Name ______________________________ Section _____________ Date _____________

CONCEPTUAL PHYSICS	Activity

Get a Half-life

Purpose
To simulate radioactive decay half-life

Apparatus
25 small color-marked cubes per group (one side red, two sides blue, three sides blank)
spray-painted sugar cubes or multifaceted dice can be used

Discussion
The rate of decay for a radioactive isotope is measured in terms of half-life—the time for one-half of a radioactive quantity to decay. Each radioactive isotope has its own characteristic half-life (Table 1). For example, the naturally occurring isotope of uranium, uranium-238, decays into thorium-234 with a half-life of 4.5 billion years. This means that only half of an original amount of uranium-238 remains after this time. After another 4.5 billion years, half of this decays leaving only one-fourth of the original amount remaining. Compare this with the decay of polonium-214, which has a half-life of 0.00016 seconds. With such a short half-life, any sample of polonium-214 will quickly disintegrate.

Table 1

Isotope	Half-life
Uranium-238	4,500,000,000 years
Plutonium-239	24,400 years
Carbon-14	5,730 years
Lead-210	20.4 years
Bismuth-210	5.0 days
Polonium-214	0.00016 seconds

The half-life of an isotope can be calculated by the amount of radiation coming from a known quantity. In general, the shorter the half-life of a substance, the faster it decays, and the more radioactivity per amount is detected.

In this activity, you will investigate three hypothetical substances, each represented by a color on the face of a cube. The first substance, represented by a given color, is marked on only one side of the cube. The second substance, represented by a second color, is marked on two sides of the cube, and the third substance, represented by a third color (or lack thereof), is marked on the remaining three sides. Rolling a large number of these identically painted cubes simulates the process of decay for these substances. As a substance's color turns face up, it is considered to have decayed and is removed from the pile. This process is repeated until all of the cubes have been removed. Since the color of the first substance is only on one side, this substance will decay the slowest (because its color will fall face up least frequently and it will stay in the game longer). The second substance, marked on two sides, will decay faster requiring fewer rolls before all the cubes are removed. The third substance, marked on three sides, will decay the fastest. After tabulating and graphing the numbers of cubes that decay in each roll for these simulated substances, you will be able to determine their half-lives.

Procedure

Step 1: Shake the cubes in a container and roll them onto a flat surface.

Step 2: Count the one-side color faces that are up and record this number under "Removed" in the data table.

Step 3: Remove the one-side color cubes in a pile off to the side.

Step 4: Gather the remaining cubes back into the container and roll them again.

Step 5: Repeat Steps 2–4 until all cubes have been counted, tabulated, and set aside.

