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PHYSICS
STANDARD LEVEL
PAPER 2

Monday 10 May 2010 (afternoon)

1 hour 15 minutes

Candidate session number

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INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet.

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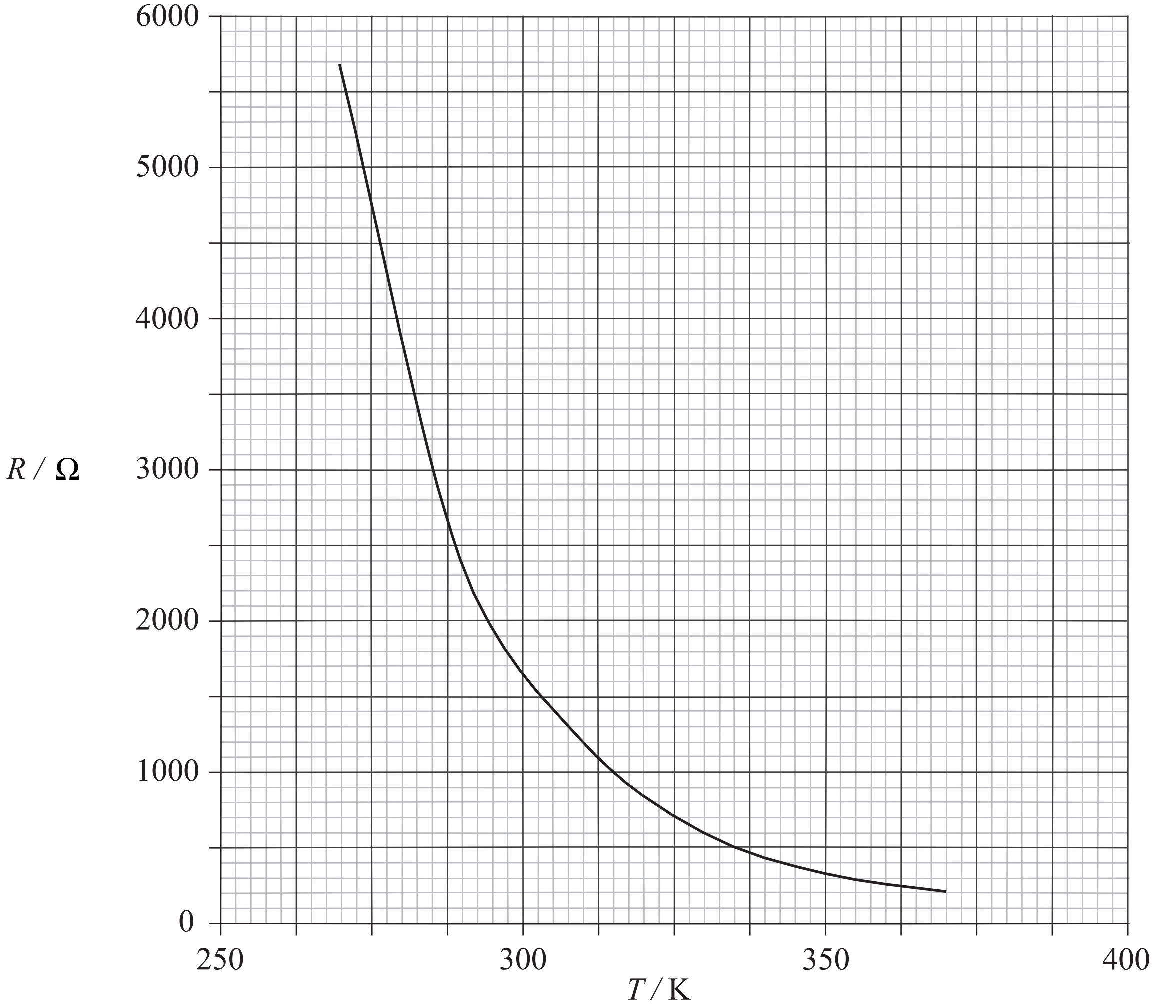
SECTION A

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

A1. This question is about electrical resistance.

The graph shows the variation with temperature T of the resistance R of an electrical component.



