Rolling Dice to Simulate Radioactive Decay & First Order Kinetics
Hands-On Activity for Chem 2 – WS12

Objectives:
    1.) Use non-radioactive materials (dice) to determine the probability that a single die will roll a given number
         on a given toss in order to simulate when a single nuclei decays in a given period of time.
    2.) Demonstrate that the number, N, of dice remaining (*number of nuclei not yet decayed*)
         and the rate of decay, dN/dt, both decrease exponentially.
    3.) Determine the rate constant, k, and initial activity, A_o, for the dice (*nuclei*).
    4.) Determine the experimental values for the half-life of the dice (*nuclei*)
         and calculate the percent error for the experimental half-life values.

Background:
        While it is not possible to predict when any given radioactive nuclei will decay; it is possible to predict with a high degree of probability the average rate of decay for a large number of nuclei within a given sample. This is because the rate of decay for each type of radioactive isotope is a constant and is a characteristic or that given isotope.
        The decay process is then a statistical process. The decay of a radioisotope is a random event. That is, it is the decay of a given nuclei is not dependent on the environment of the nucleus nor its past history. One can then use statistical analysis to determine the probability of the rate of decay; likewise, one can use statistical analysis to determine the probability that a given die will roll a specific number when tossed.
        For dice, the probability that a specific number will be tossed is based solely on the number of sides the die has. For 6-sided dice, there is a 1 in 6 probability (*chance*) or rolling a 5 (or any of the numbers 1-6). For example, if one took one hundred 6-sided dice and rolled them all at once and removed all of the 5s that were face up, then *how many of the 100 dice would one expect to remove?*
        Since the probability of rolling a 5 is 1 in 6, then multiply 1/6 by 100. The result is 16.6 or since dice come in whole numbers about 16 or 17 dice would be removed. If 17 are removed from the original 100, there would be 83 remaining. One could then predict in the next roll that the number of dice that would land with the 5 face up would be 1/6 (83) or 13.8. Thus the rate of decay is constant and can be used to simulate radioactive decay.

Experimental (Single Value)*:
    1. Acquire 80 dice in a plastic bag, a plastic cup & data packet from the stockroom.
    2. Pour all of the dice out of the bag into the cup.
    3. Shake the dice in the cup.
    4. Roll the dice out onto the lab bench. (*Each roll simulates one minute.*)
    5. Remove all of the dice that landed with your given unknown number face up. Set them aside.
    6. Record the number of remaining dice on your datasheet.
    7. Put all of the remaining dice back into the cup.
    8. Repeat steps 3-7 until all data is collected for first run.
    9. For second (and third run), put all dice back into the cup and repeat steps 3-8.
    10. Once data has been collected for three runs, average the numbers going across at each time.
         Record the average in the proper column on the datasheet.
    11. Calculate the natural log of each value in the average counts/min column.
         Record in the proper column on the datasheet.
    12. Put dice back in plastic bag. Return plastic bag with dice and plastic cup to the stockroom.

    *For the __double and triple unknown numbers__ in step #5, simply remove all dice
        that apply to the given unknown numbers.

Lab Partner's Name:_____ONLINE_____

One Number – Single Unknown #_____2_____

Note: Directions are on page 1.

Time (min)	Run 1 Counts/min	Time (min)	Run 2 Counts/min	Time (min)	Run 3 Counts/min	Tim (min)	Avg Run Counts/min	ln(cts/min)
0	_____	0	_____	0	_____	0	_____	_____
1	80	1	80	1	80	1	80	_____
2	69	2	66	2	71	2	_____	_____
3	62	3	51	3	61	3	_____	_____
4	53	4	46	4	54	4	_____	_____
5	41	5	42	5	51	5	_____	_____
6	37	6	34	6	44	6	_____	_____
7	34	7	26	7	33	7	_____	_____
8	30	8	23	8	23	8	_____	_____
9	27	9	21	9	16	9	_____	_____
10	19	10	17	10	13	10	_____	_____
11	17	11	16	11	12	11	_____	_____
12	16	12	12	12	10	12	_____	_____
13	13	13	10	13	8	13	_____	_____
14	9	14	8	14	7	14	_____	_____
15	6	15	7	15	7	15	_____	_____

Calculate the values below based on your Avg Run. (Theoretical half-life = 3.80 min.):

k = _____ 1/min $t_{1/2}$ = _____ min

A_o = _____ counts/min   %Error = _____ %

Lab Partner's Name:_____**ONLINE**_____

Two Numbers – Double Unknown #s_____**2 & 6**_____

Time (min)	Run 1 Counts/min	Time (min)	Run 2 Counts/min	Time (min)	Run 3 Counts/min		Tim (min)	Avg Run Counts/min	ln(cts/min)
0	_____	0	_____	0	_____		0	_____	_____
1	80	1	80	1	80		1	80	_____
2	61	2	56	2	53		2	_____	_____
3	48	3	40	3	44		3	_____	_____
4	27	4	31	4	29		4	_____	_____
5	22	5	26	5	17		5	_____	_____
6	15	6	12	6	11		6	_____	_____
7	8	7	5	7	9		7	_____	_____

