MEASURING NUCLEAR DECAY

Imagine that you are studying a sample of radioactive material. You know that the atoms in the material are decaying into other types of atoms. How many of the unstable parent atoms remain after a certain amount of time?

The decay constant indicates the rate of radioactive decay

If the sample contains N radioactive parent nuclei at some instant, the number of parent nuclei that decay into daughter nuclei (ΔN) in a small time interval (Δt) is proportional to N, as follows:

$$\Delta N = -\lambda N \Delta t$$

The negative sign signifies that N decreases with time; that is, ΔN is negative. The quantity λ is called the *decay constant*. The value of λ for any isotope indicates the rate at which that isotope decays. Isotopes with a large decay constant decay quickly, and those with a small decay constant decay slowly. The number of decays per unit time, $-\Delta N/\Delta t$, is called the *decay rate*, or *activity*, of the sample. Note that the activity of a sample equals the decay constant times the number of radioactive nuclei in the sample, as follows:

$$\text{activity} = \frac{-\Delta N}{\Delta t} = \lambda N$$

The SI unit of activity is the *becquerel* (Bq). One becquerel is equal to 1 decay/s. The *curie* (Ci), which was the original unit of activity, is the approximate activity of 1 g of radium. One curie is equal to 3.7×10^{10} Bq.

Did you know?

In 1898, Marie and Pierre Curie discovered two previously unknown elements, polonium and radium, both of which were radioactive. They were awarded the Nobel Prize in physics in 1903 for their studies of radioactive substances.

Half-life measures how long it takes half a sample to decay

Another quantity that is useful for characterizing radioactive decay is the **half-life,** written as $T_{1/2}$. The half-life of a radioactive substance is the time it takes for half of the radioactive nuclei in a sample to decay. The half-life of any substance is inversely proportional to the decay constant of the substance.

half-life

the time needed for half of the original nuclei of a sample of a radioactive substance to undergo radioactive decay

Why it Matters

Conceptual Challenge

1. Decay Series

Suppose a radioactive parent substance with a very long half-life has a daughter with a very short half-life. Describe what happens to a freshly purified sample of the parent substance.

2. Probability of Decay

"The more probable the decay, the shorter the half-life." Explain this statement.

3. Decay of Radium

The radioactive nucleus $^{226}_{88}$Ra (radium-226) has a half-life of about 1.6×10^3 years. Although the solar system is approximately 5 billion years old, we still find this radium nucleus in nature. Explain how this is possible.