Candidate Name:	Class:	Index No.:

FUHUA SECONDARY SCHOOL

Secondary Four Express

PRELIMINARY EXAMINATION 2024

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PHYSICS **6091/02**

Paper 2

DATE **21 Aug 2024**
TIME **1115 – 1300**
DURATION **1 hour 45 minutes**

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on the question paper and work you submit.
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/ tape.

Section A
Answer **all** questions.

Section B
Answer **one** question.

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			PARENT'S SIGNATURE
Section A	Section B	**Total**	
/70	**/10**	**/80**	

Setter: Mr Raymond Loh **Vetter:** Mr Nicholas Liu

This document consists of 17 printed pages and 1 blank page, including this page.

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Section A

Answer **all** questions in this section.

1 Fig. 1.1 shows an aircraft of mass 60 000 kg making its take-off run from rest. The engines produce a constant forward thrust of 145 000 N. Throughout the take-off run, the total resistive force acting on the aircraft can be assumed as being constant at 40 000 N.

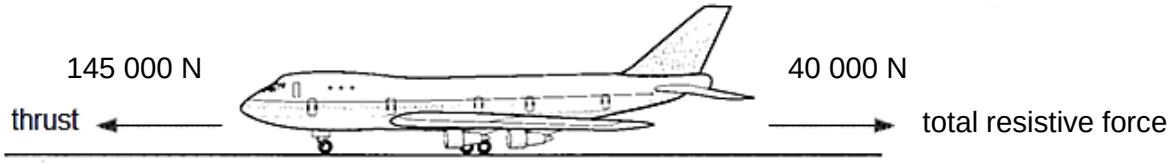


Fig. 1.1

(a) Calculate the acceleration of the aircraft along the horizontal runway.

acceleration = …….. [2]

(b) Calculate the duration of the take-off run if the aircraft becomes airborne at a speed of 60 m / s.

duration = …….. [2]

(c) Hence, calculate the distance the aircraft was on the runway before it becomes airborne.

distance = …….. [2]

(d) In reality, resistive forces during the take-off run vary. Explain the reason for this variability.

…….....

…….....

…….....

……..... [1]

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2 Fig. 2.1 shows a student doing a push-up. A total force *F* acts upwards on his hands. There is also a force *R* acting upwards on his toes.

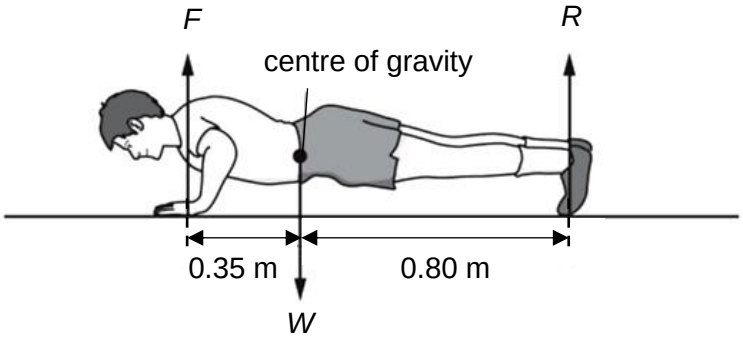


Fig. 2.1

The mass of the student is 60 kg and the gravitational field strength is 10 N / kg.

(a) Calculate the weight *W* of the student.

weight = …….. [2]

(b) Describe how work is done on his body as it rises from the ground.

……

…….. [1]

(c) At the position shown in Fig. 2.1, the student is stationary. The weight *W* of the student causes a moment about his toes. Calculate the moment due to his weight about his toes.

moment = …….. [2]

(d) Hence, calculate the magnitude of the forces *F* and *R*.

F = ……..

R = …….. [3]

(e) State the force that forms a Newton's Third Law action-reaction pair with *F*.

……

…….. [1]

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3 Fig. 3.1 shows the hydraulic braking system of a bicycle.

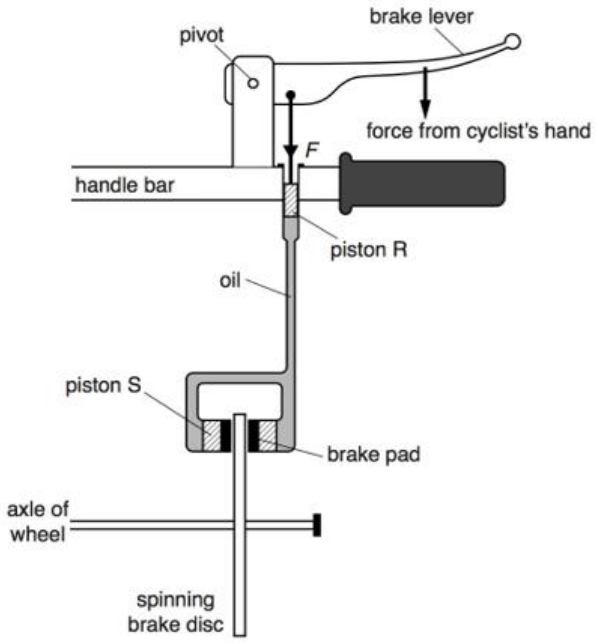


Fig. 3.1

(a) The cyclist applies a force on the brake lever. This increases the pressure in the oil by 1.2×10^{6} Pa. The cross-sectional area of piston R is 5.0×10^{-5} m^2.

Calculate the force *F* applied by the brake lever on piston R.

force *F* = …….. [2]

(b) Explain why the force applied to each of the brake pads is larger than *F*.

……

……

……

…….. [2]

(c) Suggest and explain why the hydraulic system does not work properly if the oil contains bubbles of air.

……

……

……

…….. [2]

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4 Before a small inflatable boat is used, air is pumped into its rubber chamber.
Fig. 4.1 shows a man using an air pump to inflate the boat.



Fig. 4.1

Before the man starts to use the pump, the air in the vertical cylinder of the pump is at atmospheric pressure.

(a) Explain, in terms of molecules, how the air inside the cylinder exerts a pressure.

……

……

……

…… [2]

(b) Once the boat is fully inflated, the valve is shut to seal the air within the rubber chamber, and the air pump is disconnected.

As the man sits on the side of the boat, the volume of the rubber chamber decreases, causing the air pressure inside the chamber to rise. The temperature of the air remains constant.

Explain, in terms of molecules, why the pressure increases.

……

……

……

…… [2]

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5 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. 5.1.

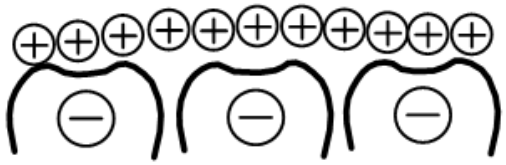


Fig. 5.1

(a) With reference to Fig. 5.1, explain why plaque clings on the teeth and is difficult to remove.

……..…….... [1]

(b) Fig. 5.2 shows a novel toothbrush designed to clean teeth using electrostatic charge. The handle is connected to the positive terminal of the battery, becoming highly positively charged. The head and bristles of the toothbrush are connected to the negative terminal of the battery, becoming negatively charged.

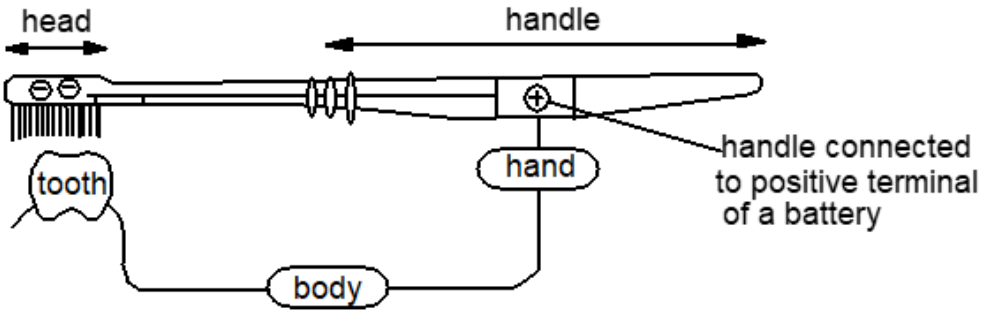


Fig. 5.2

(i) Describe how the teeth becomes positively-charged when the toothbrush is used.

……

……

……

…….. [2]

(ii) Explain why the positively charged plaque leaves the surface of the tooth.

