Substances with large decay constants have short half-lives. The relationship between half-life and decay constant is given in the equation below. A derivation of this equation is beyond the scope of this book, but it involves the natural logarithm of 2. Because ln 2 = 0.693, this factor occurs in the final equation.

**HALF-LIFE**

$$T_{1/2} = \frac{0.693}{\lambda}$$

$$\textbf{half-life} = \frac{\textbf{0.693}}{\textbf{decay constant}}$$

Consider a sample that begins with $N$ radioactive nuclei. By definition, after one half-life, $\frac{1}{2}N$ radioactive nuclei remain. After two half-lives, half of these will have decayed, so $\frac{1}{4}N$ radioactive nuclei remain. After three half-lives, $\frac{1}{8}N$ will remain, and so on.

## SAMPLE PROBLEM C

### Measuring Nuclear Decay

**PROBLEM**

**The half-life of the radioactive radium ($^{226}$Ra) nucleus is $5.0 \times 10^{10}$ s. A sample contains $3.0 \times 10^{16}$ nuclei. What is the decay constant for this decay? How many radium nuclei, in curies, will decay per second?**

**SOLUTION**

**1. DEFINE** **Given:** $T_{1/2} = 5.0 \times 10^{10}$ s $\quad N = 3.0 \times 10^{16}$

**Unknown:** $\lambda = ?$ $\quad$ activity = ? Ci

**2. PLAN** **Choose an equation or situation:**
To find the decay constant, use the equation for half-life.

$$T_{1/2} = \frac{0.693}{\lambda}$$

The number of nuclei that decay per second is given by the equation for the activity of a sample.

$$\text{activity} = \lambda N$$

**Rearrange the equation to isolate the unknown:**
The first equation must be rearranged to isolate the decay constant, $\lambda$.

$$\lambda = \frac{0.693}{T_{1/2}}$$