OXFORD
INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number | | | | | |    Candidate number | | | | |

Surname ______________________

Forename(s) ______________________

Candidate signature ______________________
I declare this is my own work.

# INTERNATIONAL AS
# PHYSICS

## Unit 1 Mechanics, materials and atoms

Time allowed: 2 hours

**Materials**
For this paper you must have:
- a Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate
- a protractor.

**Instructions**
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

**Information**
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

| For Examiner's Use | |
|---|---|
| Question | Mark |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| 11–24 | |
| **TOTAL** | |

Do not write outside the box

## Section A

Answer **all** questions in this section.

**0 1 . 1** State what is meant by background radiation.

**[1 mark]**

**0 1 . 2** Describe **one** origin of **artificial** background radiation.

**[1 mark]**

2

**0 2** Complete the equation for the beta-plus ($\beta^+$) decay of a carbon-11 nucleus.

**[2 marks]**

$$^{11}_{6}\mathrm{C} \rightarrow \,^{\_}_{\_}\mathrm{B} + \beta^+ + \_\_\_\_$$

2

**0 3** A photon of electromagnetic radiation can be converted into an electron and a second particle in a pair-production event.

**0 3 . 1** Identify the second particle that is created in this pair-production event.

**[1 mark]**

**0 3 . 2** Explain why the photon energy must be greater than a minimum value for the pair-production event to happen.

**[2 marks]**

3

Do not write outside the box

**0 4 . 1** State what is meant by a vector quantity.

**[1 mark]**

**Figure 1** shows an athletics track.

**Figure 1**


**0 4 . 2** An athlete runs at constant speed through sections **A** and **B** of the track.

State and explain whether the athlete is accelerating in sections **A** and **B**.

**[3 marks]**

**A**

**B**

4

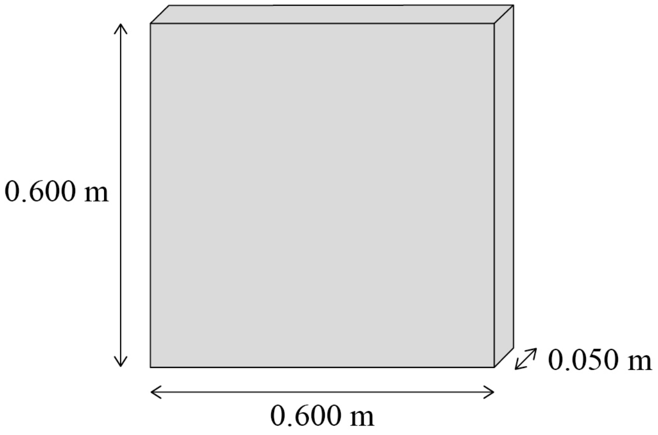
*Do not write outside the box*

**0 5 . 1** State what is meant by the centre of mass of an object.

**[1 mark]**

A uniform concrete block has the dimensions shown in **Figure 2**.

**Figure 2**




The weight of the concrete block is 343 N.

**0 5 . 2** Calculate the density of the concrete.

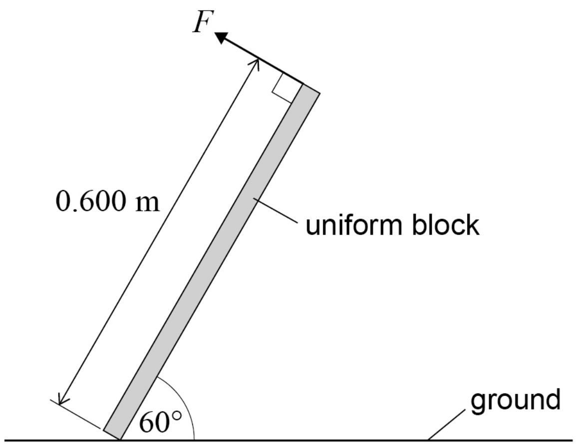
**[2 marks]**

density = ______________________ $kg\ m^{-3}$

Do not write outside the box

**0 5 . 3** **Figure 3** shows the uniform block held in equilibrium by a force $F$ that is acting at $90°$ to the block.

**Figure 3**




Calculate the magnitude of force $F$.

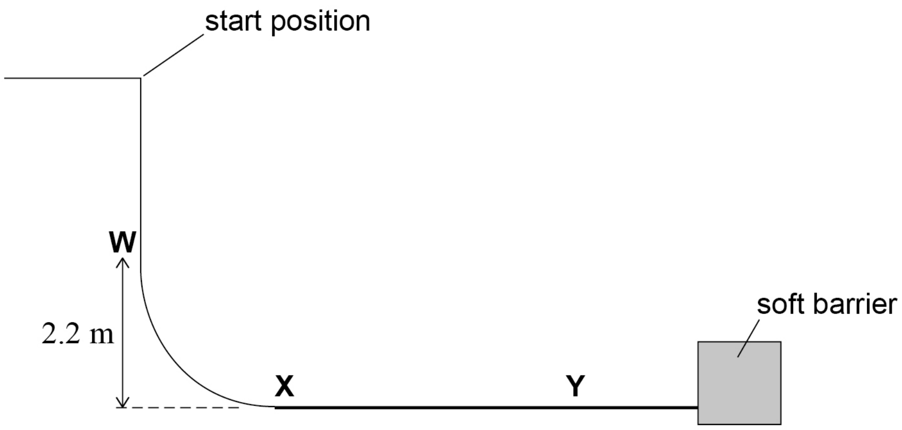
**[3 marks]**

$F =$ _______________ N

6

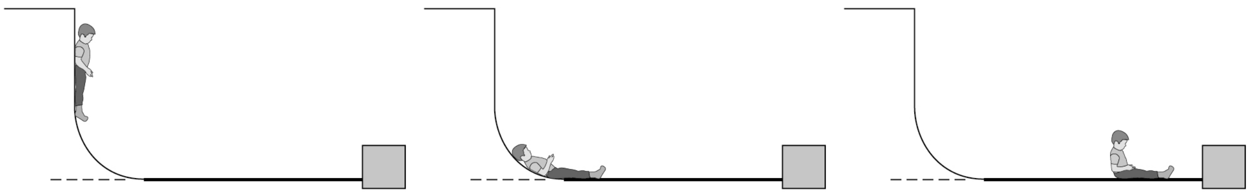
**0 6** **Figure 4** shows a drop slide in a theme park.

