Name: ______________________ Partner(s): ________________________

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Homework Questions for Investigation #14

As always, show your calculations and/or reasoning for maximum credit!

Part I: Half-life Simulation

1. Suppose that instead of removing only the dice that showed a 1 after each shake, you kept only the dice that showed 1 and removed all the dice that showed 2, 3, 4, 5, or 6. In this case, how would the half-life of the dice compare to the pennies? Why?

2. Suppose that instead of removing only the dice that showed a 1 after each shake, you kept only the dice that showed 1, 2, or 3 and removed all the dice that show 4, 5, or 6. In this case, how would the half-life of the dice compare to the pennies? Why?

3. You are studying an ancient rock sample and find that the sample has one-eighth of its original radioactivity. The sample is dated to be 30000 years old. What is the half-life of the radioactive sample? Show your reasoning/calculations. (**Hint:** How many "half-lives" does a sample go through to reach one-eighth its original activity?)

4. For both the "penny decay" and "dice decay," plot the number of <u>average</u> "nuclei" remaining versus "time interval" (shakes) and draw a smooth curve through the data. On the graphs, draw a vertical line that indicates the half-lives of the pennies and the dice. (Now that you have a graph, it is easy to get a more accurate estimate in fractions of shakes.)

   Half-life of pennies ≈ ___ shake(s). Half-life of dice ≈ ___ shake(s).

Part II: Rutherford Scattering Simulation

5. Assume a typical atom has a diameter of 1.0 x 10^{-10} m. What is the cross-sectional area of a typical atom? Express your answer in (m^2). (**Hint:** What is the area of a circle? **Hint:** Do not confuse diameter for radius.)

6. If the nucleus of the atom above has a diameter of 5.0 x 10^{-15} m, what is the cross-sectional area of this nucleus. Again, express your answer in (m^2).

7. What is the ratio of the cross-sectional area of the atom (Question #5) to the cross-sectional area of its nucleus (Question #6)? This ratio represents the average number of α particles that need to be fired at the atom to produce one "hit" on the nucleus assuming a "billiard ball" type of collision. (**Comment:** The actual number needed is significantly less than this calculation gives because electrical repulsion between the α-particle and the nucleus is the source of the scattering rather than the α-particle bouncing off the nucleus like a billiard ball.)

Part III: Nuclear Chain Reaction Simulation

8. Suppose in your critical (one hits one) nuclear chain reaction simulation you has 301 dominoes. Assuming your measured time for one "knock," (Δt_{ave} on p. 247) how long would it have taken to knock down all 301 dominoes if they were arranged single-file? (Show your work!)

$T_{301,c}$ = ______ s

9. Suppose in your super critical nuclear chain reaction simulation you were able to have each domino knock down three dominoes instead of two. The table below indicating the number of dominoes in a given row, and the total number of dominoes that have fallen from the beginning of the reaction has been started for you. Fill in the rest of the table.

	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7
# in row	1	3					
Total # fallen	1	4					

10. Assuming your measured time for one "knock," calculate how long would it have taken to knock down 101 dominoes if they were arranged in this "one hits three" fashion? Repeat for 301 dominoes. (**Hint:** In what row(s) will you find the 101^{st} domino and 301^{st} domino? **Hint:** Recall, there is one less time interval than that row number.) (Show your work!)

$T_{101,sc}$ = ______ s

$T_{301,sc}$ = ______ s

Part IV: Atomic Spectra

11. Do you think that any of the gases that you observed are present in the fluorescent lamp? If so, which one(s) and why? If not, why not?

12. The element helium was discovered on the Sun before it was discovered on Earth. Describe how this is possible. (The name helium comes from the Greek word *Helios*, meaning "sun.")