Cambridge Assessment International Education

Teaching Pack

Model to determine half-life

Cambridge O Level

Physics 5054

Version 2.0

Cambridge Pathway

In order to help us develop the highest quality resources, we are undertaking a continuous programme of review; not only to measure the success of our resources but also to highlight areas for improvement and to identify new development needs.

We invite you to complete our survey by visiting the website below. Your comments on the quality and relevance of our resources are very important to us.

www.surveymonkey.co.uk/r/GL6ZNJB

Would you like to become a Cambridge International consultant and help us develop support materials?

Please follow the link below to register your interest.

www.cambridgeinternational.org/cambridge-for/teachers/teacherconsultants/

Copyright © UCLES 2017
Cambridge Assessment International Education is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which itself is a department of the University of Cambridge.

UCLES retains the copyright on all its publications. Registered Centres are permitted to copy material from this booklet for their own internal use. However, we cannot give permission to Centres to photocopy any material that is acknowledged to a third party, even for internal use within a Centre.

Contents

Icons used in this pack:

Briefing lesson

Lab lesson: Option 1 – run the experiment

Lab lesson: Option 2 – virtual experiment

Debriefing lesson

Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities, this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, the pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.

↓

Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.

↓

Debriefing lesson (1 hour*)
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide the opportunity to practise extended writing skills.

**the timings given here are guides; you may need to adapt the lessons to suit your circumstances.*

In this pack you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Model to determine half-life

This *Teaching Pack* focuses on a model to determine half-life.

One of the fundamental properties of radioactive decay is its random nature. In this experiment, learners will model radioactive decay for a collection of atoms. This will provide them with an opportunity to practise drawing and reading from decay curves.

This experiment has links to the following syllabus content (see syllabus for detail):

- 26.4 Half-life

The experiment covers the following skills, adapted from **AO3: Experimental skills and investigation** (see syllabus for assessment objectives):

- plan experiments and investigations
- interpret and evaluate experimental observations and data.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 26.2 Characteristics of the three kinds of emission

Going forward

The knowledge and skills gained from this experiment can be used when you teach learners about exponential decay.

Briefing lesson: Planning and evaluating experiments

Resources	• A picture of a pile of coins • Graph paper • Worksheet A

Learning objectives	By the end of the lesson: • ***all*** learners should understand how radioactive atoms decay, and be able to define the term half-life • ***most*** learners should be able to determine the half-life from a graph of activity against time • ***some*** learners will be able to evaluate the experimental technique and suggest improvements.

Timings	Activity
5 min	**Starter/Introduction** Ask your learners what they would need to record if they would like to understand how materials change over time. If necessary, explain to them that the initial and final condition of the material observed would need to be recorded. What would they need to do in addition to observing the initial and final conditions if they need to describe the change? In this case the material in question needs to be observed several times between the initial and final conditions.
10 min 10 min	**Main lesson** Check that your learners are familiar with the concepts needed for this experiment. Ask them to work on their own to write definitions for the terms below: • stable nuclei • unstable nuclei • alpha emissions • beta emissions • gamma emissions • spontaneous decay of nuclei. They should share their definitions with the person next to them and in their pairs they should correct any mistakes. Allow them to check their definitions using a text book after a minute or two. Show your learners a picture of a pile of coins. Ask them to imagine that the coins each represent an unstable atom. In small groups they should discuss what might happen to the atoms over time. Ask the groups to suggest how we could use the coins in an experiment to show how unstable atoms decay. Discuss with them why throwing coins is a good example of radioactive decay by focusing on the following facts: • As they have two faces we can easily assign one to show a state of decay (heads) and one as un-decayed (tails). • The number of coins which will be taken away from the sample is defined randomly: there is a 1 in 2 chance for each coin to land heads up. • Unstable nuclei of a radioactive sample undergo a similar change in time. *Continues on the next page …*

Timings	Activity
20 min 5 min	Give your learners Worksheet A which shows the data from an experiment where 60 coins are dropped from a beaker. Your learners should use the data to draw their own decay-curve graphs. Following this, they can then use their graph to calculate the half-life for the group of coins. Ask each learner to write their own definition of half-life. They should have something similar to: ‘the time it takes for the number of nuclei of the isotope in a sample to halve’. Remind them that the radioactivity of a sample is measured as the count rate with the unit of counts per second.
10 min	**Plenary** Ask learners to record the following: • Three reasons why using coins is a good way to demonstrate the radioactive decay of unstable atoms. • Two limitations of using coins to demonstrate radioactive decay. One positive of using an object like a dice (which would have five sides assigned to the undecayed state and one assigned to the decayed state) to show radioactive decay.

