IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI



**PHYSICS**
**STANDARD LEVEL**
**PAPER 2**

Candidate number

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Tuesday 4 May 2004 (afternoon)

1 hour 15 minutes

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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.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet.

## SECTION A

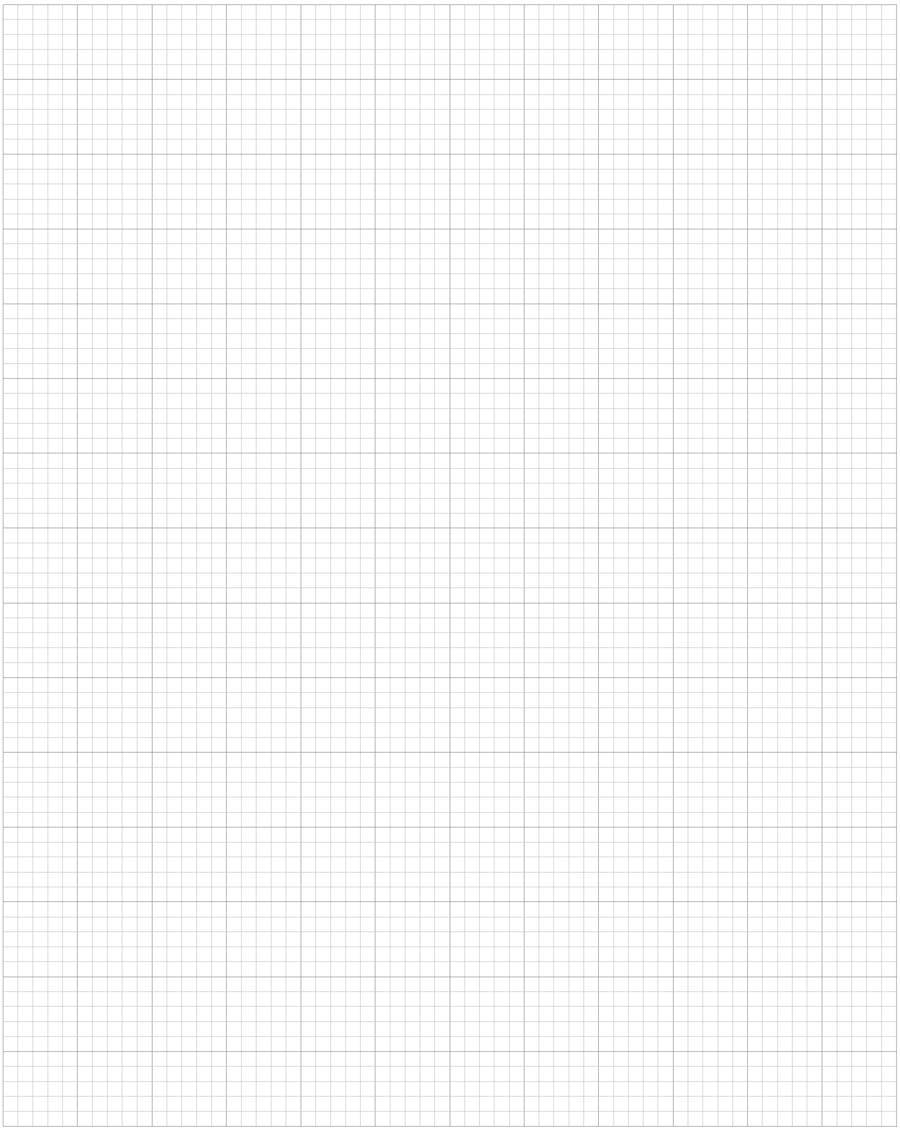
*Answer **all** the questions in the spaces provided.*

**A1.** Data based question. This question is about change of electrical resistance with temperature.

The table below gives values of the resistance $R$ of an electrical component for different values of its temperature $T$. (*Uncertainties in measurement are not shown*.)

| $T$/°C | 1.2 | 2.0 | 3.5 | 5.2 | 6.8 | 8.1 | 9.6 |
|---|---|---|---|---|---|---|---|
| $R$/Ω | 3590 | 3480 | 3250 | 3060 | 2880 | 2770 | 2650 |

