Name	Class				Index Number		

BROADRICK SECONDARY SCHOOL
SECONDARY 4 EXPRESS
PRELIMINARY EXAMINATION 2024

PHYSICS

6091/02

Paper 2 Structured and Free Response

August 2024

Candidates answer on the Question Paper

1 hour 45 minutes

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs, tables or rough working.
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		/40
Paper 2	Section A	/70
	Section B	
	Q _____	/10
Total		/120

This question paper consists of **20** printed pages including this page.

Setter: Ms Amanda de Souza

[Turn over

Section A [70 marks]

Answer **all** questions in the spaces provided.

1 (a) (i) State the difference between scalar and vector quantities.

_____

_____ [1]

(ii) Force is a vector quantity. State an example of a scalar quantity.

_____ [1]

(b) Fig. 1.1 shows three weights, X, Y and Z attached to three strings that are joined at P. The strings attached to X and Z are on frictionless pulleys. The weight of Y is 4 N and the weights of X and Z are equal. In the position shown, all three weights are at rest.

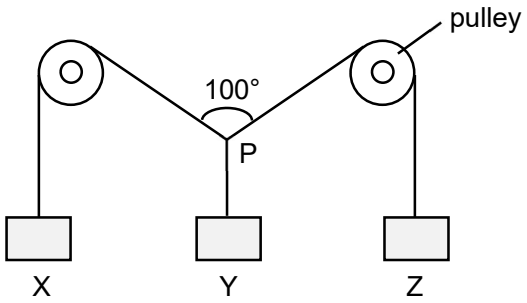

Fig. 1.1

In the space below, draw a labelled diagram to determine the tension in the string attached to X.

tension in string attached to X = …….. [3]

[Total: 5]

2 Fig. 2.1 shows the displacement-time graph of a ball falling in air from rest.

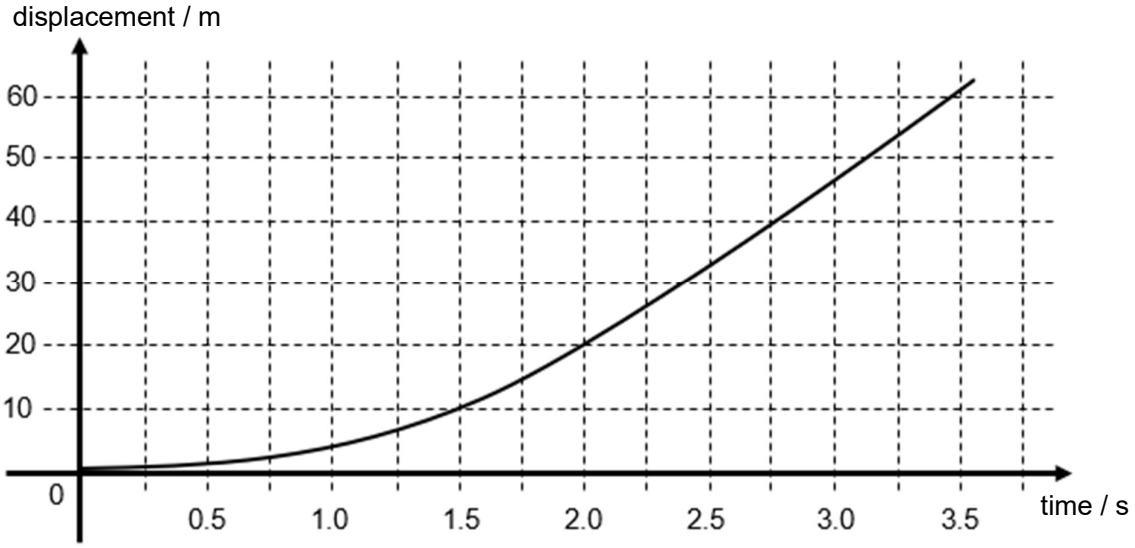

Fig. 2.1

(a) Describe how the velocity of the falling ball changes in the first 2.0 s.

_____

_____ [1]

(b) Estimate the terminal velocity of the falling ball.

terminal velocity = …….. [2]

(c) Explain, in terms of forces, how the ball reaches terminal velocity.