……

……

……

…….. [2]

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(c) It is recommended that the teeth should be brushed for 5 minutes. Calculate the total charge passing through the brush in this duration given that a steady current of 0.15 mA passes.

total charge = …….. [2]

6 Fig 6.1 shows a circuit with a 4700 Ω resistor connected in series with a light-dependent resistor (LDR), which has a resistance of 3300 Ω, and with a 12 V power supply.

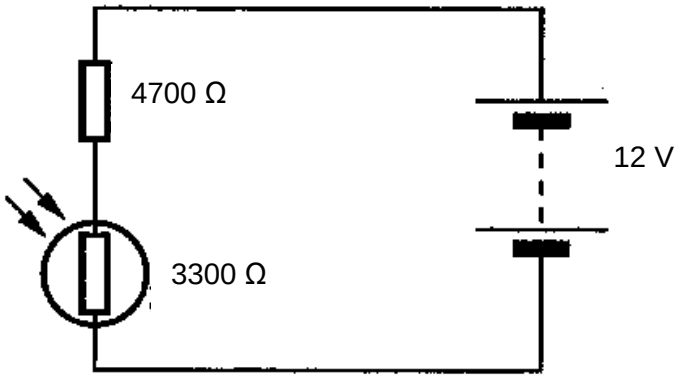


Fig. 6.1

(a) **(i)** Calculate the current through the LDR.

current = …….. [2]

(ii) Calculate the potential difference across the LDR.

potential difference across the LDR = …….. [2]

(b) Explain how the potential difference across the LDR changes as the brightness of the light that falls on it decreases.

……

……

……

…….. [2]

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7 Fig. 7.1 shows the circuit in a household connected to a 220 V mains supply.

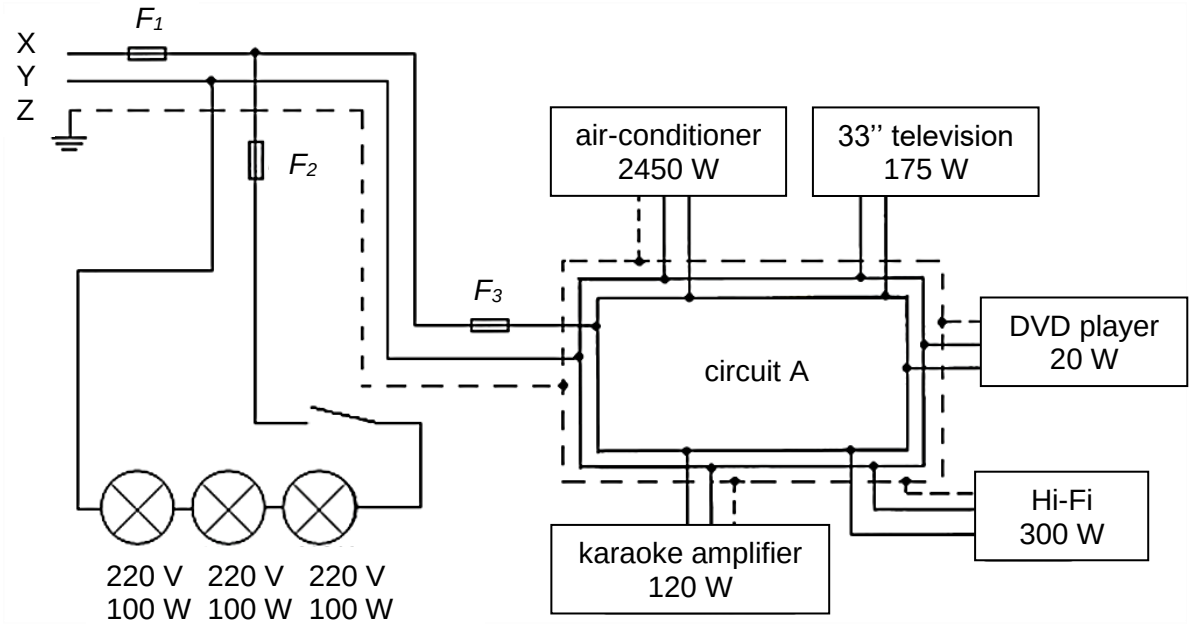


Fig. 7.1

(a) Identify wires X, Y and Z.

X = …… Y = …… Z = ……

[1]

(b) Calculate the current flowing in fuse F_2.

current = …… [2]

(c) The electrician observed that the metal casing of the TV was not linked to wire Z of circuit A. Upon discovering that the TV operated normally despite this, the electrician chose not to take any action regarding the issue.

Explain why this is dangerous.

……

……

…… [2]

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8 The distribution of electrical energy across a country occurs through a network of transmission cables, illustrated in Fig. 8.1. A power station produces 100 MW of power at a voltage of 25 kV.

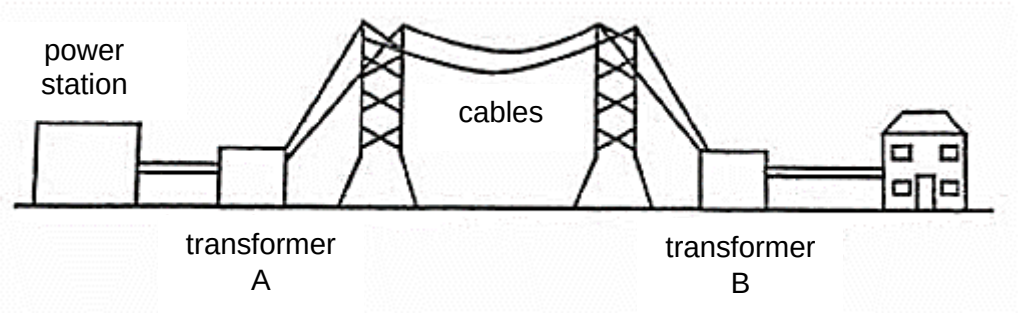


Fig. 8.1

Transformer A, which links the power station to the transmission cables, has 4000 turns in the primary coil and 44 000 turns in the secondary coil.

(a) Calculate the voltage in the secondary coil of transformer A.

voltage = …….. [2]

(b) Calculate the current in the secondary coil of transformer A.

current = …….. [2]

(c) Is electrical transmission in the cables at a high or low voltage?

Give a reason for your answer.

……..

……

……..

…… [2]

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9 The correlation between the wavelength and frequency of sound waves in a river is studied across three temperatures: 20 °C, 30 °C, and 40 °C, focusing on both shallow and deep-water areas.

Specific data are gathered from shallow and deep-water regions, and the findings are presented in the graphs depicted in Fig. 9.1.

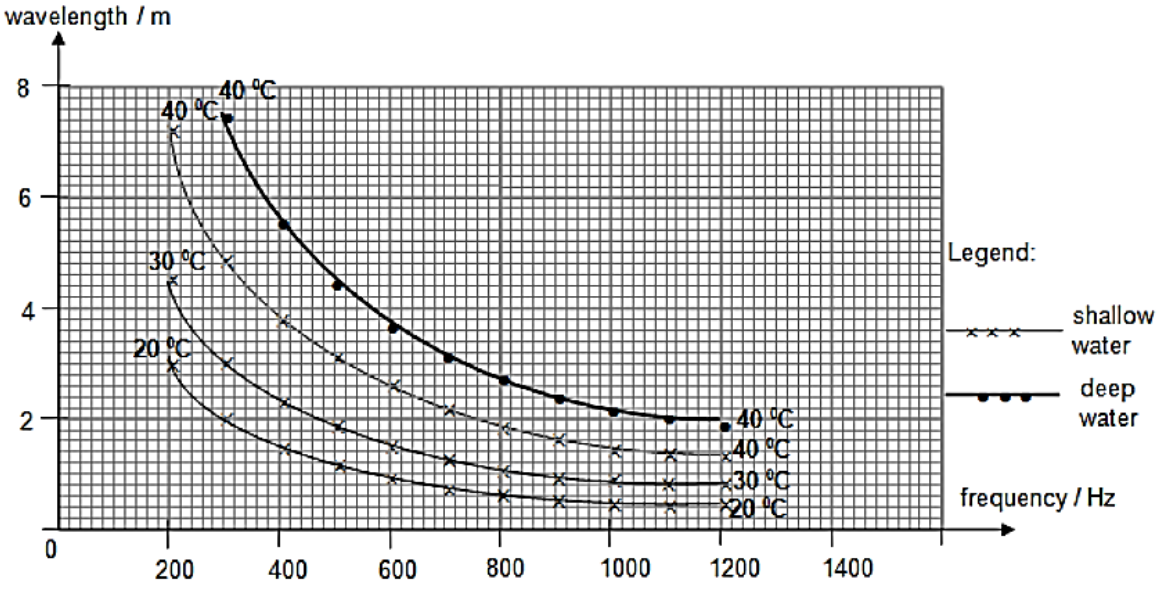


Fig. 9.1

(a) By referring to the graphs, calculate the speed of the sound waves with frequency 400 Hz at temperatures 20 °C and 40 °C in the shallow water region.