Lab lesson: Option 1 – run the experiment

Resources	• Equipment as outlined in the Teacher notes • Worksheets B, C, D and E

Learning objectives	By the end of the lesson: • ***all*** learners should have been able to conduct the experiment and record the data they have collected accurately • ***most*** learners should have been able to plot their data and use this to determine the half-life of their substance • ***some*** learners will be able to evaluate the experimental method.

Timings	Activity
10 min	**Starter/Introduction** Radioactive materials emit varying amounts of alpha, beta, or gamma radiation. The activity of the sample decreases in time as fewer atoms in the source remain unstable. This lesson activity models the radioactive decay. Before you begin, check your learners' understanding of the following statements, as they will be testing these in their experiment. • Radioactive decay is a random process; it is not possible to predict which nuclei will decay when. • The half-life of a radioactive nucleus is the time it takes for half of the nuclei to have decayed.
20 min	**Main lesson** Learners should work in pairs to carry out the experiment. They should collect the equipment and Worksheet B which explains the method. They should record their results in a table. A prepared table of results is provided on Worksheet C. **Safety** Circulate the classroom at all times during the experiments so that you can make sure that your learners are safe and that the data they are collecting is accurate.
10 min	Once they have completed the experiment, learners should tidy away the equipment and use the data to plot a decay curve for their results. Remind them that the curve should be a smooth line of best fit. Having plotted their decay curve, they should then mark onto their graph where one, two and three half-lives occur. From this, they should be able to calculate the half-life of their substance.
10 min	Now that they have completed their experiment, learners should evaluate the strengths and weaknesses of the procedure. There is a prepared table to help them do this on Worksheet D.
10 min	**Plenary** Use Worksheet E to check your learner's understanding of the concepts covered in this lesson.

Teacher notes

Watch the *Teacher walkthrough* video and read these notes.

Each pair will require:

- 100 sweets with clearly different sides or 100 identical coins.
- A low, flat box, e.g. standard lab tray.
- A beaker large enough to fit all 100 sweets or coins.
- Sheets of graph paper.

Safety

There are no specific risks associated with this experiment.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Teacher method

This is your version of the method. The learner method is shown on Worksheet B.

Before you begin
Plan how you will group your learners during the experiment.

Think about:
- the number of pairs you will have
- whether using sweets or coins would be best

Experiment
Circulate during the experiment in case learners encounter any difficulties.

1. Learners should collect all of the equipment they need and Worksheet B and Worksheet C from the front of the class.
2. Learners should throw the sweets/coins from the beaker into the tray.
3. Any sweets/coins that land marking/heads side up are removed as these represent atoms that have decayed.
4. Count how many sweets/coins remain after the first throw and record this.
5. Repeat step 3 and step 4 until all of the sweets/coins have been removed and counted.
6. Using the data from the table, plot a graph showing the number of sweets/coins which remained after each throw.
7. Data points should be joined using a smooth line of best fit.
8. Using a horizontal line to the curve and a vertical one to the axis, learners should calculate the time taken for one, two and three half-lives to occur. From this they should be able to calculate the half-life for their substance.

Explain to learners that each throw represents an arbitrary period of time.

Make sure that learners are clear which side represents an atom that has decayed and that they count and remove the correct ones each throw.

Remind learners of the need for scaling so that they use all of the graph paper.

Clean-up
After the experiment learners should:
- check their results are fully recorded in their table
- collect and return all of the equipment.

Lab lesson: Option 2 – virtual experiment

Resources	• A data projector or similar • The virtual experiment video • Worksheets D, E, F and G

Learning objectives	By the end of the lesson: • ***all*** learners should understand how the experiment was conducted and be able to use the data collected • ***most*** learners should have been able to plot the provided data and use this to determine the half-life of the substance • ***some*** learners will be able to evaluate the experimental method.

Timings	Activity
10 min	**Starter/Introduction** Radioactive materials emit varying proportions of alpha, beta, or gamma radiation from the nuclei. The activity of the sample decreases in time as fewer atoms in the source remain unstable. This activity models the radioactive decay. Before you begin, check your learners' understanding of the following statements, as they will be testing these. • Radioactive decay is a random process; it is not possible to predict which nuclei will decay when. • The half-life of a radioactive nucleus is the time it takes for half of the nuclei to have decayed.
20 min 10 min 10 min	**Main lesson** Hand out Worksheet F. They will answer on the worksheet as they watch the video. The video will stop when they need to answer a question. Show the video. You may like to ask learners to share their answers as you go. Give learners Worksheet G so that they can plot a decay curve for the provided results. Remind them that the curve should be a smooth line of best fit. Having plotted their decay curve, they should then mark onto their graph where one, two and three half-lives occur. From this, they should be able to calculate the half-life of their substance. Now that they have seen the experiment, learners should evaluate the strengths and weaknesses of the procedure. There is a prepared table to help them do this on Worksheet D.
10 min	**Plenary** Use Worksheet E to check learner's understanding of the concepts covered in this lesson.

Debriefing lesson: Extended writing skills

Resources	• Data collected from the experiment • Worksheets H, I, and J

Learning objectives	By the end of the lesson: • ***all*** learners should have been able to write a plan and method for the experiment • ***most*** learners will be able to review their work, improving it in line with the success criteria • ***some*** learners will be able to evaluate the methods and suggest possible improvements for modelling radioactive half-lives.

Timings	Activity
	Starter/Introduction
5 min	Ask learners to review their decay curves. You may want them to share their work with other learners.
10 min	Following this, ask pairs of learners to discuss what characterises a good science write up. They are likely to suggest things like: explains processes, uses clear language, the writing is concise, technical language is used or data is presented clearly. Show them Worksheet H which provides suggestions to help learners to write scientifically.
	Main lesson
20 min	Learners now need to write up their plan and methods for this experiment. Worksheet H is available to help them scaffold their writing. This worksheet identifies the key points learners need to include. It also provides the success criteria for the task. Before they begin, you may also want to share Worksheet I to discuss strategies that learners can use to improve their extended writing. For weaker learners, there are sentence starter suggestions on Worksheet J.
10 min	Now that learners have written up these parts of the experiment, they are going to formatively assess their work. They should swap their writing with the person next to them. Using the success criteria, they should give each other feedback. There is a section on Worksheet H that has space for them to identify three things their partner has done well and one thing they need to improve. They can cut this out and glue it in, or write the feedback straight into their partner's lab book.
10 min	Learners should return the work to their partner. Each learner should read the feedback they have received. They need to act on this by rewriting a section of their work, building in the improvements that their partner has suggested.
	Plenary
5 min	In the previous lesson, learners should have identified the strengths and weaknesses of this experimental method. They should now record how they could make improvements to the method. Remind them that each improvement must be carefully justified.

Worksheets and answers

	Worksheets	Answers
For use in the *Briefing lesson:*		
A: Sample data for coins	**14–15**	**26**
For use in *Lab lesson: Option 1:*		
B: Method	**16**	**—**
C: Results table	**17**	**—**
D: Strengths and weaknesses	**18**	**27**
E: Check your understanding	**19**	**28**
For use in *Lab lesson: Option 2:*		
D: Strengths and weaknesses	**18**	**27**
E: Check your understanding	**19**	**28**
F: Virtual experiment	**20**	**29**
G: Data from virtual experiment	**21**	
For use in the *Debriefing lesson:*		
H: Experiment plan and method	**22–23**	**—**
I: Using connectives	**24**	**—**
J: Sentence starters	**25**	**—**

Worksheet A: Sample data for coins

In this experiment, 60 coins have been used.

To model radioactive decay, the two sides of the coins are assigned a state:

- Any that fall heads up are said to have decayed.
- Any that fall tails up are said to have not decayed.

Each throw of the coins from the beaker represents 1 second in time.

Method:

1. At the start of the experiment all 60 of the coins are dropped from a beaker into a tray.
2. When the coins fall, all of those that have landed heads up are removed as they have decayed. The number of coins that remain in the tray is counted.
3. The coins that landed tails up are put back into the beaker and dropped again. Once more, any coin that lands heads up is removed and the remaining coins are counted.
4. This process is repeated until all of the coins have eventually landed heads up and have been removed.

The results of this experiment are shown in the table below.

Throw (represents 1 second of time passing)	Number of coins remaining
0	60
1	36
2	21
3	8
4	3
5	1

Tasks:

1. Use the data in the table above to plot a decay curve for this experiment.
2. Add a smooth line of best fit (this should be a curve).
3. Use the graph to work out how long it took for one, two and three half-lives to occur. Use this information to calculate the half-life for this experiment.

   If you are unsure of how to use the graph to calculate half-life there are instructions how to do this on the next page.

