PHYSICS
STANDARD LEVEL
PAPER 2

Candidate number

Monday 19 May 2003 (afternoon)

1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your candidate number in the box 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. You may continue your answers on answer sheets. Write your candidate number on each answer sheet, and attach them to this examination paper using the tag provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

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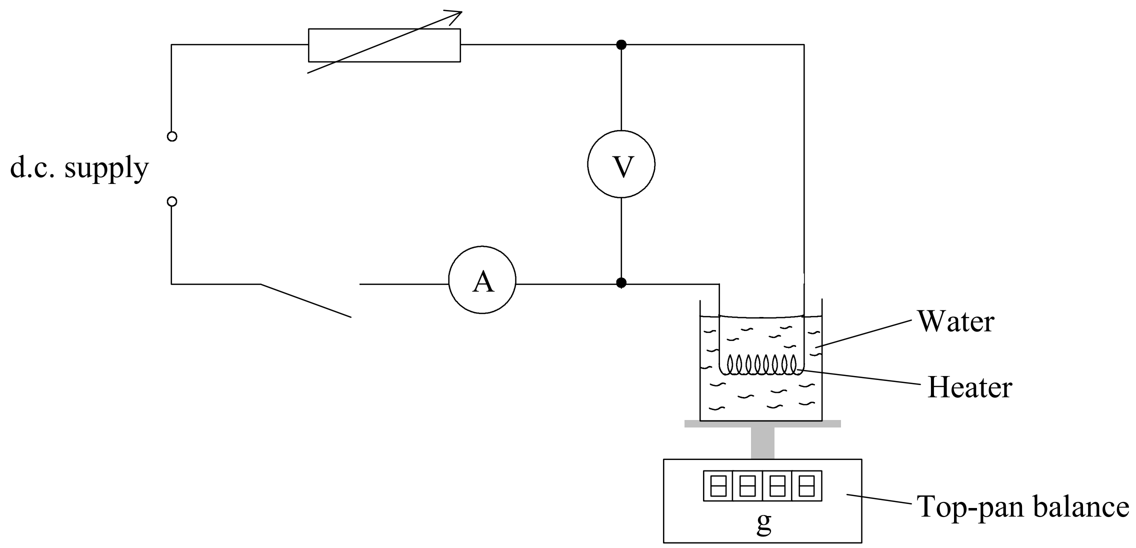
SECTION A

*Candidates must answer **all** questions in the spaces provided.*

A1. Some students were asked to design and carry out an experiment to determine the specific latent heat of vaporization of water. They set up the apparatus shown below.



The current was switched on and maintained constant using the variable resistor. The readings of the voltmeter and the ammeter were noted. When the water was boiling steadily, the reading of the top-pan balance was taken and, simultaneously, a stopwatch was started. The reading of the top-pan balance was taken again after 200 seconds and then after a further 200 seconds.

The change in reading of the top-pan balance during each 200 second interval was calculated and an average found. The power of the heater was calculated by multiplying together the readings of the voltmeter and the ammeter.

(a) Suggest how the students would know when the water was boiling steadily. *[1]*

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(b) Explain why a reading of the mass lost in the first 200 seconds and then a reading of the mass lost in the next 200 second interval were taken, rather than one single reading of the mass lost in 400 seconds. *[2]*

