N10/4/PHYSI/SP2/ENG/TZ0/XX

88106505

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

PHYSICS
STANDARD LEVEL
PAPER 2

Monday 8 November 2010 (afternoon)

1 hour 15 minutes

Candidate session number

0	0							

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.

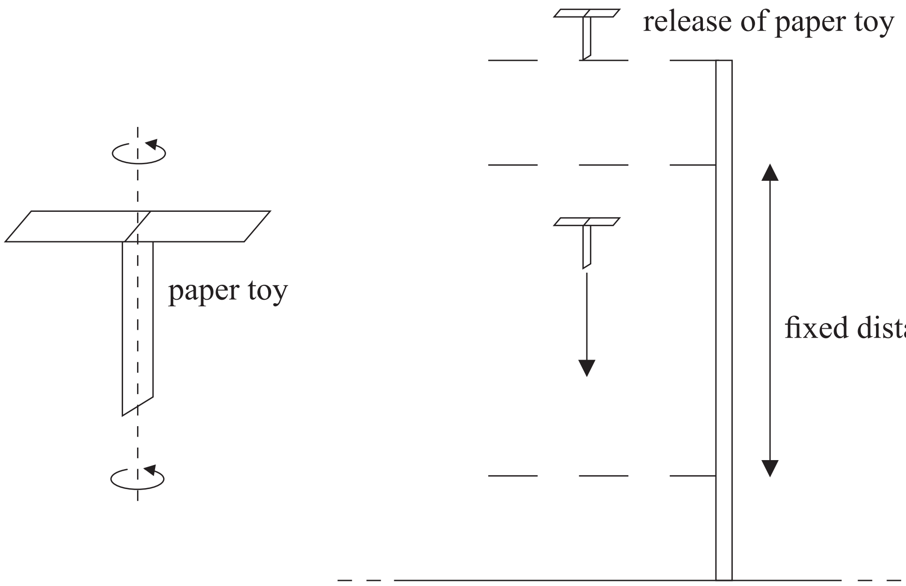
Blank page

SECTION A

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

A1. Data analysis question.

A student performs an experiment with a paper toy that rotates as it falls slowly through the air. After release, the paper toy quickly attains a constant vertical speed as measured over a fixed vertical distance.

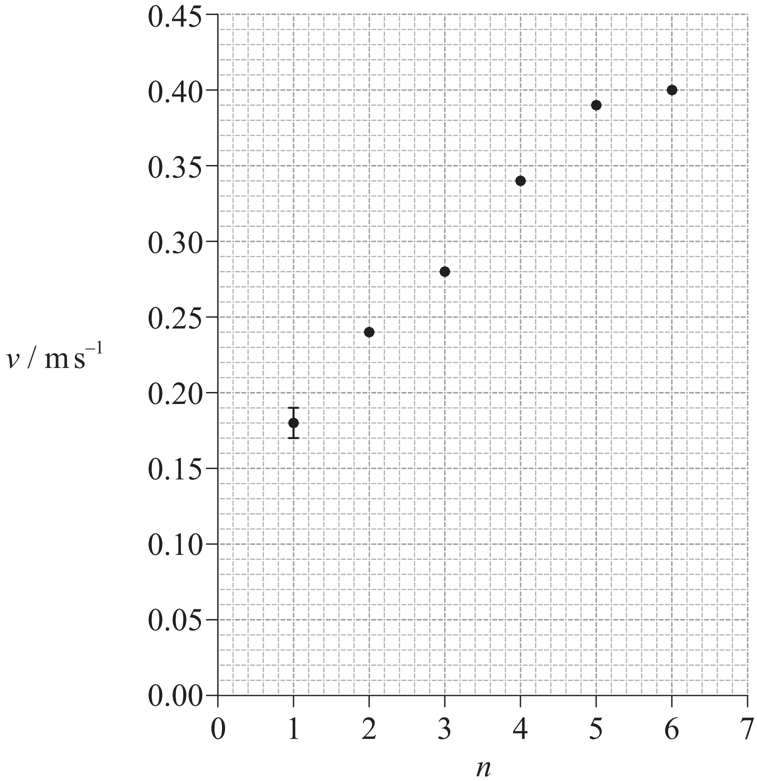


The aim of the experiment was to find how the terminal speed of the paper toy varies with its weight. The weight of the paper toy was changed by using different numbers of paper sheets in its construction.

(This question continues on the following page)

(Question A1 continued)

The graph shows a plot of the terminal speed v of the paper toy (calculated from the raw data) and the number of paper sheets n used to construct the toy. The uncertainty in v for $n=1$ is shown by the error bar.



(a) The fixed distance is 0.75 m and has an absolute uncertainty of 0.01 m. The percentage uncertainty in the time taken to fall through the fixed distance is 5 %.

(i) Calculate the absolute uncertainty in the terminal speed of the paper toy for $n=6$. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

(ii) On the graph, draw an error bar on the point corresponding to $n=6$. *[1]*

(b) On the graph, draw a line of best-fit for the data points. *[1]*

(This question continues on the following page)

(Question A1 continued)

(c) The student hypothesizes that v is proportional to n. Use the data points for $n=2$ and $n=4$ from the graph opposite to show that this hypothesis is incorrect. *[3]*

. . . .

. . . .

. . . .

. . . .

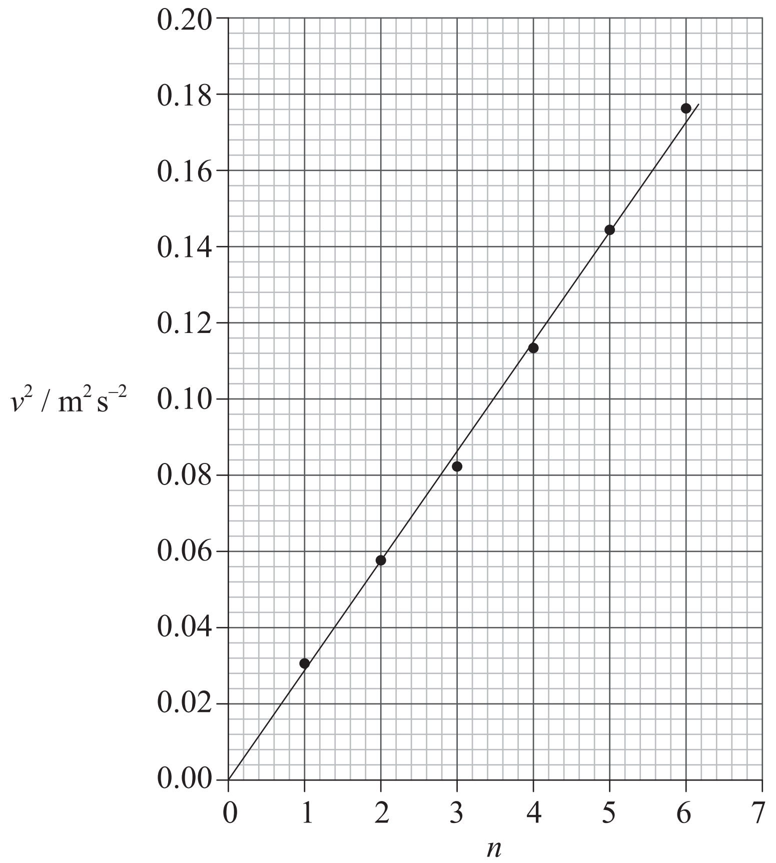
. . . .

. . . .

(This question continues on the following page)

(Question A1 continued)

(d) Another student hypothesized that v might be proportional to $\sqrt{n}$. To verify this hypothesis he plotted a graph of v^2 against n as shown below.



Explain how the graph verifies the hypothesis that v is proportional to $\sqrt{n}$. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

A2. In 1997 a high-speed car of mass 1.1×10^4 kg achieved the world land speed record. The car accelerated uniformly in two stages as shown in the table. The car started from rest.

