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PHYSICS
STANDARD LEVEL
PAPER 2

Tuesday 12 May 2009 (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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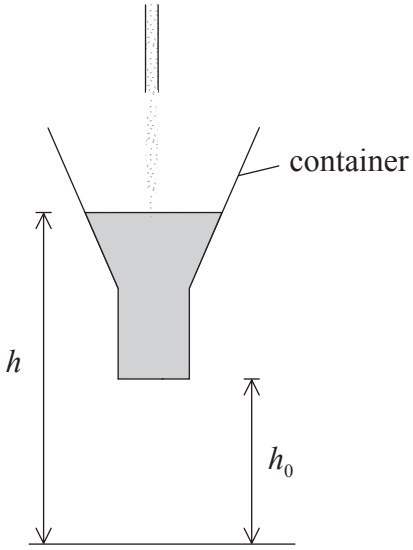
SECTION A

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

A1. This question is about liquid flow.

The diagram shows a storage container for liquids.

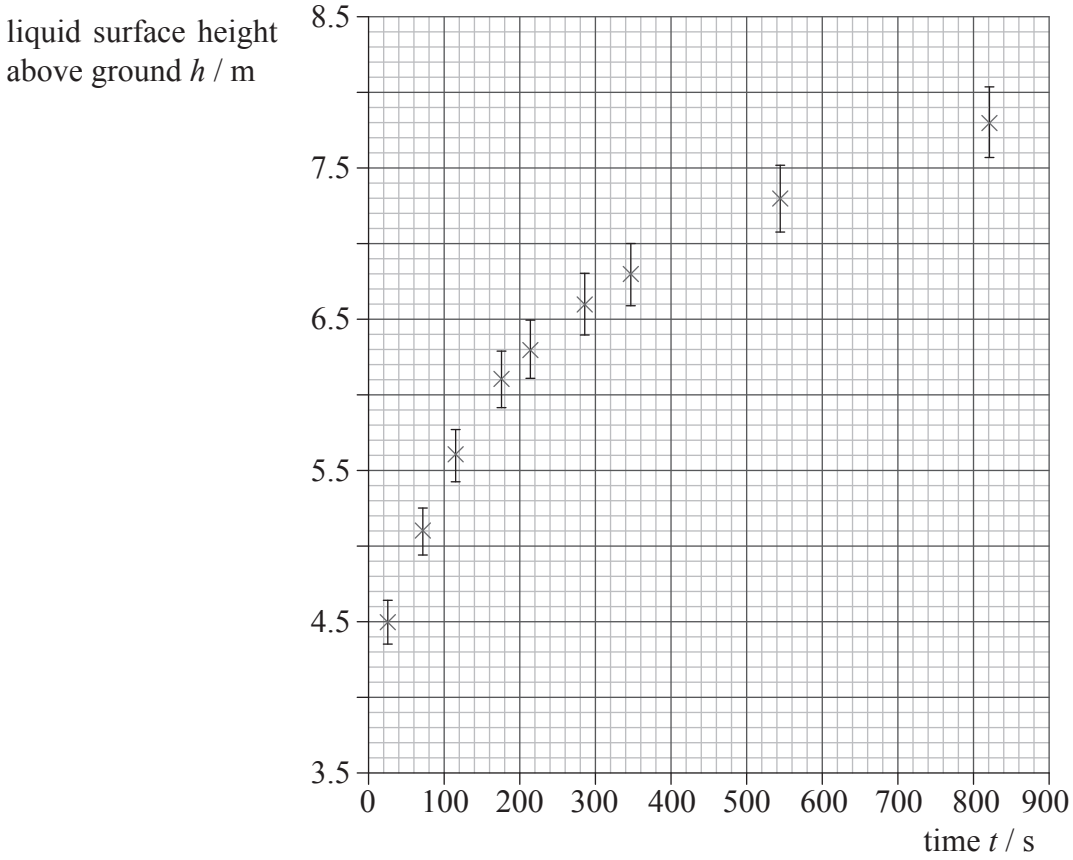


The container is filled from above. The distance between the base of the container and the ground is h_0.

