DUNMAN SECONDARY SCHOOL

CANDIDATE NAME			
CLASS		**INDEX NUMBER**	

PRELIMINARY EXAMINATION 2025
SECONDARY 4 EXPRESS

PHYSICS **6091/02**

Paper 2 Structured and Free Response

25 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 on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, 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.

Section A

Answer **all** questions.

1 A ball rolls down a slope, as shown in Fig. 1.1.

The metre rule shows the position of the ball at times t = 0.0 s, t = 1.0 s, t = 2.0 s and t = 3.0 s.

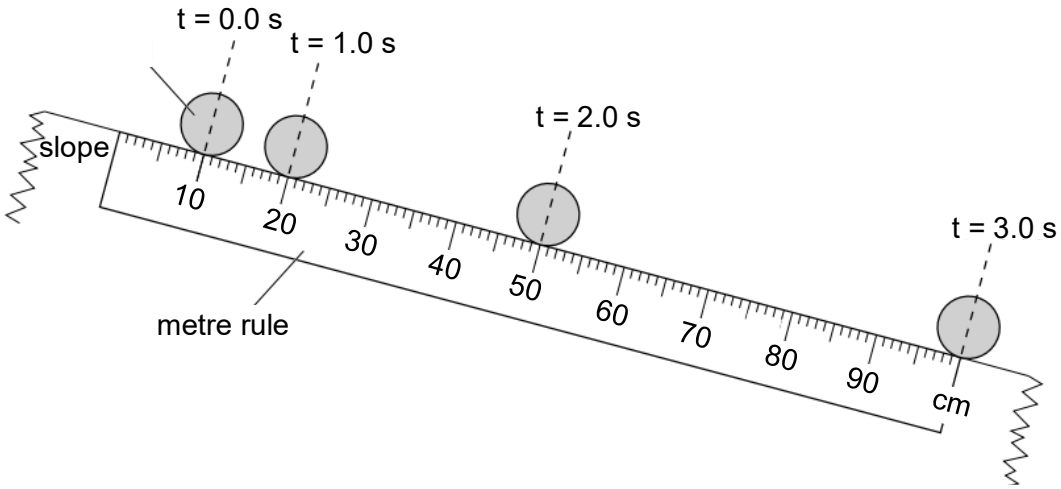

Fig. 1.1

(a) Explain how Fig. 1.1 shows that the ball is accelerating.

……..……..

……..…….... [1]

(b) Calculate the average speed of the ball between t = 1.0 s and 3.0 s.

average speed = ……..……..…….. [2]

(c) Two of the forces that act on the ball are air resistance and weight.

State the changes to these forces, if any, as the ball accelerates.

air resistance: ..……..……..

weight: ……....……..……..

[2]

(d) On Fig. 1.1, draw the direction of friction between the ball and ground at t = 2.0 s. [1]

[Total: 6]

2 A crankshaft is a shaped metal bar that is part of a car engine. It is free to rotate about an axis, as shown in Fig. 2.1.

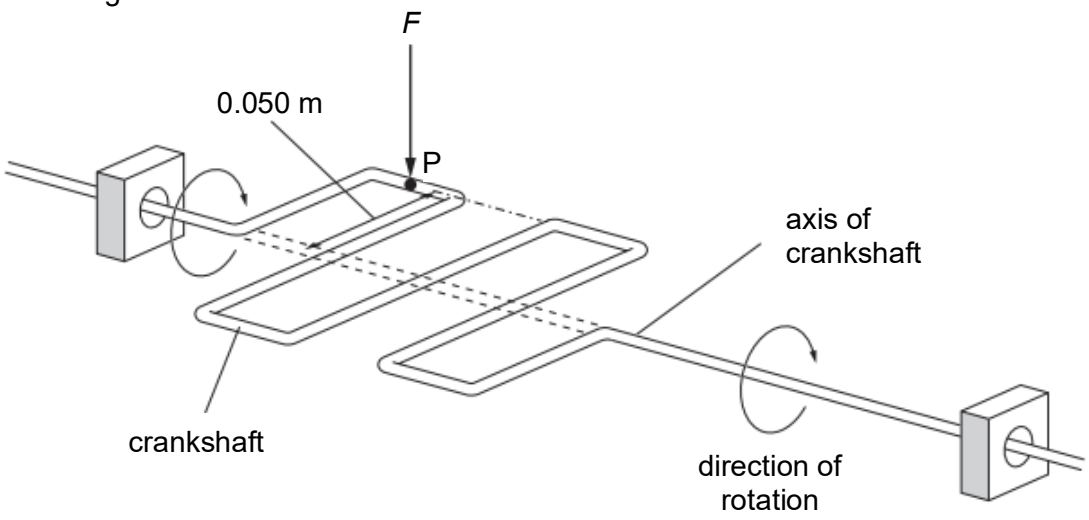

Fig. 2.1

When the crankshaft is horizontal, a vertical force *F* of 7800 N acts downwards on the crankshaft at P. This causes the crankshaft to rotate. The distance between P and the axis of the crankshaft is 0.050 m.