_____

_____

_____

_____

_____

_____ [3]

(d) On Fig. 2.1, sketch the graph of the same ball falling in another location with a higher gravitational field strength. [1]

[Total: 7]

3 Fig. 3.1 shows an axle X fixed onto wheel Y so that both can rotate together. A load of 500 N is hanging on a rope wound around axle X while another rope is wound around wheel Y. The radii for the axle and the wheel are 30 cm and 90 cm respectively.

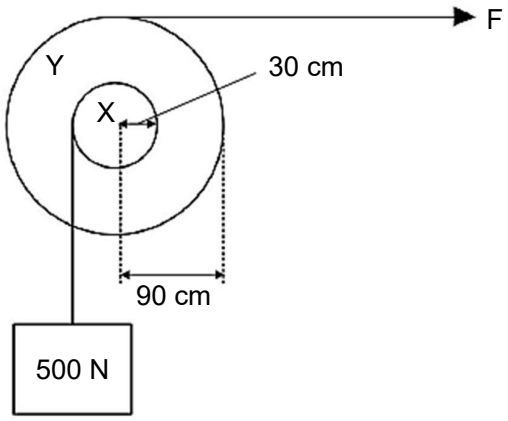

Fig. 3.1

(a) Assuming that there are no frictional forces, determine the horizontal force in the rope on wheel Y such that the load moves up at constant speed.

force = …….. [2]

(b) Explain the effect on the force calculated in **(a)** if the radius of wheel Y is increased while the radius of the axle X does not change.

_____

_____

_____ [2]

(c) An electric motor rated 0.1 kW is attached to the rope on wheel Y which pulls the rope to the right with a constant force. The load moves up at a constant speed.

If 40% of the input energy is transferred to the internal store of the surroundings as heat and sound, find the gain in height of the load after 10 s.

gain in height = …….. [2]

[Total: 6]

4 Fig. 4.1 shows two syringes that are filled with liquid and enclosed by two frictionless pistons.

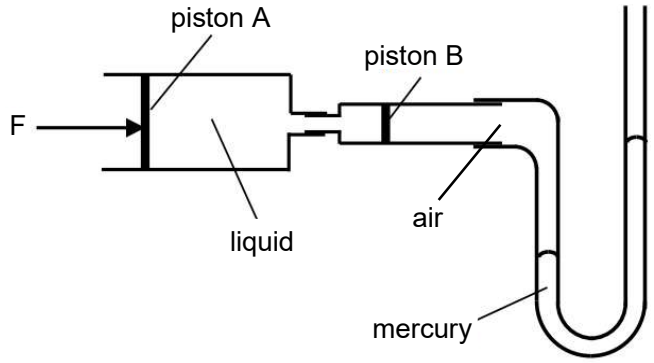

Fig. 4.1

One end of the syringe is connected to a manometer. The cross-sectional areas of piston A and piston B are 4×10^{-4} m^2 and 6×10^{-5} m^2 respectively. When a force F acts on piston A, the liquid exerts a force of 9.0 N on piston B. The atmospheric pressure is 1.0×10^5 Pa.

(a) Determine the force F acting on piston A.

force = …….. [2]

(b) Given that the density of mercury is 13 600 kg / m^3 and the gravitational field strength is 10 N / kg, determine the difference in mercury levels of the manometer.

difference in mercury level = …….. [2]

(c) State how your answer to **(b)** will be different if the following modifications were made:

(i) the manometer tube is replaced with another tube of larger cross-sectional area,

_____ [1]

(ii) mercury is replaced with glycerine of density 1259 kg / m^3.

_____ [1]

[Total: 6]

5 Fig. 5.1 shows an experiment used to determine a value for the specific latent heat of vaporisation of water.

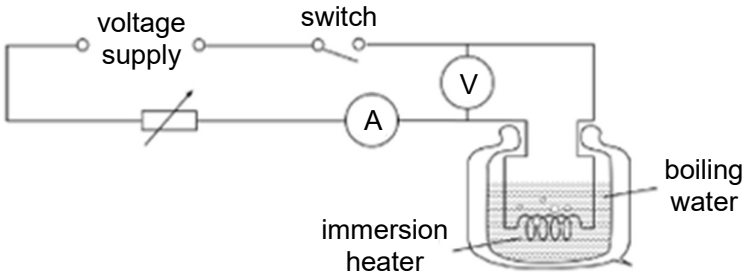

Fig. 5.1

(a) In the experiment, the immersion heater supplies 480 J / s.
He closes the switch for 2 minutes and 0.025 kg of boiling water is vaporised.

