Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

S25-3420U20-1

3420U20-1

THURSDAY, 22 MAY 2025 – MORNING

PHYSICS – Unit 2:
Forces, Space and Radioactivity

FOUNDATION TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**11**	
2.	**7**	
3.	**11**	
4.	**9**	
5.	**12**	
6.	**10**	
7.	**7**	
8.	**13**	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **4**(b)(ii).

Equations

$\text{speed} = \dfrac{\text{distance}}{\text{time}}$	
$\text{acceleration [or deceleration]} = \dfrac{\text{change in velocity}}{\text{time}}$	$a = \dfrac{\Delta v}{t}$
acceleration = gradient of a velocity-time graph	
resultant force = mass × acceleration	$F = ma$
weight = mass × gravitational field strength	$W = mg$
work = force × distance	$W = Fd$
force = spring constant × extension	$F = kx$
momentum = mass × velocity	$p = mv$
$\text{force} = \dfrac{\text{change in momentum}}{\text{time}}$	$F = \dfrac{\Delta p}{t}$
u = initial velocity v = final velocity t = time a = acceleration x = displacement	$v = u + at$ $x = \dfrac{u + v}{2}\, t$
moment = force × distance	$M = Fd$

SI multipliers

Prefix	Symbol	Conversion factor	Multiplier
milli	m	divide by 1000	1×10^{-3}
centi	c	divide by 100	1×10^{-2}
kilo	k	multiply by 1000	1×10^{3}
mega	M	multiply by 1 000 000	1×10^{6}

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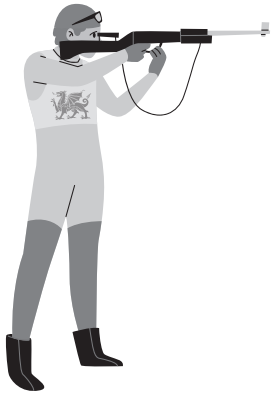
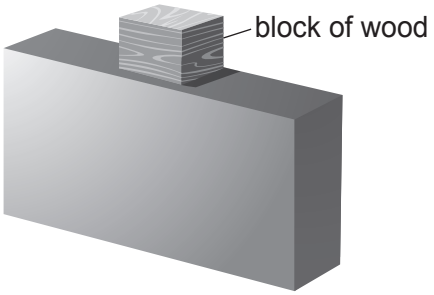
Answer **all** questions.

1. (a) The left hand column of the table describes each of Newton's laws.
Tick (✓) the **correct column** to show which of Newton's laws each one describes.
The first row has been completed for you. [3]

Description	Newton's 1st law	Newton's 2nd law	Newton's 3rd law
Balanced forces do not change the motion of an object.	✓		
If body A exerts a force on body B then body B exerts an equal and opposite force on body A.			
Resultant force = $\frac{\text{change in momentum}}{\text{time}}$			
Resultant force = mass × acceleration			

(b) A Welsh Olympic athlete takes part in a shooting event.
His loaded gun is held stationary, ready to be fired at a target, which is a block of wood.





(i) State the value of the momentum of the bullet before the gun is fired. [1]

momentum = ... kg m/s

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(ii) The gun is fired.
The bullet from the gun experiences a resultant force of 300 N for a time of 0.004 s.
Use the equation:

change in momentum = resultant force × time

to calculate the change in momentum of the bullet. [2]

change in momentum of bullet = ... kg m/s

(iii) The gun produces a force on the bullet to the right.
State the direction of the force of the bullet on the gun. [1]

.....

(iv) The bullet hits the target causing it to move.
The bullet stays in the target.
The total mass of the bullet and target is 0.5 kg.
Use your answer to (b)(ii) and the equation:

$$\text{velocity} = \frac{\text{momentum}}{\text{total mass}}$$

to calculate the value of the velocity of the target as the bullet hits it.
Ignore the effects of air resistance. [2]

velocity = ... m/s

(v) Complete the following sentences by underlining the correct word or phrase in each bracket.

During its motion, the height of the bullet above the ground
(**increases** / **decreases** / **stays the same**).
This is because (**a frictional force** / **thrust** / **a gravitational force**) acts on the bullet. [2]

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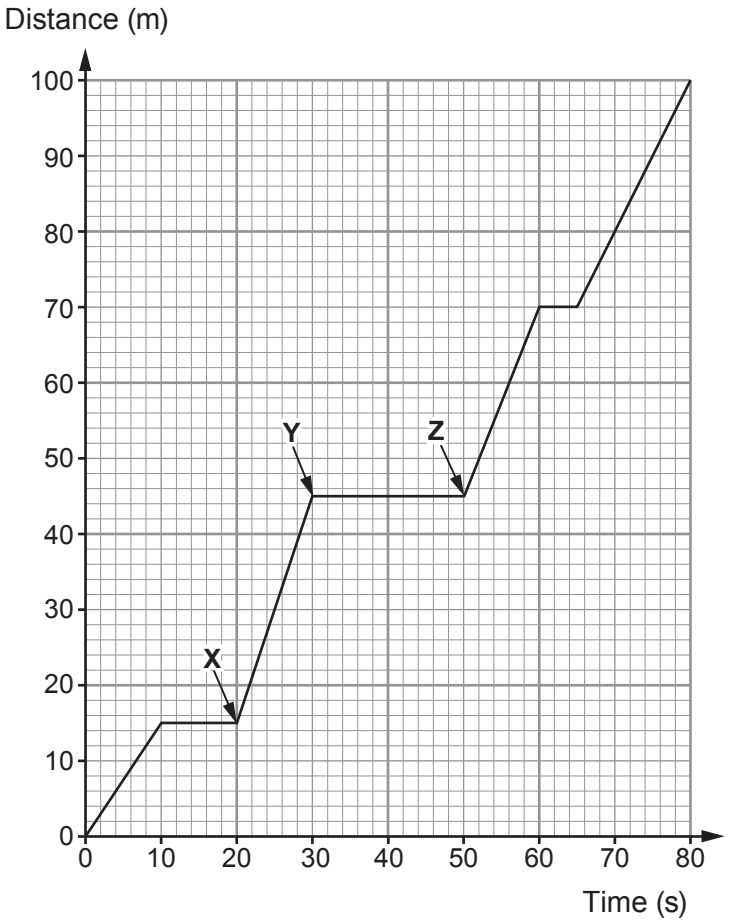
2. A bin lorry is driven along a street. It stops to collect rubbish from wheelie bins.

Only 1 wheelie bin can be emptied into the bin lorry at a time.
The distance-time graph for its complete journey along the street is shown.



(a) Use information from the graph to answer the following questions.

(i) State how many times the bin lorry stopped in the street. ..... [1]

(ii) I. Determine for how many seconds the bin lorry was stationary between **Y** and **Z**. [1]

..... s.

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II. It takes 5 seconds for a wheelie bin to be emptied into a stationary bin lorry. Calculate the maximum number of wheelie bins that were emptied between **Y** and **Z**. [1]

number of wheelie bins emptied = ...

(iii) State the length of the street. ..... m [1]

(iv) Use the equation:

$$\text{mean speed} = \frac{\text{distance}}{\text{time}}$$

to calculate the mean speed of the bin lorry along the length of the street. [2]

mean speed = ... m/s

(b) A student suggests that the bin lorry is travelling fastest between **X** and **Y**.
State whether you agree with the student.
Give a reason for your answer. [1]

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7

Turn over.

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3. The table shows information about six planets in our solar system.

Planet	Mass (units)	Gravitational field strength, g (N/kg)
Mars	6	3.7
Venus	50	8.9
Uranus	870	8.9
Neptune	1020	11.2
Saturn	5700	10.4
Jupiter	19 000	24.8

(a) (i) There are eight planets in our solar system.

Name **one** of the planets not named in the table. ..... [1]

(ii) An object weighs 24.8 N on Venus.
Using information from the table, state the name of another planet on which the object will have the same weight. [1]

.....

(b) (i) On Mars there is a rover that is exploring the Martian surface.
It lifts a rock sample with its robotic arm.
The rock sample has a mass of 0.060 kg.

Use the equation:

weight = mass × gravitational field strength

and data from the table, to calculate the weight of the rock sample on **Mars**. [3]

weight = ... N

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(ii) The rock sample is lifted 0.50 m.

Use the equation:

work done = force × distance

to calculate the work done lifting the rock sample. [2]

work done = ... J

(iii) State the gain in potential energy of the rock sample when lifted. [1]

gain in potential energy = ... J

(c) Mary states that the bigger the mass of the planet, the bigger the gravitational field strength, g.
Use information from the table to explain to what extent Mary is correct. [3]

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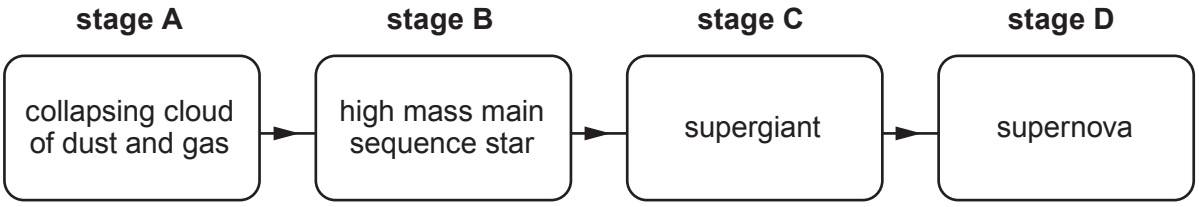
4. (a) Part of the life cycle of a high mass star is shown.
This star is currently on the main sequence.



(i) The stability of a star depends upon the balance between the gravitational force and a combination of gas and radiation pressure.
They are balanced at stage **C**, when the star is a supergiant.
State at which stage, **A**, **B** or **D**, they are also balanced.

stage = ... [1]

(ii) State at which stage, **A**, **B**, **C** or **D**, heavy elements such as uranium are produced and ejected.

stage = ... [1]

(b) When a neutron ($^{1}_{0}\mathrm{n}$) collides with a uranium-235 (U) nucleus, fission can occur.
The fission reaction is shown below.

$$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{92}_{36}\mathrm{Kr} + ^{141}_{56}\mathrm{Ba} + 3^{1}_{0}\mathrm{n}$$

(i) State the number of neutrons present after this fission reaction has occurred.

..... [1]

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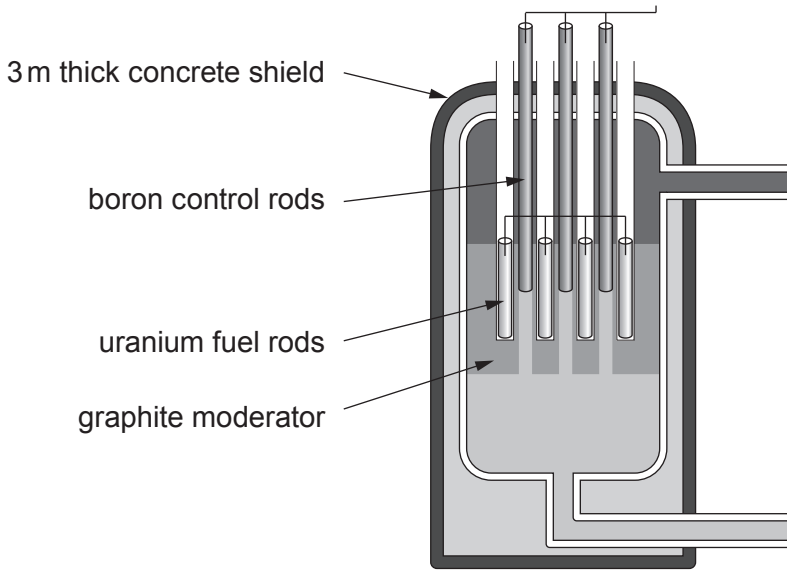
(ii) The diagram shows a nuclear fission reactor that uses uranium-235 as its fuel. The processes within the reactor heat a gas that is used to change water into steam.
Explain the role of **each of the labelled** features. [6 QER]