 Copyright © UCLES 2017

Worksheet A: Sample data for coins

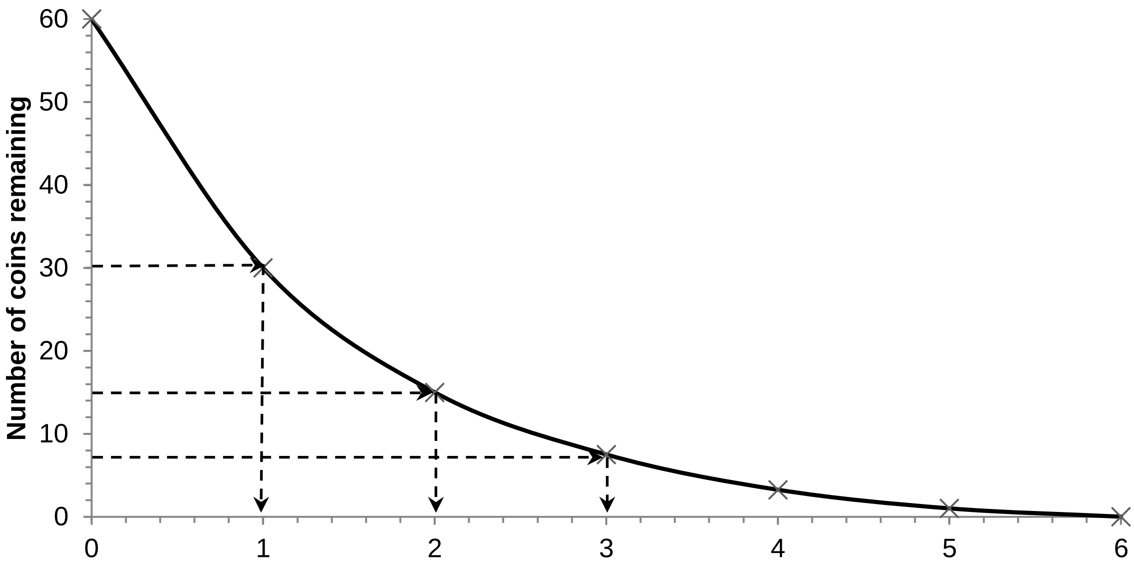
Calculating the half-life of a substance using a graph

Remember that the half-life of a substance is the time it takes for the number of radioactive nuclei to halve. In this experiment, the radioactive nuclei are represented by the coins.

In this example, one half-life occurs when 30 of the coins have landed heads up. To work out how long this takes, we must use our graph:

1. Go down the y axis until you reach 30.
2. Draw a horizontal line from here to the curve.
3. Draw a vertical line from the point you reached the curve down to the time on the y axis.
4. Read off the time from the x axis – this is the time it has taken half the radioactive nuclei to decay, so it is the half-life. From the example graph below, one half-life is a second.

A graph to show the decay curve for the coin experiment



5. To be sure that our half-life time is accurate we must measure other half-lives and take an average.
6. We now only have 30 coins left. So another half-life will have occurred when we reach 15 coins.
7. The graph is marked in the same way and the second half-life is read off. In this case, the second half-life occurs after 2 seconds.
8. This is repeated for a third half-life, which this happens after 3 seconds.
9. You can now take an average of the three half-lives to work out the average half-life.

$$\frac{\text{half-life 1 + half-life 2 + half-life 3}}{3} = \text{average half-life}$$

$$\frac{1 + 1 + 1}{3} = 1 \text{ second}$$

Copyright © UCLES 2017

Worksheet B: Method

1. Collect all of your equipment and worksheets from the front of the class.
2. Check you have 100 items in your beaker. If you need to count them out from a central supply, make sure you do this carefully.

Make sure you know which side of your item represents the undecayed state and which shows the decayed state.

3. Pour the contents of the beaker into the tray.

Don't drop the contents from too high as they might bounce out of the tray.

Remember, each throw from the beaker represents 10 seconds of time.

4. Remove any of your items that fell in the tray in the decayed state.
5. Count how many of the items fell in the undecayed state and record this in your results table.
6. Put these back in your beaker.
7. Pour the remaining items into the tray again. Remove any that fell in the decayed state and count the undecayed ones left in the tray.
8. Record the number of undecayed items in your results table.
9. Put the undecayed items back in the beaker and throw them again.
10. Repeat this process until all of the items have fallen in the decayed state and have been removed.
11. Make sure you make a note of the result after each throw.
12. Use your data to plot a decay curve for your experiment. Put the number of items on the y axis and the time (throw number) on the x axis.