(a) On the grid below, plot a graph to show the variation with temperature $T$ of the resistance $R$. Show values on the temperature axis from $T = 0\,^{\circ}\mathrm{C}$ to $T = 10\,^{\circ}\mathrm{C}$. *[3]*



*(This question continues on the following page)*

*(Question A1 continued)*

(b) (i) Draw a curve that best fits the points you have plotted. Extend your curve to cover the temperature range from $0^{\circ}C$ to $10^{\circ}C$. *[1]*

(ii) Use your graph to determine the resistance at $0^{\circ}C$ and at $10^{\circ}C$. *[2]*

Resistance at $0^{\circ}C$ = . . . . . . . . . . . . . . . . . . . . . . Ω

Resistance at $10^{\circ}C$ = . . . . . . . . . . . . . . . . . . . . . . Ω

(c) On your graph, draw a straight-line between the resistance values at $0^{\circ}C$ and at $10^{\circ}C$. This line shows the variation with temperature (between $0^{\circ}C$ and $10^{\circ}C$) of the resistance, assuming a linear change. *[1]*

(d) (i) Assuming a linear change of resistance with temperature, use your graph to determine the temperature at which the resistance is 3060 Ω. *[1]*

Temperature = . . . . . . . . . . . . . . . . . . . . . . . . . °C

(ii) Use your answer in (d)(i) to calculate the percentage difference in the temperature for a resistance of 3060 Ω that results from assuming a linear change rather than the non-linear change. *[3]*

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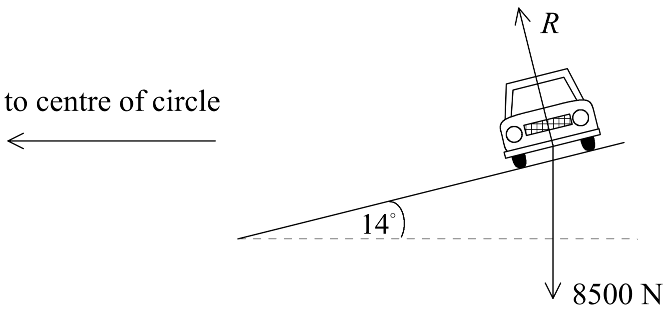
**A2.** This question is about the motion of a car.

A car of weight 8500 N is travelling at constant speed along a road that is an arc of a circle. In order that the car may travel more easily round the arc, the road is banked at $14^\circ$ to the horizontal, as shown below.




At one particular speed $v$ of the car, there is no frictional force at $90^\circ$ to the direction of travel of the car between the tyres and the road surface. The reaction force of the road on the car is $R$.

(a) Deduce that the horizontal component of the force $R$ is approximately 2100 N. *[2]*

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(b) State the magnitude and direction of the resultant force acting on the car. *[2]*

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(c) Determine the speed $v$ of the car at which it travels round the arc of radius 150 m without tending to slide. *[3]*

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(d) Deduce in which direction the car will tend to slide if it travels round the curve at a speed greater than $v$. *[2]*

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**A3.** (a) A small lump of ice (a hailstone) at $0^{\circ}\mathrm{C}$ falls to the Earth's surface. When the hailstone hits the surface, all of the kinetic energy of the hailstone is transferred to thermal energy in the ice. Calculate the minimum speed of the hailstone so that it just melts when it hits the surface. The specific latent heat of fusion of ice is $340\,\mathrm{kJ\,kg^{-1}}$. *[3]*

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(b) By reference to your answer in (a), suggest whether hailstones are likely to melt on hitting the Earth's surface. *[2]*

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## SECTION B

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

**B1.** This question is about electrical energy and associated phenomena.

**Static electricity**

A positively charged rod is brought near to the cap of an uncharged gold-leaf electroscope. The distribution of charge on the electroscope is illustrated in diagram 1. Diagrams 2, 3 and 4 are incomplete diagrams of the electroscope.