	Time / s	**Speed attained at end of stage / $m\,s^{-1}$**
Stage 1	0.0 – 4.0	44
Stage 2	4.0 – 12	280

Use the data to calculate the

(a) average acceleration of the car in stage 1. *[1]*

. . . .

. . . .

. . . .

(b) average net force required to accelerate the car in stage 2. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

(c) total distance travelled by the car in 12 s. *[2]*

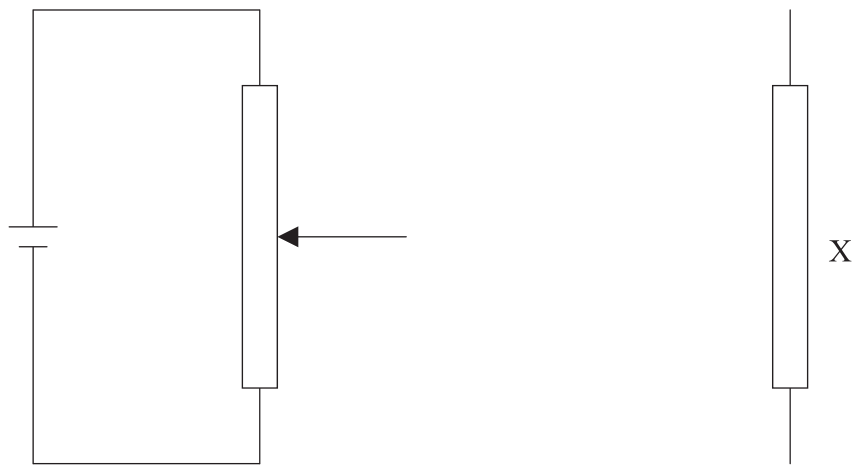
. . . .

. . . .

. . . .

. . . .

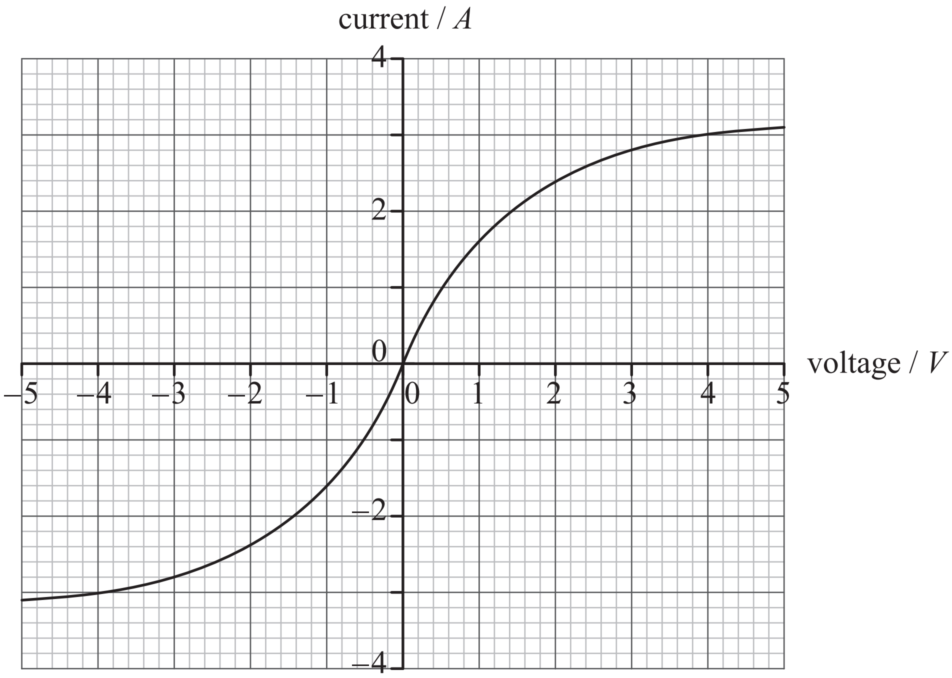
A3. (a) Draw the complete diagram of the circuit that uses a potential divider, ammeter, voltmeter and cell to measure the current-voltage characteristics for component X. *[3]*



(This question continues on the following page)

(Question A3 continued)

(b) The graph shows the current-voltage characteristics for the component X.



