

Determination of the half-life of a model radioactive source [e.g. using cubes or dice]

Introduction

Radioactive decay is a random process. The number of radioactive atoms present in a given sample will halve in a fixed time period depending on the probability of decay for that particular radioisotope. This is known as the half-life of the substance. This is a simulation in which radioactive atoms are represented by cubes. The cubes are considered to be decayed when they land with a particular face upwards.

Apparatus

50 × cubes with one face shaded
margarine tub
tray

Diagram of Apparatus



Method

1. Count the cubes to ensure that you have 50 and put them into the margarine tub.
2. Shake the tub and gently throw the cubes into the plastic tray.
3. Record the number of cubes that have landed with the shaded face upwards and remove from the tray
[These represent the radioactive atoms that have decayed.]
4. Put the cubes remaining in the tray back into the margarine tub.
[These represent the radioactive atoms that have NOT yet decayed.]
5. Repeat steps 2 and 3 another 9 times.

Analysis

1. Use the results from the whole class to plot a graph of the number of radioactive atoms remaining (y -axis) against the number of throws (x -axis).
2. Use the graph to determine the half-life of the cubes.

Risk Assessment

Hazard	Risk	Control measure
There is no significant risk in carrying out this experiment.		

Teacher / Technician Notes

Students should design their own table, but a suggested table format is shown below.

Throw	Number decayed	Number remaining
0	0	50
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

The third column may be calculated by subtracting the number decayed from the total number of cubes.

Note that rather than calculate the mean results, students should simply calculate the total class results. This effectively increases the sample size from 50 to 500. The results may be collated by providing the following grid for students, e.g. on a white board/ excel spreadsheet:

Throw	Number remaining										
	Gp 1	Gp 2	Gp 3	Gp 4	Gp 5	Gp 6	Gp 7	Gp 8	Gp 9	Gp10	TOTAL
0	50	50	50	50	50	50	50	50	50	50	500
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

The graph should be a good approximation to an exponential decay curve. Students are asked in the analysis section to find how many throws were required to reduce the number of cubes to half the original number and then half again etc. (fractions of a throw are allowed) and the concept of half-life introduced.

The half-life should be determined from the graph. The graph will start at 500 (at 0 throws). A horizontal line should be drawn from 250 to the curve and then a vertical line drawn downwards from this point on the curve. The half-life is the intercept on the number of throws axis. A second value should be obtained, e.g. by drawing a horizontal line from 125 to the curve and then a vertical line downwards. The second value of half-life is then determined by subtracting the “250 intercept” from the “125 intercept”. A mean value for the half-life can then be determined by adding the 2 values and dividing by 2.

Note that lines could be drawn onto the graph to determine the half-life using other pairs of numbers, e.g. 400 to 200 and 200 to 100.

Working scientifically skills covered

1. Development of scientific thinking

Use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.

2. Experimental skills and strategies

Recognise when to apply a knowledge of sampling techniques to ensure that any samples collected are representative

Make and record observations and measurements using a range of apparatus and methods.

3. Analysis and Evaluation

Translate data from one form to another.

Carry out and representing mathematical analysis.

Represent distributions of results and make estimations of uncertainty.