**Figure 4**




**W** is the start of the curved section. **X** is the start of the horizontal section.
A child travels along the horizontal section of the slide before coming to rest at **Y**.
There is a soft barrier as a safety precaution.
**Figures 5a**, **5b** and **5c** represent the motion of the child on the vertical section, the curved section and the horizontal section of the drop slide.

**Figure 5a** **Figure 5b** **Figure 5c**



**0 6 . 1** A child of mass $40\ \mathrm{kg}$ using the drop slide has a speed of $7.5\ \mathrm{m\ s^{-1}}$ at **W**.

Show that the kinetic energy of the child at **X** is approximately $2\ \mathrm{kJ}$.
Ignore friction between **W** and **X**.

**[3 marks]**

Do not write outside the box

**0 6 . 2** The average frictional force that acts on the moving child between **X** and **Y** is $250\ \mathrm{N}$.

Calculate the distance **XY**.

**[2 marks]**

**XY** = ______________________ m

**0 6 . 3** A man of mass $90\ \mathrm{kg}$ uses the slide. His speed as he hits the soft barrier is $3.2\ \mathrm{m\ s^{-1}}$.
The horizontal section is $12.5\ \mathrm{m}$ in length.
He loses $90\%$ of his kinetic energy along the horizontal section.

Calculate the average frictional force that acts on the man along the horizontal section.

**[3 marks]**

average frictional force = ______________________ N

**0 6 . 4** Explain why a soft barrier is used to reduce the risk of injury rather than a rigid barrier.

**[4 marks]**

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

12

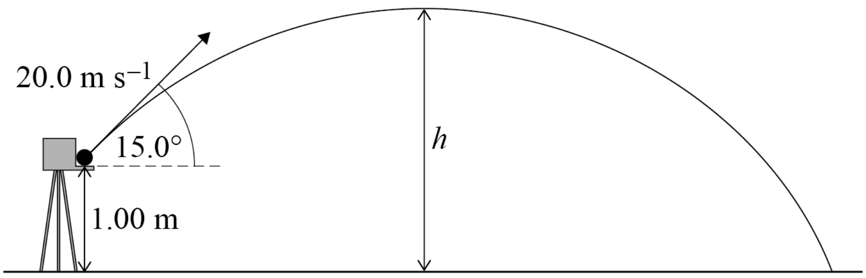
**0 7** **Figure 6** shows a machine that projects a tennis ball with an initial velocity of $20\ \mathrm{m\ s^{-1}}$ at an angle of $15.0°$ to the horizontal.

$h$ is the maximum height that the ball reaches above the ground.

Ignore air resistance in all of your calculations.

**Figure 6**

**not to scale**




**0 7 . 1** Calculate the vertical component of the initial velocity of the ball.

**[1 mark]**

vertical component = ______________________ $\mathrm{m\ s^{-1}}$

**0 7 . 2** Show that $h$ is approximately $2.4\ \mathrm{m}$.

**[3 marks]**

Do not write outside the box

**0 7 . 3** Calculate the horizontal distance the ball travels before it lands.

**[3 marks]**

distance = ______________________ m

**0 7 . 4** The machine now projects a ball of mass 58 g vertically upwards.
The machine uses a compressed spring to do this.
The spring obeys Hooke's Law and is compressed through a distance of 0.050 m in order to project the ball.
The spring constant of the spring is $9.3\ \text{kN m}^{-1}$.

Calculate the maximum height above the point of release that the ball can reach.

**[3 marks]**

maximum height = ______________________ m

**Question 7 continues on the next page**

Do not write outside the box

**0 7 . 5** The ball does not reach this maximum height.

Explain why.

**[2 marks]**

**12**

*Do not write outside the box*

**0 8 . 1** Calculate the specific charge of a nucleus of gold-197 $\left({}^{197}_{79}\mathrm{Au}\right)$.

State an appropriate unit for your answer.

**[3 marks]**

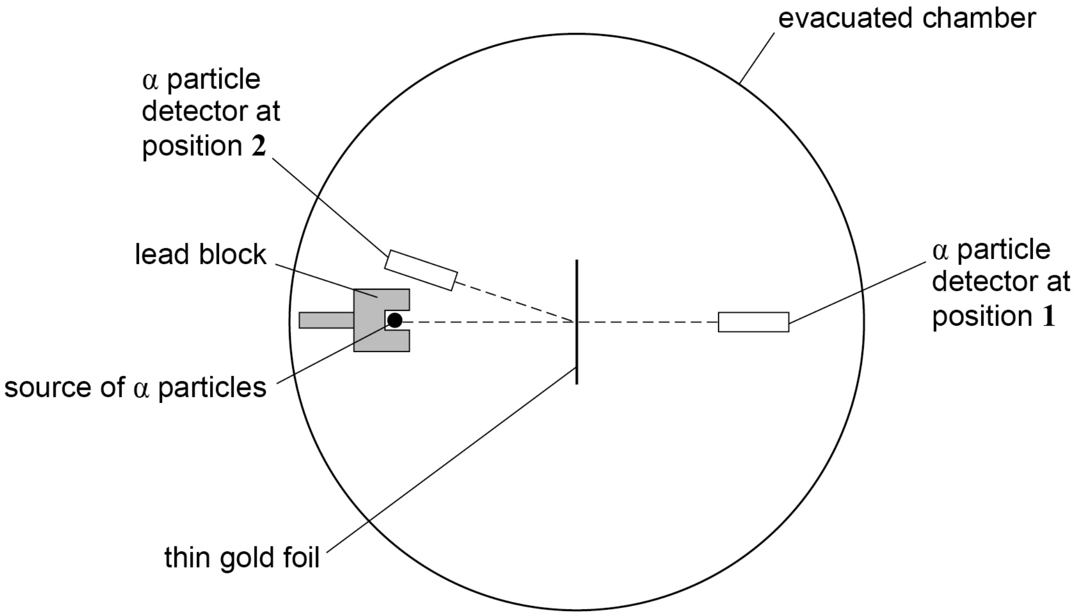
specific charge = ______________________ unit ____________

**Question 8 continues on the next page**

**Figure 7** shows a Rutherford scattering experiment in which alpha ($\alpha$) particles are directed at a thin gold foil.

A detector counts the number of alpha particles scattered by the thin gold foil per second.

**Figure 7**




**0 8 . 2** **Figure 7** shows two positions of the detector in the evacuated chamber.

Compare the numbers of alpha particles per second detected at position **1** and position **2**.

**[1 mark]**

______________________________________________________________________

______________________________________________________________________

**0 8 . 3** State **two** conclusions from the Rutherford scattering experiment about the structure of the atom.

**[2 marks]**

1 ____________________________________________________________________

______________________________________________________________________

______________________________________________________________________

2 ____________________________________________________________________

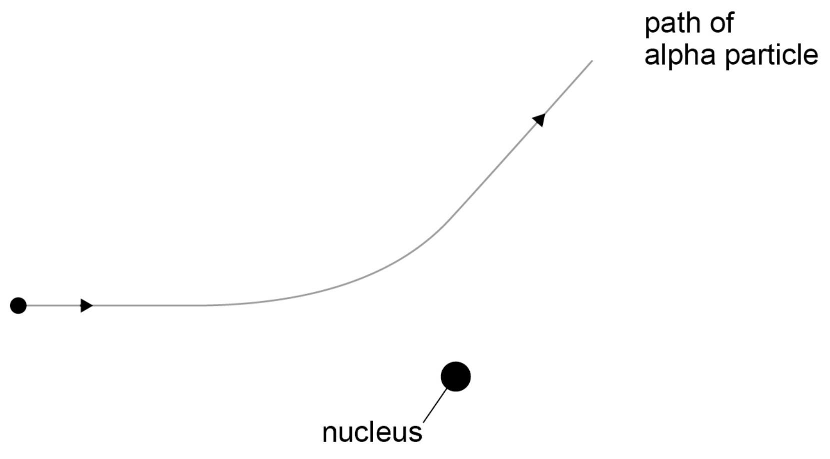
______________________________________________________________________

______________________________________________________________________

*Do not write outside the box*

**Figure 8** shows the path of an alpha particle moving close to a gold nucleus.

**Figure 8**




The experiment is repeated with thin copper-63 $\left({}^{63}_{29}\mathrm{Cu}\right)$ foil instead of gold.

**0 8 . 4** Sketch, on **Figure 8**, a line showing the path taken by an alpha particle with the same energy and starting from the same initial position.

**[1 mark]**

**0 8 . 5** Explain your answer to Question **08.4**.

**[2 marks]**

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

**9**

**END OF SECTION A**

**Turn over ►**

Do not write outside the box

## Section B

Answer **all** questions in this section.

**0 9** Technetium-99m is a radioactive isotope used in hospitals.

**0 9 . 1** Identify the type of radiation that is emitted when a technetium-99m nucleus de-excites.

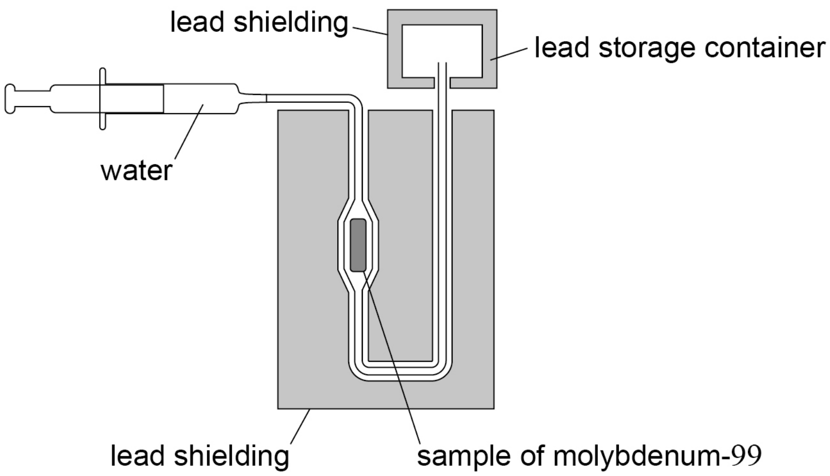
**[1 mark]**

______________________________________________________________

**0 9 . 2** Samples of technetium-99m are prepared at a hospital from a source of the radioactive isotope molybdenum-99 that is stored at the hospital.