(i) Calculate a value for the latent heat of vaporisation of water.

latent heat of vaporisation of water = …….. [2]

(ii) State and explain whether the answer in **(a)(i)** is larger or smaller than the true value of the latent heat of vaporisation of water.

_____

_____

_____ [2]

(b) In Fig. 5.2, another student conducting the same experiment inserts a thermometer into the boiling water at the start of the experiment to ensure that the temperature remains at 100 °C throughout the experiment.

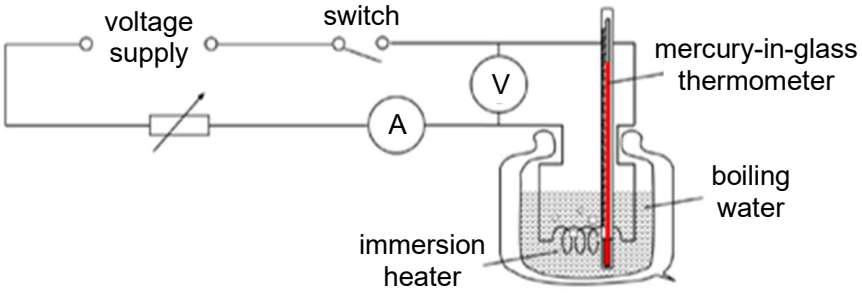

Fig. 5.2

(i) Explain why the temperature remains at 100 °C throughout the experiment.

_____

_____

_____ [2]

(ii) Table 5.3 shows some data from the experiment.

Initial temperature of thermometer	30 °C
Final temperature of thermometer	100 °C
Heat capacity of thermometer	28.5 J / K

Table 5.3

Given that the same immersion heater is used for the same duration of 2 minutes, use your answer in **(a)(i)** to calculate the mass of boiling water that is boiled off in Fig. 5.2.

mass = …….. [2]

[Total: 8]

6 A transverse wave travelling from left to right is set up along a rope as shown in Fig. 6.1

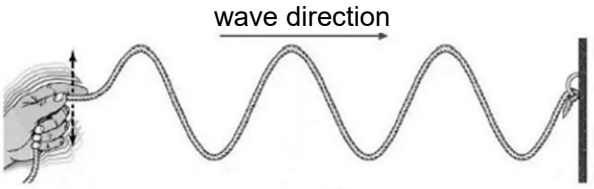

Fig. 6.1

(a) Explain what is meant by a *transverse wave*.

_____

_____ [1]

(b) On Fig. 6.1, indicate one amplitude of the wave and label it **A**. [1]

(c) Fig. 6.2 and Fig. 6.3 are the displacement-time graphs of two points P and Q on the rope over the same period of time.

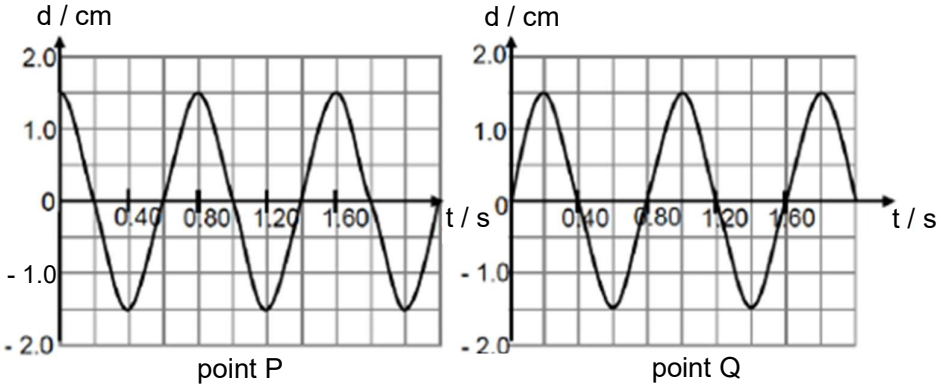

Fig. 6.2 **Fig. 6.3**

(i) Determine the frequency of the wave.

frequency = …….. [1]

(ii) Point Q is 20 cm to the right of point P.

Determine the longest possible wavelength for this wave.

wavelength = …….. [1]

(iii) Explain why there are other possible values for the wavelength.

_____

_____ [1]

[Total: 5]

7 **(a)** A small lamp is below the surface of the water in the middle of a swimming pool as shown in Fig. 7.1. Two rays from the lamp strike the surface at X and at Y.

