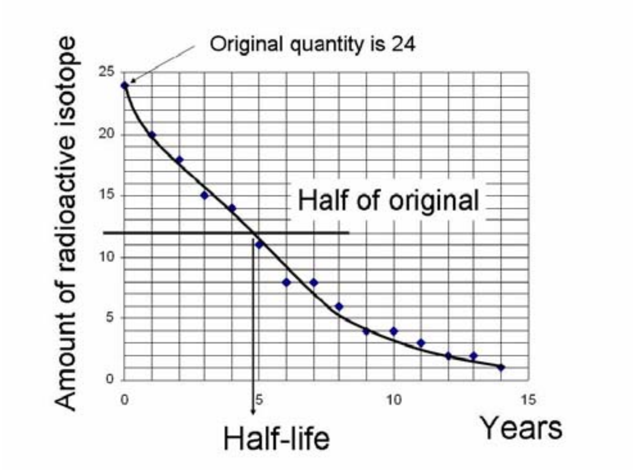
Department of Physics and Geology

Half-Life

Equipment Needed	Qty	Equipment Needed	Qty
Colored Dice	24	Mixing Bottle	1

Background

Atoms that contain like number of protons yet different number of neutrons are known as isotopes. All elements have a variety of isotopes and some isotopes are more stable than others. With time unstable atoms will radioactively decay, eventually into more stable atoms. This transformation of one atom into another is known as transmutation. The rate of decay that occurs is measured in terms of a characteristic time called the half-life. **The half-life is the time it takes for half of an original quantity of isotope to decay**. For example, if a given isotope of atom X has a half life of 10 years and you have 100 grams of isotope X.



- 10 years from now only 50 grams of X remains (the rest is now another element say Y).
- 20 years from now only 25 grams of X remains.
- 30 years from now only 12.5 grams remain.
- This goes on until X is completely gone and only Y remains.

One clever application of half-life is with radiometric dating. By comparing the amount of the original radioactive element to the amount of remaining element, the age of a material can be determined. This is a very useful technique for determining the age of rocks. Continuing from the above example, if you had found a rock that contained exactly half of atom X and half atom Y it would be 10 years old (remember the half life is 10 years). If the rock contained 1/8 atom X and 7/8 atom Y the rock would be 30 years old.

The first step is to find out the half-life of the isotope. We measure and plot the quantity of remaining isotope as a function of time as shown in the figure. The original quantity is 24. Half of the original is 12. We find 12 in the y-axis and draw a line cross the fitting curve. On x-axis, we find out a value for the cross point. That value is half-life, which is 4.8 years in the figure. Second we calculate how much is remained. If quantity of 6 is remained, 6/24=1/4 of the original remains. That means 2 half-life time has passed so that1/2 x1/2 = ¼. So the age of isotope is 2 half-life time, which is 2x4.8=9.6 years.

Examples of the half-lives for some isotopes are shown below.

Element	Half-Life	Stable Daughter Product
Uranium-238	4.5 billion years	Lead-206
Uranium-235	704 million years	Lead-207
Carbon-14	5730 years	Nitrogen-14
Bismuth-210	5 days	Lead-206

In today's experiment the dice represent atoms. The dice should have colored dots (white, black, and red). When the dice are rolled, whenever the chosen color appears, that dice has undergone radioactive decay and it is remove from the rest. This simulates radioactive decay. Because we have three colors we will be able to simulate three different radioactive isotopes. After graphing the results you will be able to determine the half life for the three different isotopes (white, black, and red dot).

SAFETY REMINDER

- Follow the directions for using the equipment.

THINK SAFETY
ACT SAFELY
BE SAFE!

For You To Do

The purpose of this laboratory activity is to study the half-life by simulating the radioactive decay of three different isotopes.

PROCEDURE:

I. Half-Life

1. Shake the dice and roll them on the table.
2. Remove all of the dice that have a black dot TO A SEPARATE PILE.
3. Record number of dice remaining and repeat steps 1-3 until all dice are removed.
4. Do steps 1-3 for white and red colored dots as well.
5. On the same graph, graph # of Throws (horizontal axis) versus Remaining Dice (vertical axis) for black, white, and red. If we set the number of throws instead to # of years (that would mean each throw corresponds to one year) we can now determine the half-life of each isotope.
6. Draw a smooth curve through your points and correctly label the graph.

II. Radiometric Dating

1. Complete the table in your lab report; consider the three scenarios each make up a sample of 24 dice.
2. Calculate how many half-lives have passed for each scenario.
3. Solve for age of material. **Age = Half life × # of half life that have passed.**

Record your results in the Lab Report section.

Name ______________________ Class _______________ Date __________

Lab Report – Half-Life

I. Half-Life

# of throws	**Remove Black Dot Dice**	**Removing White Dot Dice**	**Removing Red Dot Dice**
	Remaining Dice	Remaining Dice	Remaining Dice
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

<Graph>

From the graph, find out half-life for Black point dice ________ years
White point dice ________years
Red point dice ________years

II. Radiometric Dating

	1. Red Dot is daughter atom		**2. White Dot is daughter atom**		**3. Black Dot is daughter atom**	
	# of dice not red (atoms left-not decayed)	# of dice red (decayed atoms)	# of dice not white (atoms left-not decayed)	# of dice white (decayed atoms)	# of dice not black (atoms left-not decayed)	# of dice black (decayed atoms)
	6	18	12	12	3	21
Fraction of atoms not decayed						
# of half lives that have passed						
½ life of material (from above)						
Age of Sample						