**Figure 9** shows the generator that is used to prepare the sample of technetium-99m.

**Figure 9**




Water from a syringe passes through the molybdenum-99 sample.
The technetium-99m that forms from the decay of the molybdenum-99 dissolves in the water. The water containing technetium-99m is collected in a lead storage container.

Explain how the apparatus in **Figure 9** allows safe handling of the collected sample.

**[2 marks]**

______________________________________________________________

______________________________________________________________

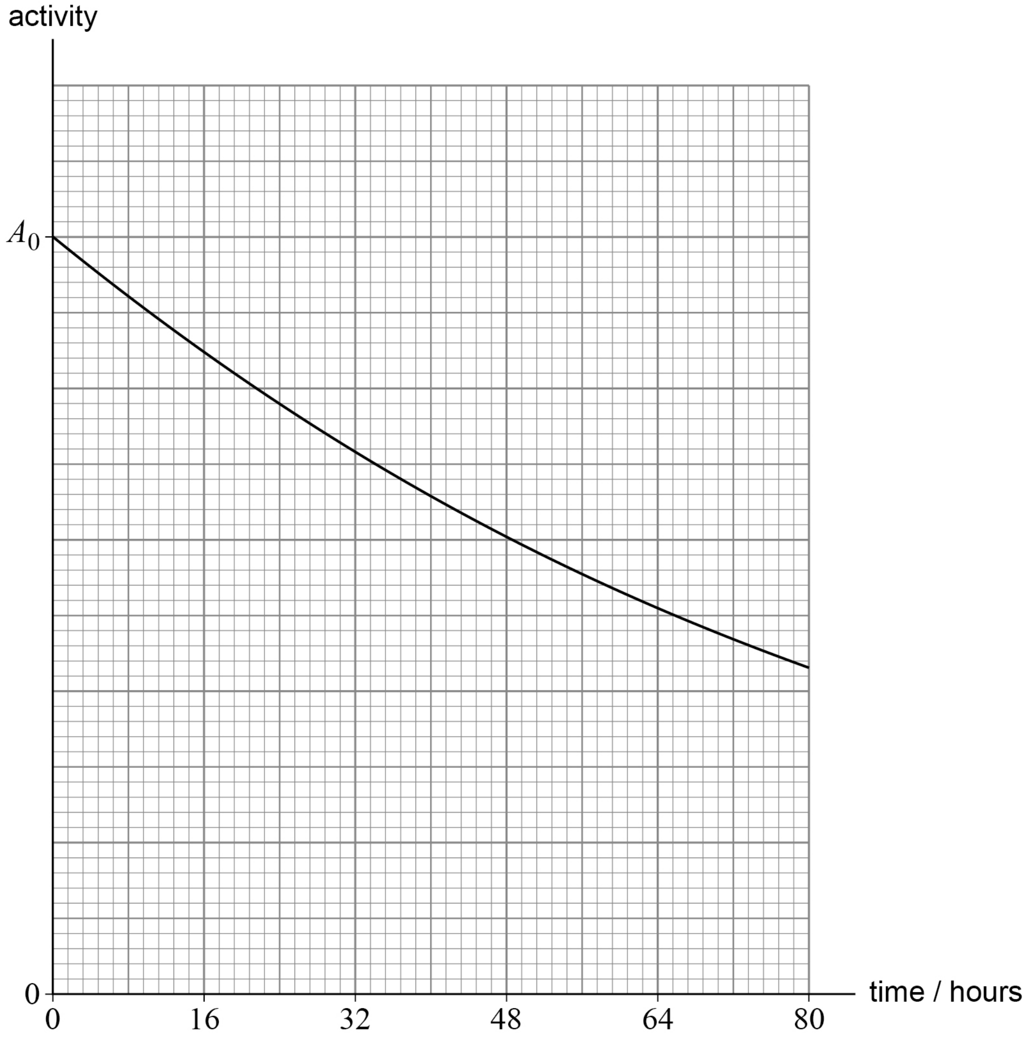
______________________________________________________________

______________________________________________________________

______________________________________________________________

**0 9 . 3** **Figure 10** shows the variation of the activity of molybdenum-99 in the generator over an 80-hour period.
$A_0$ is the initial activity of the molybdenum-99 in the generator.

**Figure 10**




Estimate the half-life of molybdenum-99.

