chapter 5
Radioactivity

Prior Knowledge: Pre-Calculus Mathematics and Applied Mathematics students will be familiar with exponential functions, including the radioactive decay function discussed in the chapter. A review of chapter three's units of measurements would be useful before the new units are introduced at the end of this chapter.

Terms You Should Know: There is a list here and at the end of the chapter highlighting important terms. Teachers could use this list as either a knowledge activation activity—have students create a concept map or definitions frame—or as a review of concepts.

Note that this list of terms is not intended to be a list for memorization or to provide lists of definitions. It is here to assist the teacher in the incorporation of new concepts and terminologies into the learning activities.

activity	Becquerel (Bq)
beta-minus particle	beta-plus particle
Curie (Ci)	daughter nucleus
decay constant	electromagnetic force
fission	fluorescence
fundamental force	Geiger counter
Geiger-Muller counter	gluon
half-life	Henri Becquerel
mass number	neutron
neutron ray	nucleon
quark	spontaneous fission
strong nuclear force	weak nuclear force

Chapter Summary: Chapter 5 explores the history of radioactivity and discoveries made over the past two hundred years. The nuclear model of the atom, radioactive decay, and half life are covered, and more units of measurement are introduced at the end of the chapter.

Page 55 | "Research Question:"

Research the June 2008 YouTube phenomenon of videos on "microwaves, cell phones, and popcorn" attempting to show how cell phones can take raw kernels of corn and convert them into popcorn. What is the hoax behind the videos? (How did they really pop the corn?) Was there any motive for promoting these videos on YouTube?

The videos claim that if you put three or four cell phones in a circle around some kernels of corn, and they all start ringing or vibrating at once, the kernels will pop because of the radiation being released by the phones. This is a hoax because cell phones do not release enough energy to pop even one kernel of corn. Most likely, there is a heat source underneath the table (they never show you what is under the table) which pops the corn. As for motives, students may offer many answers.

Page 57 | "Questions:"

1. If ^{14}C were to release an alpha particle, what would the daughter nucleus be? Write the chemical equation.

   Carbon-14's nucleus contains 6 protons and 8 neutrons. If it were to release an alpha particle consisting of two protons and two neutrons, the daughter nucleus would have four protons and six neutrons in it. The chemical equation for this process would be:

   $$^{14}C \longrightarrow He^{2+} + {}^{10}Be$$

2. If ^{14}C were to release a positron, what would be the chemical equation for this process?

   Releasing a positron usually also involves releasing γ radiation. Carbon-14 would undergo the following chemical process if it were to release a positron:

   $$^{14}C \longrightarrow {}^{14}C^{+} + \gamma$$

3. If ^{14}C were to release a beta-minus particle, what would be the chemical equation for this process? Why might ^{14}C release a beta particle instead of alpha or gamma rays?

   $$^{14}C \longrightarrow {}^{14}N + e-$$

   Releasing alpha particles or positrons (and gamma rays) cannot occur in isolation: it requires energy. Beta decay can occur spontaneously without an external energy source.

Page 58 | "Activity: The Half-Life of Pennies"

Many answers are possible.

Page 59 | "Calculation Questions:"

1. In 16 days the number of radioactive nuclei decreases to one-eighth the number present initially. What is the half-life (in days) of the mystery substance?

   ½ x ½ x ½ = 1/23 = 1/8 thus 16/3 = 5.33 days is the half life

2. Francine's thyroid disorder was treated with an isotope of iodine, 131I. If this isotope has a half-life of 8.05 days, what percentage of a pill remains after one month (30 days)?

   30/8.05 = 3.72 thus 1/23.723 x 100 = 7.55% is left after one month

3. To make the dials of 1950s watches glow in the dark, radium-226 is painted on. Assuming that the mass of paint ending up on one watch is one-billionth of a kilogram, how much radium, in kilograms, disappears while the watch is in use for 50 years? (Assume the half-life of radium is 1600 years.)

   ½ x 50/1600 x $(1x10^{-9}) = 1.5625x10^{-11}$ *kg left after 50 years*
   thus what disappears = $(1x10^{-9}) - 1.5625x10^{-11} = 9.84x10^{-10}$ *kg*

4. Two radioactive substances Q and X are being observed by researchers, with equal amounts at the start of the experiment. Three days later, there are three times as many Q atoms as there are X atoms. If the half-life of the Q atoms is 2.0 days, find the half-life of the X atoms.

   3/2 = 1.5 thus $1/2^{1.5}$ *x 100 = 35.4% left of Q after 3 days*
   35.4/3 = 11.8% left of X after 3 days
   11.8/100 = 3/? thus ? = 25.5 days, the ½ life of X

5. The number of radioactive atoms present at the beginning of an experiment is 5.0x1012. The number of radioactive atoms present thirty days later is 8.2x1011. What is the half-life (in days) of this substance?

   ½ x 30/h x $(5.0x10^{12}) = (8.2x10^{11})$ *where h = ½ life*
   Solving for h … h = 91.4 days

Page 61 | "Activity: Radioactivity of Household Objects"

Note that for this particular activity, you will likely need to disassemble the metal shield that surrounds the source to obtain readings from the Geiger Counter. Use this activity as an opportunity to compare class results in a laboratory setting.

extra chapter questions

1. How did Henri Becquerel accidentally discover natural radiation?
2. What other elements were discovered to be radioactive by the Curies?
3. Why did the use of radium get replaced? Which elements replaced it?
4. What are some disadvantages of using radium?
5. Define each of the following: isotope; strong nuclear force; electromagnetic force.
6. What does it mean for an isotope to be “stable”?
7. Describe the processes of spontaneous fission, alpha decay, and beta decay.
8. What are the differences among the three types of beta decay? What is the commonality amongst them?