O	JURONG SECONDARY SCHOOL 2024 GRADUATION EXAMINATION SECONDARY FOUR

CANDIDATE NAME	

CLASS			INDEX NUMBER	

PHYSICS — 6091/02

Paper 2 Structured and Free Response

12 August 2024
1 hour 45 min

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your Centre number, index number and name 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.

For Examiner's Use		
Paper 1 (30%)	**MCQ [40 marks]**	
Paper 2 (50%)	**SECTION A [70 marks]**	
	SECTION B [10 marks]	
	SUB-TOTAL [80 marks]	
Paper 3 (20%)	**PRACTICAL [40 marks]**	
OVERALL %	**[100 %]**	

This document consists of **24** printed pages including this page.

Section A [70 marks]
Answer **all** the questions in this section.

1 Fig. 1.1 shows the core of a transformer. It is made from thin sheets of iron.

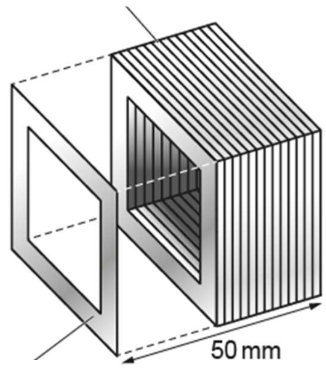

Fig. 1.1

There are 200 sheets of iron in the core of the transformer. The thickness of the core using a measuring instrument is 50.00 mm

(a) Identify the error that we are trying to eliminate by the method of averaging when we want to find the thickness of a single sheet of iron.

.... [1]

(b) Suggest and explain what measuring instrument is used to measure the thickness of the core.

....

....

....

.... [2]

(c) The density of the iron in the core is 7.65 g/cm^3. The mass of the core is 1.38 kg.

Calculate the volume of the core.

volume = ... [1]

2 Two blocks A and B of mass 3.0 kg and 2.0 kg respectively are connected by an inextensible string that passes through a smooth pulley as shown in Fig. 2.1.
When B is stationary on the table and the string is taut, A is released from rest.
Assume air resistance is negligible.

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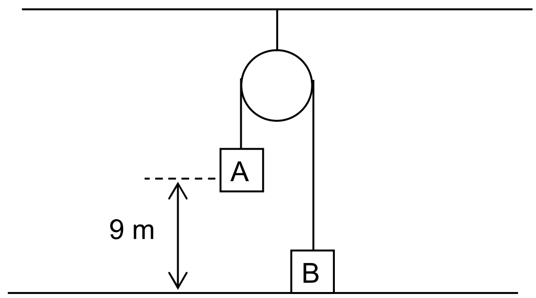


Fig. 2.1

(a) **(i)** On Fig 2.1, draw and label the weights and tensions acting on blocks A and B respectively.

[2]

(ii) Considering both boxes to move at the same rate, calculate the acceleration of A.

acceleration = …………………… [2]

(b) The speed of A just before it reaches the ground is 6.0 m/s.
Calculate the maximum height reached by B after it rises above the original height of block A as shown in Fig. 2.1.

height = …………………… [2]

3 Fig. 3.1 shows a barrier used at a car park. The beam can be raised and lowered by a man rotating it about its pivot.

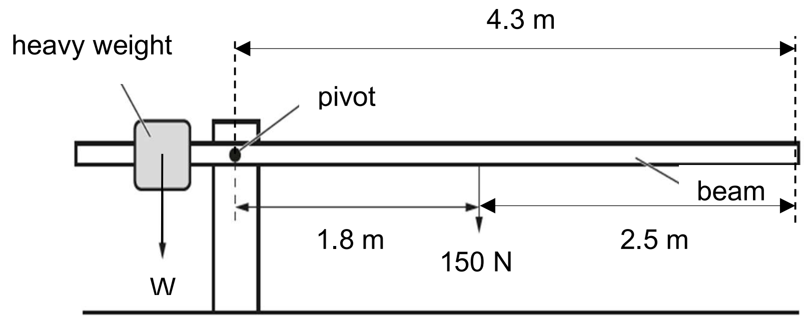


Fig. 3.1

The weight of the beam is 150 N.

(a) Calculate the moment of the weight of the beam about the pivot.

moment = …………………… [1]

(b) When the weight *W* of the heavy weight acts at a distance of 0.6 m from the pivot, the barrier is horizontal and balanced as shown in Fig. 3.1.

(i) State what is meant by the *Principle of Moments.*

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………. [1]

(ii) The man raises the barrier and the heavy weight slips to a distance of 0.8 m further from the pivot. This causes a problem for the man trying to lower the barrier to make it horizontal.