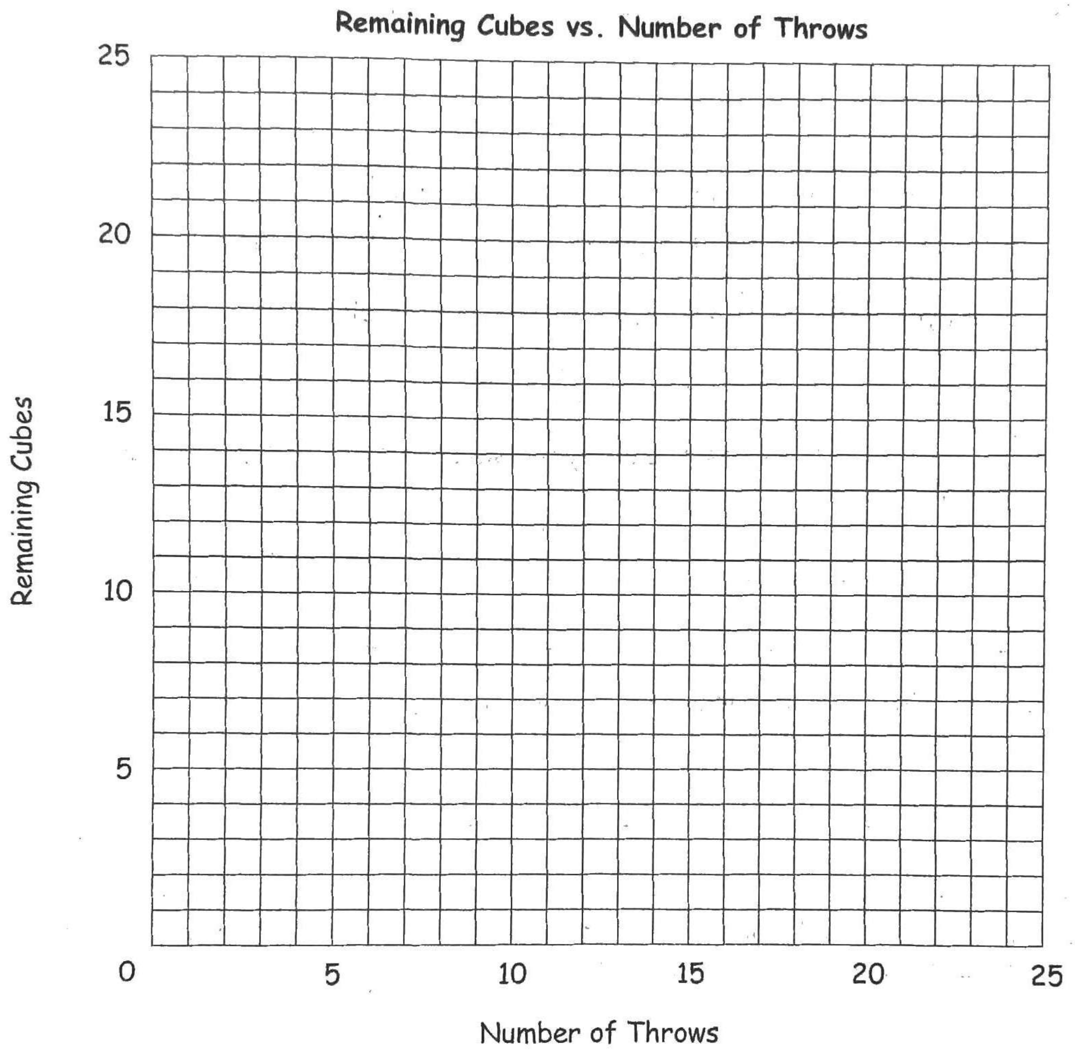
Step 6: Repeat Steps 1–5 removing cubes that show the two-side color faces up.

Step 7: Repeat Steps 1–5 removing cubes that show the three-side color faces up.

Data Table

	First Substance (One-side color)		Second Substance (Two-side color)		Third Substance (Three-side color)	
Throw	**Removed**	**Remaining**	**Removed**	**Remaining**	**Removed**	**Remaining**
Initial Count						
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						

Step 8: Plot the number of cubes remaining versus the number of throws for each substance on the following graph. Use a different color or line pattern to graph the results for each substance. For each substance, draw a single smooth line or curve that approximately connects all points. ***Do not connect the dots!*** Indicate your color or line pattern code below the graph.



First substance (one side on cube) color or line pattern:

Second substance (two sides on cube) color or line pattern:

Third substance (three sides on cube) color or line pattern:

Summing Up

1. How many rolls did it take for the number of each colored cube to be reduced by half? These are your half-life readings.

   One-side color: ________ **Two-side color:** ________ **Three-side color:** ________

2. The half-life of a decaying substance is measured in units of time. What is the unit of half-life used in this simulation?

   ____

3. In each case, how many rolls did it take to remove all of the cubes?

   One-side color: ________ **Two-side color:** ________ **Three-side color:** ________

4. Which of these hypothetical substances would be the most radioactive?

   ____

5. How might you simulate the radioactive decay of a substance that decays into a second substance that also decays?

   ____

   ____

6. Is it possible to estimate the half-life of a substance in a single throw? How accurate might this estimate be?

   ____

   ____

7. Are your lines in the graph for Step 8 fairly straight or do they curve? Do these lines correspond to a constant or nonconstant rate of decay?

   ____

   ____

8. a. Substance X has a half-life of 10 years. If you start with 1000 g, how much will be left after:

      i. 10 years? ______________________________

      ii. 20 years? ______________________________

      iii. 50 years? ______________________________

      iv. 100 years? ______________________________

   b. Will this sample of substance X ever totally disappear? If so, estimate how soon. If not, explain.

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