(This question continues on the following page)

(Question A1 continued)

The container, which is initially empty, is then filled at a **constant** rate. The height h of the liquid surface above the ground is measured as a function of time t. The results of the measurements are shown plotted below.



(a) Draw a best-fit line for the data. *[1]*

(b) It is hypothesized that h is directly proportional to t. State and explain whether this hypothesis is correct for the periods

(i) $t = 0$ to $t = 120\,\text{s}$. *[1]*

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(ii) $t > 120\,\text{s}$. *[1]*

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(Question A1 continued)

(c) Use data from the graph to determine the value of h_0. *[2]*

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(d) The area of the base of the container is $1.8\,m^2$. Deduce that the volume of liquid entering the storage container each second is approximately $0.02\,m^3\,s^{-1}$. *[3]*

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(e) The container is completely filled after 850 s. Calculate the total volume of the container. *[1]*

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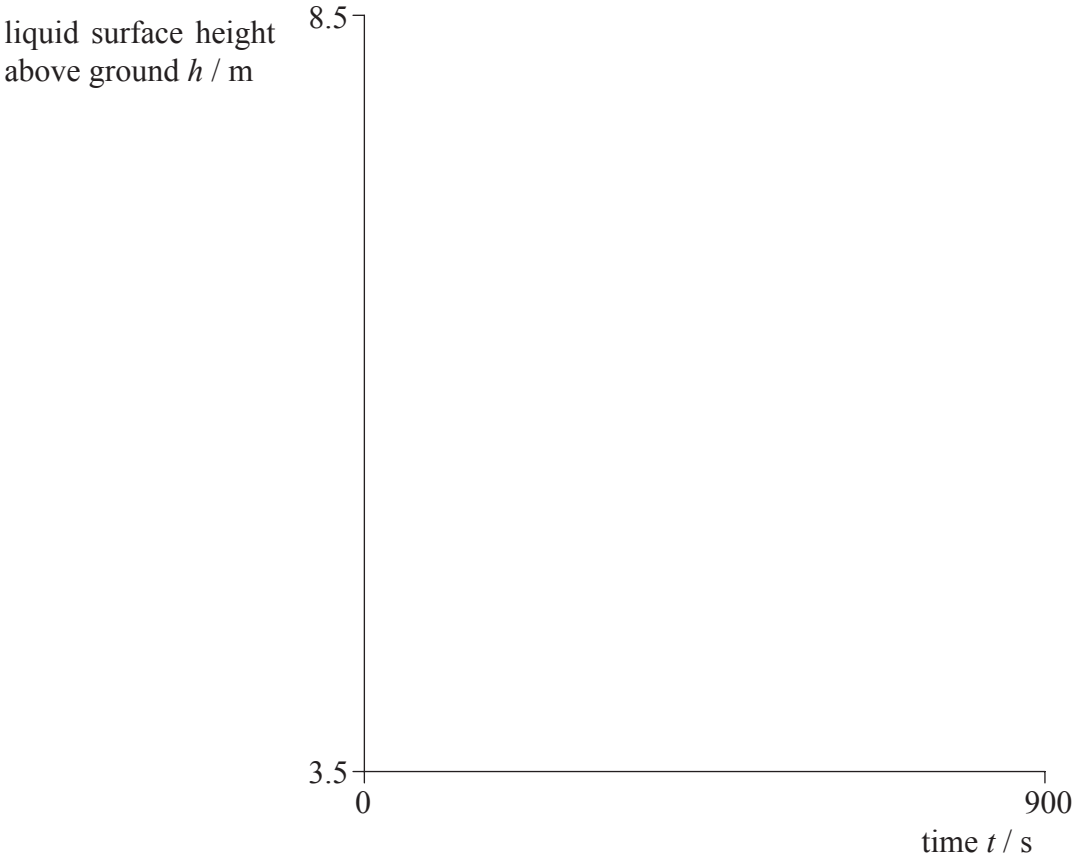
(Question A1 continued)

(f) The empty container is now filled at half the rate in (d). Using the axes, sketch a graph to show the variation of h with t in the range $t = 0$ to $t = 900\,\text{s}$. *[2]*



A2. This question is about electrical resistance.