Calculate the values below based on your Avg Run. (Theoretical half-life = 1.70 min.):

k = _____ 1/min $t_{1/2}$ = _____ min

A_o = _____ counts/min   %Error = _____ %

Odds or Evens – Triple Unknown #s_____**2, 4 & 6**_____

Time (min)	Run 1 Counts/min	Time (min)	Run 2 Counts/min	Time (min)	Run 3 Counts/min		Tim (min)	Avg Run Counts/min	ln(cts/min)
0	_____	0	_____	0	_____		0	_____	_____
1	80	1	80	1	80		1	80	_____
2	39	2	41	2	36		2	_____	_____
3	19	3	28	3	23		3	_____	_____
4	13	4	16	4	10		4	_____	_____
5	8	5	10	5	3		5	_____	_____

Calculate the values below based on your Avg Run. (Theoretical half-life = 1.00 min):

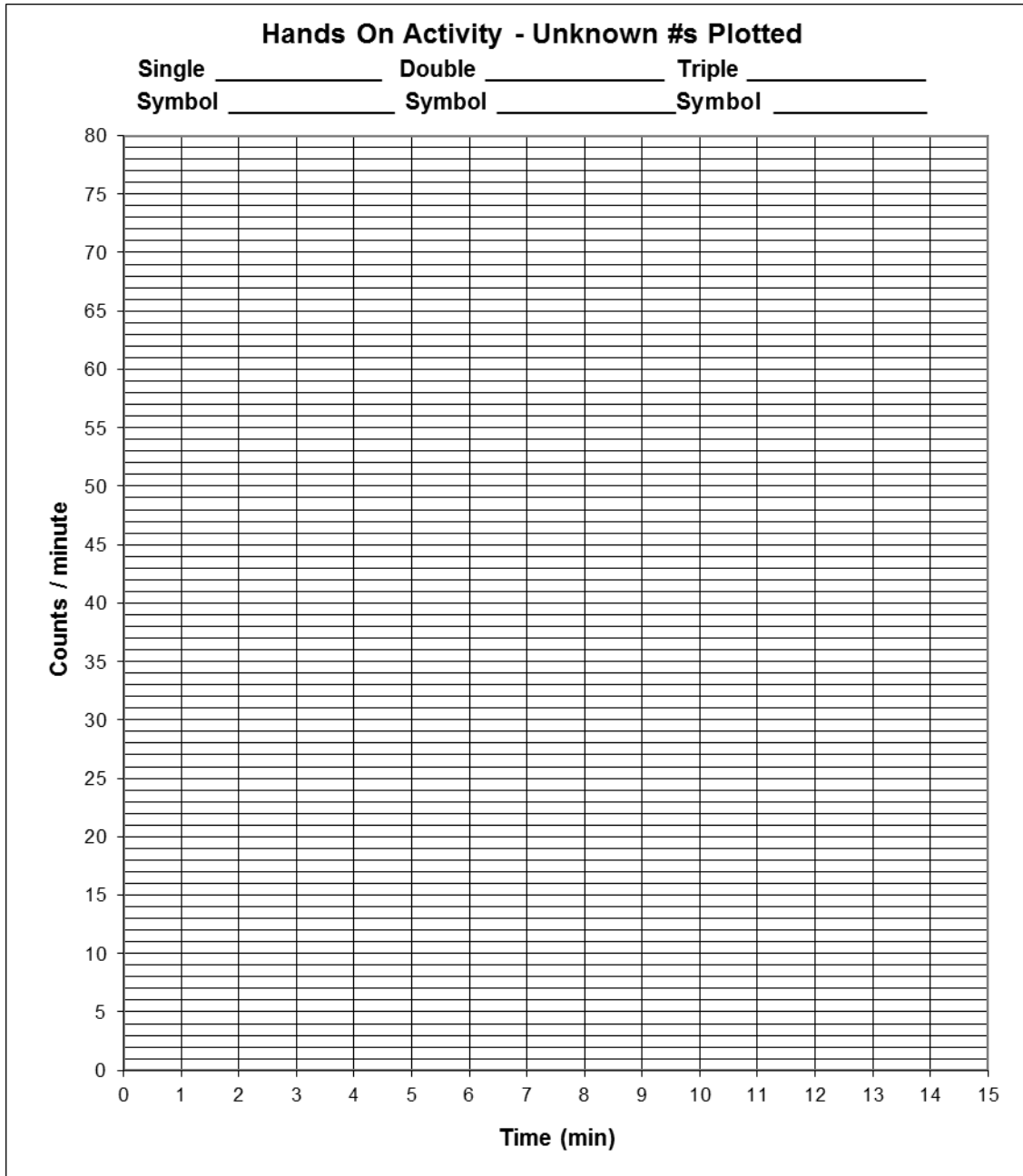k = _____ 1/min $t_{1/2}$ = _____ min

A_o = _____ counts/min   %Error = _____ %

Graphing Directions:

1. **Record Unknown Numbers** on the graph below for **single, double and triple values**.
   Indicate the the symbol you used to graph it in the title legend.

2. **Graph time (min) vs. counts /min** for the **single unknown number**. The graphed data should
   result in an exponential decay curve. **Connect the data points with a curve**.

3. **Repeat** step number 1. for the **double and triple unknowns** on the same graph.

Hands On Activity - Unknown #s Plotted

Single _____ Double _____ Triple _____
Symbol _____ Symbol _____ Symbol _____

4. Estimate the **half-life**, $t_{1/2}$, of the single unknown average. On your exponential graph, draw horizontal lines at **50 counts / min and 25 counts / min**. Wherever these lines cross the data, drop a vertical line. The distance between these two lines is the half-life. What is your estimated half-life in minutes for the following:

Estimate of Single unknown half life:

Estimate of Double unknown half-life:

Estimate of Triple unknown half-life: