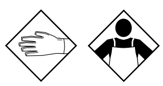
Determining the Effective Half-life of Iodine-131 in the Human Body

MATERIALS

✓ TI graphing calculator (or computer with graphing software or graph paper and a pencil)

Wear safety goggles while performing this experiment.



If you are working in the laboratory, wear gloves and a laboratory apron.

When you are done with the experiment, wash your hands thoroughly.

▶ Objectives

- ***Make a graph*** from research data that shows the decay activity of the radioactive isotope iodine-131 in the human body.
- ***Analyze*** the graph to find out how iodine-131 is taken up by the thyroid gland.
- ***Calculate*** the effective half-life of iodine-131 in the body.

▶ Identifying the Problem

Doctors sometimes administer a tiny dose of a radioactive isotope of iodine, iodine-131, to study the uptake of iodine by the thyroid gland. When administering iodine-131 to a patient, doctors must take into account the fact that a patient's body may not take up all of the isotope. In addition, not all of the isotope that is taken up will end up in the thyroid gland.

Doctors need to know the *effective half-life* of the isotope in the body to give a proper dose of it to their patients. The effective half-life will be lower than the actual half-life, which is 8.07 days. Imagine that you have been asked by a team of doctors to evaluate their data to determine the effective half-life of iodine-131 in the human body.

▶ Finding Out More Information

Iodine-131 is one of the fission products uranium-235 produces as it decays. Iodine-131 decays by emitting a beta particle, forming a stable isotope of xenon.

For your thyroid gland to produce hormones that your body needs, your thyroid gland must take up iodine. The iodine-131 that doctors administer to patients is usually in the form of sodium iodide, NaI, that is taken orally. The uptake of radioactive iodine is then measured with an instrument that is placed close to the throat, where the thyroid gland is located. This instrument counts the number of beta particles being emitted. The decay rate in counts per minute, or cpm, is related to how much iodine-131 is present.

▶ Coming Up with a Plan

To determine the effective half-life of iodine-131, you will need to evaluate the data from the research study done on 28 individuals. Each individual was given a dose of iodine-131 with an initial decay activity of 18 000 cpm. The averaged data for all 28 individuals appears in the table on the next page. If you make a graph of the data, you can use the graph to predict the effective half-life of iodine-131 in the human body.

Decay Activity for Iodine-131 in the Human Body

Day	Average decay rate (cpm)	Day	Average decay rate (cpm)
0 (start)	154		
1	10 610	11	663
2	8040	12	502
3	6093	13	380
4	4618	14	289
5	3500	15	219
6	2653	16	166
7	2010	17	127
8	1523	18	95
9	1154	19	72
10	875	20	55

▶ Performing the Experiment

Preparing for the experiment

1. Prepare a table in your lab report similar to the one shown below to record your data.

Calculating the Effective Half-life of Iodine-131

Decay rate (cpm)	Time (days)	Elapsed time to halve the decay rate (days)
10 000		
5000		
2500		
1250		
Average effective half-life		

USE YOUR DATASHEET

Setting up the graphing calculator

2. Turn on the graphing calculator. Press STAT. Select CLRLIST from the EDIT menu. Press 2nd L1, then ",". Then press 2nd L2, ",", 2nd L3, and ENTER. This will clear lists L1–L3.
3. Press 2nd MEM. Select DELETE from the MEMORY menu. Select Y-Vars, then press ENTER to delete each Y-Var that is stored in the calculator's memory.
4. Press STAT. Select EDIT from the EDIT menu. The screen will display an empty table with three columns. Label the first column "L1" and the second column "L2."

Entering the data

5. In the first column, enter the numbers 0–20 to represent the days of the research. Do this by pressing 0, then ENTER, then 1, then ENTER, etc. until you have entered each day.

6. Use the right arrow key to move the cursor to the second column. Enter the average decay rate for each day. For example, for day zero (start of the research), press 154, then ENTER, 10 610, then ENTER, etc. until you have entered each value.

Viewing the graph

7. Press 2nd STAT PLOT. Select PLOTSOFF, and then press ENTER. Press 2nd STAT PLOT again, then select PLOT1. Turn PLOT1 on by selecting ON and pressing ENTER. Use the arrow key to move the cursor to TYPE, and select the line graph (the second option). Press ENTER.
8. Enter “L1” for the Xlist and “L2” for the Ylist. Select the small square for the MARK.
9. Press ZOOM. Use the arrow key to scroll down to ZOOM-STAT, and press ENTER. You will see a graph of the data.
10. Press TRACE, and use the arrow keys to move across the graph. As you do, the x- and y-values will be displayed at the bottom of the screen.
11. Press Y=. For Y_1, enter 10 000. Use the down arrow key to move to Y_2, and enter 5000. Move down to Y_3, and enter 2500. Then move down to Y_4, and enter 1250.
12. Press GRAPH. The graph should now have four horizontal lines across it. Each line is half as high as the one above it. You will use these lines to estimate the effective half-life of iodine-131 in the human body.

▶ Analyzing Your Results

1. Use your graph to describe how the concentration of iodine in the thyroid glands of the patients changed over the 20-day research period.
2. When did the thyroid glands of the patients have the maximum concentration of iodine-131?
3. Press TRACE. Use the arrow keys to estimate (to the nearest 0.1 day) the time at which the average decay rate was 10 000 cpm. Use the horizontal line at 10 000 cpm to help you estimate. Enter your answer in your data table. Do the same to estimate the time at which the average decay rate was 5000 cpm, 2500 cpm, and 1250 cpm. Record your answers in your data table.
4. Calculate how long it took (to the nearest 0.1 day) for the average decay rate to drop from 10 000 cpm to 5000 cpm. Do this by subtracting the time at which the decay rate was 10 000 cpm from the time at which the decay rate was 5000 cpm. Record this value in your data table.

5. Repeat item 4 to find out how many days it took for the average decay rate to drop from 5000 cpm to 2500 cpm and then from 2500 cpm to 1250 cpm. Record each of your answers in your data table. These values and that from item 4 represent effective half-lives for iodine-131 in the body.

6. Calculate the average effective half-life of iodine-131 by adding the three effective half-lives you just found, and then dividing by 3. Record your answer in your data table.

▶ Reaching Conclusions

7. Explain why the concentration of iodine-131 was low initially, increased quickly, and then slowly decreased over time.

8. The actual half-life of iodine-131 is 8.07 days. How does this value compare with the average effective half-life that you calculated? Why is the effective half-life different from the actual half-life?

9. If the liver absorbs one-tenth as much iodine as the thyroid gland, how would the graph have looked if the study had been done on the liver instead of the thyroid gland?

▶ Defending Your Conclusions

10. In this study, the individuals tested each had similar results. Suppose the data had shown that the amount of iodine-131 in the thyroid varied considerably from person to person. Would these results change the way doctors use the data to determine a specific dose? Explain.

▶ Expanding Your Knowledge

1. Research the effects of nuclear weapons testing and the accident at Chernobyl that occurred in the Ukraine in 1986. Make a poster outlining how iodine-131 makes its way through the environment, eventually reaching humans.

2. Research how spent fuel rods from nuclear power plants are disposed of. In groups of four, develop a proposal for the safe storage of waste generated from nuclear power plants. Prepare a panel discussion to present and defend your proposal to your classmates.