**Marks 5**

- The generation of energy in a nuclear reactor is largely based on the fission of either $^{235}U$ or $^{239}Pu$. The fission products include every element from zinc through to the *f*-block. Explain why most of the radioactive fission products are β-emitters.

**The optimal n:p ration increases as *Z* increases. Splitting a large nucleus in two will almost certainly produce nuclides with similar n:p ratios to the parent, which will now be too high. They will emit negative charge to convert neutrons to protons, bringing about a more satisfactory n:p ratio. *i.e.* they will be β emitters.**

The radioactivity of spent fuel rods can be modelled by the exponential decay of $^{137}Cs$, which has a half-life of 30.23 years. What is the specific activity of $^{137}Cs$, in Bq g$^{-1}$?

**The number of nuclei, *N*, in 1.00 g of $^{137}Cs$ is:**

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

$$N = \left(\frac{1.00}{137}\text{ mol}\right) \times (6.022 \times 10^{23}\text{ nuclei mol}^{-1}) = 4.40 \times 10^{21}\text{ nuclei}$$

**The activity (*A*) is related to *N* by $A = \lambda N$ where $\lambda$ is the decay constant. The half life, $t_{½}$, is related to the decay constant, $\lambda$, by $t_{½} = \ln 2/\lambda$. Hence,**

$$\lambda = \ln 2/(30.23 \times 365 \times 24 \times 60 \times 60\text{ s}) = 7.271 \times 10^{-10}\text{ s}^{-1}$$

**The activity is thus,**

$$A = \lambda N = (7.271 \times 10^{-10}\text{ s}^{-1}) \times (4.40 \times 10^{21}\text{ nuclei})$$

$$= 3.19 \times 10^{12}\text{ nuclei s}^{-1} = 3.19 \times 10^{12}\text{ Bq}$$

Answer: **$3.19 \times 10^{12}$ Bq g$^{-1}$**