Make sure you label the axes and give your graph a title.

13. Use the graph to calculate the time taken for 1, 2 and 3 half-lives to occur. Take the average of these to calculate the half-life for this experiment.

*If you need help to work out the half-life from the graph, this is shown on the back of **Worksheet A**.*

 Copyright © UCLES 2017

Worksheet C: Results table

Use this table to record your results from the experiment

Throw number (each throw represents 10 secs of time)	Number of items remaining in the undecayed state
1	……………………………………………..
2	……………………………………………..
3	……………………………………………..
4	……………………………………………..
5	……………………………………………..
6	……………………………………………..
7	……………………………………………..
8	……………………………………………..
9	……………………………………………..
10	……………………………………………..

Copyright © UCLES 2017

Worksheet D: Strengths and weaknesses

Use this table to identify the strengths and weaknesses of using this method to represent the radioactive decay of nuclei.

An example for each has been completed for you.

Strengths	Weaknesses
Radioactive decay is a random process. This experiment is a good model because the way the items fall is also random.	This model does not reflect the fact that nuclei might emit different types of radiation.
....	....
....	....
....	....
....	....

 Copyright © UCLES 2017

Worksheet E: Check your understanding

For each of the questions, tick the box next to the best answer(s).

1. Some nuclei of atoms are unstable and may emit which types of particles?

- ☐ Infrared light
- ☐ Microwave radiation
- ☐ Alpha particles, beta particles or gamma rays
- ☐ Visible light

2. True or false? Radioactive decay is a random process

- ☐ True
- ☐ False

3. True or false? It is possible to predict which nuclei will decay at a specific time.

- ☐ True
- ☐ False

4. How do you describe the change in the number of remaining items after each throw in the experiment?

- ☐ It decreases
- ☐ It increases
- ☐ It decreases in a linear way (if you plotted a graph it would be a straight line)
- ☐ It decreases in a non-linear way (if you plotted a graph it would be a curve)

5. Which is the best definition for half-life?

- ☐ The time taken for half of the original atoms to disappear
- ☐ The time taken for half the original atoms to decay

Copyright © UCLES 2017

Worksheet F: Virtual experiment

1. Why have we used a sweet with a clear marking to model radioactive decay?

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

2. What is the possibility that one of the sweets will fall in a decayed state?

100%	50%	It changes every throw	It is impossible to detect

3. Which sweets (decayed or undecayed) should be returned to the beaker to be thrown again? Why?

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

4. Can you predict how many sweets will remain in the experiment after the next throw? Make sure you try to explain your prediction.

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

5. What data should we plot on the y axis?

……………………………………………………………………………………………………….

6. What would the throw number represent in real life?

……………………………………………………………………………………………………….

Copyright © UCLES 2017

Worksheet G: Data from virtual experiment

The data below is from the virtual experiment.

Throw (each represents 10 secs of time passing)	Number of sweets remaining
0	100
1	41
2	24
3	10
4	6
5	2
6	1
7	0

Tasks:

1. Use the data in the table to plot a decay curve for this experiment.
   a. The number of sweets remaining after each throw should be plotted on the y axis.
   b. The throw number (amount of time passed) should be plotted on the x axis.
   c. Make sure you label the axes and give your graph a title.
   d. Create a scale so that you use all of the graph paper.
2. Add a smooth line of best fit (this should be a curve)
3. Use the graph to work out how long it took for one, two and three half-lives to occur.
4. Take the average from this data to calculate the half-life for the experiment.

If you need help to remember how to calculate the half-life from a graph, use the information on **Worksheet A**.

Copyright © UCLES 2017

Worksheet H: Experiment plan and method

Use this worksheet to help you to write up your plan and method for this experiment.

Plan
Use this section to explain the scientific principles shown by this experiment. You should refer to: • what radioactive decay is and how it occurs • how this model helps to demonstrate the process of radioactive decay • what data you would expect to collect from this experiment – these are your predictions.
Method
Use this section to explain how the experiment is carried out. You should refer to: • the equipment needed and how it should be used • the exact steps that should be taken to complete the experiment • the steps taken to make this a fair test.

Writing check

1. Have you explained the background to this experiment and supported this with relevant examples and diagrams?

2. Is it clear what data will be collected and how this can be used to model radioactive decay?

3. Are the steps in the method clear enough so that the experiment can be repeated?

4. Has it been explained how this will be made a fair test?

Check it

Read your partner's work and look back at the success criteria.