(a) A student hypothesizes that the resistance is inversely proportional to the temperature. Use data from the graph to show whether the hypothesis is supported. *[3]*

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(This question continues on the following page)

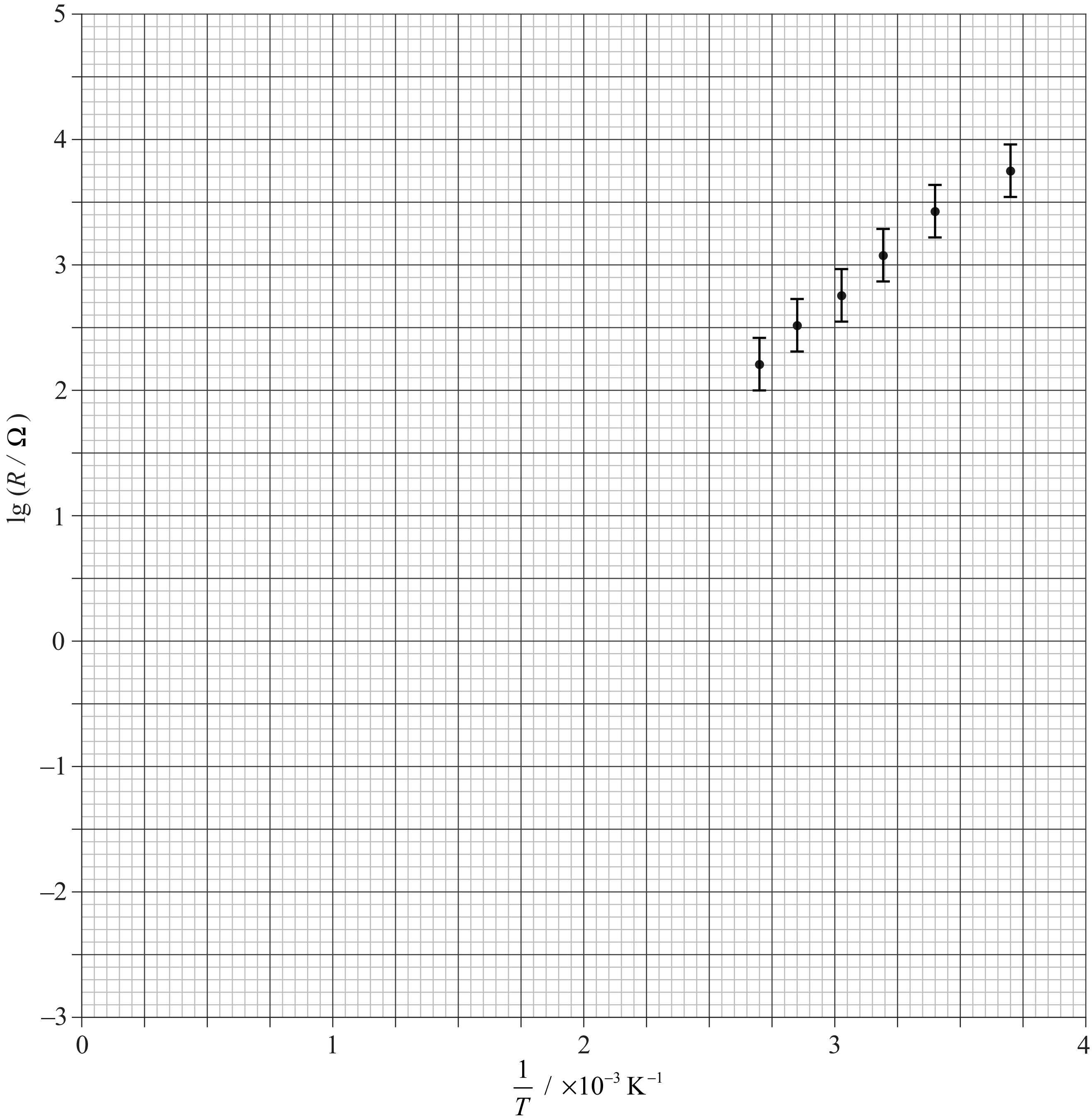
(Question A1 continued)

(b) A second student suggests that the relationship is of the form

$$\lg R = a + \frac{b}{T}$$

where a and b are constants.

The student plots the graph below. Error bars have been included for the sake of clarity.



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(Question A1 continued)

(i) Explain how the graph drawn could be used as evidence to support the student's suggestion. *[2]*

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(ii) Use the graph to determine the constants a and b. *[4]*

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a: . . . .