(a) A heating coil is to be made of wire of diameter 3.5×10^{-4} m. The heater is to dissipate 980 W when connected to a 230 V d.c. supply. The material of the wire has resistivity $1.3 \times 10^{-6}\,\Omega$m at the working temperature of the heater.

(i) Define *electrical resistance*. *[1]*

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(ii) Calculate the resistance of the heating coil at its normal working temperature. *[2]*

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(iii) Show that the length of wire needed to make the heating coil is approximately 4 m. *[2]*

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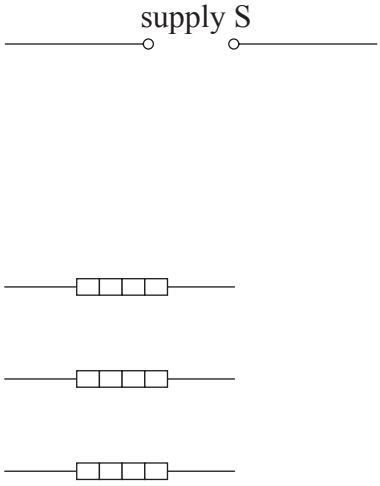
(This question continues on the following page)

(Question A2 continued)

(b) Three identical electrical heaters each provide power P when connected separately to a supply S which has zero internal resistance. On the diagram below, complete the circuit by drawing **two** switches so that the power provided by the heaters may be **either** P **or** $2P$ **or** $3P$. *[2]*



A3. This question is about force fields.

(a) Outline what is meant by a field of force. *[2]*

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(b) Five particles A to E are each placed in a different type of field. Complete the table to identify the nature of the field in which each particle is situated. *[5]*

Particle	**Charge on particle**	**Initial direction of motion of particle**	**Direction of force on particle**	**Type of field**
A	uncharged	stationary	in direction of field	. . . . .
B	negative	along direction of field	opposite to direction of field	. . . . .
C	positive	normal to direction of field	normal to direction of field	. . . . .
D	positive	normal to direction of field	in direction of field	. . . . .
E	uncharged	opposite to direction of field	in direction of field	. . . . .

