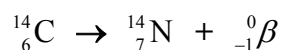


- Write down an equation representing the decay mechanism of ^{14}C .

Marks
6



The half-life of ^{14}C is 5730 years. What is the activity of precisely 1 g of this isotope, given that each atom weighs 14.00 amu? Give your answer in Bq.

As 1 mol of ^{14}C has a mass of 14.00 g, the number of nuclei, N , in 1 g is:

number of nuclei = number of moles \times Avogadro's constant

$$N = \left(\frac{1.000}{14.00} \text{ mol} \right) \times (6.022 \times 10^{23} \text{ nuclei mol}^{-1}) = 4.301 \times 10^{22} \text{ nuclei}$$

The activity (A) is related to N by $A = \lambda N$ where λ is the decay constant. The half life, $t_{1/2}$, is related to the decay constant, λ , by $t_{1/2} = \ln 2 / \lambda$. Hence,

$$\lambda = \ln 2 / (5730 \times 365 \times 24 \times 60 \times 60 \text{ s}) = 3.84 \times 10^{-12} \text{ s}^{-1}$$

The activity is thus,

$$\begin{aligned} A &= \lambda N = (3.84 \times 10^{-12} \text{ s}^{-1}) \times (4.301 \times 10^{22} \text{ nuclei}) \\ &= 1.65 \times 10^{11} \text{ nuclei s}^{-1} = 1.65 \times 10^{11} \text{ Bq} \end{aligned}$$

Answer: $1.65 \times 10^{11} \text{ Bq}$

Carbon-14 is used as a radioactive tracer in the urea breath test, a diagnostic test for *Helicobacter pylori*. Name an instrument which can be used to detect radioactive carbon dioxide in the breath of a patient.

A scintillation counter

A patient ingests 1.00 g of urea with a total activity of 1.00 μCi . What is the percentage, by weight, of carbon-14 in this sample?

As 1 Ci = 3.70×10^{10} Bq, from above, the activity per gram of ^{14}C is,

$$A = \frac{1.65 \times 10^{11}}{3.70 \times 10^{10}} \text{ Ci} = 4.46 \text{ Ci}$$

As the actual activity of urea is 1.00 μCi or 1.00×10^{-6} Ci, the percentage by weight that must be ^{14}C is,

$$\text{percentage } ^{14}\text{C} = \frac{1.00 \times 10^{-6}}{4.46} \times 100 \% = 2.2 \times 10^{-5} \%$$

Answer: $2.2 \times 10^{-5} \%$