Describe and explain the problem this causes for the man in lowering the barrier.

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………. [2]

4 A diver dives to a depth below the surface of the sea where the total pressure is 3.0×10^5 Pa.

(a) State two possible factors that will affects the total pressure that the diver will experience.

………………………………………………………………………………………………… [1]

(b) Given that atmospheric pressure is 1.0×10^5 Pa and density of the sea water is 1030 kg/m^3, calculate the depth of the diver below the surface of the sea.

depth = …………………… [2]

(c) As the diver descends deeper, the environment grows darker because less light can penetrate the deeper water.
The diver is wearing a dive computer to monitor the water pressure and observes that the screen of the dive computer becomes brighter as he descends.

(i) Draw a labelled diagram of an electrical circuit setup within the dive computer that allows the change in brightness of the screen.

Your diagram should include:

- a possible power source
- an input transducer that changes with the brightness of the environment
- a light bulb.
- **Label clearly** each electrical components in your proposed circuit.

[1]

(ii) Explain how your proposed electric circuit in **(c)(i)** allows the screen of the dive computer to become brighter as he descends.

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………….

……………………………………………………………………………………………... [2]

5 Fig. 5.1 shows a load suspended from a spring.

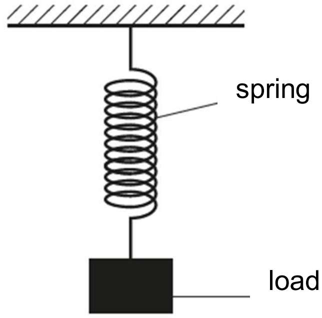


Fig. 5.1

The load is pulled down a small distance below its equilibrium position to position A, as shown in Fig. 5.2. The load then moves up and down between position A and position B in Fig. 5.2.

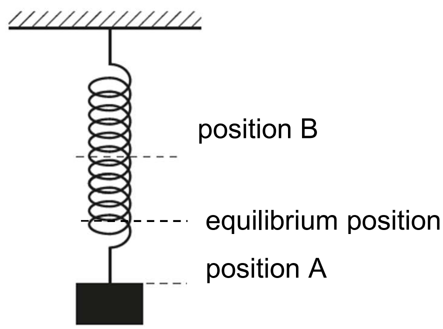


Fig. 5.2

Describe the energy store transfers which occur as the load moves:

(a) from position A to the equilibrium position

....

.... [1]

(b) from the equilibrium position to position B.

....

.... [1]

6 Medical professionals sometimes rub ethanol over the skin of a patient.
Ethanol evaporates readily at room temperature and has a low specific latent heat of vaporisation.

(a) State whether the patient experiences heating, cooling or neither at the site where the ethanol is applied. Using ideas about molecules, explain your answer.

statement ……………………………………………………………………………………………

explanation …………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) State and explain the effect on the rate of evaporation of ethanol when a fan blows air over the skin of the patient.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………… [2]

7 Both radio waves and γ-rays (gamma) are regions in the electromagnetic spectrum.
Fig. 7.1 shows the main regions of the electromagnetic spectrum. Most regions are labelled.

radio waves	microwave radiation	infrared radiation	visible light			γ-rays

Fig. 7.1

(a) On Fig. 7.1, write the names of the radiations in the other **two** parts of the electromagnetic spectrum.

[1]

(b) State **one** use of γ-rays.

....

.... [1]

(c) A star emits radio waves and γ-rays at the same time.
They travel across space to the Earth's atmosphere.

State whether the radio waves or the γ-rays, if either, arrive first at the Earth's atmosphere.
Explain your answer.

....

....

....

.... [2]

8 Fig. 8.1 below shows the side view of a glass tank PQRS filled with water.
An electric lamp, surrounded by a shield with a narrow transparent slit, is immersed in one corner of the aquarium at S.
The light ray from the slit shines on the water surface PQ at an angle of 40° as shown.

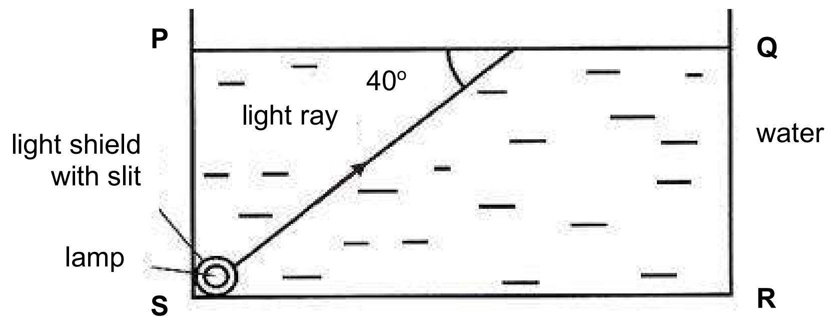


Fig. 8.1

(a) If the refractive index of water is 1.33, calculate the critical angle for a ray travelling from water to air.

critical angle = …………………… [1]

(b) On Fig 8.1 above, complete the path of the light ray after meeting the water surface PQ, clearly labelling all angles.