(a) State what is meant by the *moment* of a force.

……..……..

……..…….... [1]

(b) Calculate the moment of *F* about the axis of the crankshaft when the crankshaft is horizontal.

moment = ……..……..…….. [2]

(c) The size and direction of the vertical force *F*, acting on the crankshaft at P, remain constant. Explain why the moment of *F* decreases as the crankshaft rotates through a small angle.

……..……..

……..……..

……..…….... [1]

[Total: 4]

3 Fig. 3.1 shows a syringe mounted vertically in a block of wood and sealed at one end. A plunger is free to move inside the syringe.

There is trapped air in the syringe.

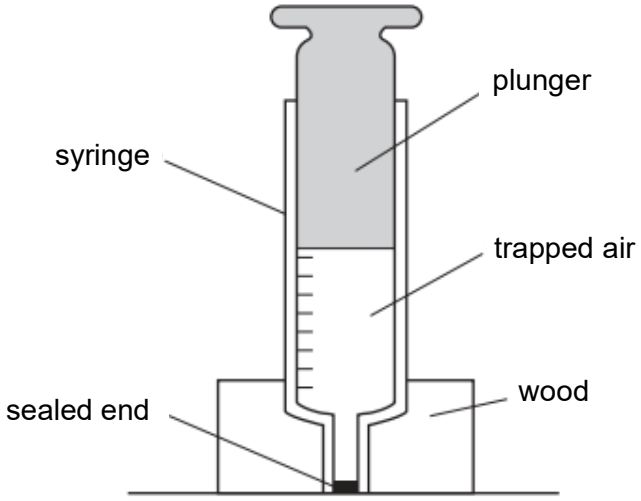

Fig. 3.1

The air inside the syringe exerts a pressure on the walls of the syringe.

(a) Define *pressure*.

……..

……..

…….... [1]

(b) Explain how the air molecules in the cylinder of the syringe create a pressure.

……..

……..

……..

……..

……..

…….... [3]

(c) A 20 N weight is placed on top of the plunger. The plunger moves down slowly so that the temperature of the air inside the syringe does not change.

Before the weight is placed on top:

- the pressure of the air inside the syringe is 1.0×10^5 Pa.
- the volume of the air is 60 cm^3.

The cross-sectional area of the plunger is 1.5×10^{-4} m^2.

Calculate the pressure of the air in the syringe after the plunger stops moving.

pressure = …….…….. [2]

[Total: 6]

4 Fig. 4.1 shows an elevator (lift) that is supported by a cable.

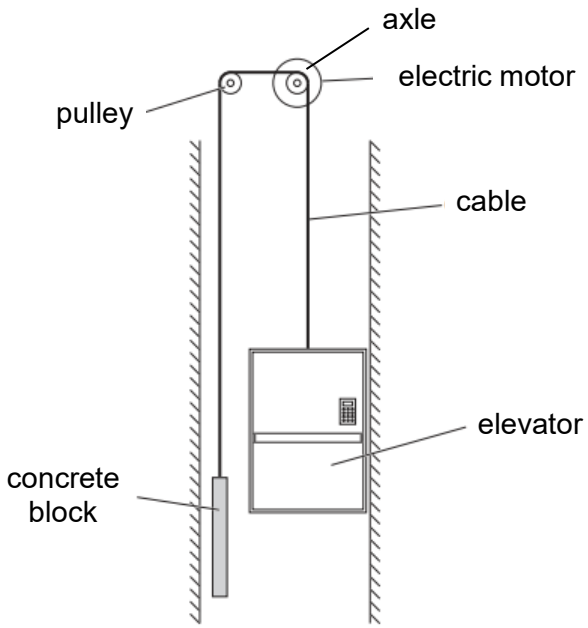

Fig. 4.1 (not drawn to scale)

The cable passes around the axle of an electric motor and over a pulley. The cable is then attached to a concrete block that has the same mass as the empty elevator. As the elevator moves up, the concrete block moves down.

