



Chemistry: A Molecular Approach, Global Edition | (4th Edition)

Problem

A meteor has a Pb-206:U-238 mass ratio of 0.855:1.00. What is the age of the meteor? (Assume that the meteor did not contain any Pb-206 at the time of its formation.)

Step-by-step solution

Step 1 of 5

Given, that the mass ratio of Pb-206: U-238 in the meteor is 0.855:1.00.

$$\therefore m_{\text{U-238}} = 1.00 \text{ g}$$

$$m_{\text{Pb-206}} = 0.855 \text{ g}$$

[Comment](#)

Step 2 of 5

U-238 decays into Pb-206 with a half life of 4.5×10^9 years. This decay reaction follows the first order kinetics.

The integrated rate law for the reaction is

$$\ln \frac{N_t}{N_0} = -kt$$

[Comment](#)

Step 3 of 5

The rate constant for the decay of U-238 to Pb-206 can be determined from the half life expression

$$k = \frac{0.693}{t_{1/2}}$$

$$k = \frac{0.693}{4.5 \times 10^9 \text{ years}}$$

$$k = 1.54 \times 10^{-10} \text{ yr}^{-1}$$

[Comment](#)

Step 4 of 5

The mass in grams of U-238 that would have been required to form the given mass of Pb-206

$$0.855 \text{ g Pb-206} \times \frac{1 \text{ mol Pb-206}}{206 \text{ g Pb-206}} \times \frac{1 \text{ mol U-238}}{1 \text{ mol Pb-206}} \times \frac{238 \text{ g U-238}}{1 \text{ mol U-238}} = 0.9878 \text{ g U-238}$$

The initial mass, N_0 of U-238 is the current mass plus the mass that has decayed into Pb-206.

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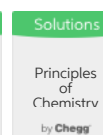
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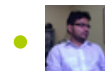
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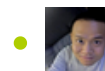
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Step 5 of 5 ^

Substituting all these values in the integrated rate law,

$$\ln \frac{N_t}{N_0} = -kt$$

$$t = -\frac{\ln \frac{N_t}{N_0}}{k}$$

$$t = -\frac{\ln \frac{1.00 \text{ g}}{(1.00 + 0.9878) \text{ g}}}{1.54 \times 10^{-10} \text{ yr}^{-1}}$$

$$t = 4.5 \times 10^9 \text{ yr}$$

The age of the meteor is $4.5 \times 10^9 \text{ yr}$.[Comment](#)

Was this solution helpful?

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Recommended solutions for you in Chapter 20

Chapter 20, Problem 15E

Explain the main concepts behind the technique of radiocarbon dating. How can radiocarbon dating be corrected for changes in atmospheric concentrations of C-14? What range of ages can be reliably determined by C-14 dating?

[See solution](#)

Chapter 20, Problem 65E

If 1.0 g of matter were converted to energy, how much energy would be formed?

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