CHAPTER 20

The Nucleus and Radioactivity

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The instrument in the photograph above is called a gamma knife due to the precision with which it removes damaged tissue. The instrument is not a knife at all, yet physicians can perform bloodless surgery with it. The gamma knife directs 201 fine beams of gamma rays directly at a brain tumour or malformed blood vessel in the brain. The gamma rays destroy the tissue that could not be surgically removed. The gamma knife is the most recent instrument in a progression that began with a cobalt therapy unit. This unit, sometimes called the "cobalt bomb", revolutionized the treatment of cancer (see Figure 20.10 on page 916). The cobalt bomb was developed by Dr. Harold E. Johns while at the University of Saskatchewan. Dr. Johns later became Head of the Department of Biophysics at the University of Toronto and was inducted into the Canadian Medical Hall of Fame.

The source of the gamma rays for these instruments is a radioactive substance called cobalt-60, which does not occur in nature. Cobalt-60 must be prepared by bombarding natural cobalt-59 with neutrons inside of a nuclear reactor. Cobalt-60 was first prepared in 1951 by physicists at the Chalk River Nuclear Plant in Ontario. For the next four years, Chalk River was the only source of cobalt-60 for therapeutic treatment or experimentation. In this chapter, you will learn about radioactivity and its many applications.

MULTI LAB

Radioactive Decay

TARGET SKILLS
- Performing and recording
- Analyzing and interpreting

Penetrating Ability of Radioactive Emissions

Obtain an end-window Geiger counter, sources of beta and gamma radiation, and sheets of lead and cardboard.

CAUTION Handle the sources using tongs.

Position the tube of the Geiger counter so that either source (beta or gamma) can be placed close to the end window and so that sheets of cardboard or lead can be placed between the source and the Geiger tube. Turn on the Geiger counter and note the reading. This reading represents the background radiation level. Slide the beta source under the counter. Note the reading. Insert a sheet of cardboard between the beta source and the tube and take the reading again. Continue adding sheets until the reading is close to the background radiation level. Determine the thickness of an individual sheet and calculate the thickness of cardboard between the tube and the beta source for each radiation reading.

Repeat the process with the gamma source. If the cardboard does not provide much change to the reading, add sheets of lead instead. Continue adding sheets until the reading is close to the background radiation level. Determine the thickness of an individual sheet and calculate the total thickness of the barrier.

Analyze and Conclude

1. Plot a graph of the radioactivity reading (y-axis) against the thickness of cardboard for the beta source.
2. Plot a graph of the radioactivity reading (y-axis) against the thickness of cardboard or lead for the gamma source.
3. Which type of radioactive emission is the more penetrating?
4. Try to determine from the graphs the thickness of material that would reduce the reading to half of the unshielded value.

Half-Life

Start with each member of the class holding a coin heads-up. Count and record the number of heads. Next, everyone should flip their coins. Count and record the number of heads. One minute later, each person who got heads on the first flip flips again. Those who got tails are "out." Count and record the number of heads. Repeat the process every minute until only one or two heads remain.

Analyze and Conclude

1. Draw a graph of the number of heads remaining versus the number of flips.
2. Draw a graph of the number of heads that changed to tails versus the number of flips.
3. What are the chances that a coin will change from head to tail during a flip?
4. Why would a minute be known as the "half-life" of the coin?
5. The number of changes during each flip represents the activity. How does the activity change as time passes?
6. If you start with 160 heads, how many flips should you expect it to take to reduce the number of heads to 5? Explain.