Radioactive Decay Simulation Report

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December 11, 2023

1 Decay Modeling and Plot

1. **Decay Modeling and Plotting:** The provided Python code simulates the decay of 20,000 atoms over time. The decay process is modeled for a sufficiently long time to allow all atoms to decay to their final states. The plot in Figure 1 illustrates the number of atoms of each isotope over time.

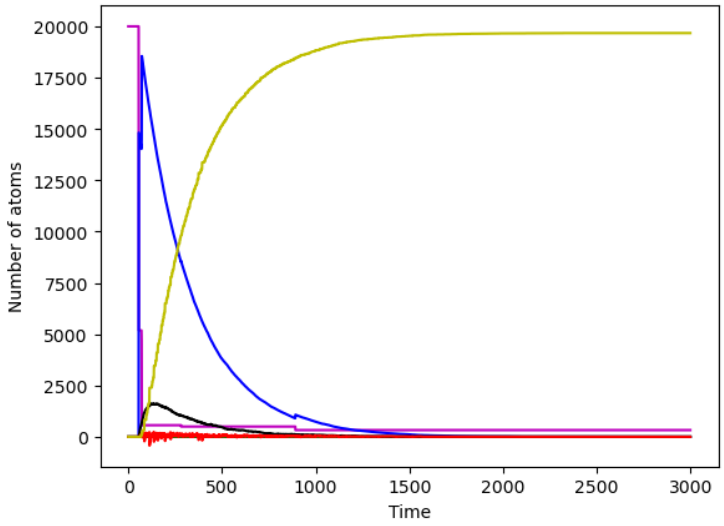

Figure 1: Number of atoms over time for different decay types

2 Number and Energy Calculation

2. **Number and Energy Calculation:** The program is utilized to calculate the number and energy generated from each of the four types of decay processes (alpha, beta, R-type, Z-type) in the radioactive decay chain.

```
Total Energy from Rn decay (R-type): 20857410 MeV

Total Energy from Po decay (a-type and b-type): 59022 MeV

Total Energy from Pb214 decay (Z-type): 32976 MeV

Total Energy from Bi decay (R-type and a-type): 78998 MeV

Total Energy from Ti decay (b-type): 178965 MeV
```

3 Average and Standard Deviation

3. **Average and Standard Deviation:** The average and standard deviation of the total and individual decay energies produced with the radioactive decay chain are calculated based on a minimum of 10 runs.

```
Average Total Energy: 16403785.057333333 MeV
Standard Deviation Total Energy: 3258936.460234924 MeV

Average Energy from Rn decay (Z-type): 16114352.781 MeV
Standard Deviation Energy from Rn decay (Z-type): 3176626.8372273524 MeV

Average Energy from Po decay (a-type and b-type): 52390.83 MeV
Standard Deviation Energy from Po decay (a-type and b-type): 13574.749268958894 MeV

Average Energy from Pb214 decay (Z-type): 25339.629333333334 MeV
Standard Deviation Energy from Pb214 decay (Z-type): 11923.414488641227 MeV

Average Energy from Bi decay (R-type and a-type): 69343.062 MeV
Standard Deviation Energy from Bi decay (R-type and a-type): 19342.404390978798 MeV

Average Energy from Ti decay (b-type): 142358.755 MeV
Standard Deviation Energy from Ti decay (b-type): 50623.100422642776 MeV
```

4 Shield Thickness Calculation

4. **Shield Thickness Calculation:** To block alpha-particle decay energy, the required thickness of a shield is calculated, taking into account the average and standard deviation from the previous calculations. The calculation assumes blocking up to 3-sigma deviation of average energy.

```
Thickness of the shield needed: 13090.297219019052 cm
```