7 **(a)** Explain, with reference to the variation of binding energy per nucleon with nucleon number, why the following nuclear fission reaction of iron-56 ($^{56}_{26}Fe$) to fluorine-20 ($^{20}_{9}F$) and chlorine-37 ($^{37}_{17}Cl$) would **not** result in an overall release of energy.

$$^{56}_{26}Fe + ^{1}_{0}n \rightarrow ^{20}_{9}F + ^{37}_{17}Cl$$

....

....

....

.... [2]

(b) A uranium-235 nucleus absorbs a neutron and becomes unstable. It then undergoes a fission reaction. One possible reaction is

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{142}_{54}Xe + ^{90}_{38}Sr + 4\,^{1}_{0}n$$

Table 7.1 shows the mass defects of the nuclei for this fission reaction.

Table 7.1

nuclei	mass defect / u
uranium-235 ($^{235}_{92}U$)	1.910
xenon-142 ($^{142}_{54}Xe$)	1.273
strontium-90 ($^{90}_{38}Sr$)	0.8405

Calculate the energy released from the fission of one nucleus of uranium-235.

energy = ... J [2]

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(c) Strontium-90 is unstable and decays into the isotope yttrium-90.

A sample initially contains only nuclei of strontium-90. The half-life of strontium-90 is 28.8 years. The ratio

$$\frac{\text{number of decayed nuclei of strontium-90}}{\text{number of undecayed nuclei of strontium-90}}$$

is equal to *R*.

Determine the value of *R* after 144 years.

R = ……………..……… [3]

(d) A power source contains 0.13 kg of strontium-90. Each nucleus of strontium-90 that decays emits 0.546 MeV of energy.

(i) Calculate the initial number N_0 of nuclei of strontium-90 in the power source.

N_0 = ……………..……… [1]

(ii) Determine the initial activity of the source.

activity = ……………..……… Bq [1]

[Turn over

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(iii) Hence, determine the initial power output from the source due to the decay of strontium-90.

power output = …………….………… W [2]

[Total: 11]