Record **three** things they have done well and **one** thing they need to improve.

Cut along the dashed line and give this back to your partner.

The three things you have done well are:

1. ....

....

2. ....

....

3. ....

....

To improve, you need to:

....

....

 Copyright © UCLES 2017

Worksheet H: Experiment plan and method

This side shows some ideas and techniques you might want to use when writing up your experiments.

Section	What to include
Plan	This section should explain the processes involved in your experiment. You might also need to explain a theory or concept linked to your experiment. • Begin with general statements to introduce the background, e.g. 'Unstable elements undergo radioactive decay.' • Your vocabulary should be precise and you should use relevant technical words. • Your language should be impersonal. Do not use words like 'I' or 'we'.
Instructions or method	This section should have a sequence of steps that show how a task should be carried out. • State what you want to achieve, e.g. 'Model the process of radioactive decay'. • Make sure you explain (or draw) the equipment and materials needed. • Explain clearly what steps should be taken to achieve the goal, e.g. 'After each throw, remove the items which fell in the decayed state'. • You should use imperatives like 'Count the undecayed items and place them back in your beaker' Your instructions should be like a series of commands. • Use numbers or temporal connectives to show the stages involved. • Your language should be clear so that someone could repeat the experiment without mistakes.
Observations	This section should be made up of what you have been able to measure or observe. • Only record what can be seen or measured – do not make guesses about what the products of an experiment are without testing them, e.g. if you see bubbles, this is all you can say (unless you have tested the gas produced). • Your observations need to be as accurate as possible. Make sure you record them using the correct units. You may need to repeat observations.
Interpretations	This is where you need to make sense of the observations you have collected. • Now you can use your scientific knowledge to explain your observations. • Support points made with evidence from your observations or measurements, e.g. 'The bubbles observed turned the limewater cloudy, therefore it is clear these were carbon dioxide.'
Evaluation	The evaluation is an opportunity to discuss both the strengths and weaknesses of an experiment. • Identify both the strengths and weaknesses of the experiment. • Avoid meaningless comments like 'It did not work very well.' Be specific and explain why the experiment did not work well and how you could improve it. • Use connectives to balance the strengths and weaknesses, e.g. 'although' or 'however'; or to give evidence, e.g. 'This is because …' or 'this shows that'.

Copyright © UCLES 2017

Worksheet I: Using connectives

Connectives help to develop your extended writing by allowing you to link ideas. This means that you can show how parts of the experiment link or how your observations might be supported by evidence.

In the table below there are examples of connectives you could use in your writing.

Useful connectives and where you might use them	
These connectives help you to show how time progresses. They are very useful in the planning and method sections.	• next • after • first, second, third etc. • 20 minutes later • meanwhile
These connectives help you to show cause and effect. They are very useful in the interpretation and evaluation sections.	• because • so • since • therefore • as a result
These connectives help you to show links and connections. They are very useful in the interpretation and evaluation sections.	• therefore • this shows • because • in fact • for example • furthermore • in conclusion
These help you to give comparisons, or to show differences. They are very useful in the interpretation and evaluation sections.	• although • while • similarly • equally • unless • whereas
These connectives help you to add evidence in your writing. They are very useful in the interpretation section.	• this shows that • as can be seen • as suggested by

Copyright © UCLES 2017

Worksheet J: Sentence starters

Below are sentence starters for each of the points that should be addressed in the plan and method sections.

Experiment plan
This section should include:
- what radioactive decay is and how it occurs
- how this model helps to demonstrate the process of radioactive decay
- what data you would expect to collect from this experiment – these are your predictions.

This experiment investigates how radioactive decay can be modelled. Unstable elements break down radioactively, releasing …

Unstable atoms decay randomly. This model demonstrates that because …

As the items are dropped there is 1 in 2 chance they will fall in the decayed state. This means at each throw approximately …

Method
This section should include:
- the equipment needed and how it should be used
- the exact steps that should be taken to complete the experiment
- the steps taken to make this a fair test.