(a) Explain why very little work is done by the electric motor when lifting up the empty elevator.

……..……..

……..……..

……..……..

……..... [2]

(b) Several people of total weight 5800 N are travelling upwards at constant speed in the elevator. They rise through a distance of 25 m in 28 s.

Calculate the minimum power output of the electric motor.

power = ……..…….. [2]

[Total: 4]

5 Fig. 5.1 shows a soldering iron. Solder is a mixture of metals used to make a permanent contact between electrical wires.

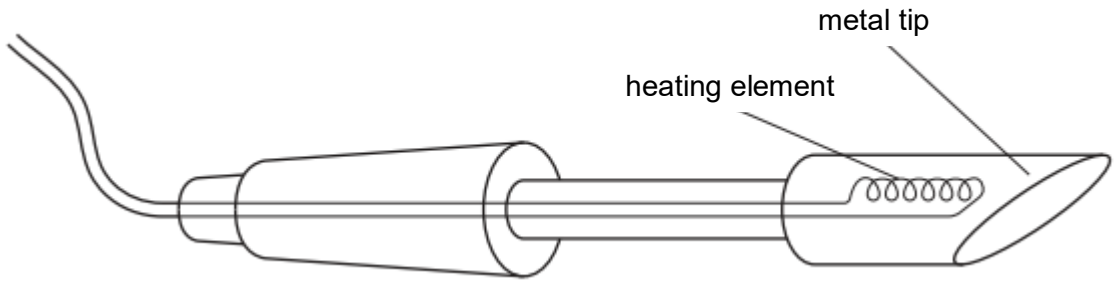

Fig. 5.1

The heating element raises the temperature of the metal tip. When solder is placed against the tip, the solder melts over the wires to be joined. When the solder cools, it solidifies and the permanent connection is made.

The working temperature of the metal tip is 360 °C.

(a) The heating element is rated at 24 V, 3.5 A. The heating element is switched on.

The temperature of the metal tip rises from 20 °C to 320 °C in the first 10 s.

(i) Calculate the electrical energy supplied to the heating element in the first 10 s.

electrical energy = ……..…….. [2]

(ii) The metal tip is made of copper and has a mass of 2.8 g. The specific heat capacity of copper is 0.39 J / (g °C). Calculate the thermal energy (heat) gained by the metal tip in the first 10 s.

thermal energy = ……..…….. [2]

(iii) Explain the difference in the answers for **(i)** and **(ii)**.

……

…… [1]

(b) Describe, in terms of free electrons, the process by which heat is transferred through the metal tip.

……

……

……

…… [2]

[Total: 7]

6 The fluorescent tube shown in Fig. 6.1 produces light via electrical pathway more efficiently than a filament lamp made of tungsten.

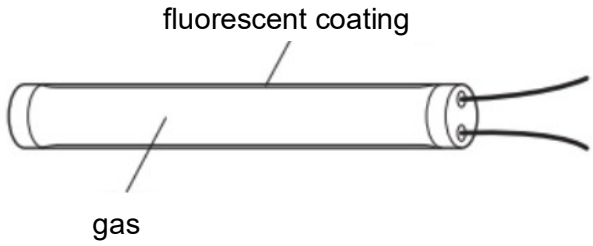

Fig. 6.1

In the gas inside the tube, both light and ultra-violet radiation are produced.

There is a fluorescent coating on the inside surface of the tube. The ultra-violet radiation reacts with the fluorescent coating to emit light.

(a) In a filament lamp, current is passed through tungsten. The tungsten filament is heated until it glows brightly.

Suggest why a fluorescent lamp is more efficient than a filament lamp made of tungsten.

……..……..

……..……..

……..……..

……..... [2]

(b) State the name of one region of the electromagnetic spectrum with wavelengths shorter than ultra-violet radiation.

……..... [1]

(c) The ultra-violet radiation inside the tube has a wavelength of 3.6×10^{-7} m.

Given that the speed of light = 3.0×10^{8} m/s, calculate the frequency of the ultra-violet radiation.

frequency = ……..…….. [2]

[Total: 5]

7 Fig. 7.1 shows part of the ray diagram of a converging lens being used as a magnifying glass.

Three rays are shown coming from the top of an object O. The points labelled F are one focal length from the lens.

