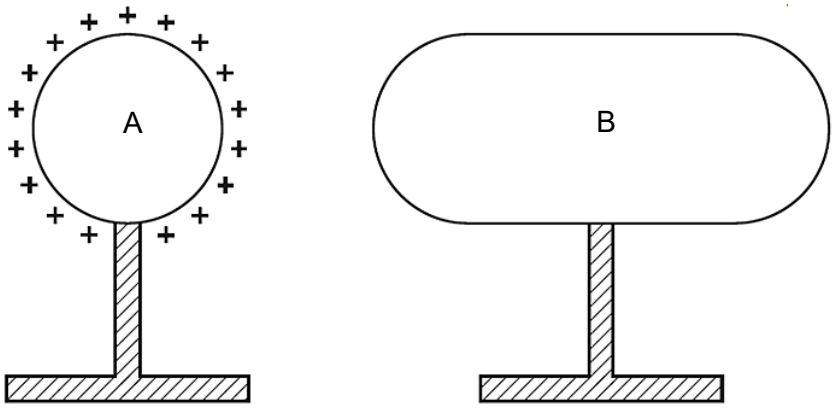

Fig. 12.1

(i) Conductor A is placed near conductor B.

On Fig 12.1, draw the charge distribution in conductor B. [1]

(ii) Explain the charge distribution in conductor B drawn in **(i)**.

……

……

……

…….. [2]

(iii) Conductor B is now connected to earth by a wire attached to the left side of conductor B.

Explain the change in the net charge of conductor B, if any.

……

…….. [1]

(b) Fig. 12.2 shows an electrostatic precipitator that stops dust and ash emerging from the chimney.

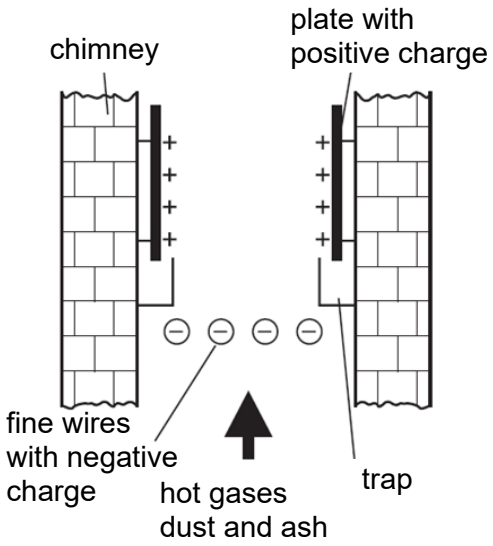

Fig. 12.2

(i) Explain how the precipitator works.

……

……

……

……[2]

(ii) Electrostatic precipitator is also used in portable electrostatic air purifiers designed for homes and offices. High voltage is often used in these devices.

Explain why, to clean the collector plates of the air purifier, the manual will advise the user to wear rubber gloves and to wait for a few minutes after switching it off.

……

……

……

…… [2]

(iii) Sometime a spark may jump when an earthed wire is brought near a charged plate. A charge of 1.8 μC flows between the wire and charged plate in a time of 1.2 ms.

Calculate the current.

current = …….. [2]

[Total: 10]

END OF PAPER