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IB Physics SL

Nuclear Decay Process

Introduction:

Nuclear decay, sometimes referred as Radioactive decay, is the spontaneous breakdown of a radioactive nuclear into a lighter nucleus. Through this process, the nucleus of an unstable atom will change its nuclear configuration by emitting radioactive particles.

This Nuclear decay lab is designed to shed light on the relationship between the initial input of atoms and half-life of nuclear decay. (as suggested by Dr. Shultz).

In Nuclear physics, the Half Life of particles holds significance because it helps determine the ages of very old artifacts.

Method:

1. Design a java simulation that considers the Randomness in the nuclear decay equation.
2. This Java simulation was designed by Dr. Shultz and can be found under www.github/trismeg by downloading zip : decay_sim-master

The ground work for this equation is already laid. Using the establish nuclear decay equation :

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

Hence, it is possible to derive a half life equation by simplifying it.

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

$$A / A_o = ½ = e^{-\pi/2}$$

$$\ln ½ = -\lambda \text{ x } T/2$$

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

Through this equation, it is possible to determine the half life by simply calculating using the missing variable → the probability of decay. (In this experiment it will be 0.01)

** Using the simulation, I will experiment using five different initial input of atoms as listed below:

1,000,000
100,000
10,000
1,000
100

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.

Data :

The formula obtained half time is derived below :

$T/2 = \ln 2 / 0.01 = 69.3$

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

Conclusion:

At first glance, the only disparity 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. It is probably due to the meager amount of atoms (100).

Otherwise, 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. (not including the 100 initial input of atoms). I think it is possible to observe a trend in this data as it seems that the smaller the initial input of atoms the higher the half life time. But as the Initial output of atoms increases, the half time difference becomes less significant, hence the half time difference of 10 between 100 and 1,000 and the difference of 0 (which is probably in the decimals) between 100,000 and 1,000,000 initial input of atoms.