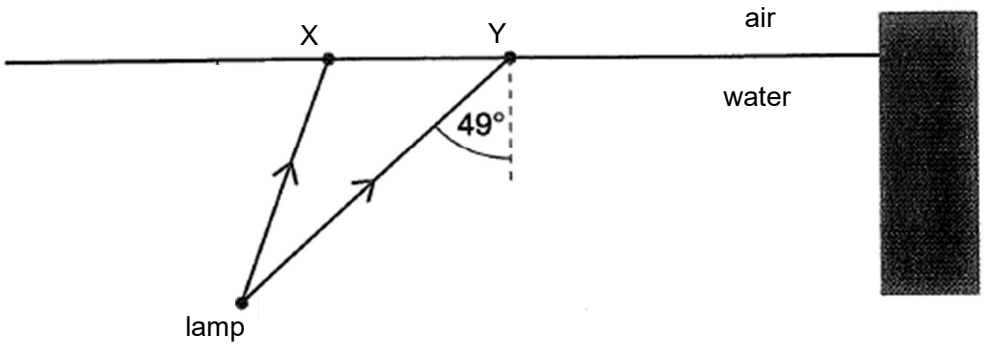

Fig. 7.1

(a) *The critical angle for light passing from water to air is 49°.*

Explain the statement above.

_____

_____ [1]

(b) On Fig. 7.1, complete the paths of the rays after they strike the surface at X and Y. [2]

(c) When viewed from above the swimming pool, light from the lamp emerges only from a circular area of the water.

Explain why this happens.

_____

_____

_____ [2]

(d) Given that the speed of light in vacuum is 3.0×10^8 m / s, determine the speed of light in water.

speed of light in water = …….. [2]

[Total: 7]

8 Plaque is a thin layer of bacteria on teeth. When it is on the teeth, the surfaces of the teeth are negatively charged and the plaque is positively charged as shown in Fig. 8.1.

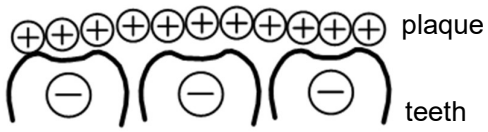

Fig. 8.1

(a) Explain why plaque is difficult to remove from the teeth.

_____

_____ [1]

(b) Fig. 8.2 shows an ionic toothbrush designed to clean teeth using electrostatic charge. The handle of the ionic toothbrush is connected to the positive terminal of the battery and is positively charged. The head and bristles of the toothbrush is connected to the negative terminal of the battery and is negatively charged.

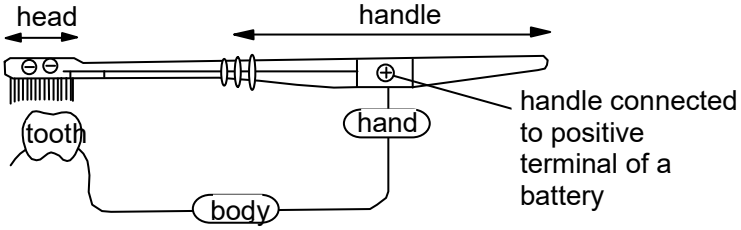

Fig. 8.2

(i) Describe **two** ways the ionic toothbrush is effective in removing the plaque from the surface of the tooth.

_____

_____

_____

_____

_____ [3]

(ii) It is recommended that the teeth should be brushed for 5 minutes.

Calculate the total charge passing through the ionic toothbrush if a steady current of 250 mA is supplied.

total charge = …….. [2]

[Total: 6]

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9 Fig. 9.1 shows a radioactive source used to measure and control the thickness of cardboard during manufacture.

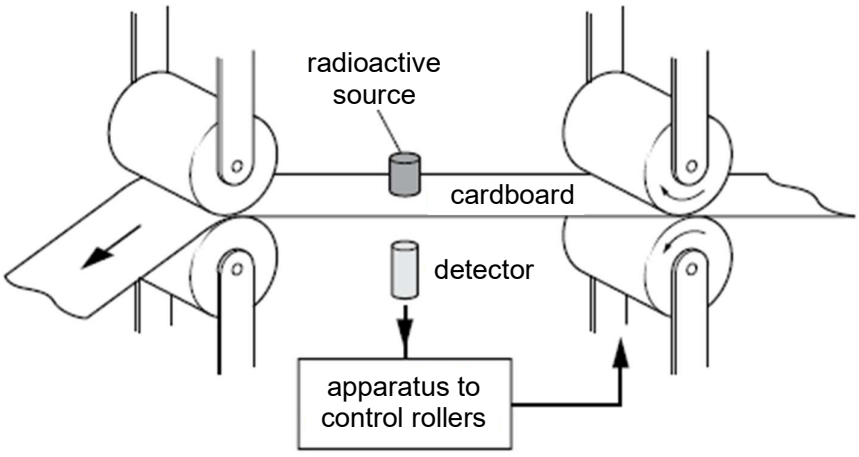

Fig. 9.1

(a) Some radioactive sources emit alpha-particles, some beta-particles and some gamma radiation. These different radiations have different penetrating abilities.

Place **one** tick (✓) in each row of Table 9.2 to compare alpha, beta and gamma radiation.

	alpha (α)	beta (β)	gamma (γ)
least penetrating			
most penetrating			

Table 9.2 [1]

(b) Strontium-90 is an isotope used in the radioactive source in Fig. 9.1.

A nucleus of strontium-90 emits a beta-particle as it decays.

(i) The radioactive decay of a nucleus is a random and spontaneous process.

1. Explain what is meant by a *random* decay.

_____

_____ [1]

2. Explain what is meant by a *spontaneous* decay.

_____

_____ [1]

(ii) In nuclide notation, strontium-90 is written as $^{90}_{38}Sr$.

When a nucleus of strontium-90 emits a beta-particle (β), it decays to an isotope of yttrium (Y).

Complete the decay equation below for this decay.

$$^{90}_{38}\text{Sr} \rightarrow \begin{matrix}\cdots\cdots\cdots \\ \cdots\cdots\cdots\end{matrix}\text{Y} + \begin{matrix}\cdots\cdots\cdots \\ \cdots\cdots\cdots\end{matrix}\beta$$

[2]

(iii) Beta decay can be considered as the decay of a neutron to a proton and an electron.

Explain how the composition of the nuclei of the strontium and yttrium isotopes illustrates this statement.

_____

_____

_____ [2]

(c) The half-life of strontium-90 is 29 years.

(i) Suggest why a radioactive source with a half-life of millions of years is unsuitable for use in the apparatus shown in Fig. 9.1.

_____

_____ [1]

(ii) A pure source of strontium-90 emits 1.6×10^5 beta-particles per second.

Calculate the number of beta-particles emitted per second by the source after 87 years.

number of particles per second = …….. [2]

[Total: 10]

10 Fig. 10.1 shows an iron bar placed inside a vertical solenoid.

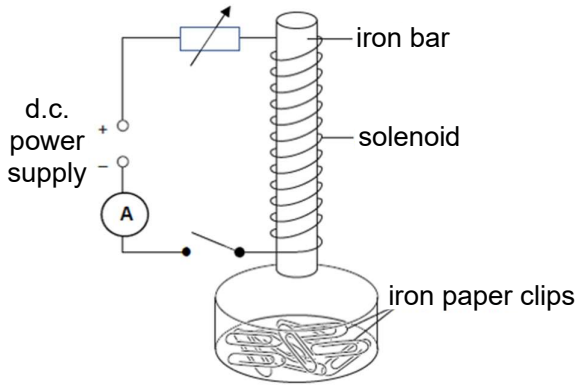

Fig. 10.1

The solenoid is a coil of several turns of insulated wire. A d.c. power supply is connected to the solenoid so that there is a current in it when the supply is switched on. The iron bar is a short distance above a small pile of iron paper clips in a glass dish.

(a) Explain why the paper clips are attracted to the iron bar when the switch is closed.

_____

_____

_____ [2]

(b) On Fig. 10.1, indicate the direction of the magnetic field produced by the solenoid with the letters (N) for the north pole and (S) for the south pole. [1]

(c) An experiment was conducted to investigate how the strength of an electromagnet varies with the current flowing through the solenoid and the number of turns of the solenoid.

Table 10.2 shows the data collected using a coil with 20 turns.
Table 10.3 shows the data collected using a current of 2.0 A.