**[1 mark]**

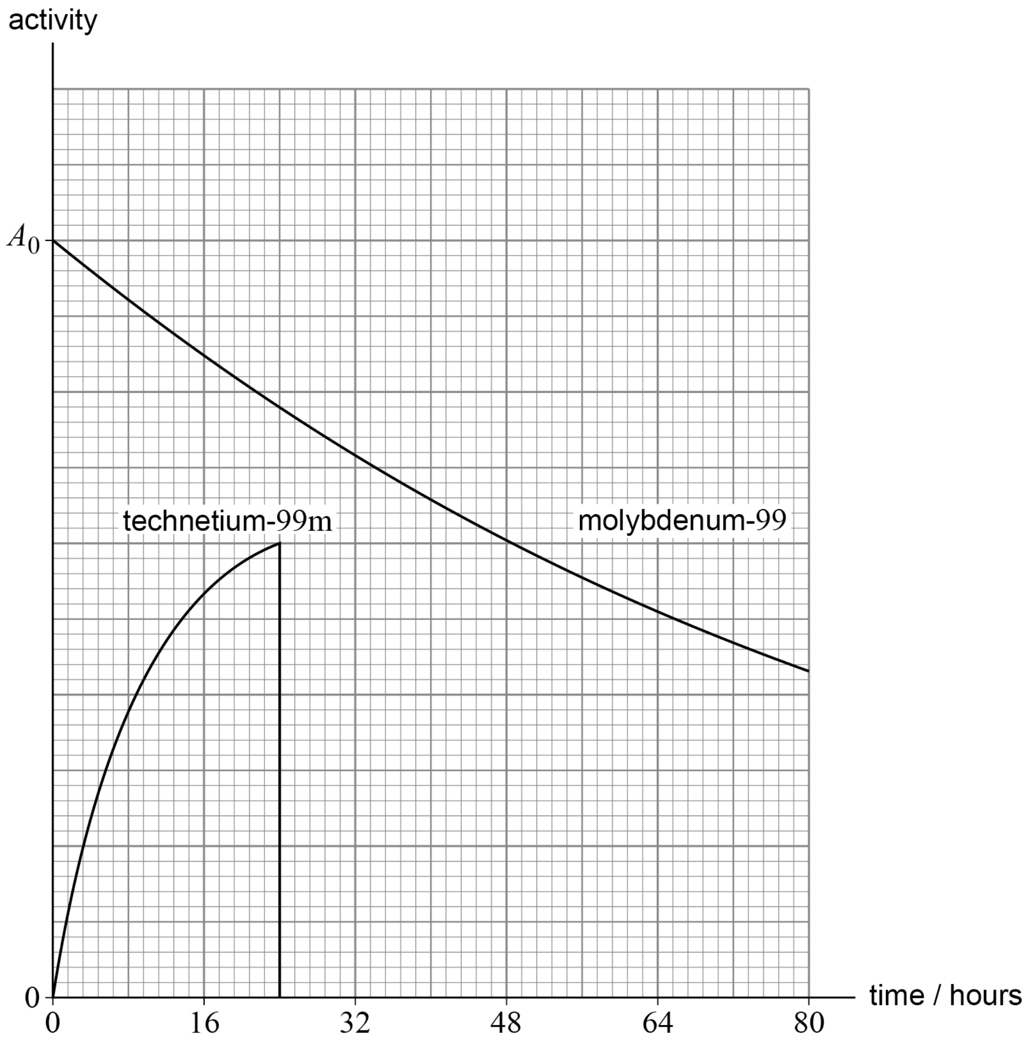
half-life = ______________________ hours

**Question 9 continues on the next page**

**Turn over ►**

**0 9 . 4** **Figure 11** shows the activity of the molybdenum-99 over an 80-hour period and the activity of the technetium-99m that is formed in the generator over the first 24 hours of the same period.

**Figure 11**




A sample of technetium-99m is collected from the generator every 24 hours causing the activity of the technetium-99m in the generator to fall to zero.

Sketch, on **Figure 11**, the activity of the **technetium-99m** between 24 and 72 hours.

