Name: ______________________

Using Dice to Explore Radioactive Decay

Background
Radioactive materials have a host of important uses in our lives including how we diagnose and treat various diseases, how we generate electricity and even how we monitor the presence of fire in our homes. The purpose of this activity is to model the radioactive decay of unstable, radioactive atoms.

Pre-lab Questions
Research two specific uses of radioactivity and describe each use below. Your description should include the specific radioactive atom or atoms involved as well as and details about how the radioactive decay is utilized to accomplish each task.

Use #1:

Use #2:

Objective
We are going use dice to model radioactive decay. The questions we are examining during this simulation include:

- What happens to radioactive atoms when they decay?
- How do scientists describe the rate of radioactive decay?

Procedure
1. You will need a data recording sheet, die, one green pencil and one red colored pencil.
2. Your group’s task is to simulate radioactive decay of 20 imaginary “atoms” of element #1 by following the steps listed below:
   
   Round One:
   a. You will roll the die twenty times (once for each atom)
   b. If you roll a “6” that atom has decayed into a non-radioactive atom* and you will color the box on the data recording sheet for that atom red.
   c. If you roll anything else, that atom has not decayed and you will color the box on the data recording sheet for that atom green.

   Round Two thru Eight:
   - **REPEAT steps 2 a, b, c FOR ONLY THOSE ATOMS THAT WERE GREEN IN PRECEEDING ROUND (still radioactive)**

3. Next you will repeat the process (steps 2 a, b, c) for 20 atoms of element #2 using a second (new) data recording sheet. This time you will mark the box for the atom red if you roll EITHER a “5” or a “6”.
4. Enter your group’s data in the appropriate place in the shared class data table.

*NOTE:* In our simulation for the sake of simplicity, once an atom decays, it is no longer radioactive. In reality, radioactive elements will often decay into other radioactive elements, which can undergo further decay.
Analysis
Part I: Graphing Our Data
1. Each student should make **stacked column** graph of the **class data** illustrating the number of “radioactive” atoms remaining (still green) and the number of “decayed” atoms (turned red) for element #1 at the end of each round.

The graph should have the following characteristics:
- X-axis: Independent variable: Rounds
- Y-axis: Dependent variable: Number of atoms (“radioactive” or “decayed”)
- Be sure to include a key, descriptive title, & label your axes

2. Each student will also make a **line graph** of the **class data** for the number of “radioactive” atoms (still green) at the end of each round for **BOTH** element #1 and element #2.

Your graph should have the following characteristics:
- X-axis: Independent variable: time (rounds)
- Y-axis: Dependent variable: # of “radioactive” atoms remaining (still green)
- Both data sets plotted on one graph.
- Each data set with points connected in a smooth curve
- Be sure to include a key, descriptive title, & labeled axes.

Part II: Analyzing Our Graphs
1. Melanie thinks that when radioactive isotopes “decay” it means the atom disappears into nothing releasing radioactivity. Melanie’s idea is not completely correct. Explain using specific data we collected today to support your response.

2. Scientists often measure the rate of decay of radioactive elements in terms of “half-life” or the amount of time required for half of a radioactive sample to decay. Using your **line graph**, determine the half-life for each element in today’s simulation. **NOTE:** Your unit of time will be “rounds”.

   a. Half-life of element #1:

   b. Half-life of element #2:
3. After one half-life, $\frac{1}{2}$ of the sample has decayed so $\frac{1}{2}$ is still radioactive. After a second half-life, $\frac{1}{2}$ of the remaining material ($\frac{1}{2}$ of the original) has decayed leaving $\frac{1}{4}$ of the original ($\frac{1}{2}$ of $\frac{1}{2}$) still radioactive. At the end of three half-lives, what fraction of a radioactive isotope would you expect to still be “radioactive” (1/2, 1/4, 1/8, etc.)? What about five half-lives?

4. 
   a. Based on the class data half-life you calculated above, how many rounds would it take until $1/8$ of the original element #1 sample was still radioactive? HINT: how many half-lives must have occurred?

   b. Based on the class data half-life you calculated above, how many rounds would it take until $1/8$ of the original element #2 sample was still radioactive? HINT: how many half-lives must have occurred?

5. Consider the following statement:
The longer the half-life, the faster the rate of radioactive decay.
   
   a. Is this statement true or false?
   
   b. Explain using specific data we collected today to support your choice.
6. Consider the following statement:
The rate of radioactive decay is always the same, constant value for all radioactive isotopes no matter what element they are.

   a. Is this statement true or false?

   b. Explain using specific data we collected today to support your choice.

**Conclusion**

Based on what you learned today, answer the following questions:

1. What happens to radioactive atoms when they decay? (Be specific, but be careful not to overgeneralize)
2. How do scientists describe the rate of radioactive decay? Is it linear?