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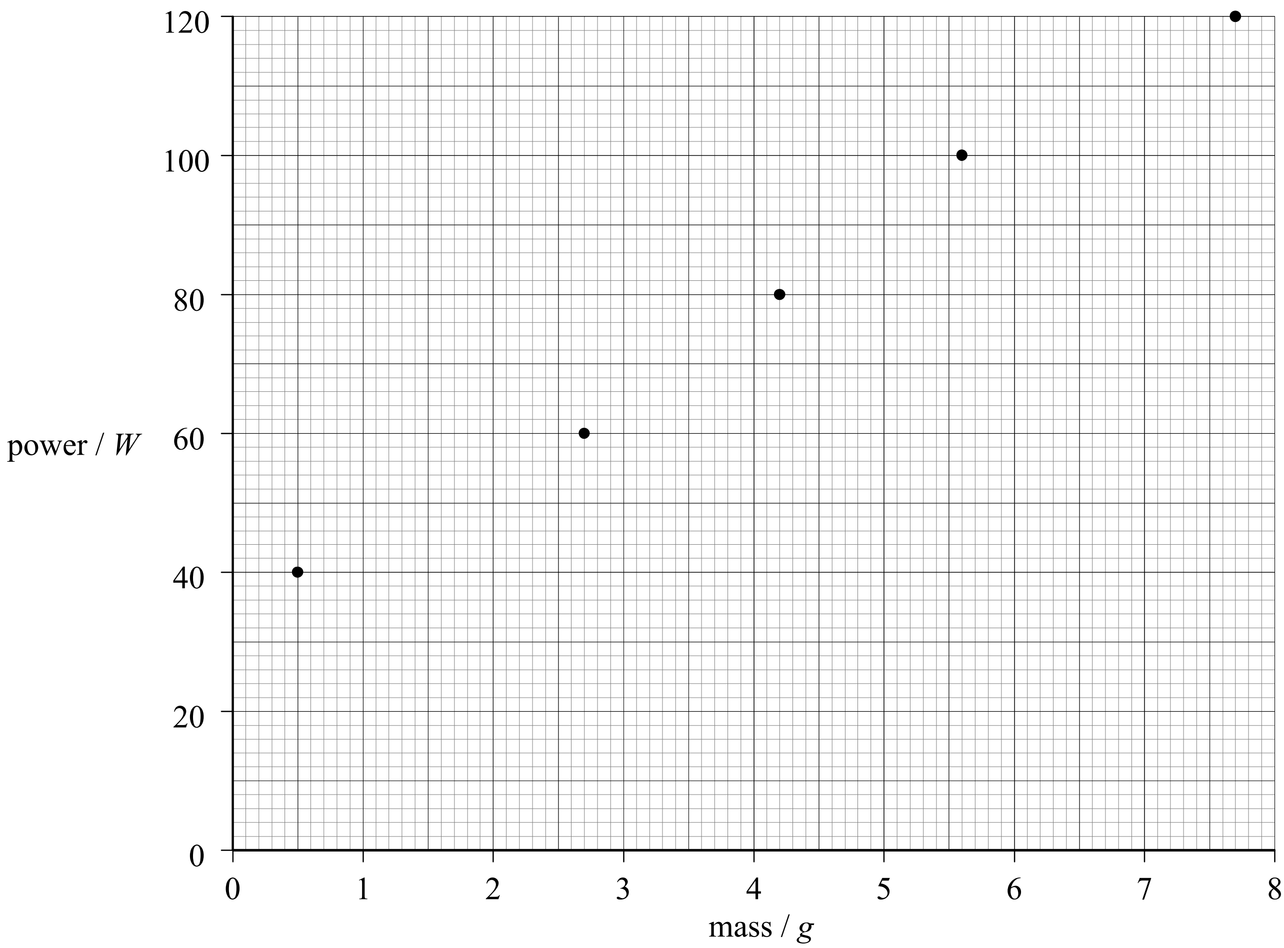
(Question A1 continued)

The students repeated the experiment for different powers supplied to the heater. A graph of the power of the heater against the mass of water lost (the change in balance reading) in 200 seconds was plotted. The results are shown below. *(Error bars showing the uncertainties in the measurements are not shown.)*



(c) (i) On the graph above, draw the best-fit straight line for the data points. *[1]*

(ii) Determine the gradient of the line you have drawn. *[3]*

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(Question A1 continued)

In order to find a value for the specific latent heat of vaporization L, the students used the equation

$$P = mL,$$

where P is the power of the heater and m is the mass of water evaporated **per second**.