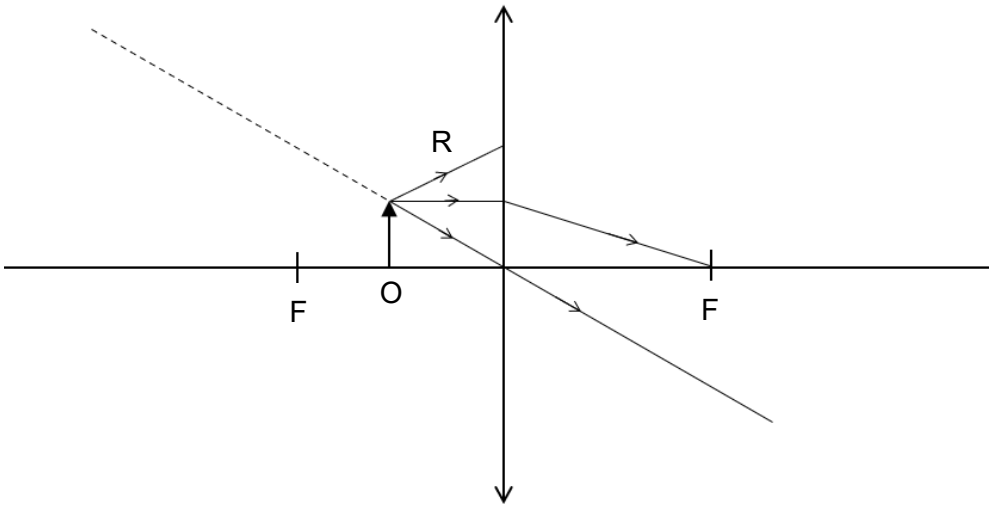

Fig. 7.1

(a) Describe what happens to the ray of light R

(i) as it enters the lens; and

……..…….....

……..……..... [1]

(ii) as it leaves the lens.

……..…….....

……..……..... [1]

(b) Using all three rays from O, complete Fig. 7.1 to locate the image.

Label the image I. [2]

[Total: 4]

8 Fig. 8.1 shows a child holding a balloon.

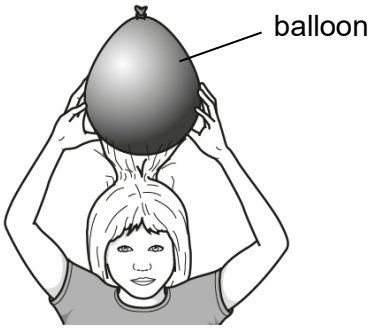

Fig. 8.1

(a) The balloon is rubbed on the child's hair and the child's hair becomes positively charged.

(i) Describe how rubbing causes the hair to become positively charged.

……

…… [1]

(ii) Explain why the hair is pulled towards the balloon.

……

……

……

…… [2]

(b) Fig. 8.2 shows the balloon brought near two metal spheres X and Y which are placed on insulating stands.

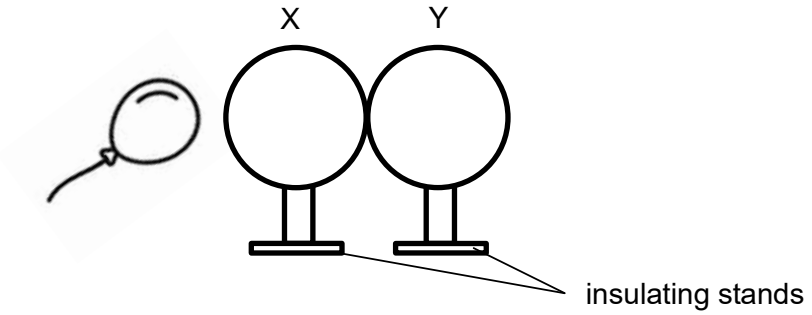

Fig. 8.2

Sphere Y is then moved very far away from sphere X as shown in Fig. 8.3.

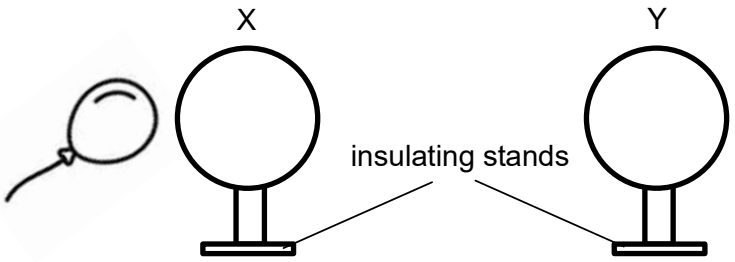

Fig. 8.3

(i) On Fig. 8.3, draw the charge distribution on sphere Y. [1]

(ii) Explain the final charge distribution on sphere X.