(i) At 20 °C

speed = …….. [1]

(ii) At 40 °C

speed = ……. [1]

(b) State and explain the relationship between the speed of the sound waves of the same frequency and the temperature of water in which they travel.

……

……

…… [2]

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(c) The sound wave moves from shallow water to deep water, with the water temperature maintained at a constant 40 °C and the emitted sound waves having a frequency of 400 Hz.

(i) Identify the nature of sound waves.

……..…... [1]

(ii) State the changes, if any, that could occur to the frequency, wavelength and speed of the sound wave.

……

……

……

……

…….. [3]

(iii) Fig. 9.2 (not drawn to scale) illustrates the propagation of sound waves moving perpendicularly from shallow water to deep water. Areas of compression are denoted as C, and areas of rarefaction are denoted as R.

Referring to the graphs in Fig. 9.1, depict the complete formation of sound waves in deep water in Fig. 9.2. Indicate in Fig. 9.2, the wavelengths of the sound waves in both regions. [2]

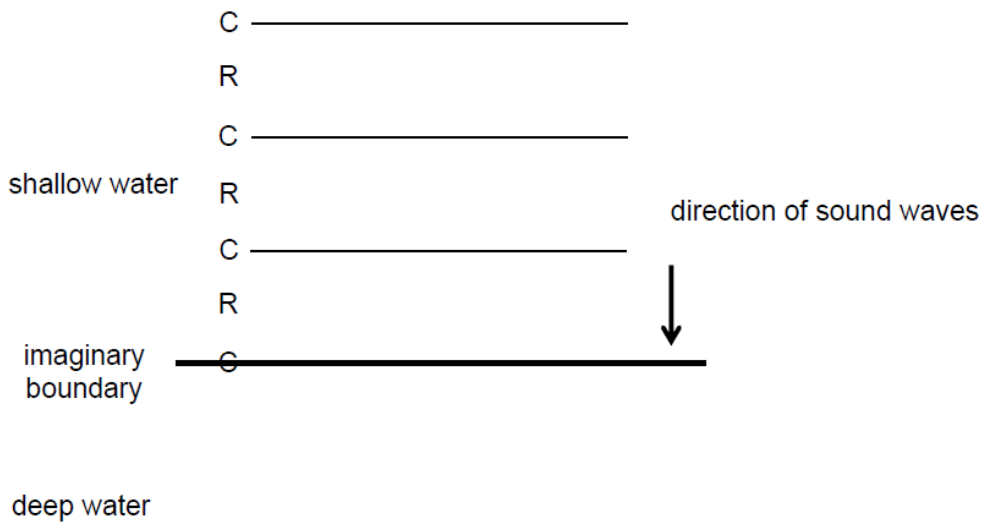


Fig. 9.2 (not drawn to scale)

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10 **(a)** Fig. 10.1 shows a small but intense light source S is placed at the bottom of a swimming pool. The refractive index of the water in the pool is 1.33.

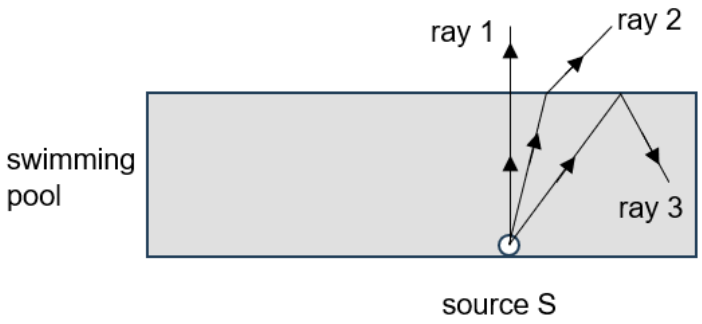


Fig. 10.1 (not drawn to scale)

(i) Explain what happens to each ray as it reaches the surface of the pool in Fig. 10.1.