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(iii) Using your answers to (b)(ii), determine a value for the resistance of the component at a temperature of 260 K. *[2]*

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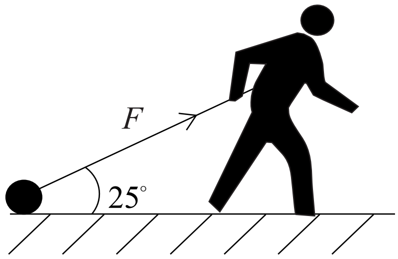
A2. This question is about forces.

An athlete trains by dragging a heavy load across a rough horizontal surface.



The athlete exerts a force of magnitude F on the load at an angle of 25° to the horizontal.

(a) Once the load is moving at a steady speed, the average horizontal frictional force acting on the load is 470 N.

Calculate the average value of F that will enable the load to move at constant speed. *[2]*

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(b) The load is moved a horizontal distance of 2.5 km in 1.2 hours.

Calculate

(i) the work done on the load by the force F. *[2]*

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(ii) the minimum average power required to move the load. *[2]*

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(c) The athlete pulls the load uphill at the same speed as in part (a).

Explain, in terms of energy changes, why the minimum average power required is greater than in (b)(ii). *[2]*

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A3. This question is about solar heating panels.

(a) State the energy change that takes place in a solar panel. *[1]*

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(b) A village consists of 120 houses. It is proposed that solar panels be used to provide hot water to the houses.

The following data are available.

average power needed per house to heat water = 3.0 kW
average surface solar intensity = $650\ \text{W m}^{-2}$
efficiency of energy conversion of a solar panel = 18 %

Calculate the minimum surface area of the solar panels required to provide the total power for water heating. *[3]*

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(c) Suggest **two** disadvantages of using solar power to provide energy for heating water. *[2]*

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SECTION B

This section consists of three questions: B1, B2 and B3. Answer ***one*** *question.*

B1. This question is in **two** parts. **Part 1** is about solar radiation. **Part 2** is about kicking a football.

Part 1 Solar radiation

(a) State the Stefan–Boltzmann law for a black body. *[2]*

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(b) The following data relates to the Earth and the Sun.

Earth-Sun distance	$= 1.5 \times 10^{11}$ m
radius of Earth	$= 6.4 \times 10^{6}$ m
radius of Sun	$= 7.0 \times 10^{8}$ m
surface temperature of Sun	$= 5800$ K

(i) Use data from the table to show that the power radiated by the Sun is about 4×10^{26} W. *[1]*

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(ii) Calculate the solar power incident per unit area at a distance from the Sun equal to the Earth's distance from the Sun. *[2]*

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(This question continues on the following page)

(Question B1, part 1 continued)

(iii) The average power absorbed per unit area at the Earth's surface is $240\,W\,m^{-2}$. State **two** reasons why the value calculated in (b)(ii) differs from this value. *[2]*

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(iv) Show that the value for power absorbed per unit area of $240\,W\,m^{-2}$ is consistent with an average equilibrium temperature for the Earth of about 255 K. *[2]*

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(c) Explain, by reference to the greenhouse effect, why the average temperature of the surface of the Earth is greater than 255 K. *[3]*

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(d) Suggest why the burning of fossil fuels may lead to an increase in the temperature of the surface of the Earth. *[3]*

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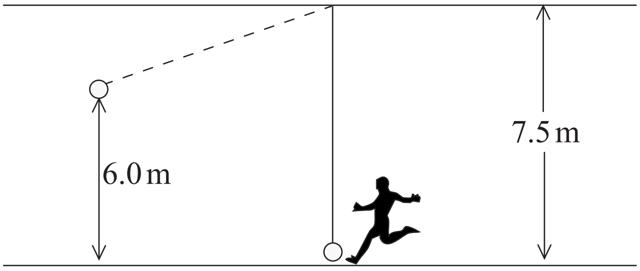
(Question B1 continued)

Part 2 Kicking a football

A ball is suspended from a ceiling by a string of length 7.5 m. The ball is kicked horizontally and rises to a maximum height of 6.0 m.



(a) Assuming that the air resistance is negligible, show that the initial speed of the ball is 11 m s^{-1}. *[2]*

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(b) The mass of the ball is 0.55 kg and the impact time of the kicker's foot with the ball is 150 ms. Estimate the average force exerted on the ball by the kick. *[2]*

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(c) (i) Explain why the tension in the string increases immediately after the ball is kicked. *[3]*

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(ii) Calculate the tension in the string immediately after the ball is kicked. Assume that the string is vertical. *[3]*

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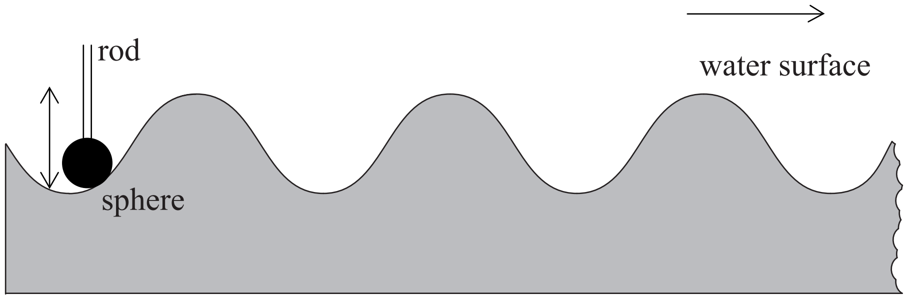
B2. This question is in **two** parts. **Part 1** is about water wave motion. **Part 2** is about nuclear processes.

Part 1 Water waves

A small sphere, mounted at the end of a vertical rod, dips below the surface of shallow water in a tray. The sphere is driven vertically up and down by a motor attached to the rod. The oscillations of the sphere produce travelling waves on the surface of the water.



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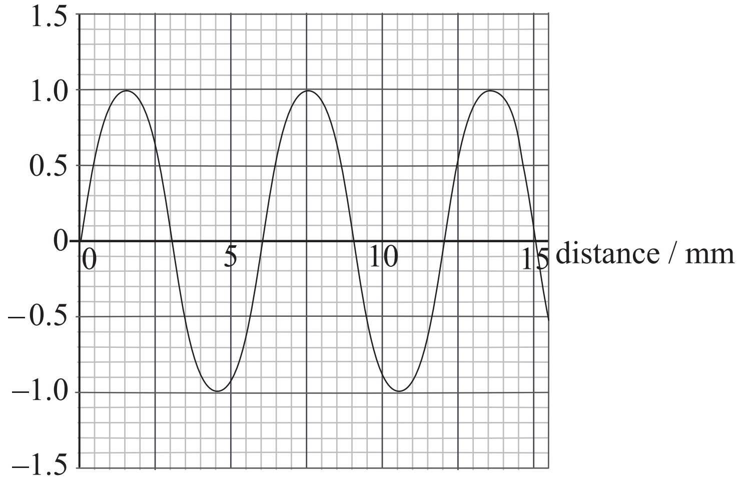
(Question B2, part 1 continued)

(a) The diagram shows how the displacement of the water surface at a particular instant in time varies with distance from the sphere. The period of oscillation of the sphere is 0.027 s.



Use the diagram to calculate, for the wave,

(i) the amplitude. *[1]*

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(ii) the wavelength. *[1]*

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(iii) the frequency. *[1]*

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(iv) the speed. *[1]*

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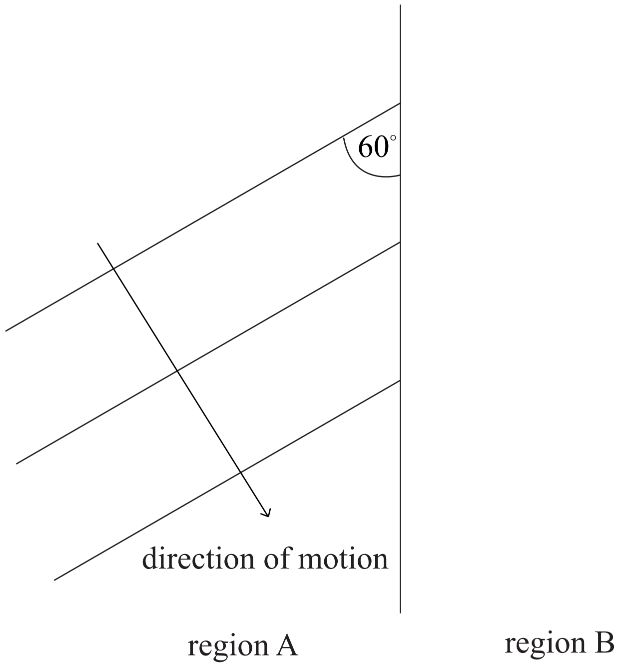
(This question continues on the following page)

(Question B2, part 1 continued)

(b) The wave moves from region A into a region B of shallower water. The waves move more slowly in region B. The diagram (not to scale) shows some of the wavefronts in region A.