[1]

(c) Explain your answer in **(b)**

………………………………………………………………………………………………………

……………………………………………………………………………………………… [1]

9 Fig. 9.1, drawn to scale, shows an object O to the left of a thin converging lens L.
The principal axis and the principal focus F are also shown.

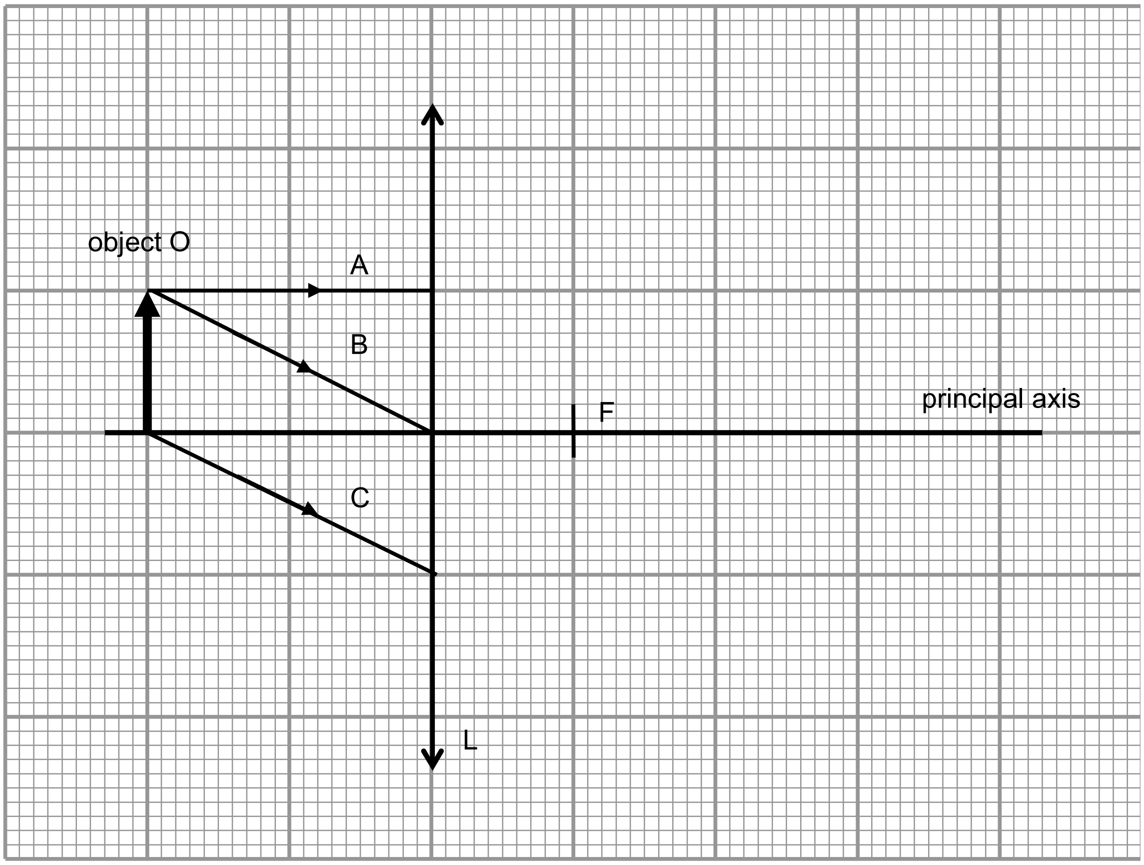


Fig. 9.1

On Fig 9.1, draw

(a) rays **A** and **B** to find the position of the image. Label the image **I**. [2]

(b) draw the refracted ray of ray **C**. [1]

