Nuclear Physics

Have a go at the following exam questions.

OCR, G485, Jan 2013

4 **(a)** In the core of a nuclear reactor, one of the many fission reactions of the uranium-235 nucleus is shown below.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{140}_{54}Xe + ^{94}_{38}Sr + 2^{1}_{0}n$$

(i) State **one** quantity that is conserved in this fission reaction.

.... **[1]**

(ii) Fig. 4.1 illustrates this fission reaction.

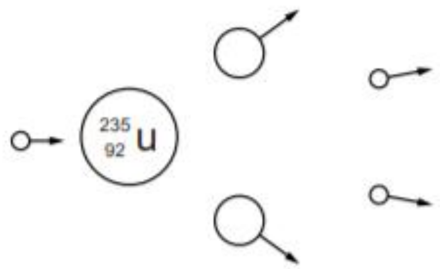

Fig. 4.1

Label all the particles in Fig. 4.1 and extend the diagram to show how a chain reaction might develop. **[2]**

(b) Fusion of hydrogen nuclei is the source of energy in most stars. A typical reaction is shown below.

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n$$

The $^{2}_{1}H$ nuclei repel each other. Fusion requires the $^{2}_{1}H$ nuclei to get very close and this usually occurs at very high temperatures, typically 10^9 K.

(i) Use the data below to calculate the energy released in the fusion reaction above.

mass of $^{2}_{1}H$ nucleus = 3.343×10^{-27} kg

mass of $^{3}_{2}He$ nucleus = 5.006×10^{-27} kg

mass of $^{1}_{0}n$ = 1.675×10^{-27} kg

energy = ... J **[3]**

(ii) State in what form the energy in **(b)(i)** is released.

.... **[1]**

(iii) The $^{2}_{1}H$ nuclei in stars can be modelled as an ideal gas. Calculate the mean kinetic energy of the $^{2}_{1}H$ nuclei at 10^{9} K.

energy = ... J **[2]**

(iv) Suggest why some fusion can occur at a temperature as low as 10^{7} K.

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.... **[1]**

[Total: 10]

5 The radioactive nucleus of plutonium ($^{238}_{94}Pu$) decays by emitting an alpha particle ($^{4}_{2}He$) of kinetic energy 5.6MeV with a half-life of 88 years. The plutonium nucleus decays into an isotope of uranium.

(a) State the number of neutrons in the **uranium** isotope.

.... **[1]**

(b) The mass of an alpha particle is 6.65×10^{-27} kg.

(i) Show that the kinetic energy of the alpha particle is about 9×10^{-13} J.

[1]

(ii) Calculate the speed of the alpha particle.

speed = ... $m\,s^{-1}$ **[2]**

(c) In a space probe, a source containing plutonium-238 nuclei is used to generate 62W for the onboard electronics.

(i) Use your answer to **(b)(i)** to show that the initial activity of the sample of plutonium-238 is about 7×10^{13} Bq.

(ii) Calculate the decay constant of the plutonium-238 nucleus.

1 year = 3.16×10^7 s

decay constant = ... s^{-1} [2]

(iii) The molar mass of plutonium-238 is 0.24 kg. Calculate

1 the number of plutonium-238 nuclei in the source

number of nuclei = ... [2]

2 the mass of plutonium in the source.

mass = ... kg [1]

[Total: 10]

(a) Radon gas ($^{222}_{86}\text{Ra}$) is radioactive and can be a significant health hazard in areas that have a high natural concentration of the gas. Radon decays to a stable form of lead (Pb) via 4 alpha decays and 4 beta decays and radon has a half-life of 3.8 days.

(i) Calculate the mass number and atomic number of this stable isotope of lead (Pb). [2]

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(ii) Give **three** reasons why radon gas is particularly dangerous. [3]

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(b) Calculate the time taken for the number of radon gas particles to decrease to 9.0% of their initial number. [4]

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(c) When radon gas is kept in a lead lined container for 3.8 days, the number of radon gas particles halves. However, the activity inside the container is considerably higher than half the original activity. Suggest a reason why. [1]

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