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9

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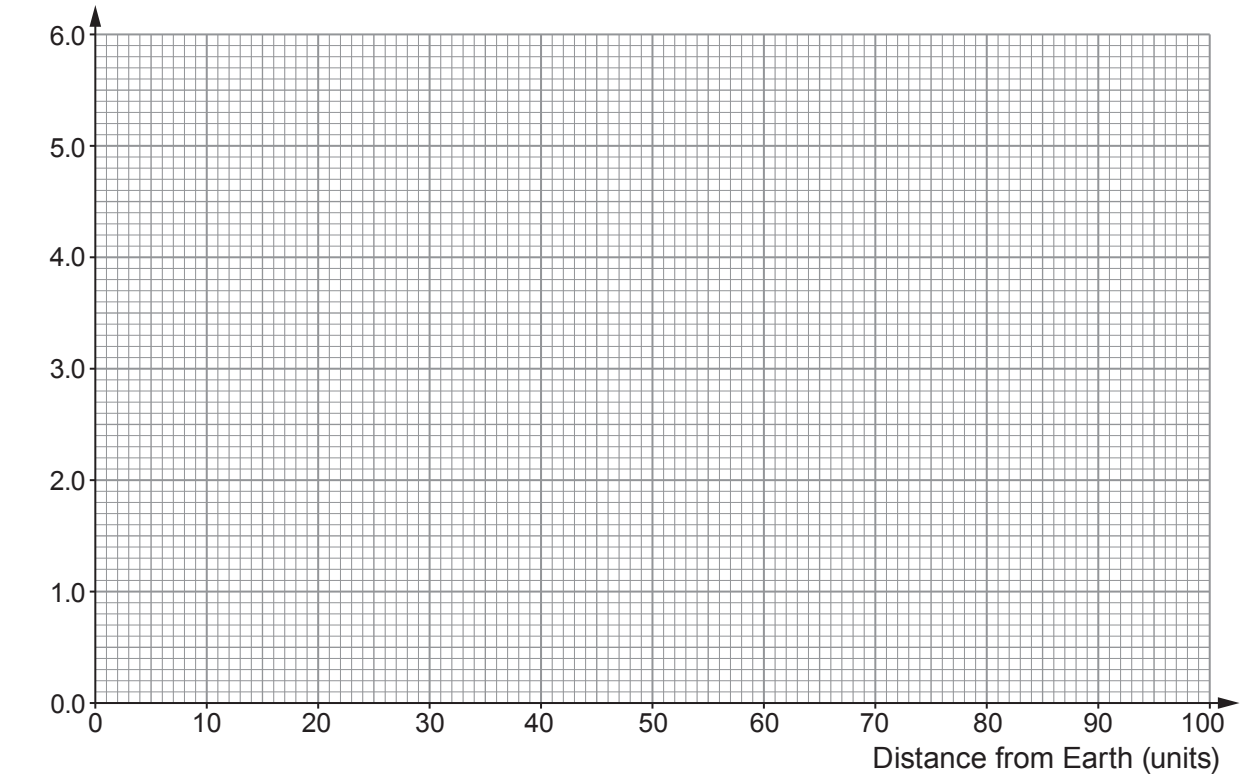
5. A local university physics department gives a school science club some data about six galaxies. The data are shown in the table.

Galaxy	Distance from Earth (units)	Cosmological red shift
A	10	0.6
B	20	1.2
C	45	2.7
D	65	3.9
E	80	4.8
F	90	5.4

(a) Plot the data on the grid below and draw a suitable line. [3]



(b) Describe the relationship between distance from Earth and cosmological red shift. [2]

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(c) Cosmological red shift provides evidence supporting the Big Bang model.

(i) Explain how the cosmological red shift data in the table supports the Big Bang model. [2]

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(ii) The university informs the science club that the greater the cosmological red shift the faster the galaxy is moving away from Earth.
State which galaxy, A, B, C, D, E or F, is moving away from Earth the fastest. [1]

galaxy = ...

(iii) Lucy states that every time the distance from the Earth doubles, the cosmological red shift also doubles.
Use data from the table or the graph to explain whether you agree. [3]

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(iv) Tick (✓) **one** box to show another piece of evidence that currently supports the Big Bang model. [1]

- ☐ Cosmic X-ray Background Radiation (CXBR)
- ☐ Cosmic Microwave Background Radiation (CMBR)
- ☐ Cosmic Gamma Wave Background Radiation (CGBR)
- ☐ Cosmic Infra-red Wave Background Radiation (CIBR)

12

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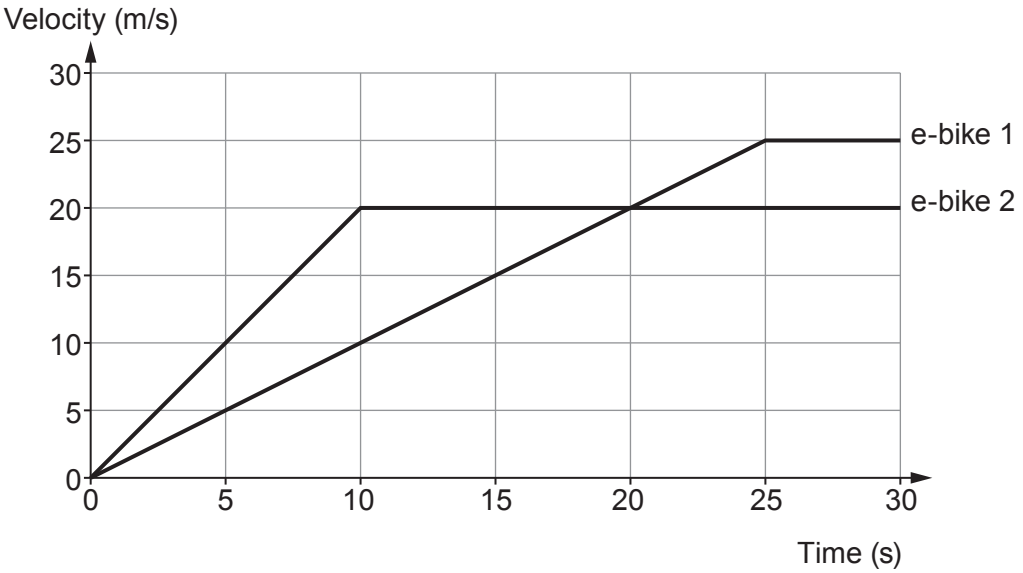
6. A class carries out an experiment on two e-bikes.
Both e-bikes are tested to find their maximum velocity.
Their results are collected and used to produce the velocity-time graphs below.
Each e-bike has an identical mass and is ridden by the same cyclist along the same route.



(a) Tick (✓) the **three** correct conclusions for the experiment. [3]

E-bike 1 reaches a greater velocity than e-bike 2. ☐

Initially, the acceleration of e-bike 2 is greater than e-bike 1. ☐

At 20 seconds, the two bikes have the same acceleration. ☐

E-bike 2 reaches its maximum velocity before e-bike 1. ☐

At 20 seconds, e-bike 2 has more kinetic energy than e-bike 1. ☐

E-bike 2 stays at rest for longer than e-bike 1. ☐

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(b) Use an equation from page 2 **and** information from the graph to calculate the acceleration of **e-bike 2** in the first 10 seconds.
Give the unit of acceleration. [3]

acceleration = ...

unit = ...

