Oxford Cambridge and RSA

A Level Physics A

H556/02 Exploring physics

Question Set 28

1 (a) Fig. 21 shows stable and unstable nuclei of some light elements plotted on a grid. This grid has number of neutrons *N* on the vertical axis and number of protons *Z* on the horizontal axis.

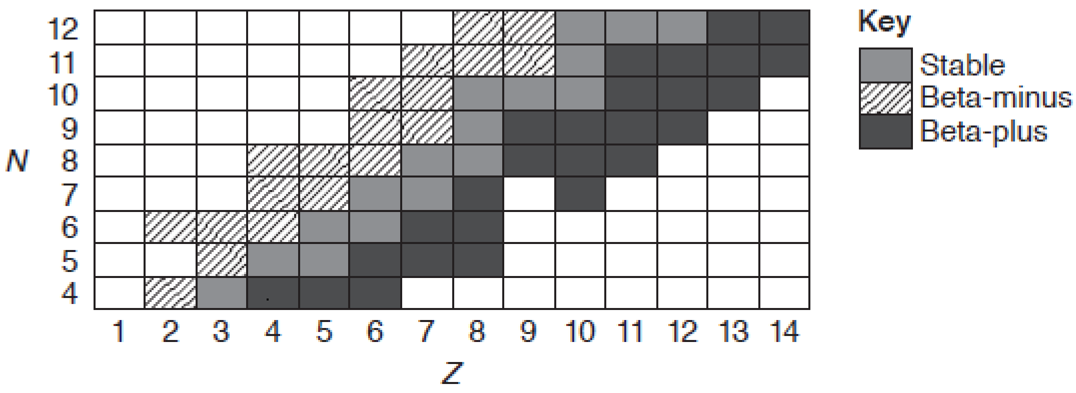

Fig. 21

The key on Fig. 21 shows whether a nucleus is stable, emits a beta-plus particle or emits a beta-minus particle to become stable.

For *Z* = 7, suggest in terms of *N* why an isotope may emit

(i) a beta-minus particle

If N is 9-11, i.e. if much more neutrons compared to protons, so beta-minus so that neutron decays to proton.

[1]

(ii) a beta-plus particle.

If N = 5 or 6, i.e too few neutrons compared to protons, so beta-plus so that proton decays to neutron.

[1]

(b) Inside a nuclear reactor, fission reactions are controlled and **chain reactions** are prevented. A typical fission reaction of the uranium-235 nucleus ($^{235}_{9}U$) is illustrated below.

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{55}Cs + ^{93}_{37}Rb + 2^{1}_{0}n$$

The neutron triggering the fission reaction moves slowly. The neutrons produced in the fission reaction move fast.

(i) Describe what is meant by **chain reaction**.

[2]

Where one individual reaction triggers the next, producing a self sustaining cascade of reactions.

(ii) Explain how chain reactions are prevented inside a nuclear reactor.

[2]

- Control rods absorb excess neutrons, meaning only one survives each fission, producing stable reaction.

(iii) The energy released in each fission reaction is equivalent to a decrease in mass of 0.19 u.
A fuel rod in a nuclear reactor contains 3.0% of uranium-235 by mass.

Estimate the total energy produced from 1.0 kg of fuel rod.

molar mass of uranium-235 = 0.235 kg mol^{-1}
1 u = 1.66 × 10^{-27} kg

0.03 Kg of U-235

$\frac{0.03}{0.235} \times 6.02\times10^{23} = 7.7\times10^{22}$ U-235 particles

$\Delta mass = 7.7\times10^{22} \times 0.19 \times 1.661\times10^{-27} = 2.4\times10^{-5}$

$E = \Delta mass\ c^2 = 2.4\times10^{-5} \times (3\times10^{8})^2 = 2.18\times10^{12}$ J

energy = ...2.2×10^{12}...... J **[4]**

Total Marks for Question Set 28: 10