The Half-Life of M&Ms™

Lee Marek

Topic

Half-lives of radioactive substances

Time

45 minutes to 1 hour

Safety

Please click on the safety icon to view the safety precautions.

Materials

200 M&M's™ candies ("M&M's" is a registered trademark of Mars, Incorporated.)
shoe box

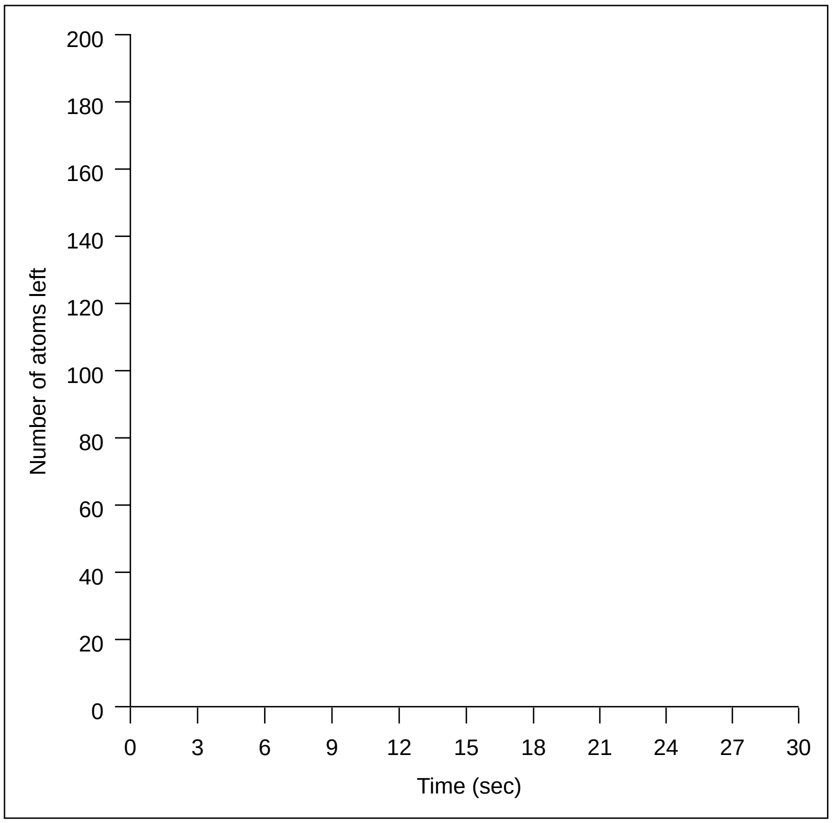
Procedure

1. Place 200 M&M's™ chocolate candies in the shoe box, lettered sides up. The candies will stand for atoms of a hypothetical radioactive element.
2. Cover the box and shake it vigorously for 3 sec. This is 1 time interval.
3. Remove the lid and take out any atoms (candies) that have "decayed," that is, that are now showing lettered sides down. Record on the data table the numbers of decayed and remaining atoms.

DATA TABLE

Trial 1			Trial 2		
Time (sec)	Atoms decayed	Atoms left	Time (sec)	Atoms decayed	Atoms left
0			0		
3			3		
6			6		
9			9		
12			12		
15			15		
18			18		
21			21		
24			24		
27			27		
30			30		

4. Replace the cover on the box, and shake for another 3-sec time interval. Record the number of “radioactive” atoms remaining.
5. Keep repeating time interval trials until all atoms have decayed or you have reached 30 sec on the data table.
6. Repeat the whole experiment a second time, and record all data. Average the number of atoms left at each time interval by adding the results from the two trials and dividing by 2.
7. Make a graph of your data showing the average number of atoms remaining versus time (follow the scale shown).



8. After how many time intervals (shakes) did one-half of your atoms (candies) decay?
9. What is the half-life of your candies?
10. If the half-life model decayed perfectly, how many atoms would be left after 12 sec?
11. If you increased the amount of atoms (candies), would the overall shape of the graph be altered?
12. Go back to your data table and for each 3-sec interval divide the number of candies decayed by the number previously *remaining* and multiply by 100. This will give you the percentage of candies decayed during each half-life. If the model worked perfectly, at every point exactly 50% of the candies would decay. Did it work perfectly? If not, what do you notice about how close the percentage came to 50% at each time interval? About how close did it come during the intervals of 3 to 12 sec? How close did it come during the intervals of 18 to 30 seconds? If you see any pattern, can you guess a reason for it?

What's Going On

The half-life of your candies should be about 1 time interval, or 3 sec. To solve this, first you need to know how many half-lives occur in 12 sec, in this instance 4. Then divide 200 by ½ four times. This will give you a dividend of 12.5. So after 12 sec or four half-lives, you will have 12 to 13 atoms left. Since the half-life of an element is always consistent for that element, there will be no change. It would still take 3 sec for half your sample to decay, and it would take the same amount of time for another half to decay, and so on.

The shape of the graph would be the same. The model does not work perfectly. Generally the percentage of candies decayed is consistently close to 50% in the first few time intervals. At later intervals, it may vary widely. This is because this method of averaging depends on having a large sample—a large number of candies for accuracy. With just a few candies, the percentage decayed can easily shift. This reflects a similar situation with actual radioactive half-life, which only works very accurately for large samples of atoms. Since atoms are so tiny, even a very little sample of a radioactive element will contain millions of them. In fact, if you had only 5 or 10 atoms of a given substance, the half-life of that substance would be useless for predicting when those individual atoms would decay, for the same reason that your model became inconsistent when you had only a few candies left.

Connections

All radioactive matter decays—that is, becomes nonradioactive over time. Scientists have found that each different radioactive element has a unique rate of decay. Half-life is a measure of these rates. The half-life of a radioactive substance is the period of time it takes for half a sample of that element to change into a nonradioactive element. Knowing the half-life of a substance does not tell us how long it takes for a single atom of that element to decay, which is unpredictable. Instead, half-life describes a sort of average: the time it takes for about half a large group of atoms to decay. Since the scale of atoms is so small, any visible sample of radioactive material contains a large number of atoms. This is why half-life is a useful concept for radioactive decay in our world. In this experiment, you investigated a model of half-life to find out more about how it works.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES