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IB Physics SL

Nuclear Decay Process

1. Introduction:

The purpose of this lab is to understand and observe the relationship between half-live of the decay and the initial output of the product.

2. Definition:

Nuclear decay is the process by which a nucleus of an unstable atom loses energy by emitting radiation. It is a random process at the level of single atoms, in that, according to quantum theory, it is impossible to predict when a particular atom will decay. The chance that a given atom will decay never changes, that is, it does not matter how long the atom has existed. For a large collection of atoms however, the decay rate can be calculated from their measured decay constants or half-lives, which is the basis of radiometric dating.

3. Method:

To better observe the relation between half-live of the decay and the initial output of the product a simulator, run by Java application and developed by Dr. Schultz, will be used.

4. Equations:

First, we use the established nuclear decay equation:

$A = Ao \ x \ e^{-\lambda t}$

Second, we can derive a half-life equation by simplifying the first one:

$A = Ao \ x \ e^{-\lambda t}$

$A / Ao = ½ = e^{-\pi/2}$

$\ln ½ = -\lambda \ x \ T/2$

$t/2 = \ln 2 / \lambda$

With this equation it is possible to determine the half-life by simply calculating using the missing variable.

5. Hypothesis:

Based on prior knowledge and a few calculation conducted on a piece of paper, I assume that the time of the half life calculation obtained by the formula will be close, if not exactly the same, as the T(time) of the simulation.

6. Data:

During the simulation these five different initial inputs of atoms will be experimented:

1,000,000

100,000

10,000

1,000

100

Moreover, the formula obtained to determine half-time is derived below:

T/2 = ln2 / 0.01 = 69.3

Initial Output of Atoms	λ(Probability of Decay)	T(Obtained by Forumal)
100	0.01	69.3
1,000	0.01	69.3
10,000	0.01	69.3
100,000	0.01	69.3
1,000,000	0.01	69.3

The following data was collected using the Nuclear decay simulation:

Initial atom Input of 100

```
75 53 36 11
76 53 35 12
77 51 37 12
78 51 36 13
79 50 36 14
80 49 37 14
81 48 38 14
82 48 38 14
```

Initial atom Input of 1,000

```
67 510 329 161
68 505 331 164
69 501 330 169
70 493 336 171
71 489 335 176
72 481 343 176
```

Initial atom Input of 10,000

```
68 5116 3470 1414
69 5049 3514 1437
70 5008 3525 1467
71 4966 3533 1501
72 4907 3559 1534
73 4855 3580 1565
```

Initial atom Input of 100,000

```
66 51449 34251 14300
67 50952 34415 14633
68 50439 34560 15001
69 49933 34717 15350
70 49439 34902 15659
```

Initial atom Input of 1,000,000

```
67 510068 344918 145014
68 505091 346474 148435
69 499965 348172 151863
70 494830 349741 155429
```

Initial Output of Atoms	λ(Probability of Decay)	T(Obtained by Foruma)	T(Obtained by simulation)
100	0.01	69.3	80
1,000	0.01	69.3	70
10,000	0.01	69.3	71
100,000	0.01	69.3	69
1,000,000	0.01	69.3	69

7. Conclusion:

When first observing the data, the only difference observable from the data is the half-life obtained from the 100 Initial output of atoms because it fails to follow the pattern. Instead of remaining around 69.3, the half-life obtained is 80. This probably happened because of the small amount of atoms, 100.

All in all, as previously stated by the hypothesis, the half time obtained through the formula resembles the one obtained by the simulation with error margin of +/- 2. Also, I believe that there is a trend in this data, as it seems that the smaller the initial input of atoms the higher the half-life time. However, as the Initial output of atoms increases, the half time difference becomes less significant.