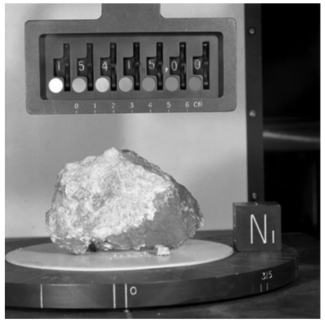
ACTIVITY 11 - Dating The Moon



Apollo 15 Anorthosite sample

Radioactive isotopes can be used to determine the age of rocks. The oldest Earth rock has been dated at around 4 billion years old. In fact, some of the oldest rocks on Earth are some of those brought back from the Moon by the Apollo astronauts.

Potassium-40 (^{40}K) is a radioactive isotope that decays by beta emission to Calcium-40 (^{40}Ca) and Argon-40 (^{40}Ar). ^{40}K has an average half-life of around 1.26 billion years. ^{40}K is the parent nuclei, and ^{40}Ar one of the daughter nuclei. By looking at the ratio of ^{40}K to ^{40}Ar in a sample of rock, it is possible to use this isotopic ratio to date the rock.

This activity uses dice to model the radioactive decay of an isotope:

Rules

1. A roll of 6 on any die indicates that the nuclei has decayed
2. All 30 dice start of as un-decayed nuclei at time t = 0 seconds
3. After 15 seconds, roll all the dice and sort into decayed and un-decayed
4. Fill in the table
5. At 30 seconds, roll all un-decayed dice and sort again
6. Fill in the table
7. Repeat at every 15 seconds until you reach 2 minutes

Time/seconds	Number of un-decayed	Number of decayed (6 rolled)
0	30	0
15		
30		
45		
60		
75		
90		
105		
120		

Plot a graph of your un-decayed nuclei vs. time and estimate the half-life – the time taken for half the nuclei to decay.

Pool the results from the class to produce a graph using more dice. How does using more results change the shape of the graph? How does this change the error associated with the results?

Suppose we find a rock in which only 1/8 of the original Potassium-40 remained. How old would the rock be? (Use the half-life value given for ^{40}K above)

Extension

For one die, the probability of decay is 1/6 in 15 seconds. This means that the decay constant $\lambda = \frac{1}{6 \text{ x } 15} s^{-1}$

Given that $t_{1/2} = \frac{ln2}{\lambda}$, and $N = N_0 e^{-\lambda t}$

Calculate a) the half-life and (b) the age where 10% remained un-decayed.