Ray 1 ……

……

Ray 2 ……

……

Ray 3 ……

……..… [3]

(ii) Calculate the critical angle.

critical angle = …….. [2]

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(b) A collector observes a postage stamp, which is 1.5 cm tall, through a lens. The lens is positioned 2.0 cm away from the stamp, and the ratio of the image height to the object height is 3.0. The resulting image is virtual.

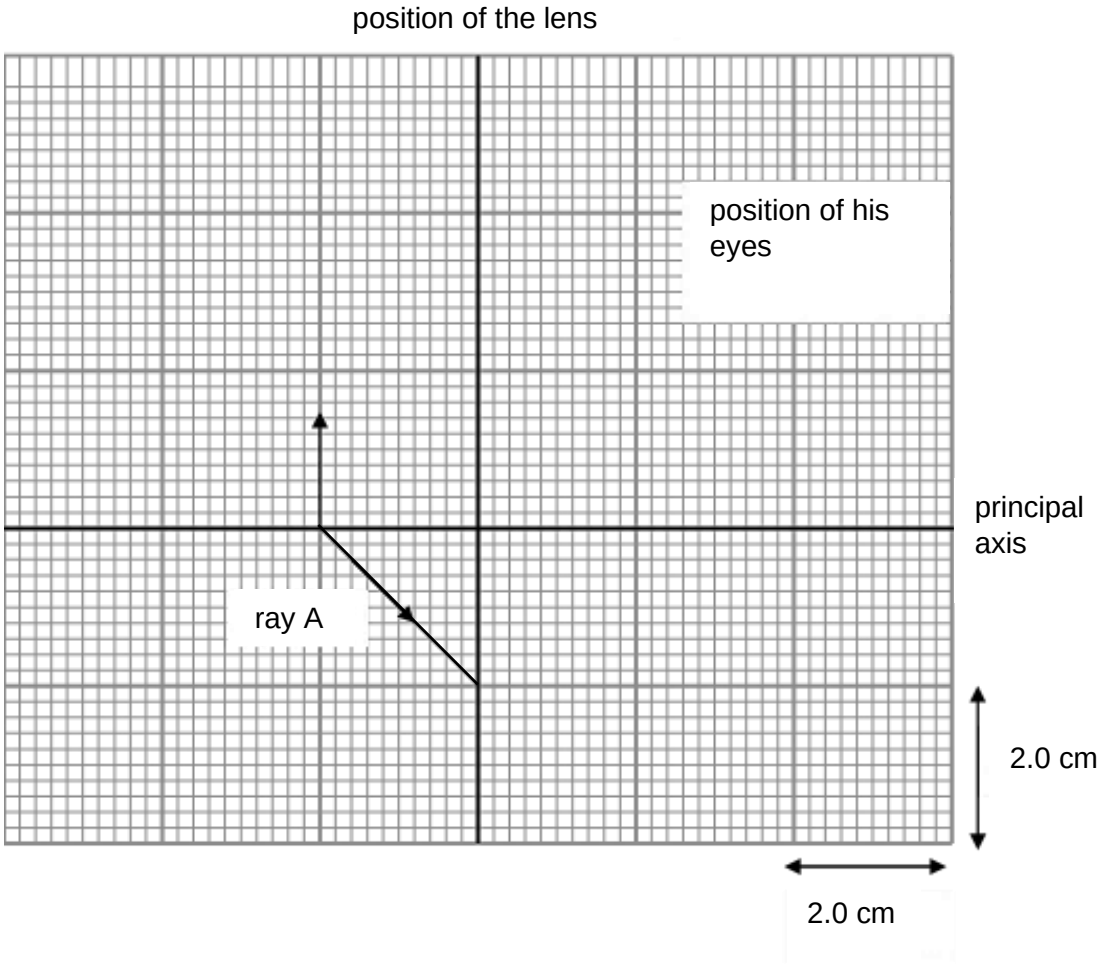


Fig. 10.2 (drawn to scale)

(i) State what is a virtual image.

……... [1]

(ii) On Fig. 10.2, complete the ray diagram to determine the image of the stamp.