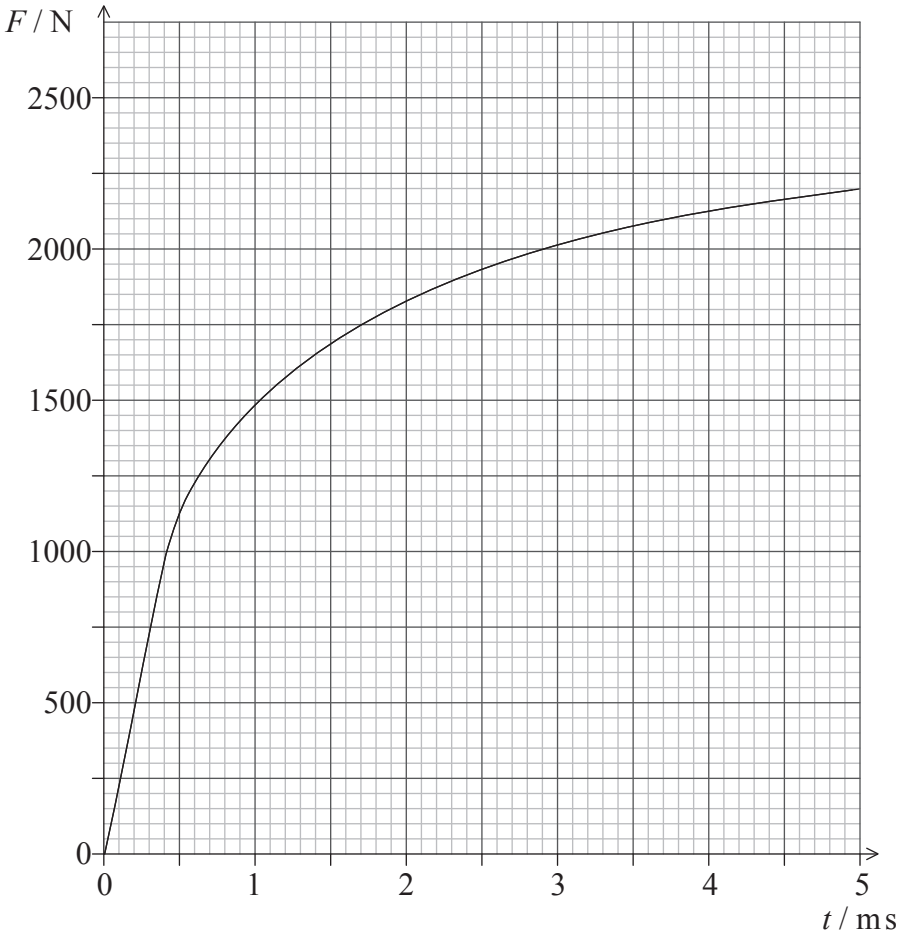
SECTION B

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

B1. This question is in **two** parts. **Part 1** is about dynamics and energy. **Part 2** is about the use of fossil fuels.

Part 1 Dynamics and energy

A bullet of mass 32 g is fired from a gun. The graph shows the variation of the force F on the bullet with time t as it travels along the barrel of the gun.



The bullet is fired at time $t = 0$ and the length of the barrel is 0.70 m.

(This question continues on the following page)

(Question B1, part 1 continued)

(a) State and explain why it is inappropriate to use the equation $s = ut + \frac{1}{2}at^2$ to calculate the acceleration of the bullet. *[2]*

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(b) Use the graph to

(i) determine the average acceleration of the bullet during the final 2.0 ms of the graph. *[2]*

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(ii) show that the change in momentum of the bullet, as the bullet travels along the length of the barrel, is approximately 9 N s. *[3]*

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(This question continues on the following page)

(Question B1, part 1 continued)

(c) Use the answer in (b)(ii) to calculate the

(i) speed of the bullet as it leaves the barrel. *[2]*

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(ii) average power delivered to the bullet. *[3]*

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(d) Use Newton's third law to explain why a gun will recoil when a bullet is fired. *[3]*

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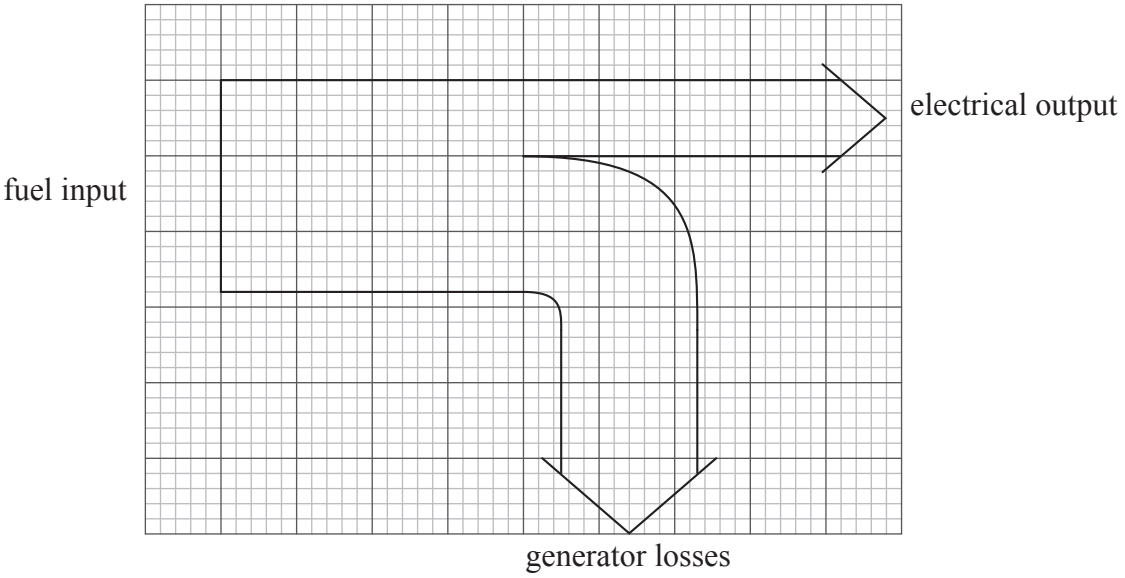
(Question B1 continued)

Part 2 Fossil fuels

(a) A Sankey diagram for the generation of electrical energy using fossil fuel as the primary energy source is shown.



(i) State what is meant by a fuel. *[1]*

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(ii) State **two** examples of fossil fuels. *[2]*

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2. . . . . .

(iii) Explain why fossil fuels are said to be non-renewable. *[2]*

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(This question continues on the following page)

(Question B1, part 2 continued)

(iv) Use the Sankey diagram to estimate the efficiency of production of electrical energy and explain your answer. *[2]*

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(b) Despite the fact that fossil fuels are non-renewable and contribute to atmospheric pollution there is widespread use of such fuels. Suggest **three** reasons for this widespread use. *[3]*

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2. . . . . .

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3. . . . . .

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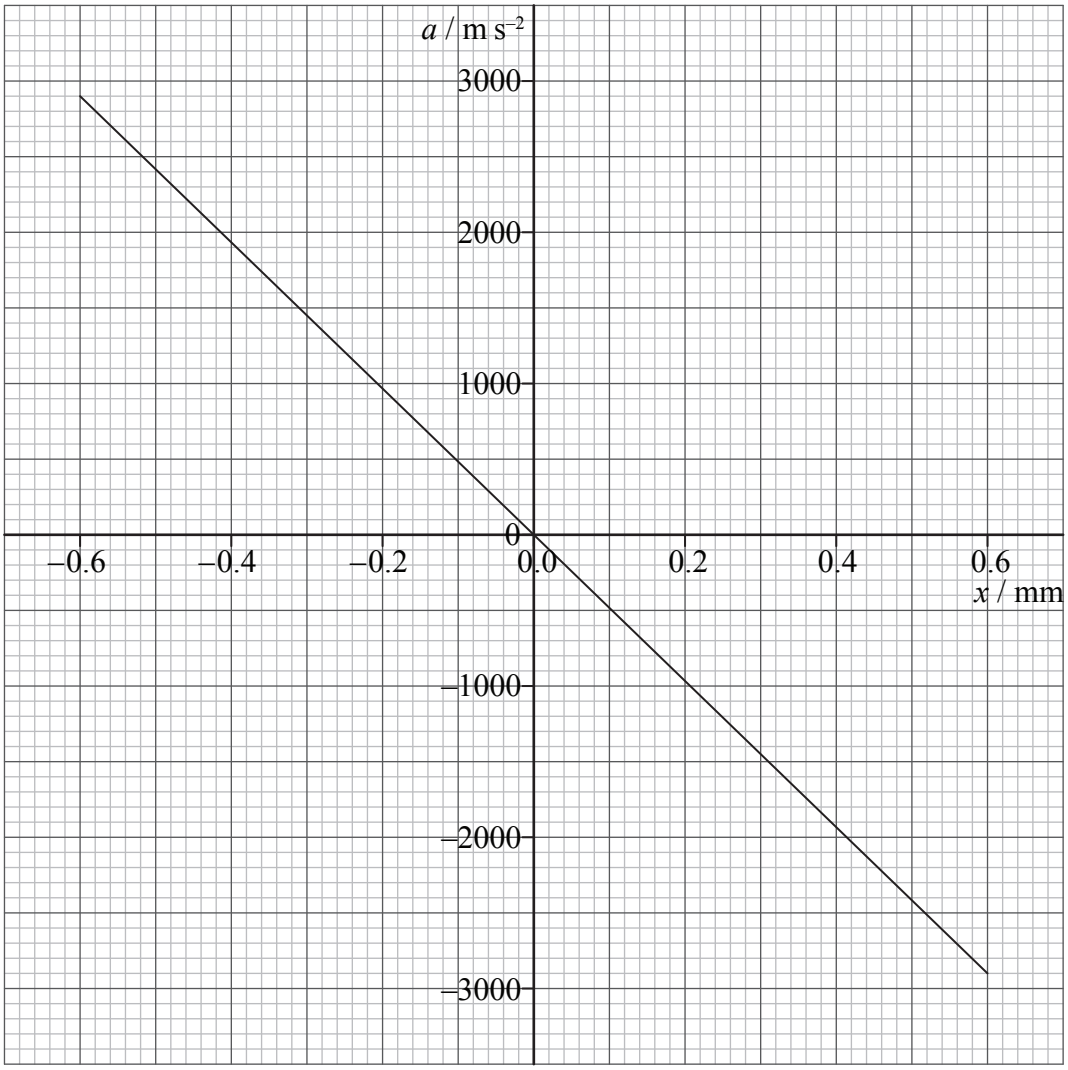
B2. This question is in **two** parts. **Part 1** is about simple harmonic motion and waves. **Part 2** is about α-particle scattering and nuclear processes.