(c) While e-bike 2 is accelerating, it travels 100 m.
Joe says that e-bike 1 travels twice as far whilst it is accelerating.
Use information from the graph and the equation:

$$x = \frac{u+v}{2}t$$

to investigate whether Joe is correct.

[u = initial velocity, v = final velocity, t = time, x = displacement]

Space for calculations. [4]

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10

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7. (a) When the driver of a vehicle needs to make an emergency stop, the overall stopping distance is made up of two parts, called the thinking distance and the braking distance.

overall stopping distance = thinking distance + braking distance

(i) An average driver drives at 13 m/s and has a reaction time of 0.70 s.
The table below shows the Highway Code's thinking and braking distances for an average driver.

A Formula 1 racing driver is driving the same car at the same speed.
The reaction time of this driver is half the time of an average driver.
Complete the following table. [3]

	Reaction time (s)	Thinking distance (m)	Braking distance (m)	Overall stopping distance (m)
Average driver	0.70	9	14	23
Formula 1 racing driver	0.35	.....	.....	.....

(ii) During wet weather, the braking distance doubles.
One student suggests that the overall stopping distance for an average driver also doubles.
Consider whether this statement is true. [2]
Space for calculations.

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(b) Seatbelts provide the most effective way of protecting yourself when travelling in a car.
Explain how a seatbelt protects a driver from injury during a head-on collision. [2]

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8. Americium-241 decays by alpha particle emission to produce neptunium (Np) as shown by the following nuclear decay equation.

$$^{241}_{95}\mathrm{Am} \rightarrow \ ^{\ldots\ldots}_{\ldots\ldots}\mathrm{Np} + \ ^{4}_{2}\alpha$$

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

(ii) Complete the following sentence about the nuclear structure of americium-241. [3]

A **nucleus** of americium-241 contains ..... protons,

..... neutrons and ..... electrons.

(b) The mass of americium in a new smoke detector is 0.25 micrograms with an activity of 32 kBq.
Calculate the mass that has an activity of 128 kBq. [2]

mass = ... micrograms

TURN OVER FOR THE REST OF THE QUESTION.