Component X is now connected across the terminals of a cell of emf 2.0 V and negligible internal resistance. Use the graph to show that the resistance of X is 0.83 Ω. *[2]*

. . . .

. . . .

. . . .

. . . .

(c) A resistor of constant resistance 1.0 Ω is connected in series with the cell in (b) and with X. Use the graph to deduce that the current in the circuit is 1.3 A. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

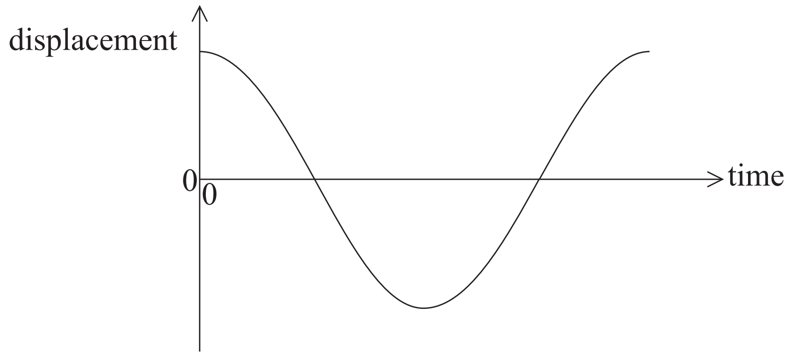
SECTION B

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

B1. This question is in **two** parts. **Part 1** is about a simple pendulum. **Part 2** is about the Rutherford model of the atom.

Part 1 Simple pendulum

(a) A pendulum consists of a bob suspended by a light inextensible string from a rigid support. The pendulum bob is moved to one side and then released. The sketch graph shows how the displacement of the pendulum bob undergoing simple harmonic motion varies with time over one time period.



On the sketch graph above,

(i) label with the letter A a point at which the acceleration of the pendulum bob is a maximum. *[1]*

(ii) label with the letter V a point at which the speed of the pendulum bob is a maximum. *[1]*

(b) Explain why the magnitude of the tension in the string at the midpoint of the oscillation is greater than the weight of the pendulum bob. *[3]*

. . . .

. . . .

. . . .

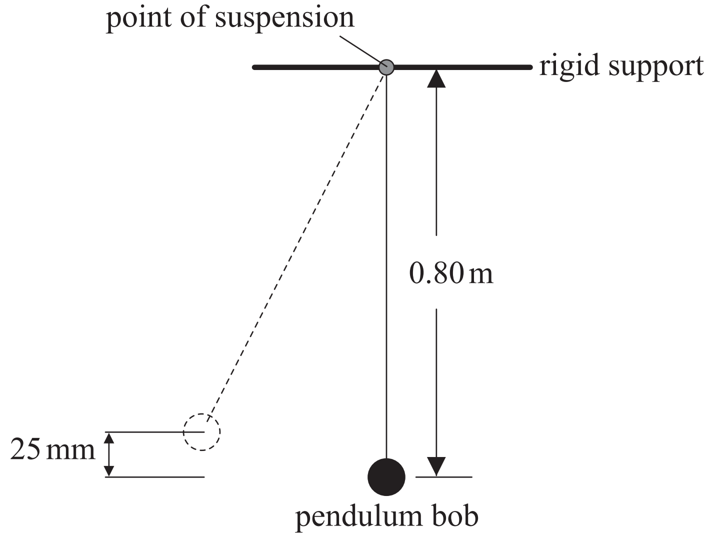
. . . .

. . . .