……

……

……

…… [2]

[Total: 6]

9 Fig. 9.1 is the circuit diagram for the volume control of a loudspeaker.

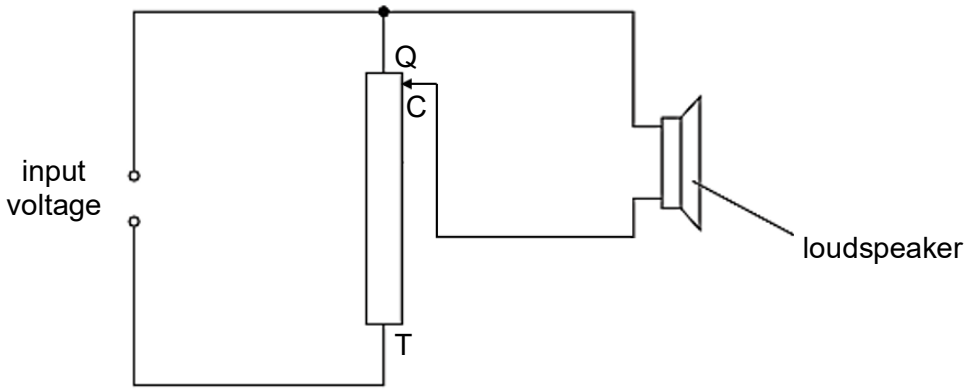

Fig. 9.1

The circuit includes a variable potential divider (potentiometer). The input voltage is connected across the ends of the potential divider. The loudspeaker is connected between the sliding contact C and the terminal Q.

(a) The sliding contact C is moved from Q to T. State and explain the effect on the sound produced.

……..

……..

……..

……..... [2]

(b) The loudspeaker emits a sound of constant pitch. Over a period of time, this sound becomes louder.

State the change, if any, on the amplitude and the frequency of the sound wave as the sound becomes louder.

amplitude ……..……..

frequency ……..……..

[2]

[Total: 4]

10 Fig. 10.1 shows part of a toy which contains two ring-shaped, permanent magnets. A plastic rod passes through the centre of both magnets.

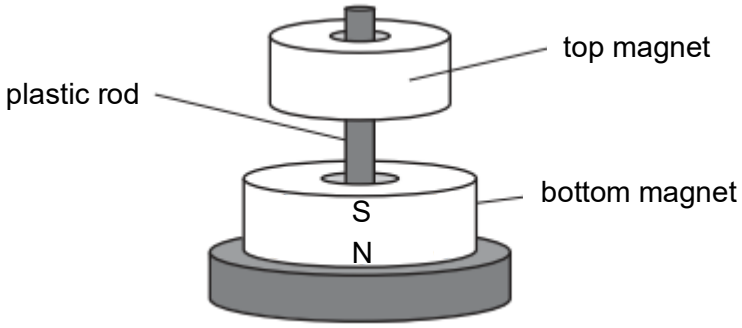

Fig. 10.1

The top magnet can move up and down freely around the plastic rod.

The magnetic poles on the bottom magnet are shown in Fig. 10.1.

(a) The top magnet floats in the air above the bottom magnet.

On Fig. 10.1, mark the poles on the top magnet and explain why it floats in the air above the bottom magnet.

……

……

……

…… [2]

(b) The top magnet is replaced with a ring made of iron.

Explain why the iron ring sticks to the bottom magnet.

……

……

……

…… [2]

[Total: 4]

11 Fig. 11.1 shows a wire XY placed between the poles of two magnets.

A direct current (d.c.) power supply is connected to the wire.

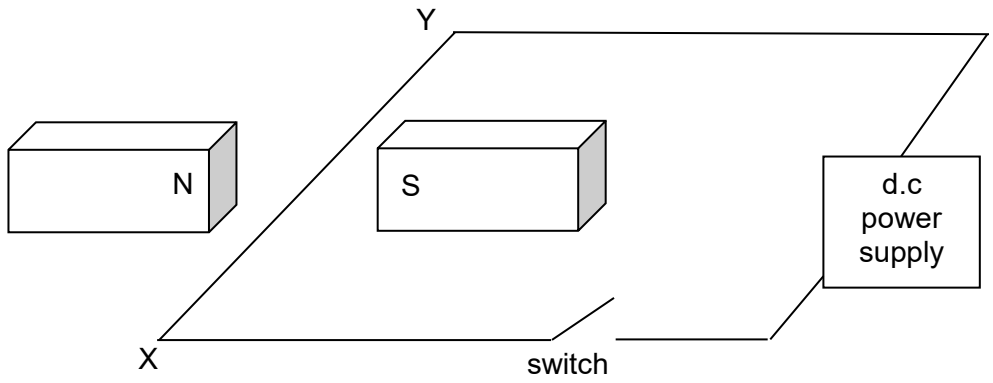

Fig. 11.1

Once the switch is closed, wire XY is pushed upwards by the magnetic field produced by the magnets.

