- Write two possible mechanisms for the radioactive decay of ^{83}Rb to ^{83}Kr.

Marks 5

$^{83}_{37}Rb \rightarrow ^{83}_{36}Kr + ^{0}_{+1}e$ **(positron decay)**

$^{83}_{37}Rb + ^{0}_{-1}e \rightarrow ^{83}_{36}Kr$ **(electron capture decay)**

The half-life of ^{83}Rb is 86.2 days. Calculate the activity (in Bq) of an isotopically pure 1.000 g sample of ^{83}Rb. (The molar mass of ^{83}Rb is 82.915110 g mol^{-1}.)

As 1 mol of ^{83}Rb has a mass of 82.915110 g, the number of nuclei, *N*, in 1.000 g is:

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

$$N = \left(\frac{1.000}{82.915110} \text{ mol}\right) \times (6.022 \times 10^{23} \text{ nuclei mol}^{-1}) = 7.263 \times 10^{21} \text{ nuclei}$$

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,

$$\lambda = \ln2/(86.2 \times 24 \times 60 \times 60 \text{ s}) = 9.31 \times 10^{-8} \text{ s}^{-1}$$

The activity is thus,

$$A = \lambda N = (9.31 \times 10^{-8} \text{ s}^{-1}) \times (7.263 \times 10^{21} \text{ nuclei})$$
$$= 6.76 \times 10^{14} \text{ nuclei s}^{-1} = 6.76 \times 10^{14} \text{ Bq}$$

Answer: **6.76×10^{14} Bq**

How many days will it take for this sample to diminish to 1 % of its initial activity?

The number of radioactive nuclei decays with time according to $\ln(N_0/N_t) = \lambda t$. As the activity is proportional to the number of nuclei ($A = \lambda N$), this can be rewritten as:

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

If the activity drops to 1% of its initial value, $A_0/A_t = (100/1) = 100$.
As $\lambda = 9.31 \times 10^{-8}$ s^{-1}:

$$\ln(100) = (9.31 \times 10^{-8} \text{ s}^{-1})t$$

$$t = 49000000 \text{ s} = 600 \text{ days}$$

Answer: **600 days**