Newcastle University

School of Maths, Stats, and Physics

Cloud Chambers

Worksheet with extension activity

Question 1

Watch carefully for the trails of cloud left by the alpha particles. You should see that they are fairly short, around 5 cm long. Why do they stop?

Question 2

The number of radioactive nuclei remaining in a sample decreases exponentially. If we know the initial number of atoms N_0, we can work out the number remaining after a given time t using the equation

$$N(t) = N_0 e^{-\lambda t},$$

where λ is the **decay constant**. This is related to the **half life** $t_{\frac{1}{2}}$ (the time it takes for the number of particles to halve) by the equation

$$\lambda = \frac{\ln(2)}{t_{\frac{1}{2}}}.$$

We can define the **activity** as the number of particles decaying per second, or the rate of change of the number of particles. This is given by

$$A = -\frac{dN}{dt} = \lambda N.$$

Watch your cloud chamber for 10 seconds, and count the number of trails you see in this time. Repeat this three times, and fill in the table below:

Time (s)	Number of Trails

Average: ________

What is the activity of the source? $A =$ _____ s^{-1}

Question 3

The half-life of thorium-232 (^{232}Th) is 1.4×10^{10} yr. How many atoms of ^{232}Th are there in your source? There are $3.155\,76 \times 10^{7}$ s in a year.

$N =$ __________

The atomic mass of ^{232}Th is 232.038 u. What is the mass of your source? (you may use $1\,\mathrm{u} = 1.66 \times 10^{-27}$ kg, $N_A = 6.02 \times 10^{23}\,\mathrm{mol}^{-1}$)

$m =$ ________ g

We already know that alpha particles produced near the centre of the source don't have as much kinetic energy by the time they leave the source. In fact, much of the alpha particles produced near the centre will never leave the sample. The rod is 2 mm in diameter. Assuming that we only see alpha particles from the outermost 22 µm of the rod, adjust your answer to the previous question to account for this.

$m =$ ______ g

The total mass of the rod is 10.5 g (it is mostly tungsten, a very dense metal). What percentage of the rod is ^{232}Th?

______ % ^{232}Th.

Question 4

We have so far assumed that all α particles observed have come from the decay of ^{232}Th to ^{228}Ra. However, ^{228}Ra is also unstable, and itself decays into ^{228}Ac. The full decay chain is shown in figure 1 below.

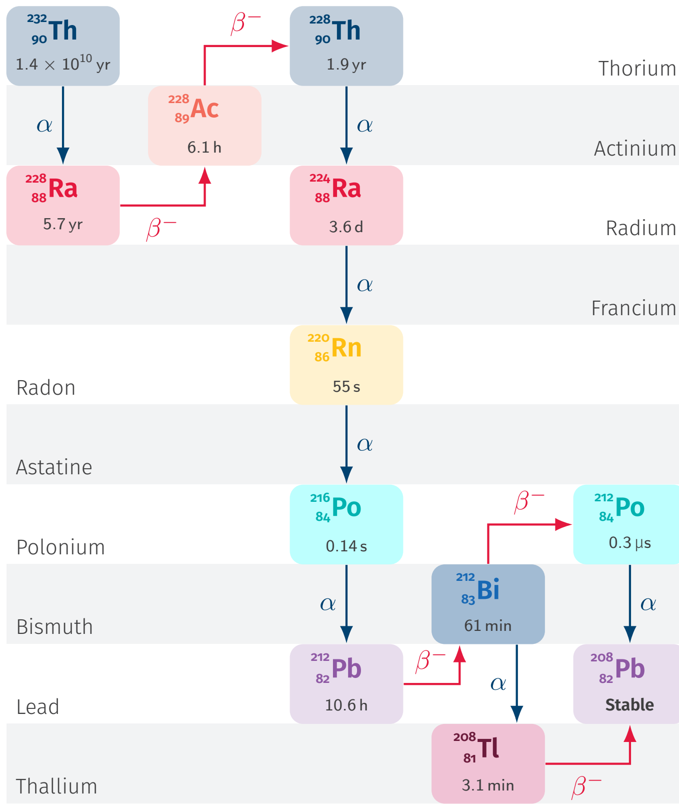

Figure 1: The decay chain of ^{232}Th.

Because of the huge difference in half-life between ^{232}Th and all the other unstable isotopes, we can approximate this entire chain as one process, with a half life of 1.4×10^{10} yr which produces 6 α particles, one of which is due to the ^{232}Th to ^{228}Ra decay. (Bismuth has two possible decay paths, both of which produce one α particle.) In effect, this means that the real activity due to ^{232}Th is $\frac{1}{6}$ of the observed activity. With this knowledge, what is the actual mass of ^{232}Th in the sample?

Hint: You do **not** need to re-do all the calculations. Just work out how the activity directly affects the mass.

$m =$ ______ g

This is about ____ % of the sample.