For this experiment, you will need the following equipment:

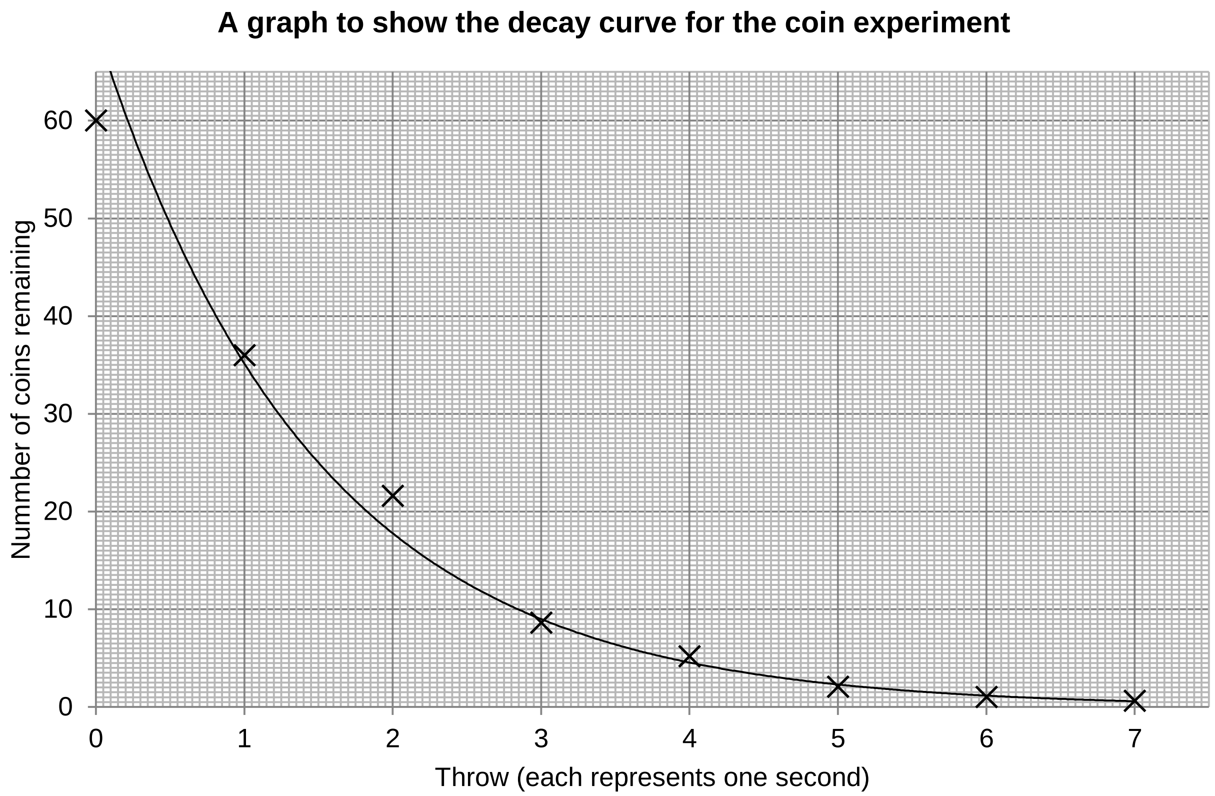
- 100 sweets or coins with clearly different sides.

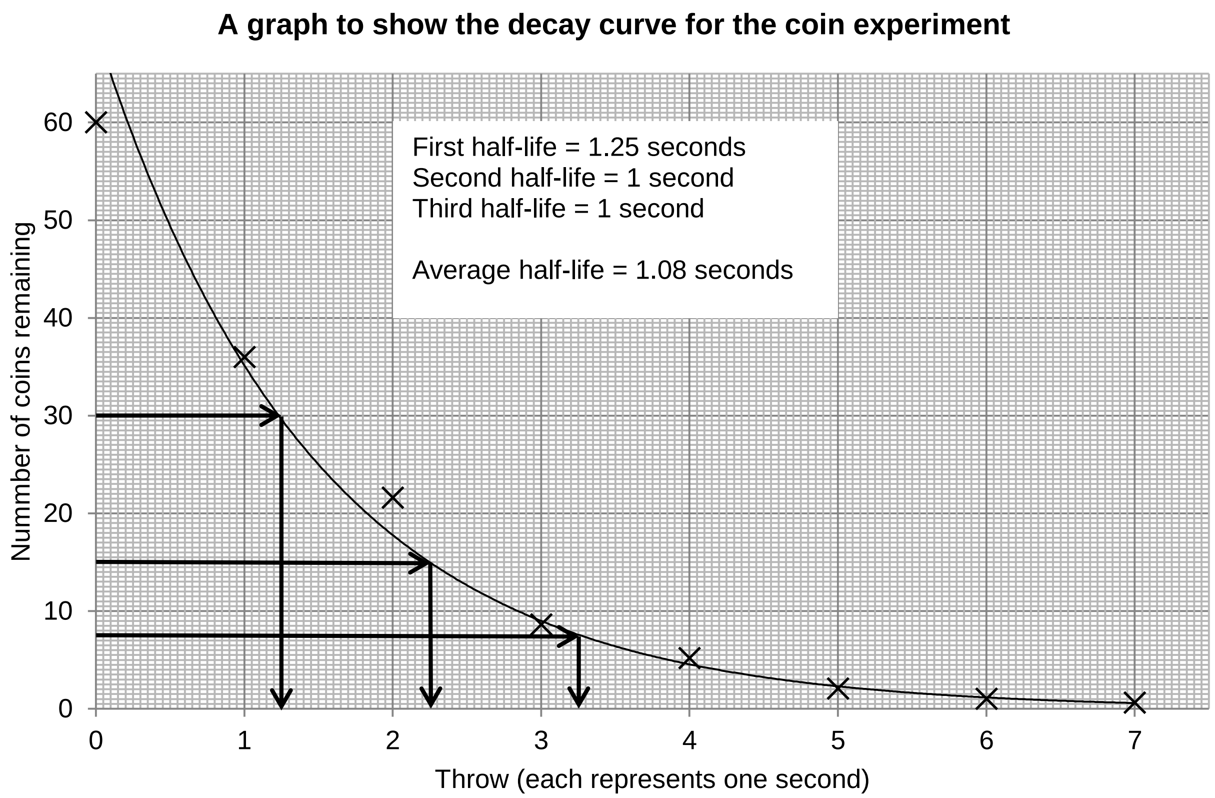
To begin the experiment, count out 100 of the items that will be used and place them in a beaker. Next