Part 1 Simple harmonic motion and waves

An object is vibrating in air. The variation with displacement x of the acceleration a of the object is shown below.



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(Question B2, part 1 continued)

(a) State and explain **two** reasons why the graph opposite indicates that the object is executing simple harmonic motion. *[4]*

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(b) Use data from the graph to show that the frequency of oscillation is 350 Hz. *[4]*

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(c) State the amplitude of the vibrations. *[1]*

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(d) The motion of the object gives rise to a longitudinal progressive (travelling) sound wave.

(i) State what is meant by a longitudinal progressive wave. *[2]*

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(ii) The speed of the wave is $330\,m\,s^{-1}$. Using the answer in (b), calculate the wavelength of the wave. *[2]*

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(Question B2 continued)

Part 2 α-particle scattering and nuclear processes

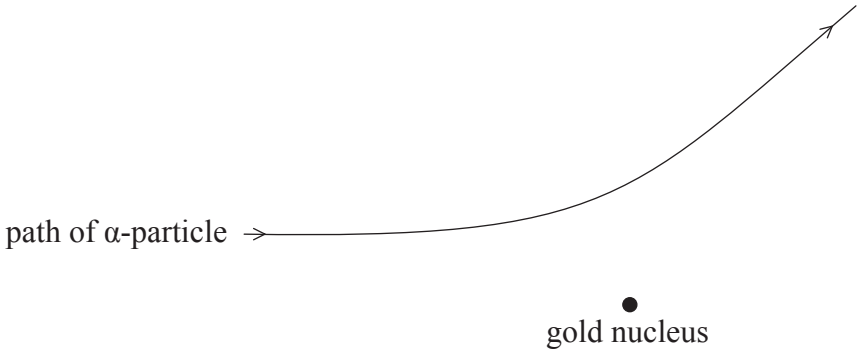
α-particle scattering

Radium-226 decays with the emission of α-particles to radon (Rn).

(a) Complete the nuclear reaction equation. *[2]*

$$^{226}_{88}\text{Ra} \rightarrow \qquad \text{Rn} \quad +$$

(b) Experimental evidence that supports a nuclear model of the atom was provided by α-particle scattering. The diagram represents the path of an α-particle as it approaches and then recedes from a stationary gold nucleus.



(i) On the diagram, draw lines to show the angle of deviation of the α-particle. Label this angle *D*. *[1]*

(ii) The gold nucleus is replaced by another gold nucleus that has a larger nucleon number. Suggest and explain the change, if any, in the angle *D* of an α-particle with the same energy and following the same initial path as in (b)(i). *[2]*

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(Question B2, part 2 continued)

(c) The diagram shows the initial path of an α-particle that approaches the gold nucleus along a line joining their centres. On the diagram draw the subsequent path of the α-particle. *[1]*

