Marks 8

- Sixteen unstable isotopes of strontium are known to exist. Of greatest importance are ^{90}Sr with a half-life of 28.78 years and ^{89}Sr with a half-life of 50.5 days. ^{90}Sr is found in nuclear fallout as it is a by-product of nuclear fission.

  Calculate the activity (in Bq) of 20.0 g of ^{90}Sr.

As 1 mol of ^{90}Sr has a mass of 90.0 g, the number of nuclei, N, in 20.0g is:

number of nuclei = number of moles × Avogadro's constant

$$N = \left(\frac{20.000}{90.0}\text{ mol}\right) \times (6.022 \times 10^{23}\text{ nuclei mol}^{-1}) = 1.34 \times 10^{23}\text{ nuclei}$$

The activity (A) is related to N by $A = \lambda N$ where λ is the decay constant. The half life, $t_{½}$, is related to the decay constant, λ, by $t_{½} = \ln2/\lambda$. Hence,

$$\lambda = \ln2/(28.78 \times 365 \times 24 \times 60 \times 60\text{ s}) = 7.64 \times 10^{-10}\text{ s}^{-1}$$

The activity is thus,

$$A = \lambda N = (7.64 \times 10^{-10}\text{ s}^{-1}) \times (1.34 \times 10^{23}\text{ nuclei})$$

$$= 1.02 \times 10^{14}\text{ nuclei s}^{-1} = 1.02 \times 10^{14}\text{ Bq}$$

Answer: **1.02 × 10^{14} Bq**

Calculate the age (to the nearest year) of a sample of ^{90}Sr that has an activity one-eighth of a freshly prepared sample.

The number of radioactive nuclei changes with time according to the equation:

$$\ln(N_0/N_t) = \lambda t$$

As the activity is proportional to the number of nuclei, this can also be written in terms of activities:

$$\ln(A_0/A_t) = \lambda t$$

If the activity has decreased to one eighth of its original value, $A_0/A_t = 8$. Hence:

$$\ln(8) = (7.64 \times 10^{-10}\text{ s}^{-1}) \times t$$

$$t = 2.72 \times 10^{9}\text{ s} = (2.72 \times 10^{9} / (365 \times 24 \times 60 \times 60)\text{ years} = 86.3\text{ years}$$

Answer: **86 years**

ANSWER CONTINUES ON THE NEXT PAGE

Determine the specific activity of ^{90}Sr in Ci g^{-1}.

From above, the activity of 20.0 g of ^{90}Sr is 1.02 × 10^{14} Bq so the activity of one gram is (1.02 × 10^{14} Bq)/ (20 g) = 5.11 × 10^{12} Bq g^{-1}.

As 1 Ci = 3.70 × 10^{10} Bq, this corresponds to:

specific activity = (5.11 × 10^{12}) / (3.70 × 10^{10}) Ci g^{-1} = 138 Ci g^{-1}

Answer: **138 Ci g^{-1}**

^{90}Sr presents a long-term health problem as it substitutes for calcium in bones. Comment on why Sr can substitute for Ca so readily.

Sr has similar electronic structure to Ca - both have *s*^{2} valence shell configuration.

The Sr^{2+} and Ca^{2+} cations have the same charge and are of similar size.