10 Fig. 10.1 is a **full-scale** diagram that represents a sound wave travelling in air.

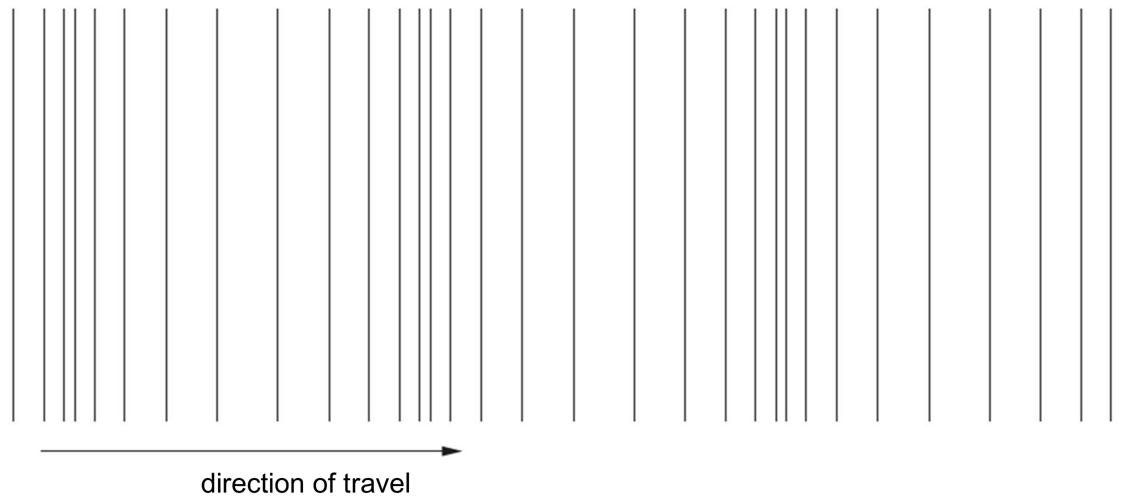


Fig. 10.1

(a) On Fig. 10.1, mark two points and label them as **X**, one at the centre of a compression and a rarefaction. Label the compression as **C** and the rarefaction as **R**.

[1]

(b) The speed of sound in air is 330 m/s.
Measure the appropriate dimension on Fig. 10.1 and determine the frequency of the sound.

frequency = …………………… [2]

11 An aircraft flies just below a negatively charged thunder cloud as shown in Fig. 11.1. Electrostatic charges are induced on the aircraft.

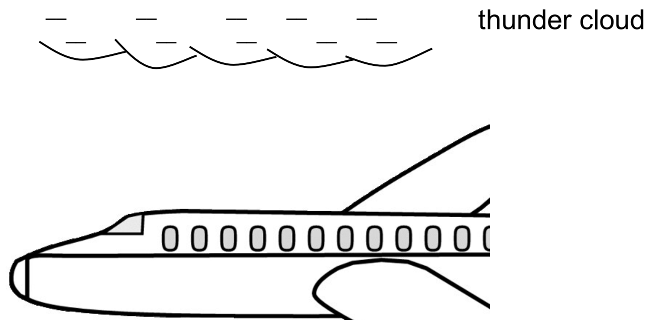


Fig. 11.1

(a) On Fig. 11.1, label the distribution of the induced charges on the aircraft. [1]

(b) In terms of the movement of electrons, explain the distribution of charges in **(a)**.

....

....

....

.... [2]

12 Fig. 12.1 shows a circuit powered by a battery with an electromotive force (e.m.f.) of 12 V.

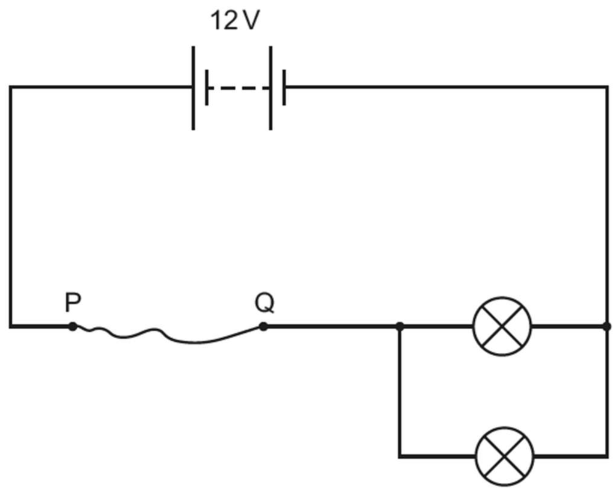


Fig. 12.1

(a) State what is meant by an *electromotive force* (*e.m.f.) of 12 V.*

....

.... [1]

(b) The two lamps shown are identical. Each lamp has a potential difference (p.d.) of 3.0 V across it and a current of 2.0 A in it. PQ is a length of uniform metal wire. The resistance of PQ is *R*.

(i) Calculate the value of *R*.

R = ... [2]

(ii) Another piece of wire is made of the same metal as PQ. The length of the new piece of wire is twice the length of PQ. The diameter of the new piece of wire is twice the diameter of PQ.

