Random decay: a dice model

Student activity • investigation and reasoning

YEAR 11 / LESSON 92 / PHYSICS + SCIENCE (DOUBLE AWARD)

The question

How can individual decay be unpredictable while a large sample has a trend?

Use dice to model a fixed probability of decay, then distinguish the three radiation types.

Equipment

- 60 dice and a shallow rolling tray per group
- Booklet, continuation sheet and graph paper

Roll dice gently inside trays. Keep small pieces out of mouths and off the floor; retrieve dropped dice promptly. No radioactive source is used.

Course coverage: Shared Physics / Double Award: 7.4–7.5. Random nuclear decay and alpha, beta-minus and gamma radiation.

Plan, model or apparatus sketch

Draw a labelled particle, nuclear-symbol or detector model appropriate to the task.

Method and reasoning

Read the whole sequence before starting

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1. Work in five groups of six. Count 60 ordinary six-sided dice into a shallow tray and record 60 undecayed model nuclei at round zero.

2. Roll all remaining dice gently in the tray. Remove every die showing six and record the removed count and remaining count. Removed dice are not rolled again in this run.

3. Repeat for ten rounds, retaining all actual counts in a continuation table after the first five rounds shown. Check that remaining plus removed in a round equals the previous remaining count.

4. Plot remaining dice against round number. Compare group results and discuss why they differ even though every surviving die has the same one-in-six removal probability each round.

5. Explain that a surviving nucleus does not become more likely to decay merely because it has survived longer. State that dice rounds are a model, not a physical time unit or a radiation measurement.

6. Make a comparison of alpha particles as helium nuclei, beta-minus particles as electrons emitted in nuclear decay, and gamma rays as electromagnetic radiation. Explain ionisation as removing electrons from atoms.

Cleanup

- Count all dice back to 60 per group, clear trays and retain graphs.

Record your evidence

Blank spaces are for your own work

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Reference and task data

The expected remaining fraction per round is 5/6, but actual counts fluctuate. Do not force results onto a smooth curve. Beta-minus electrons are produced in the nuclear transformation; they are not simply orbital electrons escaping.

Round	Removed this round	Remaining
0		60
1		
2		
3		
4		
5		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Can you predict which die is removed next?

2. What is the removal probability each round?

3. Does a surviving die become older and more likely to show six?

4. Why do group curves differ?

5. What is an alpha particle?

6. What distinguishes beta-minus and gamma?