Critical Mass

1. Natural uranium consists of 99.3% $^{238}_{92}U$ and 0.7% $^{235}_{92}U$. In many nuclear reactors, the fuel consists of enriched uranium enclosed in sealed metal containers.

(a) (i) Explain what is meant by *enriched uranium.*

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(ii) Why is enriched uranium rather than natural uranium used in many nuclear reactors?

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(2)

(b) (i) By considering the neutrons involved in the fission process, explain how the rate of production of heat in a nuclear reactor is controlled.

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(ii) Explain why all the fuel in a nuclear reactor is **not** placed in a single fuel rod.

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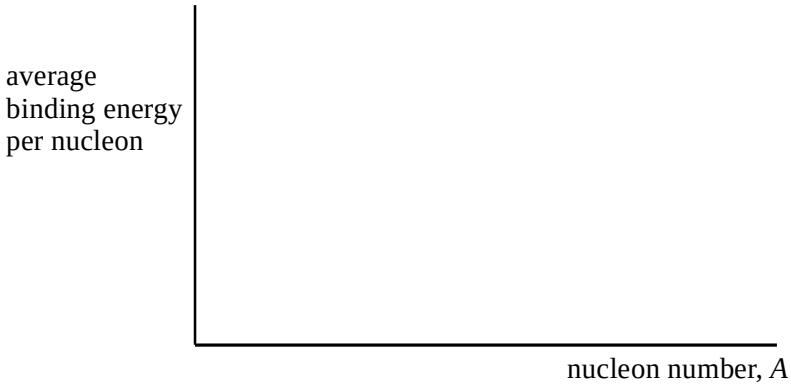
(5)
(Total 7 marks)

2. (a) (i) Explain what is meant by the term *binding energy* for a nucleus.

(ii) Sketch on the axes a graph of the average binding energy per nucleon against nucleon number *A*, giving approximate values of the scale on each axis.



(b) Use your graph to explain why energy is released when a neutron collides with a $^{235}_{92}\mathrm{U}$ nucleus causing fission.

(2)

(c) Neutrons are released when nuclear fission occurs in $^{235}_{92}\mathrm{U}$. Some of these neutrons induce further fission, others are absorbed without further fission and others escape from the surface of the material. The average number of neutrons released per fission is 2.5, of which at least one must produce further fission if a chain reaction is to be sustained.

Explain how a chain reaction can occur only if the piece of uranium has a certain minimum mass (the *critical mass*).

(3)
(Total 10 marks)

3. (a) Explain why, after a period of use, the fuel rods in a nuclear reactor become

(i) less effective for power production,

(ii) more dangerous.

(3)

(b) Describe the stages in the handling and processing of spent fuel rods after they have been removed from a reactor, indicating how the active wastes are dealt with.

You may be awarded marks for the quality of written communication in your answer.

(5)
(Total 8 marks)