**[2 marks]**

Do not write outside the box

**0 9 . 5** Explain why a sample of technetium-99m is collected every 24 hours and not more frequently.

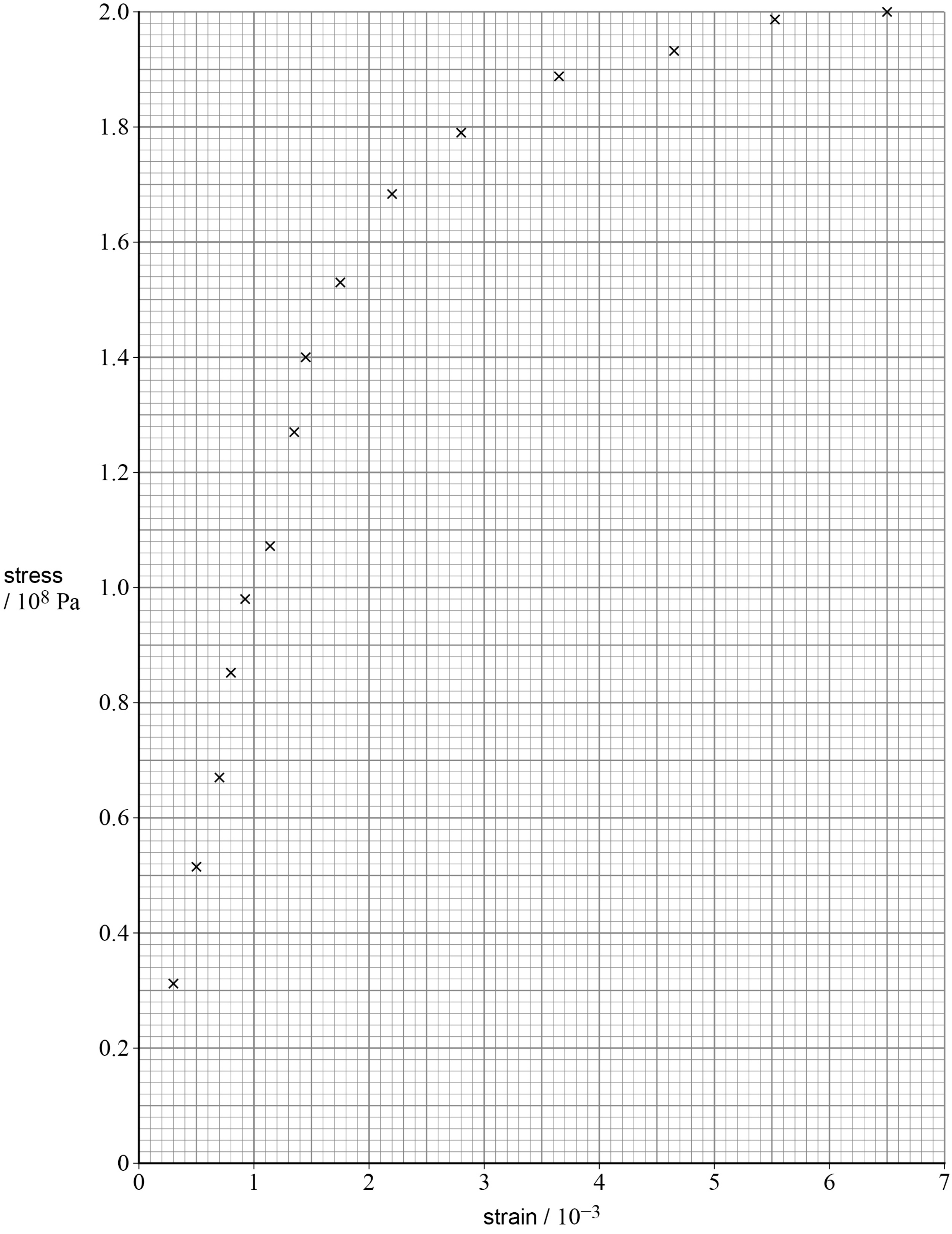
**[2 marks]**

8

**Turn over for the next question**

**1 0** **Figure 12** shows the data from an experiment in which a copper wire was stretched by applying a known tensile force.
The total extension of the wire was recorded for each value of applied force.

**Figure 12**



Do not write outside the box

**1 0 . 1** Draw a line of best fit on **Figure 12**.

**[1 mark]**

**1 0 . 2** Determine, using **Figure 12**, a value for the Young modulus for copper.

**[2 marks]**

Young modulus for copper = ______________________ Pa

**1 0 . 3** Describe how the uncertainty in your value for the Young modulus could be estimated from the graph.

**[1 mark]**

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

**1 0 . 4** The area under a stress–strain graph represents the mechanical work done per unit volume on the material as it is deformed.
The original length of the wire used in this experiment is $1.50\ \mathrm{m}$ and its cross-sectional area is $0.397\ \mathrm{mm}^2$.

Determine the work done on the wire as its original length is increased by $6.0\ \mathrm{mm}$.

**[4 marks]**

work done = ______________________ J

8

**END OF SECTION B**

*Do not write outside the box*

## Section C

Each of the questions in this section is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD  WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

You may do your working in the blank space around each question but this will not be marked.
Do **not** use additional pages for this working.

**1 1** What is the unit of energy in SI (fundamental) base units?

**[1 mark]**

**A** N m

**B** $kg\ m\ s^{-1}$

**C** $kg\ m^2\ s^{-2}$

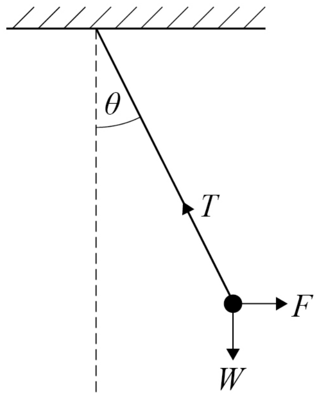
**D** $N\ m\ s^{-1}$

**1 2** Which row shows a scalar quantity and a vector quantity?

**[1 mark]**

| | Scalar | Vector |
|---|---|---|
| **A** | displacement | acceleration |
| **B** | kinetic energy | displacement |
| **C** | weight | speed |
| **D** | distance | temperature |

**1 3** The bob of a pendulum is held in equilibrium as shown in the diagram.




Which expression is correct?

**[1 mark]**

**A** $F = T \times \cos\theta$ ○

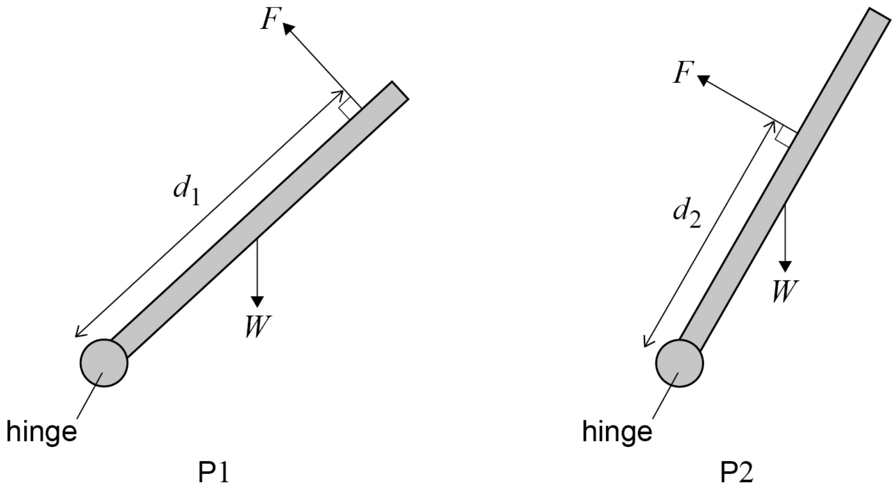
**B** $F = T \times \sin\theta$ ○

**C** $\dfrac{\sin\theta}{F} = T$ ○

**D** $\dfrac{F}{\cos\theta} = T + W$ ○

**Turn over for the next question**

**1 4** A hinged pole of weight $W$ is in equilibrium at positions P1 and P2. Force $F$ has the same magnitude in both positions. $F$ is applied at right angles to the pole at different distances $d_1$ and $d_2$ from the hinge.



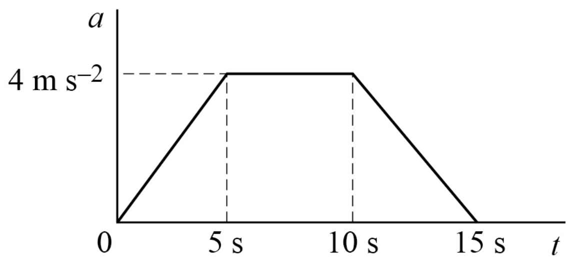

Which row is correct?