(a) On Fig. 11.1, indicate the direction of conventional current flow in wire XY. [1]

(b) Fig. 11.2 shows the wire XY between the two magnets.

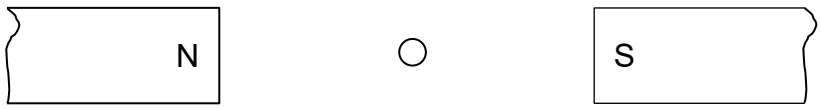

Fig. 11.2

(i) When the switch is closed, there are magnetic fields produced.

On Fig. 11.2, draw the magnetic field due to wire XY only. [2]

(ii) Explain why wire XY moved upwards when there is a current in it.

……

……

……

…… [2]

(c) State what will happen to wire XY if the current from the d.c power supply is increased.

……

…… [1]

(d) The d.c power supply is disconnected and replaced by an alternating current power supply. State and explain what happens to wire XY.

……

……

……

…… [2]

[Total: 8]

12 **(a)** Technetium-99 is a radioactive isotope that emits gamma-rays.

In a hospital, a solution containing this isotope is injected into a patient. The solution travels around the body and the isotope attaches to cancer cells. A few hours after the injection, an instrument is used to detect the gamma rays emitted by the isotope. A high reading on the instrument indicates the position of cancer cells.

The activity of technetium-99 was measured at 5-hour intervals and recorded in Table 12.1.

Table 12.1

time / h	0	5	10	15	20	25
activity / MBq	500	270	140	90	50	30

(i) On the grid of Fig. 12.1, draw a graph to show how the activity of technetium-99 varies with time.

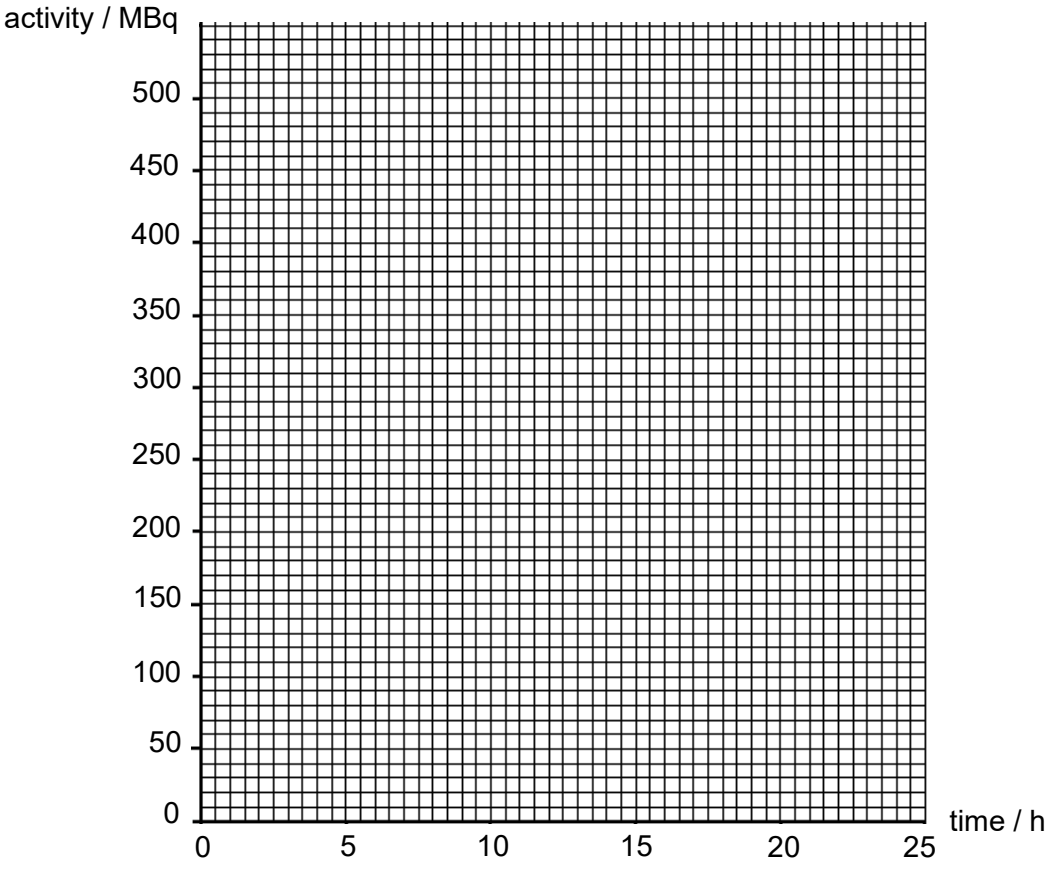

Fig. 12.1

[2]