(i) With reference to a wave, distinguish between a ray and a wavefront. *[2]*

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(ii) The angle between the wavefronts and the interface in region A is 60°. The refractive index ${}_{\mathrm{A}}n_{\mathrm{B}}$ is 1.4.

Determine the angle between the wavefronts and the interface in region B. *[2]*

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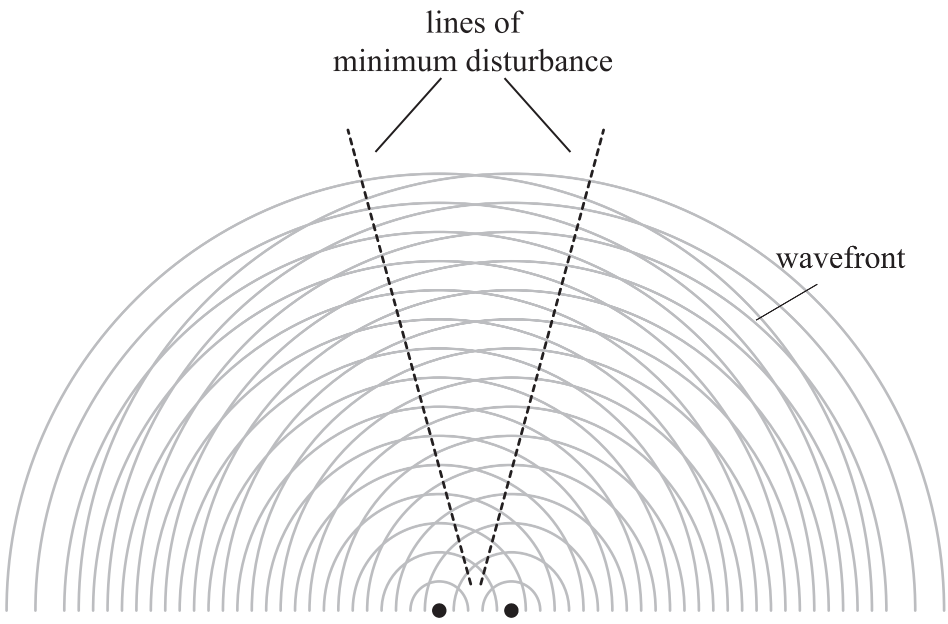
(iii) On the diagram above, construct **three** lines to show the position of three wavefronts in region B. *[2]*

(This question continues on the following page)

(Question B2, part 1 continued)

(c) Another sphere is dipped into the water. The spheres oscillate in phase. The diagram shows some lines in region A along which the disturbance of the water surface is a minimum.



(i) Outline how the regions of minimum disturbance occur on the surface. *[3]*

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(ii) The frequency of oscillation of the spheres is increased.

State **and** explain how this will affect the positions of minimum disturbance. *[2]*

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(This question continues on the following page)

(Question B2 continued)

Part 2 Nuclear processes

(a) A nucleus of radium-91 $\left({}^{226}_{91}\text{Ra}\right)$ undergoes alpha particle decay to form a nucleus of radon (Rn).

(i) Identify the proton number and nucleon number of the nucleus of Rn. *[2]*

Proton number: . . . .

Nucleon number: . . . .

(ii) The half-life of radium-91 is 1600 years. Determine the length of time taken for 87.5% of the radium to disintegrate. *[2]*

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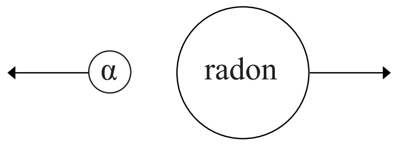
(b) Immediately after the decay of a stationary radium nucleus, the alpha particle and the radon nucleus move off in opposite directions and at different speeds.