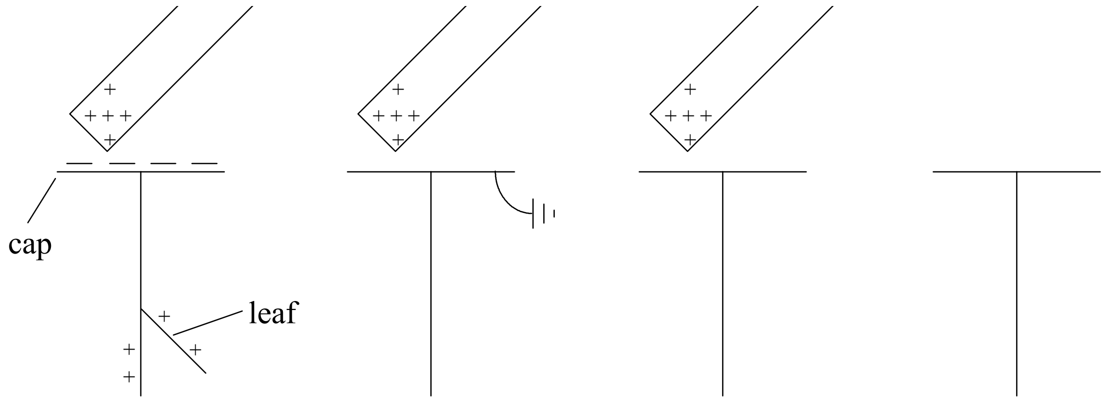


Diagram 1 Diagram 2 Diagram 3 Diagram 4

(a) (i) The cap of the electroscope is then earthed. On diagram 2, show the deflection, if any, of the leaf and the distribution of charge on the electroscope. *[2]*

(ii) The earth connection is now removed. On diagram 3, show the deflection, if any, of the leaf and the distribution of charge on the electroscope. *[1]*

(iii) Finally, the positively charged rod is removed. On diagram 4, show the deflection, if any, of the leaf and the distribution of charge on the electroscope. *[2]*

(b) (i) Define *electric potential difference* between two points. *[2]*

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(ii) Using your answers to (a), explain whether a gold-leaf electroscope measures electric charge **or** electric potential difference. *[3]*

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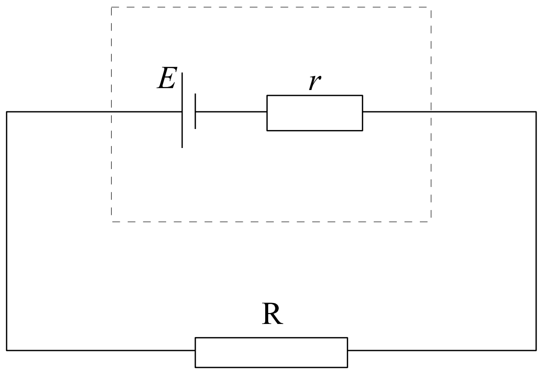
*(This question continues on the following page)*

*(Question B1 continued)*

**Current electricity**

A cell of electromotive force (e.m.f.) $E$ and internal resistance $r$ is connected in series with a resistor R, as shown below.




The cell supplies $8.1\times10^3$ J of energy when $5.8\times10^3$ C of charge moves completely round the circuit. The current in the circuit is constant.

(c) (i) Calculate the e.m.f. $E$ of the cell. *[2]*

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(ii) The resistor R has resistance 6.0 Ω. The potential difference between its terminals is 1.2 V. Determine the internal resistance $r$ of the cell. *[3]*

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(iii) Calculate the total energy transfer in the resistor R. *[2]*

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*(This question continues on the following page)*

*(Question B1 continued)*

(iv) Describe, in terms of a simple model of electrical conduction, the mechanism by which the energy transfer in the resistor R takes place. *[5]*