Calculate the resistance of the new piece of wire.

new R = ... [2]

13 Fig. 13.1 shows a door lock which can be opened from a flat inside a building.

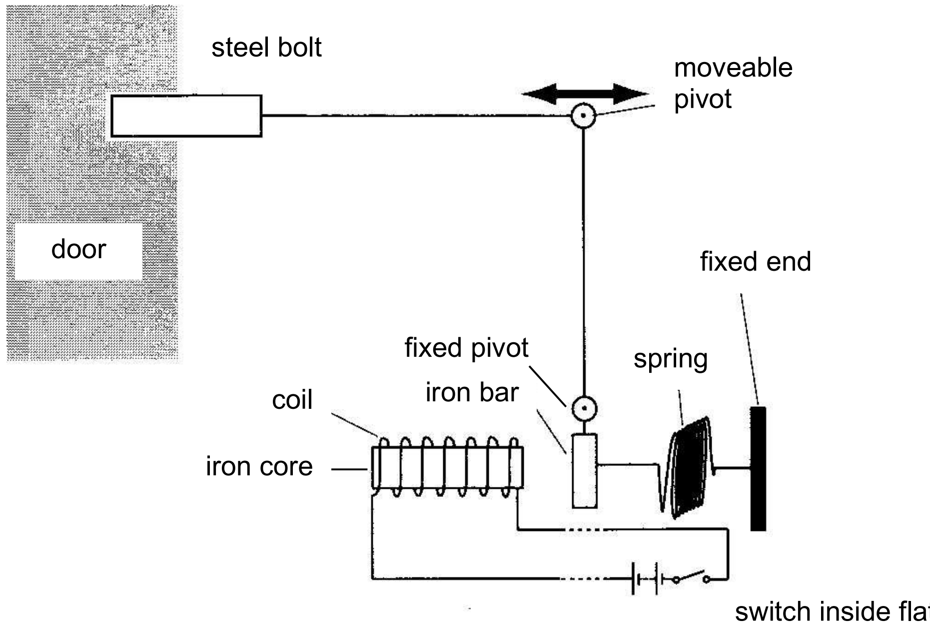


Fig. 13.1

(a) Explain how the door is unlocked when the switch is closed.

....

....

....

.... [2]

(b) On Fig. 13.1, label the direction of the current of the coil and the polarity of the iron core with the switch is closed.

[1]

14 A transformer is set up in three different modes to change the output voltage. The number of primary turns and secondary turns are varied to obtain the readings as shown in Table 14.1. A load resistor is connected to the secondary coil of the transformer.

Setup	Column 1	2	3	4	5	6	7	8
	primary turns	secondary turns	input voltage / V	input current / A	input power / W	output voltage / V	output current / A	Actual output power of the load resistor / W
1	120	40	6.00	1.2	7.2		3.6	4.61
2	120	120					1.2	6.91
3	120	240					0.6	7.13

Table 14.1

(a) Draw a labelled diagram of the setup of the transformer. Your diagram should show

- the structure of the transformer
- the connection of a suitable power supply
- the load resistor
- meters that allow the measurements in columns 3, 4, 6 and 7 to be made. **Label clearly** each meter to show which measurement it makes.

[2]

(b) State which setup suggests that the transformer is a step-up or a step-down transformer. Explain your answer.

………

………

………

……… [2]

(c) Using relevant information in Table 14.1, calculate the output voltage of the transformer for setup 1, 2 and 3. Record your answer in the empty boxes at column 6.

output voltage for setup 1 = ……………………

output voltage for setup 2 = ……………………

output voltage for setup 3 = …………………… [2]

(d) **(i)** Identify which of the three setups has the lowest efficiency.
Calculate the efficiency of the chosen setup.

Set up = ……………………….

efficiency = …………………… [2]

(ii) Suggest why the chosen setup in **(d)(i)** has the lowest efficiency.

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

………………………………………………………………………………………… [2]

15 There are three types of nuclear emissions, α-emissions, β- emissions and γ-emissions.

(a) Describe the respective nature and charges of each emission.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) Radium-226 (Ra) decays by emission of an α-particle to form an isotope of Radon (Rn) which has a proton number of 86.