(This question continues on the following page)

(Question B1, part 1 continued)

(c) The pendulum bob is moved to one side until its centre is 25 mm above its rest position and then released.



(i) Show that the speed of the pendulum bob at the midpoint of the oscillation is $0.70\,\text{m s}^{-1}$. *[2]*

. . . .

. . . .

. . . .

. . . .

(ii) The mass of the pendulum bob is 0.057 kg. The centre of the pendulum bob is 0.80 m below the support. Calculate the magnitude of the tension in the string when the pendulum bob is vertically below the point of suspension. *[3]*

. . . .

. . . .

. . . .

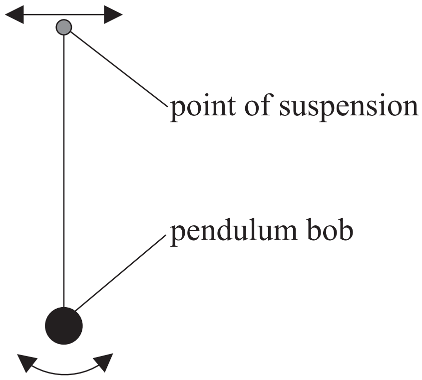
. . . .

. . . .

(This question continues on the following page)

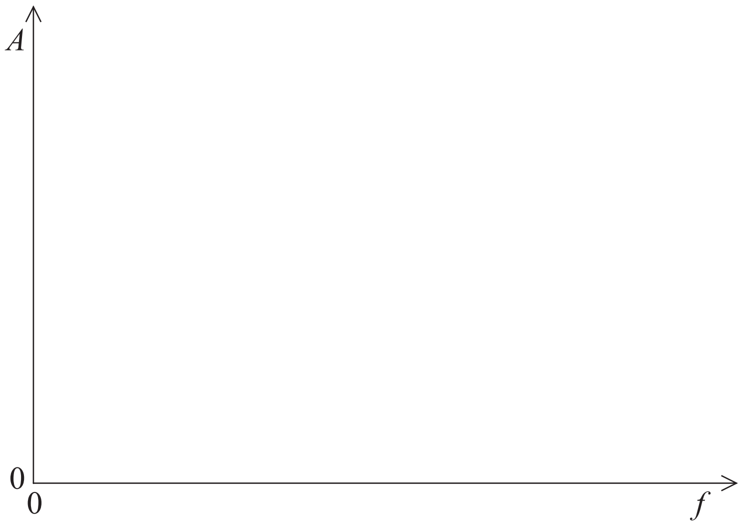
(Question B1, part 1 continued)

(d) The point of suspension of the pendulum bob is moved from side to side with a small amplitude and at a variable driving frequency *f*.



For each value of the driving frequency a steady constant amplitude *A* is reached. The oscillations of the pendulum bob are lightly damped.

(i) On the axes below, sketch a graph to show the variation of *A* with *f*. *[2]*



(ii) Explain, with reference to the graph in (d)(i), what is meant by resonance. *[2]*

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B1, part 1 continued)

(e) The pendulum bob is now immersed in water and the variable frequency driving force in (d) is again applied. Suggest the effect this immersion of the pendulum bob will have on the shape of your graph in (d)(i). *[2]*

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B1 continued)

Part 2   Rutherford model of the atom

(a) Most alpha particles used to bombard a thin gold foil pass through the foil without a significant change in direction. A few alpha particles are deviated from their original direction through angles greater than 90°. Use these observations to describe the Rutherford atomic model. *[5]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B1, part 2 continued)

(b) The isotope gold-197 $\left({}^{197}_{79}Au\right)$ is stable but the isotope gold-199 $\left({}^{199}_{79}Au\right)$ is not.

(i) Outline, in terms of the forces acting between nucleons, why, for large stable nuclei such as gold-197, the number of neutrons exceeds the number of protons. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(ii) A nucleus of ${}^{199}_{79}\text{Au}$ decays to a nucleus of ${}^{199}_{80}\text{Hg}$ with the emission of an electron and another particle. State the name of this other particle. *[1]*

. . . .

. . . .

B2. This question is in **two** parts. **Part 1** is about a lightning discharge. **Part 2** is about fuel for heating.

Part 1 Lightning discharge

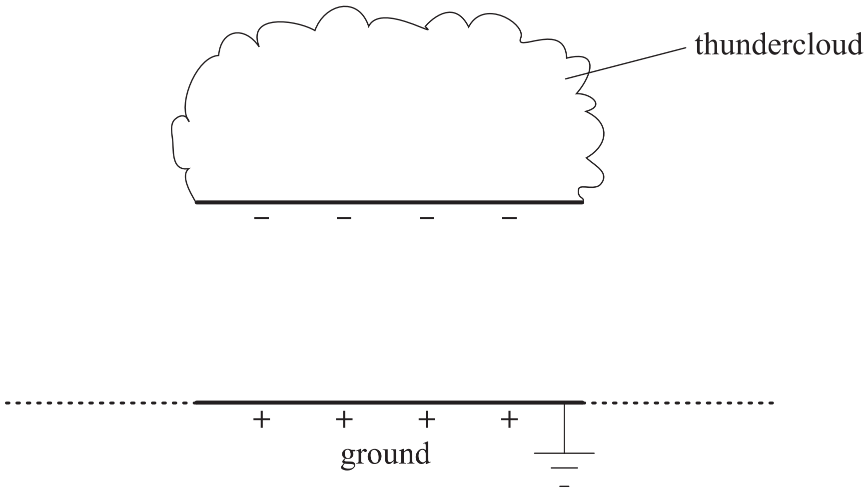
(a) Define *electric field strength*. *[2]*

. . . .

. . . .

. . . .

(b) A thundercloud can be modelled as a negatively charged plate that is parallel to the ground.



The magnitude of the charge on the plate increases due to processes in the atmosphere. Eventually a current discharges from the thundercloud to the ground.

On the diagram, draw the electric field pattern between the thundercloud base and the ground. *[3]*

(This question continues on the following page)

(Question B2, part 1 continued)

(c) The magnitude of the electric field strength E between two infinite charged parallel plates is given by the expression

$$E = \frac{\sigma}{\varepsilon_0}$$

where σ is the charge per unit area on one of the plates.

A thundercloud carries a charge of magnitude 35 C spread over its base. The area of the base is $1.2 \times 10^7\,\text{m}^2$.

(i) Determine the magnitude of the electric field between the base of the thundercloud and the ground. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(ii) State **two** assumptions made in (c)(i). *[2]*

1. . . . .

. . . .

2. . . . .

. . . .

(iii) When the thundercloud discharges, the average discharge current is 1.8 kA. Estimate the discharge time. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B2, part 1 continued)

(iv) The potential difference between the thundercloud and the ground before discharge is 2.5×10^{8} V. Determine the energy released in the discharge. *[4]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B2 continued)

Part 2 Fuel for heating

(a) Define the *energy density* of a fuel. *[1]*

. . . .

. . . .

(b) A room heater burns liquid fuel and the following data are available.

Density of liquid fuel	$= 8.0 \times 10^2\,\text{kg}\,\text{m}^{-3}$
Energy produced by $1\,\text{m}^3$ of liquid fuel	$= 2.7 \times 10^{10}\,\text{J}$
Rate at which fuel is consumed	$= 0.13\,\text{g}\,\text{s}^{-1}$
Latent heat of vaporization of the fuel	$= 290\,\text{kJ}\,\text{kg}^{-1}$

(i) Use the data to calculate the power output of the room heater, ignoring the power required to convert the liquid fuel into a gas. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

(ii) Show why, in your calculation in (b)(i), the power required to convert the liquid fuel into a gas at its boiling point can be ignored. *[2]*

. . . .

. . . .

. . . .

. . . .

(c) State, in terms of molecular structure and their motion, **two** differences between a liquid and a gas. *[2]*

1. . . . .