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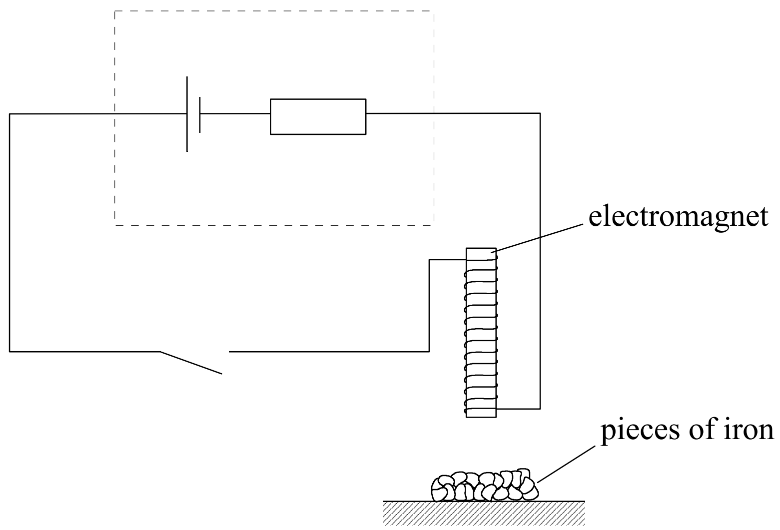
The resistor R is now replaced with an electromagnet and a switch, as shown below.




When the current is switched on, small pieces of iron, initially on the ground below the electromagnet, are attracted to, and stick to, the electromagnet.

(d) State briefly the energy changes occurring from the time that the current is switched on. *[3]*

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**B2.** This question is about waves and wave motion.

(a) (i) Define what is meant by the *speed of a wave*. *[2]*

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(ii) Light is emitted from a candle flame. Explain why, in this situation, it is correct to refer to the "speed of the emitted light", rather than its velocity. *[2]*

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(b) (i) Define, by reference to wave motion, what is meant by *displacement*. *[2]*

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(ii) By reference to displacement, describe the difference between a longitudinal wave and a transverse wave. *[3]*

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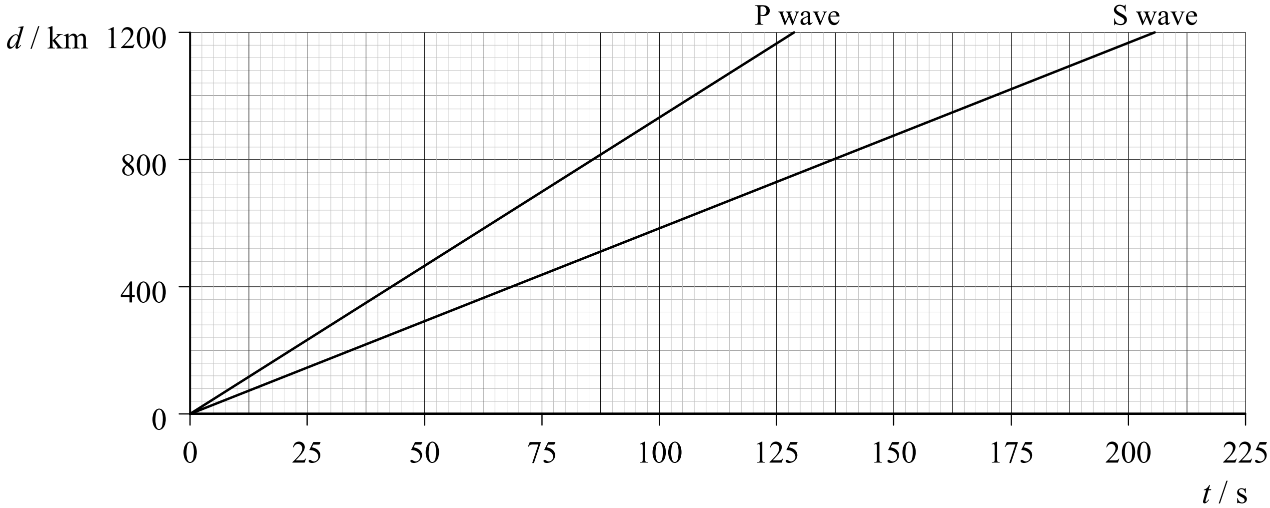
*(This question continues on the following page)*

*(Question B2 continued)*

The centre of an earthquake produces both longitudinal waves (P waves) and transverse waves (S waves). The graph below shows the variation with time $t$ of the distance $d$ moved by the two types of wave.




(c) Use the graph to determine the speed of

(i) the P waves. *[1]*

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(ii) the S waves. *[1]*

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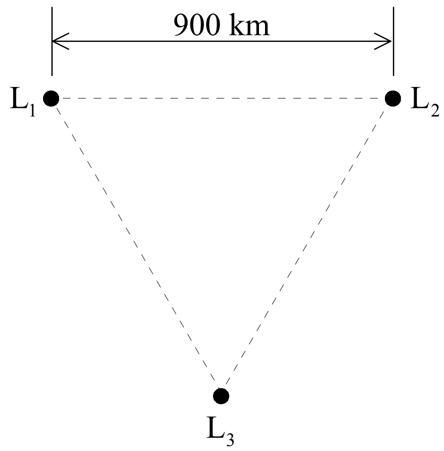
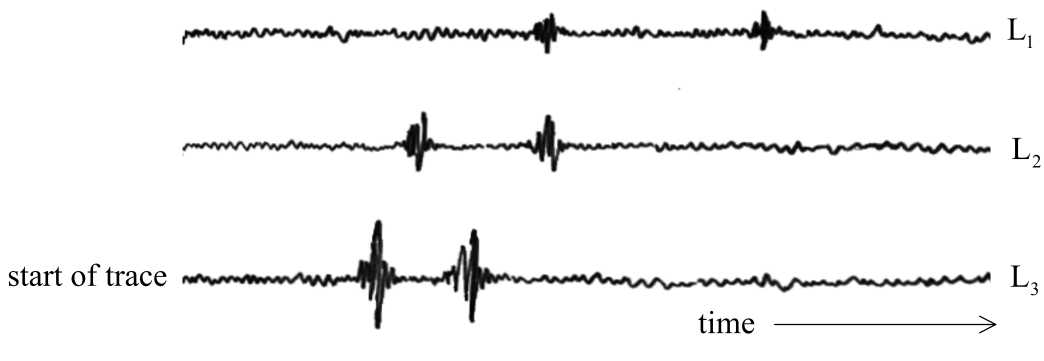
*(This question continues on the following page)*

*(Question B2 continued)*

The waves from an earthquake close to the Earth's surface are detected at three laboratories $L_1$, $L_2$ and $L_3$. The laboratories are at the corners of a triangle so that each is separated from the others by a distance of 900 km, as shown in the diagram below.




The records of the variation with time of the vibrations produced by the earthquake as detected at the three laboratories are shown below. All three records were started at the same time.




On each record, one pulse is made by the S wave and the other by the P wave. The separation of the two pulses is referred to as the S-P interval.

*(This question continues on the following page)*

*(Question B2 continued)*

(d) (i) On the trace produced by laboratory $L_2$, identify, by reference to your answers in (c), the pulse due to the P wave (label the pulse P). *[1]*

(ii) Using evidence from the records of the earthquake, state which laboratory was closest to the site of the earthquake. *[1]*

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(iii) State **three** separate pieces of evidence for your statement in (d)(ii). *[3]*

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(iv) The S-P intervals are 68 s, 42 s and 27 s for laboratories $L_1$, $L_2$ and $L_3$ respectively. Use the graph, or otherwise, to determine the distance of the earthquake from each laboratory. Explain your working. *[4]*

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Distance from $L_1$ = . . . . . . . . . . . . . . . . . . . . . km

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Distance from $L_2$ = . . . . . . . . . . . . . . . . . . . . . km

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Distance from $L_3$ = . . . . . . . . . . . . . . . . . . . . . km