**[1 mark]**

| | Clockwise moment about the hinge | Anticlockwise moment about the hinge | |
|---|---|---|---|
| **A** | larger in P1 than in P2 | smaller in P1 than in P2 | ⬭ |
| **B** | larger in P1 than in P2 | larger in P1 than in P2 | ⬭ |
| **C** | smaller in P1 than in P2 | smaller in P1 than in P2 | ⬭ |
| **D** | smaller in P1 than in P2 | larger in P1 than in P2 | ⬭ |

Do not write outside the box

**1 5** The graph shows the variation of acceleration $a$ with time $t$ for an object.




What is the change in velocity of the object due to this acceleration?

**[1 mark]**

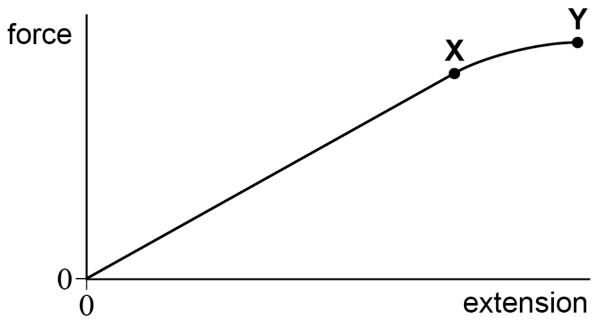
**A** $0$ ⬭

**B** $30\ \mathrm{m\ s^{-1}}$ ⬭

**C** $40\ \mathrm{m\ s^{-1}}$ ⬭

**D** $60\ \mathrm{m\ s^{-1}}$ ⬭

**1 6** A force is applied to a metal wire and causes it to extend.
The force is gradually increased from zero and then reduced back to zero.
The force–extension curve is the same during loading and unloading.



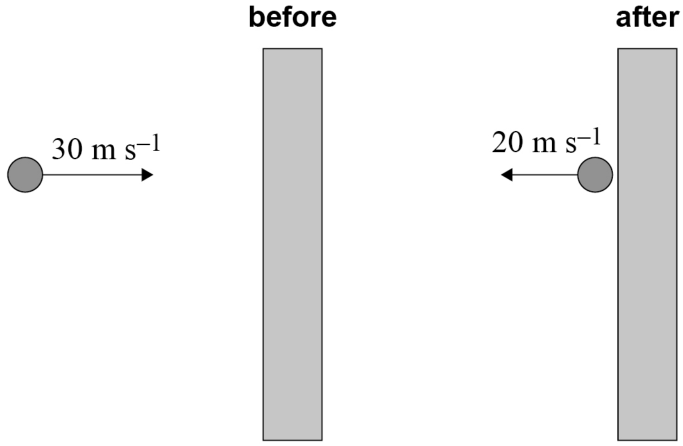

What is the behaviour of the wire between 0 and **X** and between **X** and **Y**?

**[1 mark]**

| | **0X** | **XY** | |
|---|---|---|---|
| **A** | elastic | plastic | ⬭ |
| **B** | elastic | elastic | ⬭ |
| **C** | plastic | plastic | ⬭ |
| **D** | plastic | elastic | ⬭ |

**Turn over ►**

**1 7** A ball of mass $0.1\ \mathrm{kg}$ hits a wall and rebounds.




What is the magnitude of the impulse that acts on the ball?

**[1 mark]**

**A** $1\ \mathrm{N\ s}$

**B** $2\ \mathrm{N\ s}$

**C** $3\ \mathrm{N\ s}$

**D** $5\ \mathrm{N\ s}$

**1 8** A box is pushed a distance $x$ with a force $F$ in a time $t$. The rate of energy transfer is $P$.

The same box is pushed a distance $2x$ with a force $5F$ in a time $\frac{t}{2}$.

What is the new rate of energy transfer?

**[1 mark]**

**A** $2P$

**B** $5P$

**C** $10P$

**D** $20P$

Do not write outside the box

**1 9** Which pair of nuclei has the same number of neutrons?

**[1 mark]**

**A** ${}^{22}_{10}\mathrm{Ne}$ ${}^{23}_{11}\mathrm{Na}$

**B** ${}^{32}_{14}\mathrm{Si}$ ${}^{32}_{15}\mathrm{P}$

**C** ${}^{16}_{8}\mathrm{O}$ ${}^{17}_{8}\mathrm{O}$

**D** ${}^{11}_{5}\mathrm{B}$ ${}^{11}_{6}\mathrm{C}$

**2 0** Which is a possible annihilation event?

**[1 mark]**

**A** $\mathrm{p} + \overline{\mathrm{p}} \rightarrow \gamma$

**B** $\mathrm{p} + \mathrm{p} \rightarrow \gamma + \gamma$

**C** $\mathrm{e}^{-} + \mathrm{e}^{+} \rightarrow \gamma$

**D** $\mathrm{e}^{-} + \mathrm{e}^{+} \rightarrow \gamma + \gamma$

**2 1** Alpha particles

**[1 mark]**

**A** can be deflected by a strong magnetic field.

**B** are less ionising than beta particles.

**C** have a greater specific charge than beta particles.

**D** obey the inverse-square law in air.

**Turn over for the next question**

Do not write outside the box

**2 2** A radioactive source has a half-life of 3 days.

Initially a detector at a fixed distance from the source records an average count rate of 180 counts per minute.