Number of turns of coil: 20	
Current / A	Number of paper clips attracted
0.0	0
0.4	3
0.8	8
1.2	15
1.6	30
2.0	53
2.4	100
2.8	136
3.2	147
3.6	149
4.0	150

Table 10.2

Current: 2.0 A	
Number of turns of coil	Number of paper clips attracted
0	0
4	2
8	7
12	15
16	29
20	54
24	99
28	135
32	147
36	150
40	150

Table 10.3

(i) Using the number of paper clips attracted as a measure of the strength of the electromagnet, explain how the strength of the electromagnet varies with current.

[2]

(ii) Draw a conclusion about the strength of the electromagnet based on data collected in Table 10.2 and Table 10.3.

[1]

(iii) The amount of magnetisation, *M*, produced in a magnetic material is defined as

$$M = \text{current} \times \text{number of turns}$$

Using the data collected in Table 10.2 and 10.3, explain whether the experiment supports the equation above.

[2]

(d) In a second experiment, the iron rod is removed from the solenoid and a steel rod is inserted.

State and explain any effect this change has on the number of paper clips attracted.

[2]

[Total: 10]

Section B [10 marks]

Answer **one** question from this section.

11 **(a)** Electrical energy is transmitted to households at a high voltage. The voltage is stepped down by a transformer to 240 V.

Explain why electrical energy is transmitted at a high voltage.

_____

_____

_____ [2]

(b) Fig. 11.1 shows the electrical wiring in a water heater. The mains supply 240 V to the water heater which consists of a heater coil rated '240 V, 7500 W' and an exhaust fan rated '240 V, 300 W'.

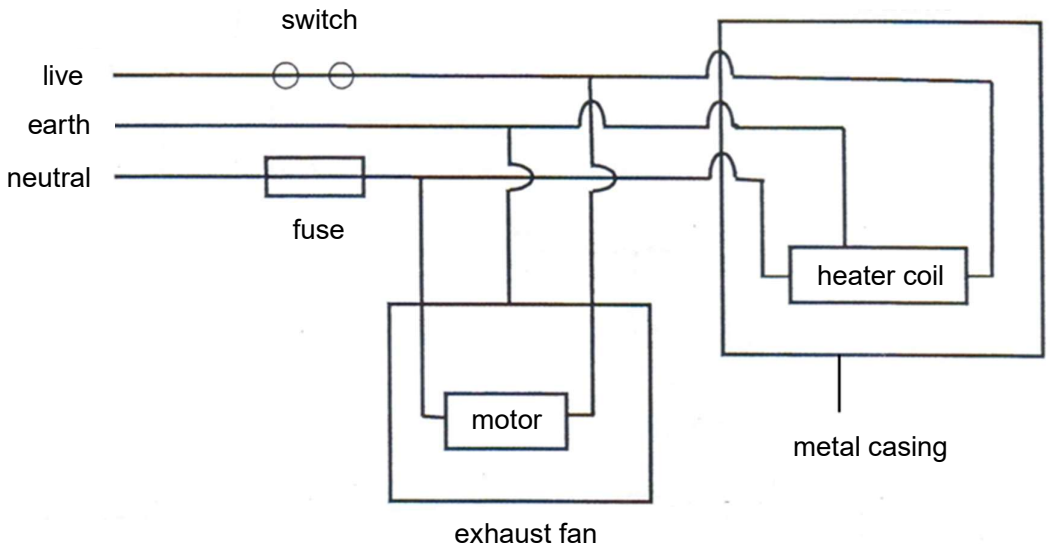

Fig. 11.1

(i) Identify two mistakes in the wiring of the circuit in Fig. 11.1 and describe how these mistakes should be corrected.

1. _____

_____

2. _____

_____ [2]

(ii) The fuse rating of the fuse in Fig. 11.1 is 32 A.

With the aid of calculations, explain whether this fuse is suitable.

[2]

(iii) The water heater is used for 20 minutes each day.
Each kWh of electrical energy costs 25 cents.

Calculate the total cost of electrical energy consumption for 30 days.

cost of electrical energy consumption = …….. [2]

(iv) All of the energy input to the heater coil is used to heat water.
The rate at which the heated water emerges from the shower is 7.8 kg / min.
The specific heat capacity of water is 4200 J / (kg °C).

Calculate the increase in temperature of the water.

increase in temperature = …….. [2]

[Total: 10]

12 (a) Fig. 12.1 shows how the resistance of a thermistor varies with temperature.

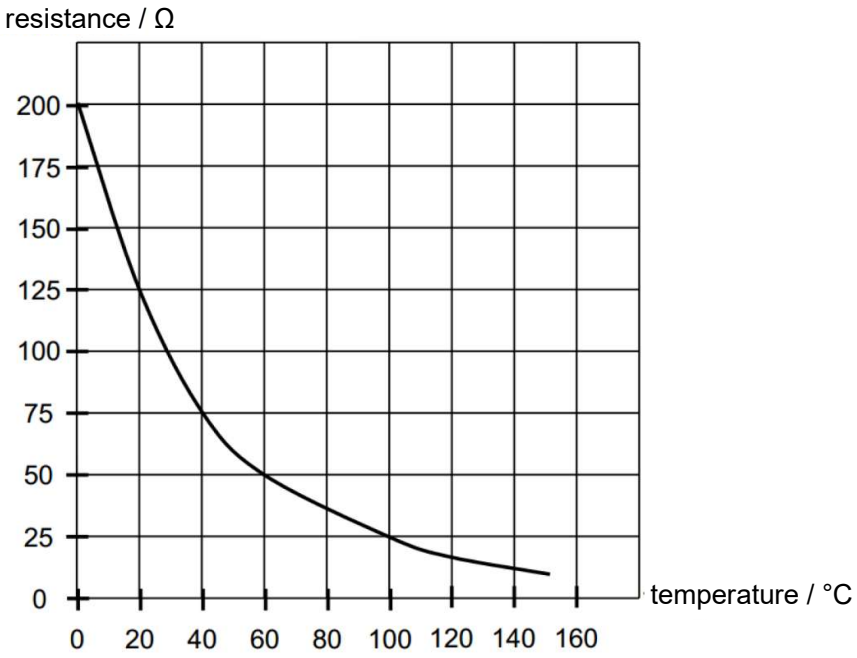

Fig. 12.1

The thermistor is connected in a circuit with a heating element as shown in Fig. 12.2.

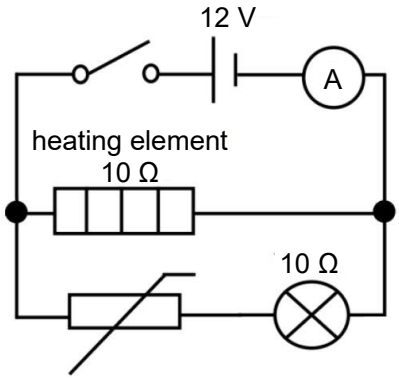

Fig. 12.2

(i) State the resistance of the thermistor at a temperature of 20 °C.

resistance = …….. [1]

(ii) The thermistor is at a temperature of 20 °C before gradually increasing to 100 °C.

Without any calculations, explain the effect of this temperature change on the heating element and the lamp.

[3]

(iii) Calculate the reading on the ammeter when the thermistor is at 100 °C.

reading on ammeter = …….. [2]

(b) Thermistors are used in infra-red toasters as shown in Fig. 12.3.
An infra-red toaster operates with two infra-red lamps positioned above and below the holding trays. The infra-red lamps emit infra-red radiation of different frequencies to cook the surface and the interior of the food concurrently.

Fig. 12.3

(i) Explain why the interior surface of the infra-red toaster is silver-coloured and smooth.

_____

_____ [1]

(ii) Fig. 12.4 shows a convection oven. The convection oven uses a heater to warm up the air and a fan to circulate the hot air within the oven in order to cook food.

convection oven (side view)

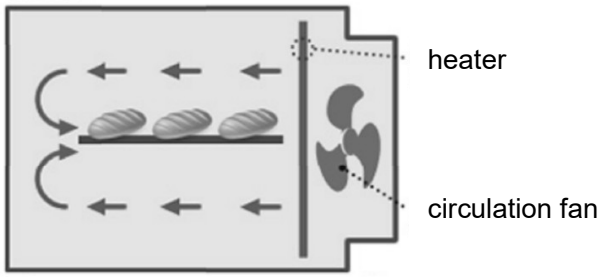

Fig. 12.4

Explain why the infra-red toaster cooks the same type and amount of food faster than the convection oven.

_____

_____

_____ [2]

(iii) State one use of infra-red radiation in households, **other than** for heating.

_____ [1]

[Total: 10]

End of Paper 2