Exponential Decay

Certain quantities decay exponentially over time, and the amount P present at time t is given by the equation $P = P_0 e^{kt}$ where k is the decay constant and P_0 is the initial amount present.

Radioactive material decays exponentially. The **half-life** of a radioactive element is the amount of time it takes for half of its atoms to decay into something else.

Part 1

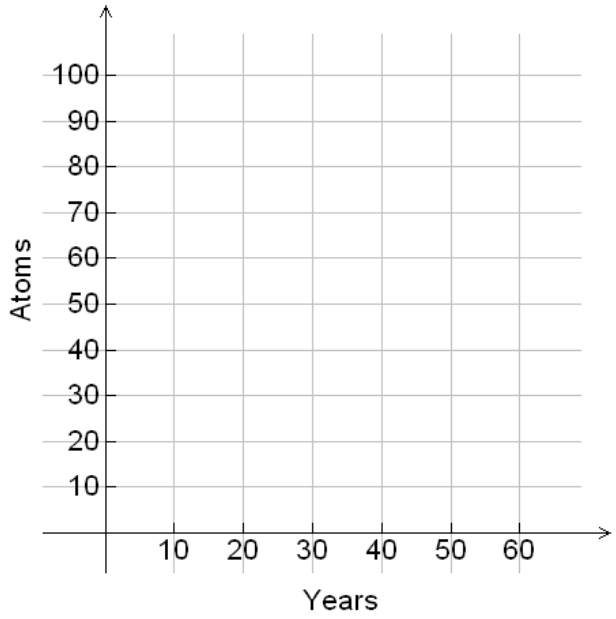
Suppose you have 100 atoms of a radioactive element whose half-life is 10 years. Fill in the following table.

Years (x)	0	10	20	30	40	50	60
Number of Radioactive Atoms (y)	100						

Your group will begin with 100 M&M candies that will each represent a radioactive atom with a half-life of 10 years. Place the candies into a paper cup and shake them into your shoebox. Pull out (and eat) any candies that do not show an "M" on top – these represent decayed atoms. Count the number of candies that remain in the box – this is the number of radioactive atoms that remain. Repeat this process until you have data for 60 years and record it in the following table.

Years (x)	0	10	20	30	40	50	60
Number of Radioactive Atoms (y)	100						

Graph, using two different colors, the x-y data from the two tables above. For each set of data draw a smooth curve that passes through the points.



Compare and contrast your two graphs. Are they similar or different?

Part 2

If a radioactive element has a half life of λ years, then the decay constant k can be calculated using the formula $k = \frac{\ln 0.5}{\lambda}$.

Calculate k for the radioactive element in **Part 1**. $k =$ _____

Use that value of k and the formula $P = P_0 e^{kt}$ to predict how many atoms would remain after 35 years. _____ atoms

Is your answer consistent with the experimental data from **Part 1**?

Use that value of k and the formula $P = P_0 e^{kt}$ to predict how many years it would take until only 15 atoms remained. _____ years

Is your answer consistent with the experimental data from **Part 1**?

Part 3

Carbon-14 is a radioactive isotope of carbon that is found in all living things. Once the living thing dies, carbon-14 begins to decay to nitrogen-14. By determining the percentage of original carbon-14 that is present, we can determine how old a once-living object is. This is known as radiocarbon dating, and is used to date objects that are up to 60,000 years old. The half-life of carbon-14 is 5730 years.

Calculate k for carbon-14. $k =$ _____

Select a numbered bag containing a total of 100 candies, some plain M&M's (carbon-14) and some peanut M&M's (nitrogen-14). Assume these represent atoms found in a bone excavated from your back yard.

Use the value of k for carbon-14 and the formula $P = P_0 e^{kt}$ to determine how old your bone is.

Bag Number: _____

Number of Plain M&M's (carbon-14): _____

Number of Peanut M&M's (nitrogen-14): _____

Age of the bone: _____ years