(ii) Determine the half-life of the source. Show on your graph how you arrived at your answer.

half-life = ……..…….. [2]

(iii) Explain why an isotope emitting gamma rays is used rather than an isotope emitting alpha-particles.

……

……

……

..... [2]

(b) Another radioactive isotope, iodine-123 is also used in hospitals. It has a half-life of 13 hours. A sample of this isotope and a detector are placed in a lead box. The count rate is recorded every minute for three minutes. The values obtained are 2958, 3182 and 3460 counts per minute.

(i) Explain why the three readings are not the same.

……

……..... [1]

(ii) Estimate the time taken for the average count rate to fall to 200 counts per minute.

time taken = …… [3]

(iii) In nuclide notation, iodine-123 is written as $^{123}_{53}\mathrm{I}$.

When a nucleus of iodine-123 emits a beta-particle (β), it decays to an isotope of tellurium (Te).

Complete the decay equation below for this decay.

$$^{123}_{53}\mathrm{I} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\mathrm{Te} + {}^{\cdots\cdots}_{\cdots\cdots}\beta$$

[2]

[Total: 12]

Candidate Name:	Class:	Index No:

Section B

Answer **one** question from this section.

Answer either **Question 13** or **Question 14**.

13 **(a)** An aeroplane flies through the air in a straight line, with its engines at full power. The weight of the aeroplane is 150 kN. There is also a force of 350 kN acting upwards on the aeroplane at 30° to the horizontal.

In the space below, use a graphical method to determine the size and the direction of the resultant of these two forces.

Use a scale of 1.0 cm : 50 kN.

size of resultant force = ...

direction of resultant force = ...

[4]

(b) An aeroplane is travelling in a straight line at a constant height. The aeroplane accelerates. As the aeroplane accelerates, the pilot keeps the engines at constant power. The aeroplane eventually reaches a constant speed.

Explain why the aeroplane stops accelerating and reaches a constant speed.

……

……

……

…… [2]

(c) Fig. 13.1 shows the velocity-time graph of the aeroplane before it lifts off into the air.

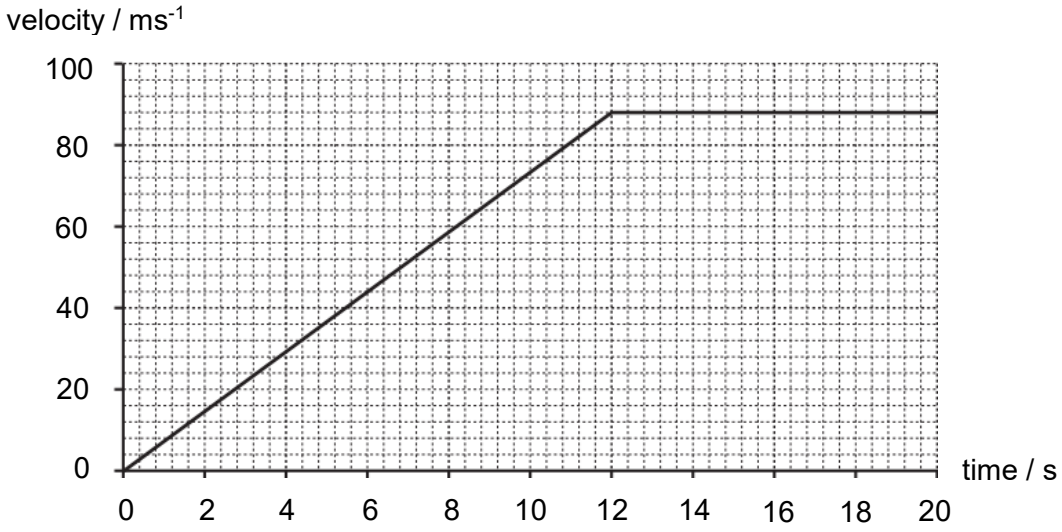

Fig. 13.1

(i) Describe the motion of the aeroplane from t = 0 s to t = 20 s.