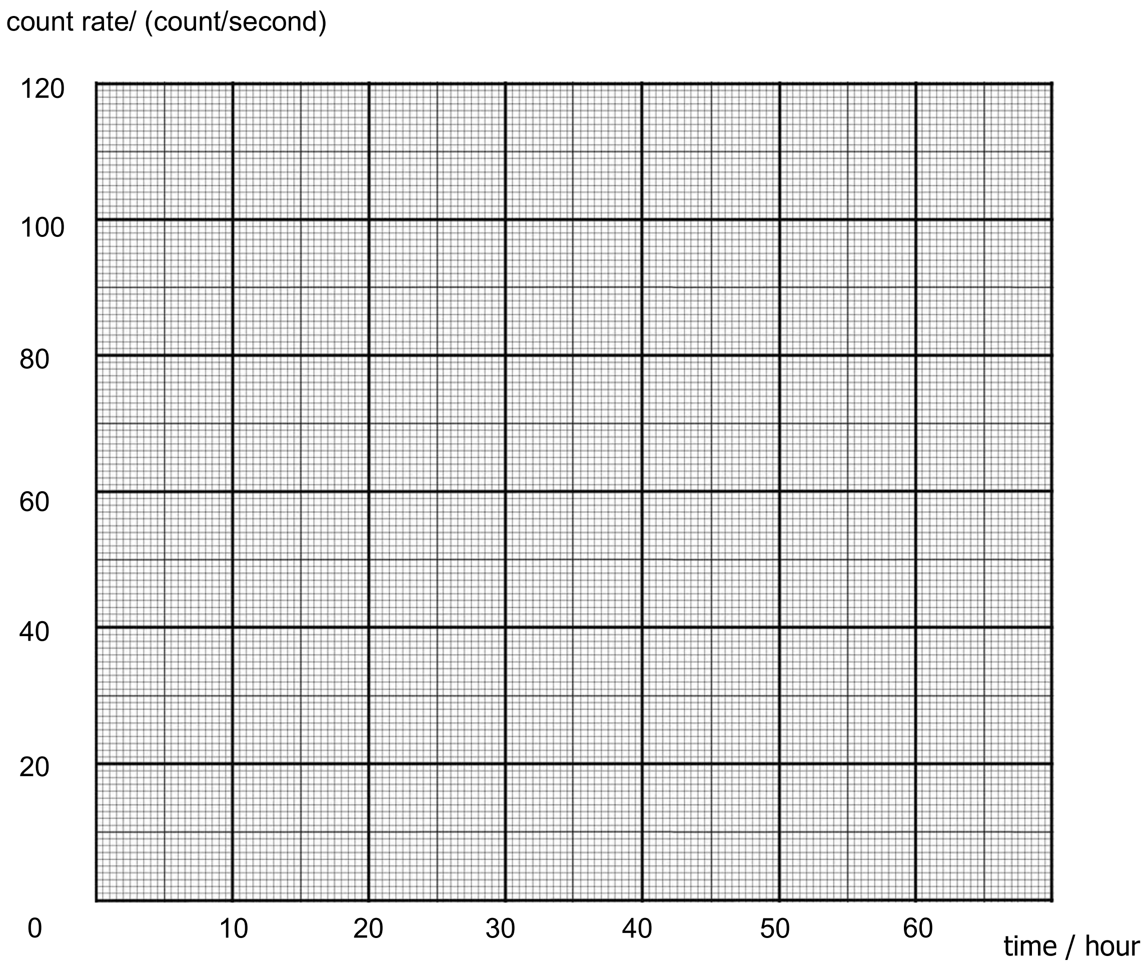
Write the complete nuclide equation for this reaction.

[2]

(c) Sodium-24 is a radioactive isotope that decays into a stable magnetism atom by the emission of β- emissions and γ-emissions.
The following shows the count rate of a sample of sodium-24 over a 60 hour period.

Time (hours)	0	12	24	36	48	60
Count Rate (counts/second)	120	69	41	22	13	7

(i) On the graph paper below, plot a graph of count-rate against time. [2]



(ii) Use the graph to calculate the half-life of sodium-24.

half life = …………………… [1]

(d) A rock specimen was obtained and a scientist suspected that the rock is radioactive. Hence, the rock is placed in front of a radiation detector and a sheet was placed in between the detector and the rock.

The following were observed:

- a large decrease in the count rate (but above the background count rate) when the sheet is a piece of lead with a thickness of 1 cm;
- no change in the count rate when the sheet is a piece of paper;
- a very slight decrease in the count rate when the sheet is a piece of aluminum with a thickness of 1 mm.

(i) Suggest the possible type of radiation coming from the rock.
Explain your answer.

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

………………………………………………………………………………………………. [2]

(ii) Suggest one negative effect of the radiation in **(d)(i)** on human cells.

…………………………………………………………………………………………………….

………………………………………………………………………………………………. [1]

Section B [10 marks]

Answer **one** question from this section.