To make this a fair test all of the objects used are the same. In addition, …

Copyright © UCLES 2017

Worksheet A: Answers





Worksheet D: Answers

Use this table to identify the strengths and weaknesses of using this method to represent the radioactive decay of nuclei.

An example for each has been completed for you.

Strengths	Weaknesses
Radioactive decay is a random process. This experiment is a good model because the way the items fall is also random.	This model does not reflect the fact that nuclei might emit different types of radiation.
The experiment is simple. This means multiple repetitions can be carried out to increase reliability.	Differences in the way the best-fit lines are drawn will result in a different value for the half-life, even if the original data was the same.
The data collected shows similar patterns to real decay curves. This shows it is a reliable model for demonstrating this process.	In elements the radioactive nuclei that have decayed don't just disappear as our model suggests.
It is possible to use this data to calculate the half-life of the sample in the same way it would be done for a real element.	The chance of a nucleus decaying is not necessarily 1 in 2. You could use dice and only remove those that land on a six. This would increase the resolution of the data and produce even more realistic decay curves.

Worksheet E: Answers

For each of the questions, tick the box next to the best answer(s).

1. Some nuclei of atoms are unstable and may emit which types of particles?

   ■ Alpha particles, beta particles or gamma rays

2. True or false? Radioactive decay is a random process

   ■ True

3. True or false? It is possible to predict which nuclei will decay at a specific time.

   ■ False

4. How do you describe the change in the number of remaining items after each throw in the experiment?

   ■ It decreases in a non-linear way (if you plotted a graph it would be a curve)

5. Which is the best definition for half-life?

   ■ The time taken for half the original atoms to decay

Worksheet F: Answers

1. Why have we used a sweet with a clear marking to model radioactive decay?

   Radioactive decay is a random process. By dropping the sweets, they too will fall randomly. By having clear markings, we can assign one side to the decayed state and one to the undecayed state. This means that we can remove those that have fallen in the decayed state after each throw and begin to model the process of radioactive decay.

2. What is the possibility that one of the sweets will fall in a decayed state?

100%	50%	It changes every throw	It is impossible to detect

1. Which sweets (decayed or undecayed) should be returned to the beaker to be thrown again? Why?

   The undecayed sweets should be collected and returned to the beaker as these are the ones yet to emit radiation. They therefore still have the chance to decay, unlike the others.

2. Can you predict how many sweets will remain in the experiment after the next throw? Make sure you try to explain your prediction.

   About half of the number should remain after the next throw, so approximately 20 should be returned to the beaker. This is because each has a 50% chance of decaying, so about half of the sample will be removed.

3. What data should we plot on the y axis?

   Number of sweets remaining.

4. What would the throw number represent in real life?

   Time

Cambridge Assessment International Education
The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA, United Kingdom
t: +44 1223 553554
e: info@cambridgeinternational.org   www.cambridgeinternational.org

Copyright © UCLES September 2017