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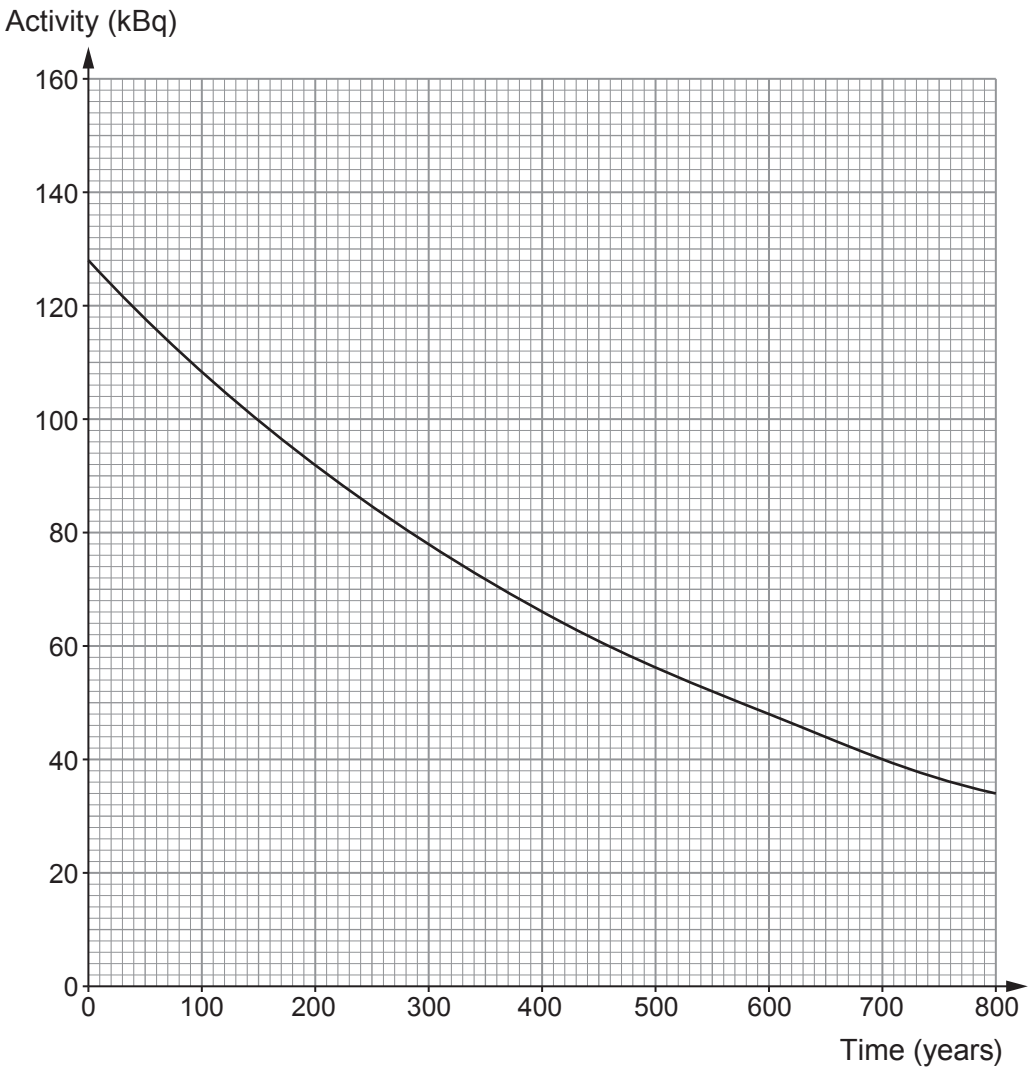
(c) Some americium-241 with an initial activity of 128 kBq decays for a number of years as shown by the graph below.



(i) **Draw lines on the graph** to show that the half-life of americium-241 is 420 years. [2]

(ii) State the time it would take for the activity to fall to a $\frac{1}{4}$ (25%) of its initial activity. [1]

time = ... years

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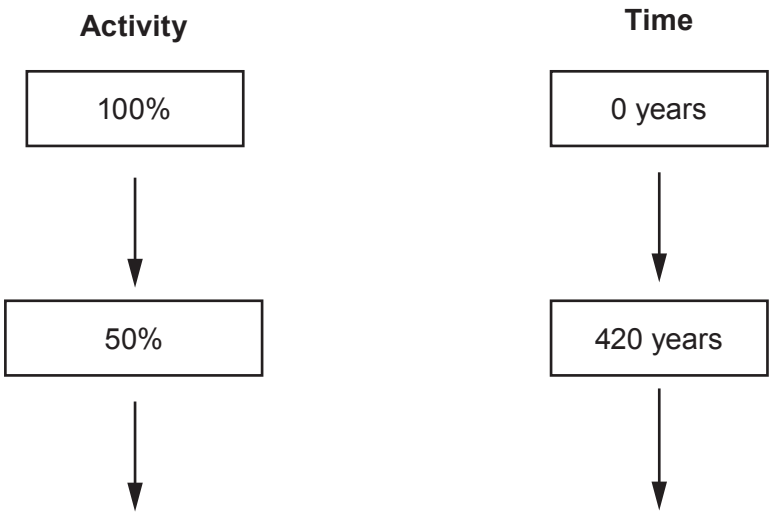
(iii) Americium-241 is difficult to detect when its activity falls to about 3%.
Theresa states that the activity will fall to about 3% after 2000 years.
Explain whether she is correct.
Continue the diagram to show your working. [3]



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13

END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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