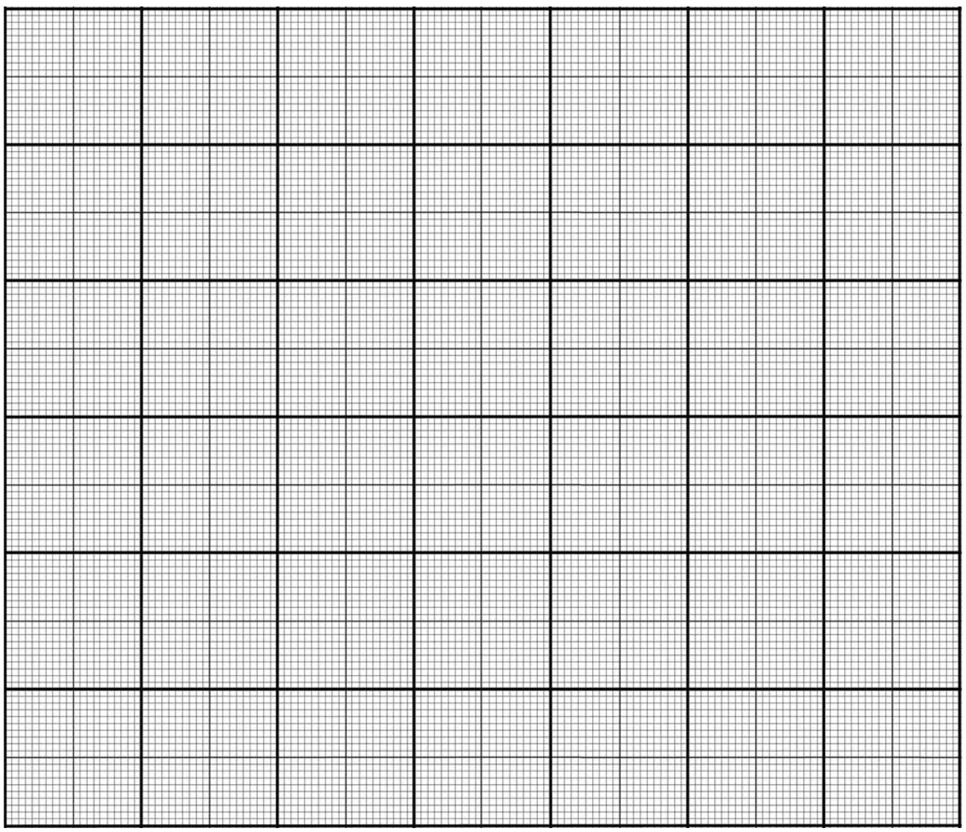
16 The various stages of the motion of an electric-powered car on a level road is described below.

Stage	Motion of the car
1	accelerates uniformly from rest for 2.0 s and reaches a velocity of 10 m/s.
2	then accelerates uniformly for the next 4.0 s to reach a velocity of 50 m/s.
3	then applied the brakes, and it slows down uniformly and takes 4.0 s to come to rest.

(a) On the graph paper provided below, plot a graph of velocity against time of the motion of the electric car for the first 10 seconds.

[3]

velocity
m/s



time / s

(b) **(i)** State what is meant by *uniform acceleration*.

……………………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) Predict which stage (1 or 2) of the motion is the electric car accelerating the most. Justify your answer with appropriate calculations.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) The electric car is powered by a battery with a capacity of 3400 mAh.

(i) The current drawn by the electric engine from a charging point is 10 A. Calculate the time it takes to charge fully the battery from 0% level.

time = …………………… [2]

(ii) When the electric car is fully charged and accelerating uniformly from rest for 2.0 s and reaches a velocity of 10 m/s in stage 1, the voltmeter on the car dashboard indicated a reading as shown in Fig. 16.1.

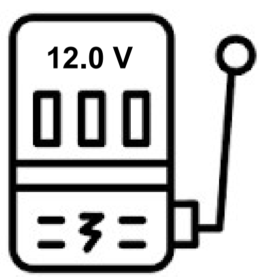


Fig. 16.1

Calculate the electrical energy generated by the electric motor of the car to enable it to accelerate from rest to a velocity of 10 m/s.

energy = …………………… [2]

17 Fig. 17.1 shows a cross-section of a pipe transporting cold air from a cold-air compressor to the outlet of a freezer.

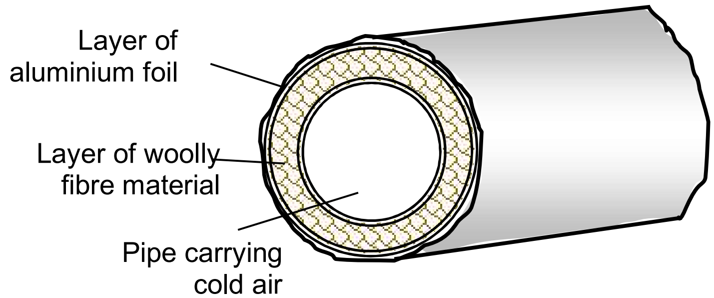


Fig. 17.1

(a) Explain how the features of the pipe keep the air inside the pipe cold.