Nuclear processes

(d) The main nuclear process that gives rise to energy emission from the Sun may be simplified to

$$4\text{H} \rightarrow \text{He} + \text{energy}.$$

(i) State the name of this nuclear process. *[1]*

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(ii) The total mass of four hydrogen (H) nuclei is 6.693×10^{-27} kg and the mass of a helium (He) nucleus is 6.645×10^{-27} kg. Show that the energy released in this reaction is 4.3×10^{-12} J. *[2]*

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(iii) The Sun has a radius R of 7.0×10^{8} m and emits energy at a rate of 3.9×10^{26} W. The nuclear reactions take place in the spherical core of the Sun of radius $0.25R$. Use these data and the answer in (d)(ii) to determine the number of nuclear reactions occurring per cubic metre per second in the core of the Sun. *[3]*

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B3. This question is in **two** parts. **Part 1** is about wave power. **Part 2** is about the albedo of the Earth.

Part 1 Wave power

(a) Outline how the energy of a wave can be converted to electrical energy. *[2]*

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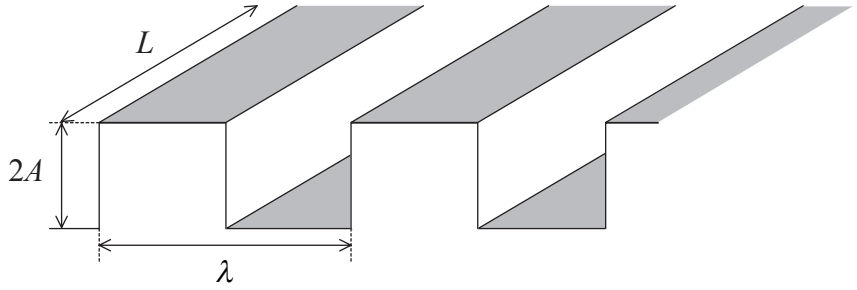
(b) A wave on the surface of water is assumed to be a square-wave of height $2A$, as shown.



The wave has wavelength λ, speed v and has a wavefront of length L. For this wave,

(i) show that the gravitational potential energy E_P stored in one wavelength of the wave is given by

$$E_P = \tfrac{1}{2} A^2 \lambda g \rho L$$

where ρ is the density of the water and g is the acceleration of free fall. *[3]*

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(ii) deduce that the gravitational wave power P per unit length of the wavefront is given by

$$P = \tfrac{1}{2} A^2 v g \rho$$ *[2]*

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(Question B3, part 1 continued)

(c) The density of sea-water is $1.2 \times 10^3\,\text{kg m}^{-3}$. Using the expression in (b)(ii), estimate the gravitational power per metre length available in a wave of height 0.60 m. *[2]*

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(d) In practice a water wave is approximately sinusoidal in cross-section. Outline whether a sine wave of the same height as in (b) transfers a greater **or** a smaller amount of power than that derived in (b)(ii). *[2]*

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(e) List **two** advantages of the utilisation of wave power rather than photovoltaic cells for the generation of electric power. *[2]*

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(Question B3 continued)

Part 2 Albedo of the Earth

(a) Outline the mechanism by which a gas, such as carbon dioxide, absorbs infra-red radiation. *[2]*

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(b) State, with reference to your answer in (a), why carbon dioxide is known as a greenhouse gas. *[1]*

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(c) State the **name** of another greenhouse gas. *[1]*

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(d) In the last fifty years the amount of carbon dioxide in the Earth's atmosphere has increased significantly. Explain

(i) why this increase could account for global warming. *[1]*

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(ii) what effect this has had on the average albedo of the Earth. *[3]*

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(Question B3, part 2 continued)

(e) It has been estimated that doubling the amount of carbon dioxide in the Earth's atmosphere changes the albedo of the Earth by 0.01. Use the data to show that this doubling will lead to a change of about $3\,\text{W}\,\text{m}^{-2}$ in the intensity being reflected by the Earth into space. *[3]*

Average intensity received at Earth from the Sun $= 340\,\text{W}\,\text{m}^{-2}$
Average albedo $= 0.30$

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(f) State **one** reason why the answer to (e) is an estimate. *[1]*

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