……

……

……

…… [2]

(ii) On the grid provided in Fig. 13.2, sketch the displacement-time graph of the aeroplane from t = 0 s to t = 20 s.

Label the relevant values on both displacement and time axes. [2]

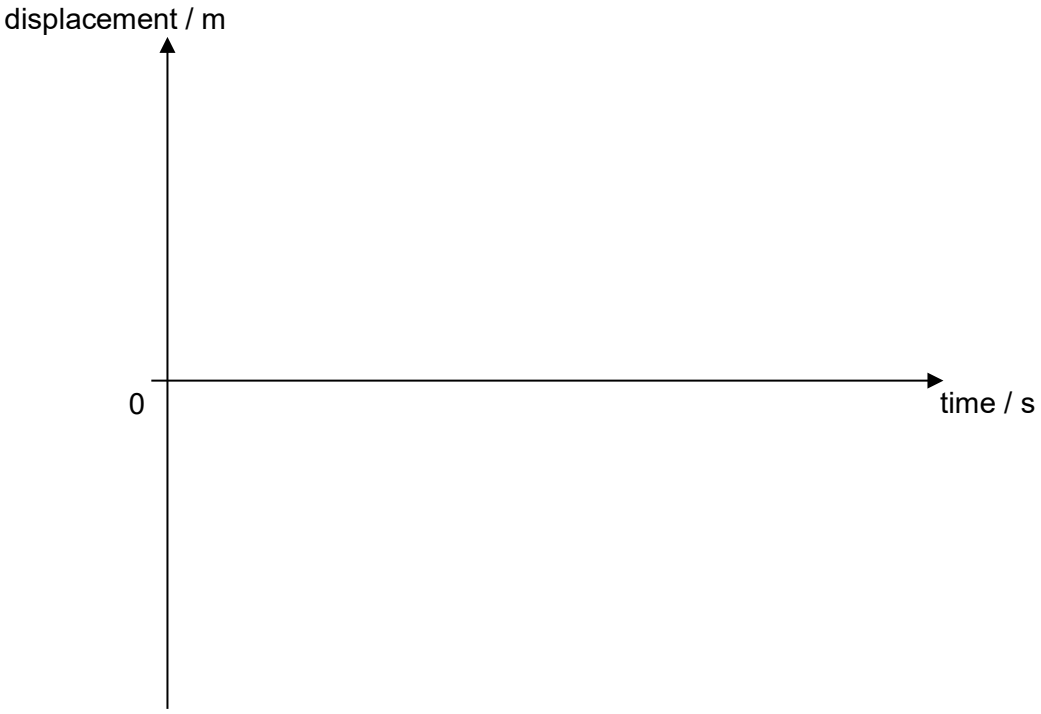

Fig. 13.2

[Total: 10]

14 A student places a small electrical heater inside a cup of water, as shown in Fig. 14.1.

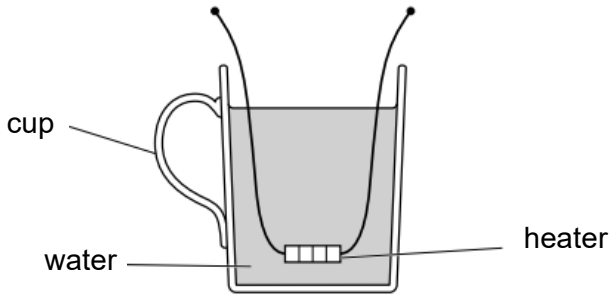

Fig. 14.1

The student connects an electrical circuit to determine the electrical power of the heater.

(a) In the space above the cup on Fig. 14.1, draw the electrical circuit that the student uses. Include an ammeter, a voltmeter and a power supply. [2]

(b) The voltage of the power supply is 12 V and the current is 4.5 A.

(i) Calculate the electrical power input to the heater.

power = ……..…….. [1]

(ii) Calculate the energy input to the heater in 8.0 minutes. Give your answer in kWh.

energy = ……..……kWh [1]

(c) During heating, the student notices that some of the water evaporates from the cup.

(i) Using ideas about molecules of water, describe what happens during evaporation.

……

……

……

…… [2]

(ii) The student finds that the rate of evaporation increases when the temperature of the water is higher.

State and explain one other change that increases the rate of evaporation.

……

……

……

…… [2]

(d) The student turns off the power supply and the water cools.

Describe and explain how convection in the air causes the water to cool.

……

……

……

…… [2]

[Total: 10]