....

....

....

.... [2]

(b) A pack of liquid coolant was placed in a freezer.
After some time, the coolant changed from liquid to solid.
The solid coolant pack was then placed in a cool-box with some food as shown in Fig. 15.2 below.

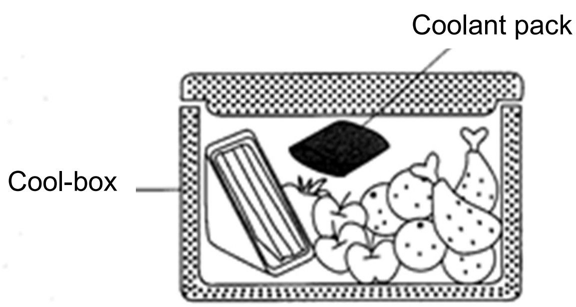


Fig. 17.2

Fig. 17.3 below shows the variation of temperature of the coolant and the food with time in the cool-box.

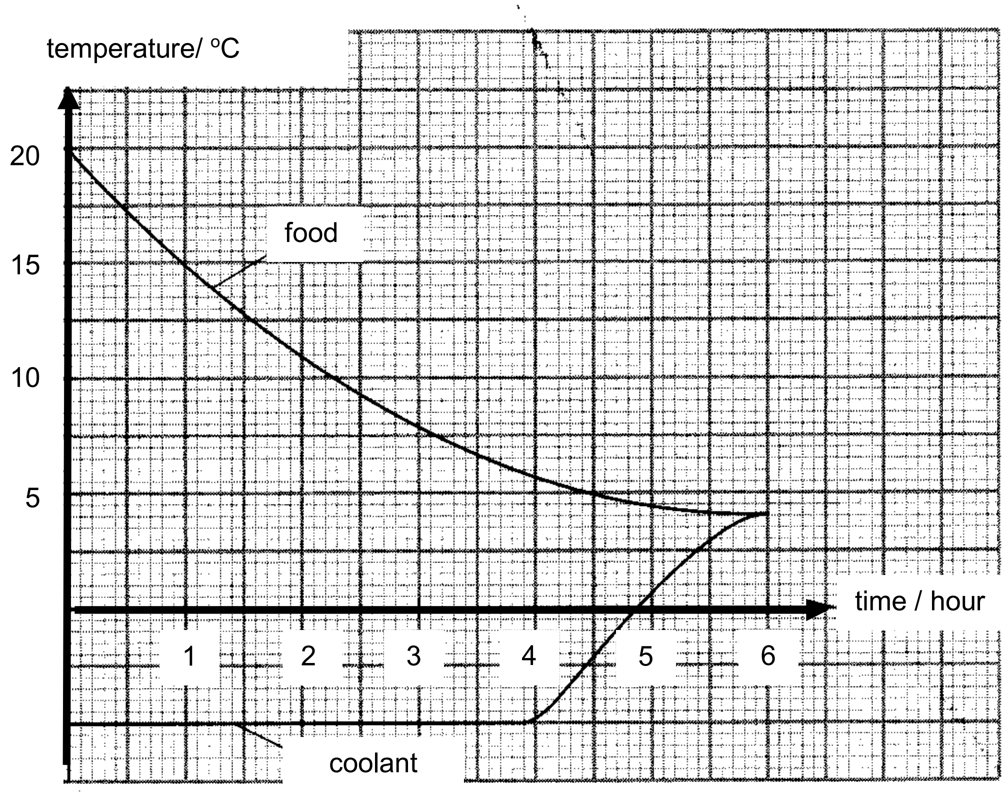


Fig. 17.3

(i) The temperature of the coolant remains unchanged during the first four hours but the temperature of the food falls.

Explain why the temperature of the coolant remains unchanged.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(ii) The mass of the coolant inside the pack is 0.30 kg.

The following information of the coolant are provided:

- specific heat capacity = 4000 J/ (kg °C)
- specific latent heat of fusion = 2.0×10^5 J/ kg
- specific latent heat of vaporisation = 3.4×10^5 J/ kg.

Calculate the energy gained by the coolant during the first four hours.

energy = …………………… [2]

(iii) Calculate the energy gained by the coolant during the next two hours.

energy = …………………… [2]

(iv) Assuming there is no energy exchange with the environment, calculate the heat capacity of the food in the box.

heat capacity = …………………… [2]

END OF PAPER