(d) Use your answer for the gradient of the graph to determine a value for the specific latent heat of vaporization of water. *[3]*

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(e) The theory of the experiment would suggest that the graph line should pass through the origin. Explain briefly why the graph does not pass through the origin. *[2]*

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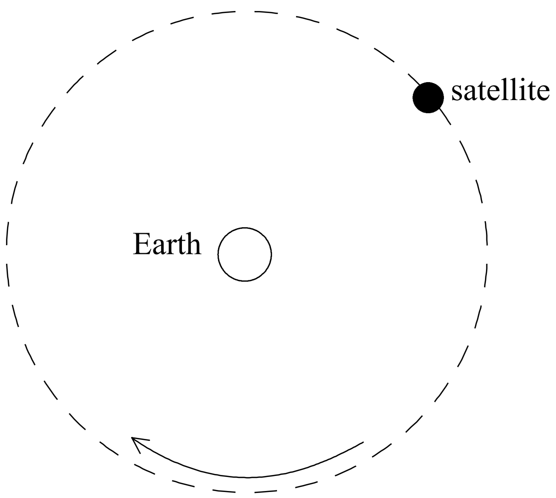
A2. A satellite orbits the Earth at constant speed as shown below.



(a) Draw on the diagram

(i) an arrow labelled F to show the direction of the gravitational force of the Earth on the satellite.

(ii) an arrow labelled V to show the direction of the velocity of the satellite. *[2]*

(b) Although the speed of the satellite is constant, it is accelerating. Explain why it is accelerating. *[2]*

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(c) Discuss whether or not the gravitational force does work on the satellite. *[3]*

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A3. (a) State what is meant by an *ideal* gas. *[2]*

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(b) The internal volume of a gas cylinder is $2.0 \times 10^{-2}\ \text{m}^3$. An ideal gas is pumped into the cylinder until the pressure becomes 20 MPa at a temperature of 17 °C.

Determine

(i) the number of moles of gas in the cylinder. *[2]*

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(ii) the number of gas atoms in the cylinder. *[2]*

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SECTION B

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

B1. This question is about waves and wave properties.

(a) By making reference to waves, distinguish between a *ray* and a *wavefront*. *[3]*

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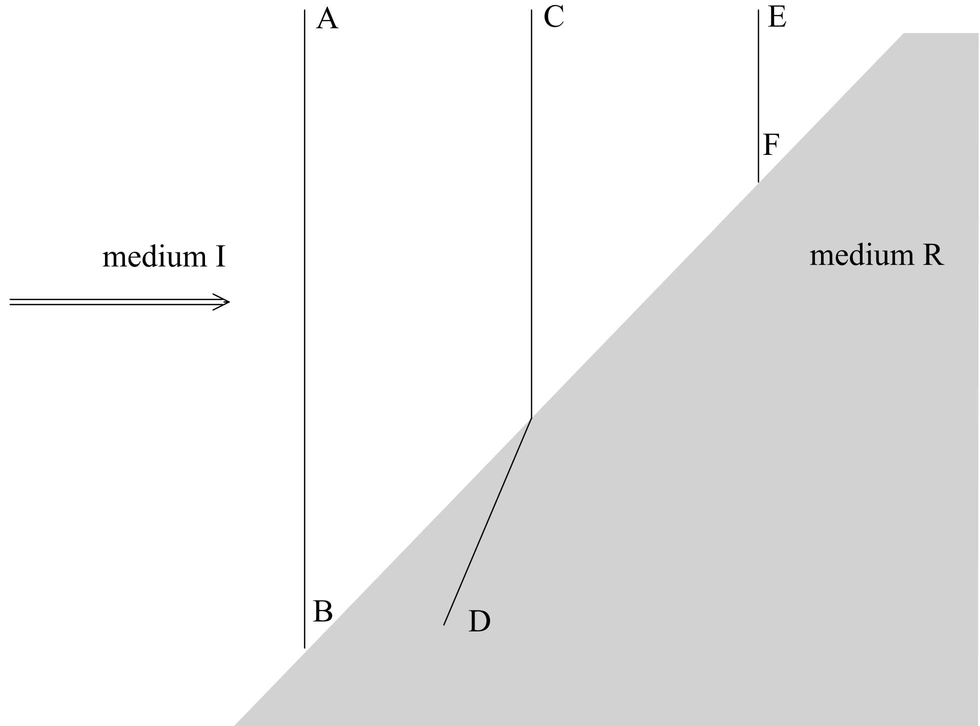
The diagram below shows three wavefronts incident on a boundary between medium I and medium R. Wavefront CD is shown crossing the boundary. Wavefront EF is incomplete.



