

# Unstable nuclei, decay and half-life

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lab answers

Model answers use the sample table. Your own numbers will be a little different because every throw is random, but the shape of the curve and the half-life of about 4 throws should appear in good results.

**Level:** Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS1-8, GCSE P4

## Question 1 The analogy

A die represents **one unstable nucleus**; a throw represents **a fixed interval of time**; a six represents **that nucleus decaying**.

## Question 2 Plotting the curve

The curve starts steeply and gets shallower. **The number falls quickly at first and then more slowly, never quite reaching zero.** This is an exponential decay shape.

## Question 3 Half-life of the model

From 100 to 50: the graph reaches 50 at about 3.9 throws. From 50 to 25: the graph reaches 25 at about 7.5 throws, so  $7.5 - 3.9 = 3.6$  throws. Mean =  $(3.9 + 3.6) \div 2 =$  **about 3.8 throws**.

## Question 4 Prediction

After throw 1:  $100 \times 5/6 = 83.3$ . After throw 5:  $100 \times (5/6)^5 = 100 \times 0.402 =$  **40.2**. Sample results: 85 and 40, which are within a few dice of the predictions.

## Question 5 Why not identical?

Each die falls at random, so the number removed varies from throw to throw, and with only 100 dice the chance fluctuations are large. **Starting with more dice, or repeating the lab and averaging, would bring the results closer to the prediction.**

## Question 6 A different rule

Half-life:  $(2/3)^n = 0.5$ , so  $n = \ln 0.5 \div \ln (2/3) = -0.693 \div -0.405 =$  **1.7 throws**. The chance of decay in each throw is greater, so the sample halves faster, which is a shorter half-life.

### Question 7 Limits of the model

Real nuclei do not interact or get thrown; the number of nuclei is vastly bigger than 100; and throws happen in discrete steps while real decay is continuous. **Any two of these points** are acceptable.