

## Algebra II: Age of the Earth

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### 1 Lead dating of Meteorites

Scientists can use radioactive decay to determine how old the solar system is. By comparing different amounts of lead in meteorites, geologists can use the decay rate of Uranium to determine when the meteorite was made.



Figure 1: Meteorite found in Canyon Diablo, Arizona

We know that **uranium-235** decays into **lead-207**, and **uranium-238** decays into **lead-206**. We can use the different **rates** of decay of uranium and the amount of lead found in the meteorites with the following equation:

$$\Delta Pb_{207} = \left( \frac{e^{\lambda_{U235}T} - 1}{137.88(e^{\lambda_{U238}T} - 1)} \right) \Delta Pb_{206} \quad (1)$$

This kind of complicated equation can be reduced to the equation for a line

$$\Delta Pb_{207} = m(\Delta Pb_{206}) \quad (2)$$

## 2 Decay Rate of Uranium

The **half-life** of uranium is:

- **U235** -  $7.038 \times 10^8$  years
- **U238** -  $4.468 \times 10^9$  years

### Question 1

Convert the two half lives into rates. That is, what should  $\lambda$  be to make  $e^{\lambda t} = (1/2)^{t/t_{1/2}}$

- $\lambda_{U235} =$
- $\lambda_{U238} =$

### 3 Comparing two meteorites

To determine the age of the Canyon Diablo Meteorite, we need to compare it to a different meteorite. Take a look at:

Table 1. The isotopic compositions of lead in meteorites

Meteorite	Pb Composition		
	206/204	207/204	208/204
Nuevo Laredo, Mexico	50.28	34.86	67.97
Forest City, Iowa	19.27	15.95	39.05
Modoc, Kansas	19.48	15.76	38.21
Henbury, Australia	9.55	10.38	29.54
Canyon Diablo, Arizona	9.46	10.34	29.44

Figure 2: Amount of lead found in different meteorites (Patterson 1956)

We think the Nuevo Laredo Meteorite is relatively new, while the Canyon Diablo Meteorite was formed at the same time as the Earth.

#### Question 2

If the Canyon Diablo Meteorite is from the beginning of the solar system, and the Nuevo Laredo Meteorite is from the solar system now, what is the difference in lead between the two?

- $\Delta Pb_{207} =$

- $\Delta Pb_{206} =$

## 4 Finding the Slope/Age of the Earth

### Question 3

Using your values for  $\Delta Pb_{206}$  and  $\Delta Pb_{207}$ , find the slope of the line  $\Delta Pb_{207} = m(\Delta Pb_{206})$

### Question 4

By setting your slope equal to the slope from Equation (1), you can solve for the age of the Earth,  $T$ .

$$m = \frac{e^{\lambda_{U235}T} - 1}{137.88(e^{\lambda_{U238}T} - 1)}$$

There are two different ways to solve this equation:

1. You can plug in different guesses for  $T$  until the right side equals the left side, or
2. You can use your calculator plot the right hand side and see what  $T$  gives you  $m$

HINT: If you want to use the guess and check method, start around 1 billion years.