(b) (i) On the diagram above, draw a line to complete the wavefront EF. *[1]*

(ii) Explain in which medium, I **or** R, the wave has the higher speed. *[3]*

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(This question continues on the following page)

(Question B1(b) continued)

(iii) By taking appropriate measurements from the diagram, determine the ratio of the speeds of the wave travelling from medium I to medium R. *[2]*

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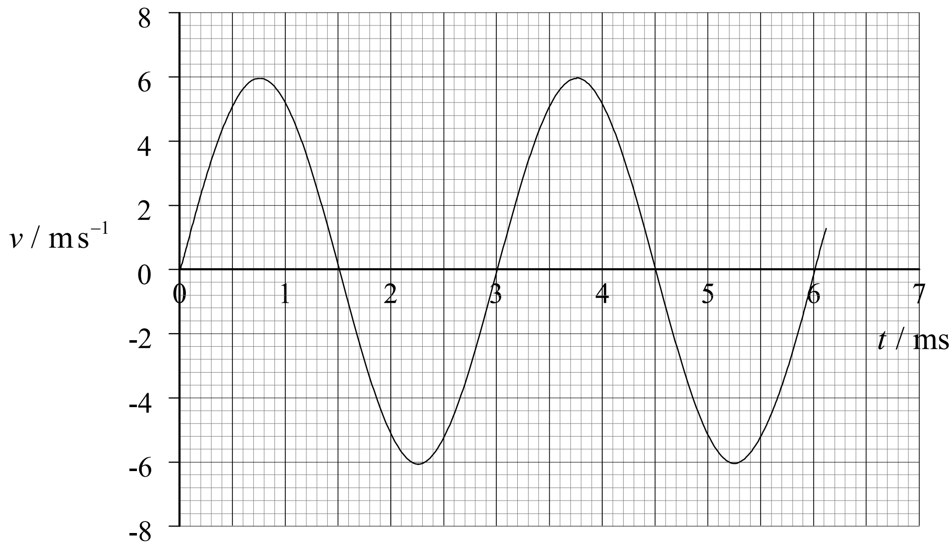
The graph below shows the variation with time t of the velocity v of one particle of the medium through which the wave is travelling.



(c) (i) Explain how it can be deduced from the graph that the particle is oscillating. *[2]*

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(ii) Determine the frequency of oscillation of the particle. *[2]*

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(iii) Mark on the graph with the letter M one time at which the particle is at maximum displacement. *[1]*

(iv) Estimate the area between the curve and the x-axis from the time t = 0 to the time t = 1.5 ms. *[2]*

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(Question B1(c) continued)

(v) Suggest what the area in c (iv) represents. *[1]*

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(d) By reference to energy transfer and the amplitude of vibration of particles in a wave, distinguish between a travelling wave and a standing wave. *[4]*

Energy transfer: . . . .

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Amplitude: . . . .