The average background count rate is 20 counts per minute.

What is the average count rate recorded by the detector 6 days later?

**[1 mark]**

**A** 40 counts per minute ⬭

**B** 45 counts per minute ⬭

**C** 60 counts per minute ⬭

**D** 65 counts per minute ⬭

**2 3** A detector is placed 30 cm from a gamma source and records an average count rate of 290 counts per minute.

A second identical detector is placed a distance of 90 cm from the source.
The average background count rate is 20 counts per minute.

What is the average count rate measured by the second detector?

**[1 mark]**

**A** 30 counts per minute ⬭

**B** 32 counts per minute ⬭

**C** 50 counts per minute ⬭

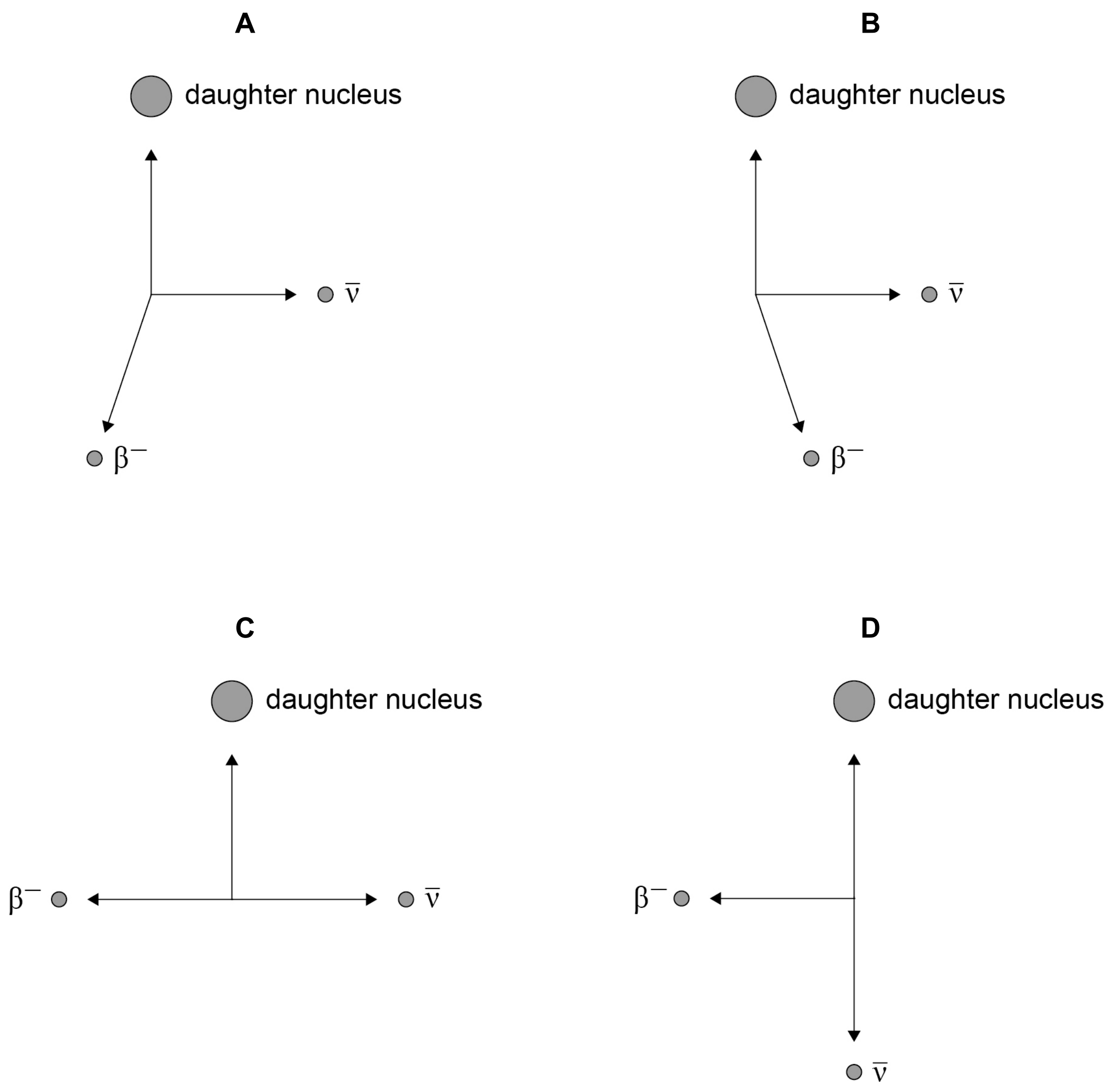
**D** 97 counts per minute ⬭

Do not write outside the box

**2 4** Which diagram represents the beta-minus ($\beta^-$) decay of a stationary nucleus with the emission of an antineutrino $(\bar{\nu})$?

The arrows show the direction of movement of the products of the decay.

**[1 mark]**




**A** ⬭

**B** ⬭

**C** ⬭

**D** ⬭

14

**END OF QUESTIONS**

*Do not write outside the box*

**There are no questions printed on this page**

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

*Do not write outside the box*

| Question number | **Additional page, if required. Write the question numbers in the left-hand margin.** |
|---|---|
| | |

*Do not write outside the box*

| Question number | **Additional page, if required. Write the question numbers in the left-hand margin.** |
| --- | --- |
| | |

*Do not write outside the box*

| Question number | **Additional page, if required. Write the question numbers in the left-hand margin.** |
| --- | --- |
| | |

*Do not write outside the box*

**There are no questions printed on this page**

**DO NOT WRITE ON THIS PAGE**
**ANSWER IN THE SPACES PROVIDED**