. . . .

2. . . . .

. . . .

B3. This question is in **two** parts. **Part 1** is about the production of energy in nuclear fission. **Part 2** is about collisions.

Part 1 Production of energy in nuclear fission

(a) A possible fission reaction is

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{92}_{36}Kr + ^{141}_{56}Ba + x\,^{1}_{0}n.$$

(i) State the value of x. *[1]*

. . . .

. . . .

(ii) Show that the energy released when one uranium nucleus undergoes fission in the reaction in (a) is about 2.8×10^{-11} J. *[4]*

Mass of neutron	= 1.00867 u
Mass of U-235 nucleus	= 234.99333 u
Mass of Kr-92 nucleus	= 91.90645 u
Mass of Ba-141 nucleus	= 140.88354 u

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(iii) State how the energy of the neutrons produced in the reaction in (a) is likely to compare with the energy of the neutron that initiated the reaction. *[1]*

. . . .

. . . .

(This question continues on the following page)

(Question B3, part 1 continued)

(b) Outline the role of the moderator. *[2]*

. . . .

. . . .

. . . .

. . . .

. . . .

(c) A nuclear power plant that uses U-235 as fuel has a useful power output of 16 MW and an efficiency of 40 %. Assuming that each fission of U-235 gives rise to 2.8×10^{-11} J of energy, determine the mass of U-235 fuel used per day. *[4]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B3 continued)

Part 2 Collisions

(a) State the principle of conservation of momentum. *[2]*

. . . .

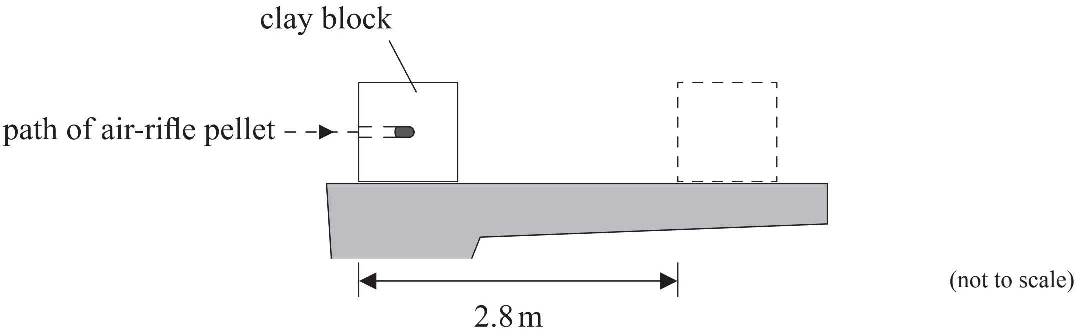
. . . .

. . . .

(This question continues on the following page)

(Question B3, part 2 continued)

(b) In an experiment, an air-rifle pellet is fired into a block of modelling clay that rests on a table.



The air-rifle pellet remains inside the clay block after the impact.

As a result of the collision, the clay block slides along the table in a straight line and comes to rest. Further data relating to the experiment are given below.

Mass of air-rifle pellet	= 2.0 g
Mass of clay block	= 56 g
Velocity of impact of air-rifle pellet	= 140 m s^{-1}
Stopping distance of clay block	= 2.8 m

(i) Show that the initial speed of the clay block after the air-rifle pellet strikes it is 4.8 m s^{-1}. *[2]*

. . . .

. . . .

. . . .

. . . .

(ii) Calculate the average frictional force that the surface of the table exerts on the clay block whilst the clay block is moving. *[4]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question B3, part 2 continued)

(c) Discuss the energy transformations that occur in the clay block and the air-rifle pellet from the moment the air-rifle pellet strikes the block until the clay block comes to rest. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(d) The clay block is dropped from rest from the edge of the table and falls vertically to the ground. The table is 0.85 m above the ground. Calculate the speed with which the clay block strikes the ground. *[2]*

. . . .

. . . .

. . . .

. . . .