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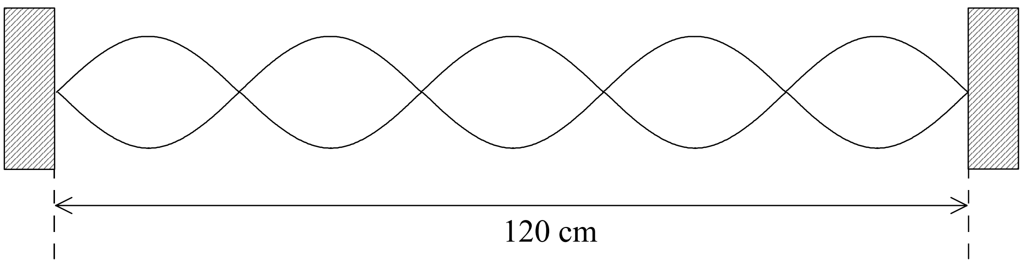
A stretched string is fixed at both ends and then plucked at its centre. The diagram below illustrates the vibrating string.



The distance between the fixed points is 120 cm.

(e) (i) Mark on the diagram a distance equal to the wavelength of the standing wave. *[1]*

(ii) The frequency of vibration of the string is 250 Hz. Determine the speed of the wave on the string. *[3]*

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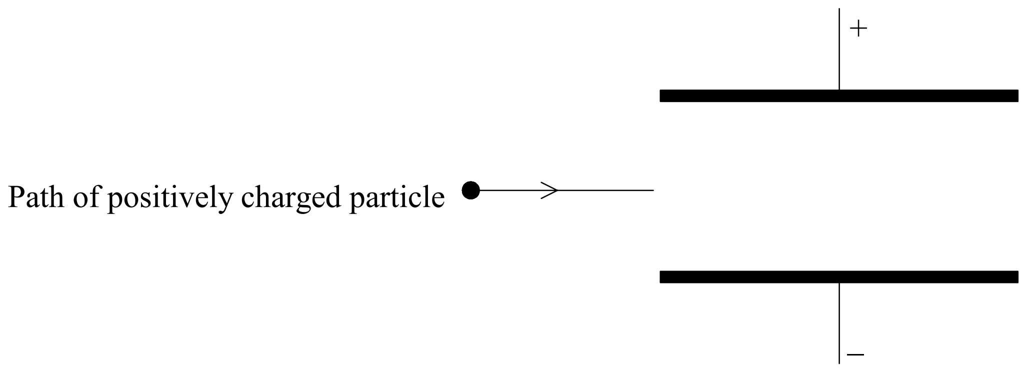
B2. This question is about forces on charged particles in electric and magnetic fields.

The diagram shows two parallel plates situated in a vacuum. One plate is at a positive potential with respect to the other.



A positively charged particle passes into the region between the plates. Initially, the particle is travelling parallel to the plates.

(a) On the diagram,

(i) draw lines to represent the electric field between the plates. *[3]*

(ii) show the path of the charged particle as it passes between, and beyond, the plates. *[2]*

(b) An electron is accelerated from rest in a vacuum through a potential difference of 750 V.

(i) Determine the change in electric potential energy of the electron. *[2]*

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(ii) Deduce that the final speed of the electron is $1.6 \times 10^{7}\ \text{m s}^{-1}$. *[2]*

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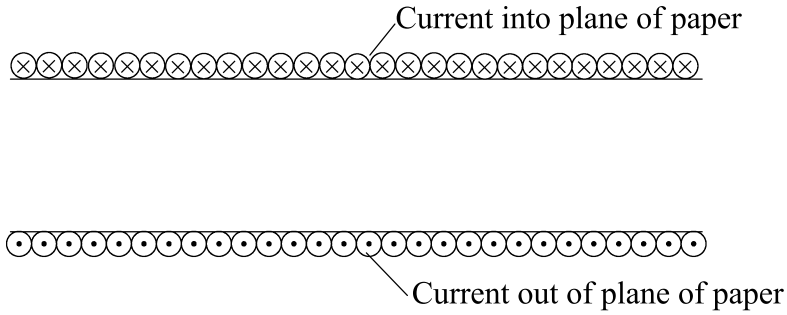
(Question B2 continued)

