Investigating nuclear radiation 2

A group of students conducted an experiment to compare the penetration abilities of alpha, beta and gamma radiation. They chose three isotopes:

- americium-241 (^{241}Am, an alpha-emitter used in smoke detectors),
- strontium-90 (^{90}Sr, a beta-emitter used in radioisotope thermoelectric generators), and
- cobalt-60 (^{60}Co, a gamma-emitter used in radiotherapy).

To test the penetration, three types of barriers were used: cardboard, aluminium and lead. 20 sheets of each material were available to place between detector and source. Each sheet was 0.8 mm thick.

The students used a Geiger tube and counter that could detect the three types of radiation. They arranged the equipment as shown in the diagram below.

Data collected are tabulated on the following page.

Americium-241 (alpha radiation)

	percentage of radiation emitted that penetrates the barrier		
number of sheets	cardboard	aluminium	lead
0	100%	100%	100%
1	0%	0%	0%

Strontium-90 (beta radiation)

	percentage of radiation emitted that penetrates the barrier		
number of sheets	cardboard	aluminium	lead
0	100%	100%	100%
2	95%	90%	0%
4	89%	65%	
6	85%	0%	
8	78%		
10	69%		
12	50%		
14	29%		
16	15%		
18	8%		
20	0%		

Cobalt-60 (gamma radiation)

	percentage of radiation emitted that penetrates the barrier		
number of sheets	cardboard	aluminium	lead
0	100%	100%	100%
1	100%	99%	94%
2	100%	98%	88%
3	100%	98%	83%
4	99%	97%	77%
5	99%	96%	73%
6	99%	95%	68%
7	99%	95%	64%
8	99%	94%	56%
9	99%	93%	56%
10	98%	92%	53%

There are three types of variables that students needed to consider in this experiment.

- **Controlled variables**
  The investigator controls these to keep them known and constant for each measurement. This means that one variable at a time is tested.
- **Independent variable**
  This is also called the manipulated variable. The investigator deliberately alters it in some way to see the effect (if any) on the dependent variable.
- **Dependent variable**
  This is also called the responding variable. It is the unknown response to conditions of the experiment, and the reason for setting up the experiment.

The students considered the following variables to be important in this investigation:

- distance between source and detector
- source of radiation
- percentage of radiation that penetrated
- thickness of each barrier
- number of barriers
- type of barrier
- instrument
- recording data (how was the reading taken and by whom?)
- time for collection of radioactive counts

1. Locate the shaded column in the supplied results table. Write the variables involved in collecting these data in the correct columns in the table below:

controlled variable(s)	independent variable(s)	dependent variable(s)

2. Using your knowledge of the composition of alpha and beta particles, suggest why alpha radiation is much less penetrating than beta radiation.

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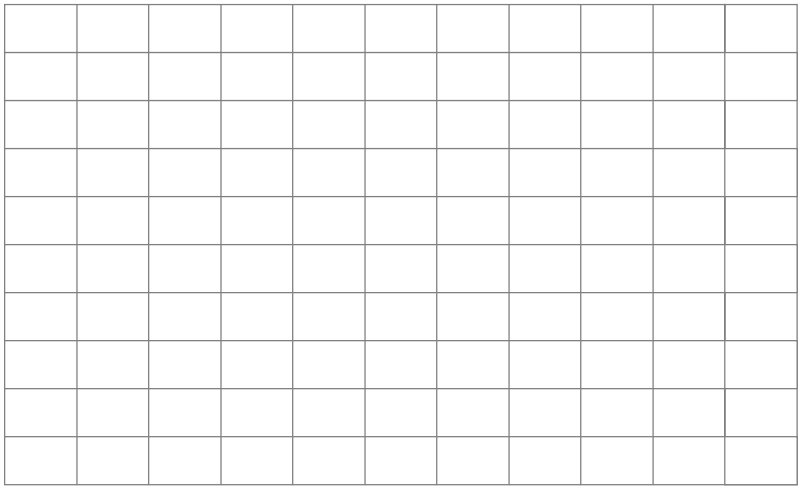
3. On the grid below construct a column graph showing how absorption of gamma radiation is affected by increasing the thickness of lead shielding. Place thickness of lead on the x-axis and quantity of gamma radiation on the y-axis.



4. Suggest why only 77% of gamma radiation penetrates four sheets of lead, but 97% of gamma radiation penetrates the same thickness of aluminium.

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5. Predict how many sheets of lead would be necessary to completely stop penetration of gamma radiation. Explain why you chose your answer.

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6. Why is it more appropriate to construct a column graph to represent these data rather than a continuous line graph?

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7. Why is it important not to accidentally ingest materials that emit alpha radiation?

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