Outline the reasons for these observations. *[3]*

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(c) Outline why a beta particle has a longer range in air than an alpha particle of the same energy. *[3]*

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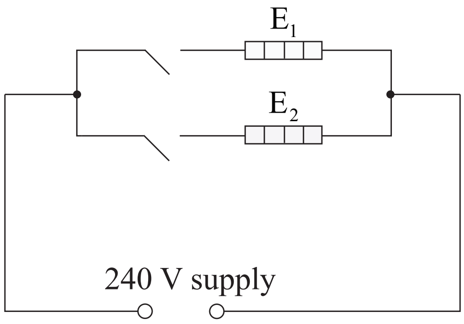
B3. This question is in **two** parts. **Part 1** is about an electrical heater. **Part 2** is about heating a liquid.

Part 1 Electrical heater

An electrical heater consists of two heating elements E_1 and E_2. The elements are connected in parallel. Each element has a switch and is connected to a supply of emf 240 V. The supply has negligible internal resistance.



Element E_1 is made from wire that has a cross-sectional area of $6.8\times10^{-8}\,m^2$. The resistivity of the wire at the operating temperature of the element is $1.1\times10^{-6}\,\Omega\,m$.

(a) (i) The total length of wire is 4.5 m. Show that the resistance of E_1 is 73 Ω. *[1]*

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(ii) Calculate the power output of E_1 with only this element connected to the supply. *[2]*

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(iii) Element E_2 is made of wire of the same cross-section and material as E_1. The length of wire used to make E_2 is 1.5 m. Determine the total power output when both E_1 and E_2 are connected to the supply. *[3]*

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(Question B3, part 1 continued)

(iv) With reference to the power output, explain why it would be inappropriate to connect the heating elements in series. *[3]*

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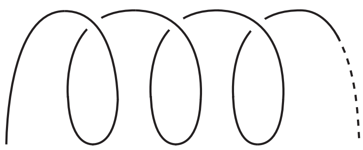
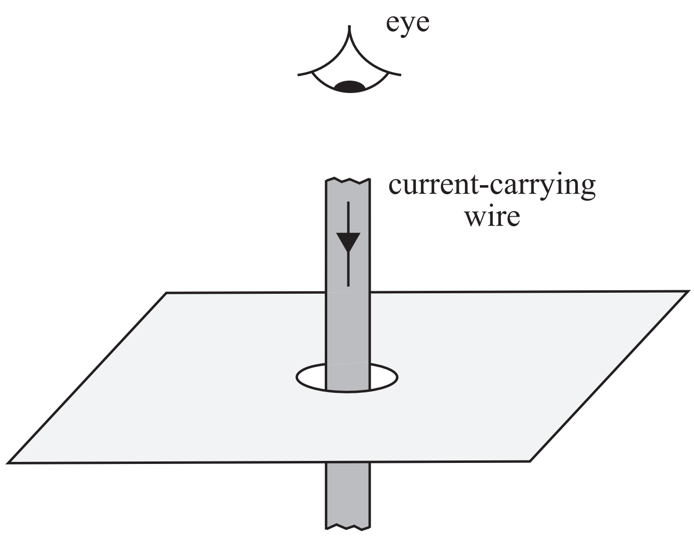
(b) Each element in the electrical heater is wound as a coil as shown.



Each turn of the coil may be considered to act as a current-carrying long straight wire.

(i) On the diagram, draw the magnetic field around a current-carrying long straight wire. The arrow shows the direction of the current. *[3]*



(ii) State **and** explain whether the turns of wire will attract or repel one another. *[3]*

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(Question B3 continued)

Part 2 Heating a liquid

(a) Suggest why, in terms of the molecular model, the energy associated with melting is less than that associated with boiling. *[2]*

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(b) Milk in a cup is heated to boiling point by passing steam through it. Whilst cooling subsequently, some milk evaporates.

(i) Distinguish between evaporation and boiling. *[2]*

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(ii) The cup contains 0.30 kg of milk at an initial temperature of 18 °C. Estimate the minimum mass of steam at 100 °C that is required to heat the milk to 80 °C. *[4]*

Specific latent heat of vaporization of water	$= 2.3 \times 10^6\ \text{J kg}^{-1}$
Specific heat capacity of water	$= 4200\ \text{J kg}^{-1}\text{K}^{-1}$
Specific heat capacity of milk	$= 3800\ \text{J kg}^{-1}\text{K}^{-1}$

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(Question B3, part 2 continued)

(iii) State **two** reasons, other than evaporation, why the answer to (b)(ii) is likely to be different from the actual mass of condensed steam. *[2]*

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2: . . . .

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