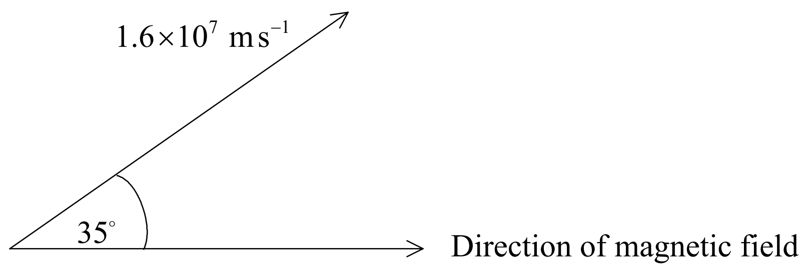
The diagram below shows a cross-section through a current-carrying solenoid. The current is moving into the plane of the paper at the upper edge of the solenoid and out of the plane of the paper at the lower edge. There is a vacuum in the solenoid.



(c) (i) Sketch lines to represent the magnetic field inside and at each end of the solenoid. *[4]*

(ii) A positively charged particle enters the solenoid along its axis. On the diagram, show the path of the particle in the solenoid. *[1]*

An electron is injected into a region of uniform magnetic field of flux density 4.0 mT. The velocity of the electron is $1.6\times10^{7}\ \text{m s}^{-1}$ at an angle of 35° to the magnetic field, as shown below.



(d) (i) Determine the component of the velocity of the electron normal to the direction of the magnetic field. *[2]*

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(ii) Describe, making calculations where appropriate, the motion of the electron due to this component of the velocity. *[4]*

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(Question B2(d) continued)

(iii) Determine the component of the velocity of the electron along the direction of the magnetic field. *[1]*

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(iv) State and explain the magnitude of the force on the electron due to this component of the velocity. *[2]*

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(e) With reference to your answers in (d), describe the shape of the path of the electron in the magnetic field. You may draw a diagram if you wish. *[2]*

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B3. This question is about nuclear reactions.

(a) Complete the table below, by placing a tick (✓) in the relevant columns, to show how an increase in each of the following properties affects the rate of decay of a sample of radioactive material. *[2]*

Property	Effect on rate of decay		
	increase	decrease	stays the same
temperature of sample			
pressure on sample			
amount of sample			

Radium-226 ($^{226}_{88}Ra$) undergoes natural radioactive decay to disintegrate spontaneously with the emission of an alpha particle (α-particle) to form radon (Rn). The masses of the particles involved in the reaction are

radium:	226.0254 u
radon:	222.0176 u
α-particle:	4.0026 u

(b) (i) Complete the nuclear reaction equation below for this reaction. *[2]*

$$^{226}_{88}Ra \rightarrow \,^{\cdots\cdots}_{\cdots\cdots}\cdots\cdots + \,^{\cdots\cdots}_{\cdots\cdots}Rn$$

(ii) Calculate the energy released in the reaction. *[3]*

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(c) The radium nucleus was stationary before the reaction.

(i) Explain, in terms of the momentum of the particles, why the radon nucleus and the α-particle move off in opposite directions after the reaction. *[3]*

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(Question B3(c) continued)

(ii) The speed of the radon nucleus after the reaction is v_R and that of the α-particle is v_α. Show that the ratio $\frac{v_\alpha}{v_R}$ is equal to 55.5. *[3]*

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(iii) Using the ratio given in (ii) above, deduce that the kinetic energy of the radon nucleus is much less than the kinetic energy of the α-particle. *[3]*

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(d) Not all of the energy of the reaction is released as kinetic energy of the α-particle and of the radon nucleus. Suggest **one** other form in which the energy is released. *[1]*

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(Question B3 continued)

Another type of nuclear reaction is a fusion reaction. This reaction is the main source of the Sun's radiant energy.

(e) (i) State what is meant by a *fusion reaction*. *[3]*

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(ii) Explain why the temperature and pressure of the gases in the Sun's core must both be very high for it to produce its radiant energy. *[5]*

High temperature: . . . .

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High pressure: . . . .

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