Marks

- Balance the following nuclear reactions by identifying the missing nuclear particle or nuclide. **3**

$$^{36}_{17}\mathrm{Cl} + {}^{0}_{-1}\mathrm{e} \rightarrow \boxed{^{36}_{16}\mathbf{S}}$$

$$^{236}_{92}\mathrm{U} \rightarrow {}^{92}_{36}\mathrm{Kr} + {}^{141}_{56}\mathrm{Ba} + 3\,\boxed{^{1}_{0}\mathbf{n}}$$

$$^{99}_{42}\mathrm{Mo} \rightarrow {}^{0}_{-1}\mathrm{e} + \boxed{^{99}_{43}\mathbf{Tc}}$$

- The half-life of plutonium-239 is 24110 years. How many years (to the nearest year) must pass after $^{239}_{94}\mathrm{Pu}$ is produced for the number of $^{239}_{94}\mathrm{Pu}$ atoms to decay to 0.01000 of the original number? **3**

The number of radioactive nuclei N decreases with time according to the equation,

$$\ln\left(\frac{N_0}{N_t}\right) = \lambda t$$

where λ is the decay constant. The decay constant is related to the half life by

$$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{24110} = 2.875\times10^{-5}\ \text{years}^{-1}$$

If $N_t = 0.01N_0$ then:

$$\ln\left(\frac{1}{0.01}\right) = 2.875\times10^{-5} t$$

Hence, t = 160, 183 years.

Answer: **t = 160, 183 years**

- Provide a brief explanation of the process by which nuclear radiation causes biological damage. **2**

Nuclear radiation is of sufficient energy to ionise atoms in living tissues. The free radicals thus formed are highly reactive (due to having unpaired electrons) and cause unwanted chemical reactions in the tissues. This in turn can lead to cell damage, destruction of DNA, etc.