



- 8 (a) The radioactive decay of the isotope strontium-90 is both spontaneous and random. Explain what is meant by

- (i) *spontaneous* decay,

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[1]

- (ii) *random* decay.

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[2]

- (b) A sample contains  $N$  nuclei of strontium-90 at time  $t$ . At time  $(t + \Delta t)$ , the sample contains  $(N - \Delta N)$  nuclei of strontium-90.

Give expressions, in terms of  $N$ ,  $\Delta N$ ,  $t$  and  $\Delta t$ , for

- (i) the activity of the sample,

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[1]

- (ii) the probability of decay of a strontium nucleus in time  $\Delta t$ ,

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[1]

- (iii) the decay constant  $\lambda$  for strontium-90.

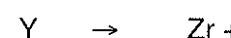
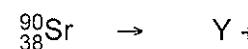
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[1]

- (c) Strontium-90 ( ${}_{38}^{90}\text{Sr}$ ) undergoes  $\beta^-$ -decay to form yttrium (Y).

Yttrium is itself radioactive and decays by the emission of  $\beta^-$ -particles. The yttrium decays to form zirconium (Zr) which is stable.

- (i) Complete the nuclear equations below for the decay of strontium-90 to form zirconium.



[3]





- (ii) The half-life of this isotope of yttrium is 65 hours.

Calculate the decay constant  $\lambda$  of this yttrium isotope. Give your answer in SI base units.

$$\lambda = \dots \quad [2]$$

- (d) A sample of strontium-90 is stored for a time of 50 years in a lead container having walls approximately 5 mm thick. The half-life of strontium-90 is 28 years.

- (i) Calculate the fraction of the strontium-90 that remains after 50 years.

$$\text{fraction} = \dots \quad [2]$$

- (ii) Despite the presence of some yttrium in the sample, the number of zirconium nuclei is almost equal to the number of strontium nuclei that have decayed.

By reference to the half-lives, explain this observation.

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[3]



- (iii) Explain why, although the lead container provides adequate shielding for the  $\beta$ -particle emissions, some X-ray radiation may be detected outside the lead container.

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[4]