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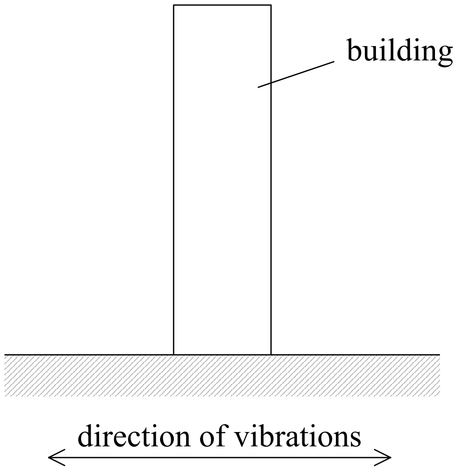
(v) Mark on the diagram a possible site of the earthquake. *[1]*

*(This question continues on the following page)*

*(Question B2 continued)*

There is a tall building near to the site of the earthquake, as illustrated below.




The base of the building vibrates horizontally due to the earthquake.

(e) (i) On the diagram above, draw the fundamental mode of vibration of the building caused by these vibrations. *[1]*

The building is of height 280 m and the mean speed of waves in the structure of the building is $3.4\times10^{3}\,\mathrm{m\,s^{-1}}$.

(ii) Explain quantitatively why earthquake waves of frequency about 6 Hz are likely to be very destructive. *[3]*

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**B3.** This question is about nuclear reactions.

(a) (i) Distinguish between *fission* and *radioactive decay*. *[4]*

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A nucleus of uranium-235 $\left({}^{235}_{92}\text{U}\right)$ may absorb a neutron and then undergo fission to produce nuclei of strontium-90 $\left({}^{90}_{38}\text{Sr}\right)$ and xenon-142 $\left({}^{142}_{54}\text{Xe}\right)$ and some neutrons.

The strontium-90 and the xenon-142 nuclei both undergo radioactive decay with the emission of $\beta^-$ particles.

(ii) Write down the nuclear equation for this fission reaction. *[2]*

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(iii) State the effect, if any, on the mass number (nucleon number) and on the atomic number (proton number) of a nucleus when the nucleus undergoes $\beta^-$ decay. *[2]*

Mass number: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

Atomic number: . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .

The uranium-235 nucleus is stationary at the time that the fission reaction occurs. In this fission reaction, 198 MeV of energy is released. Of this total energy, 102 MeV and 65 MeV are the kinetic energies of the strontium-90 and xenon-142 nuclei respectively.

(b) (i) Calculate the magnitude of the momentum of the strontium-90 nucleus. *[4]*

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*(This question continues on the following page)*

*(Question B3 continued)*

(ii) Explain why the magnitude of the momentum of the strontium-90 nucleus is not exactly equal in magnitude to that of the xenon-142 nucleus. *[2]*

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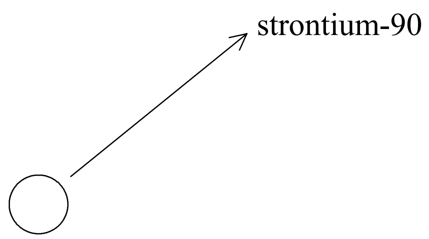
On the diagram below, the circle represents the position of a uranium-235 nucleus before fission. The momentum of the strontium-90 nucleus after fission is represented by the arrow.




(iii) On the diagram above, draw an arrow to represent the momentum of the xenon-142 nucleus after the fission. *[2]*

*(This question continues on the following page)*

*(Question B3 continued)*

(c) In a fission reactor for the generation of electrical energy, 25% of the total energy released in a fission reaction is converted into electrical energy.

(i) Using the data in (b), calculate the electrical energy, in joules, produced as a result of nuclear fission of one nucleus. *[2]*

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(ii) The specific heat capacity of water is $4.2\times10^{3}\,\text{J kg}^{-1}\,\text{K}^{-1}$. Calculate the energy required to raise the temperature of 250 g of water from $20\,^{\circ}\text{C}$ to its boiling point $(100\,^{\circ}\text{C})$. *[3]*

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(iii) Using your answer to (c)(i), determine the mass of uranium-235 that must be fissioned in order to supply the amount of energy calculated in (c)(ii). The mass of a uranium-235 atom is $3.9\times10^{-25}\,\text{kg}$. *[4]*

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