Marks 8

- 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 neutron : proton ratio increases as *Z* increases.

Splitting a large nucleus in two will almost certainly produce nuclides with similar neutron : proton 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 neutron : proton ratio. *i.e.* they will be β emitters.

Much of the fission yield is concentrated in two peaks, one in the second transition row and the other later in the periodic table. Identify the missing "sister" products of the following daughter nuclides of ^{235}U by writing balanced nuclear equations. The fission reactions are triggered by the absorption of one neutron, and release three neutrons upon disintegration of the short-lived ^{236}U nucleus.

^{141}Ba	$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + \mathbf{3}\,{}^{1}_{0}n$
^{95}Sr	$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{95}_{38}Sr + {}^{138}_{54}Xe + \mathbf{3}\,{}^{1}_{0}n$

Many of the fission products are short lived, and spent fuel rods are eventually contaminated by longer-lived species. The radioactivity of spent fuel can be modelled simply by the exponential decay of the ^{137}Cs and ^{90}Sr. The % yields and half lives of these nuclides are given in the table.

nuclide	%Yield *per fission event*	Half-life (years)
^{90}Sr	4.505	28.9
^{137}Cs	6.337	30.23

After use, nuclear fuel rods are stored in ponds of cooling water, awaiting safe disposal. If 3 % of the mass of used fuel rods consists of fission products of ^{235}U and ^{239}Pu, what percentage of the mass is made up by each of these nuclides?

Using:

percentage mass = percentage yield × (atomic mass / 235) × 3%

% ^{90}Sr = 0.04505 × (90/235) × 0.03 × 100% = 0.05%

% ^{137}Cs = 0.06337 × (137/235) × 0.03 × 100% = 0.11%

^{90}Sr: **0.05%**	^{137}Cs: **0.11%**

THIS QUESTION CONTINUES ON THE NEXT PAGE.