[2]

(iii) Hence, determine the focal length of the lens.

focal length = ……. [1]

(iv) On Fig. 10.2, complete the path of ray A after passing through the lens. [1]

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Section B

Answer **one** question from this section.

11 Table 11.1 presents information on seven distinct nuclides.

nuclide	radiation emitted	half-life
hydrogen-2	none	-
hydrogen-3	beta	12 year
francium-223	beta	22 min
iridium-192	gamma	74 day
phosphorus-32	beta	14 day
radon-222	alpha	4 day
technetium-99	gamma	6 hour

Table. 11.1

(a) **(i)** Hydrogen-2 and hydrogen-3 are isotopes of the element hydrogen.

Define the term *isotope*.

……...

……. [1]

(ii) The equation for the decay of phosphorus-32 (P-32) as it emits a beta particle is:

$$^{32}_{15}\mathrm{P} \rightarrow {}^{0}_{-1}\beta + {}^{32}_{16}\mathrm{Q}$$

Explain whether the equation indicates that Q is another isotope of phosphorus. Q does not represent the chemical symbol for the atom.

……...

……. [1]

(b) One of the sources listed in Table 11.1 is employed in a medical procedure to identify abnormal bone structures. It is administered to a patient through injection, and the emitted radiation is detected externally.

(i) State which source in Table 11.1 is most suitable for this type of medical use.

……. [1]

(ii) Explain **two** reasons for your choice.

……...

……...

……...

……. [2]

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(c) Radon-222 decays by alpha-particle emission to a stable isotope.

(i) State how a nucleus of radon-222 changes when it emits an alpha-particle.

……...

……...

……. [2]

(ii) In a laboratory without radioactive samples, there is a radiation detector that, when switched on, registers an average count rate of 22 counts per minute.

Explain why the radiation detector registers a count rate.

……...

……. [1]

(iii) A sample of radon-222 is positioned 2 cm from the detector, displaying a reading of 8000 counts per minute. When the sample is moved 10 cm away from the detector, the reading reverts to an average value of 22 counts per minute.

Explain why the reading returns to its original value.

……...

……...

……...

……. [2]

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12 Fig. 12.1 shows the heating element positioned in the base of the kettle. The casing of the electric kettle is made of white plastic.

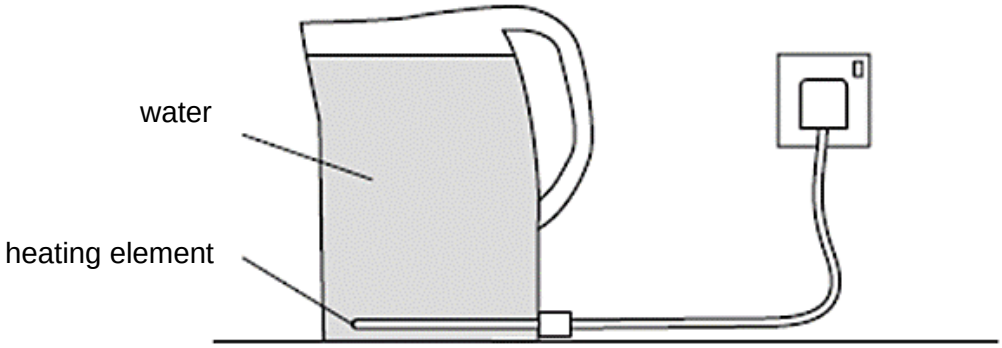


Fig. 12.1

(a) The heating element supplies thermal energy to the water at the bottom of the kettle.

Describe and explain how the thermal energy is transferred throughout the water.

……

……

……

…… [3]

(b) The kettle operates using a 230 V power supply. It remains switched on for 3.5 min with a current of 9.6 A flowing through the heating element.

(i) Calculate the energy transfer by heating in the heating element during this time.

energy = …… [2]

(ii) The kettle holds 1.6 kg of water initially at a temperature of 22 °C. The specific heat capacity of water is 4200 J / (kg °C).

Determine the highest achievable temperature of the water.

temperature = …… [2]

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(c) Explain one advantage of choosing white as the colour for the outside of the casing.

……...

…….....

……..... [1]

(d) The kettle is turned on again, causing the water to reach its boiling point where it starts boiling continuously.

Describe what happens to the supplied thermal energy in terms of molecules when the water boils.

……...

……...

……...

……... [2]

End of Paper

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