

## **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.

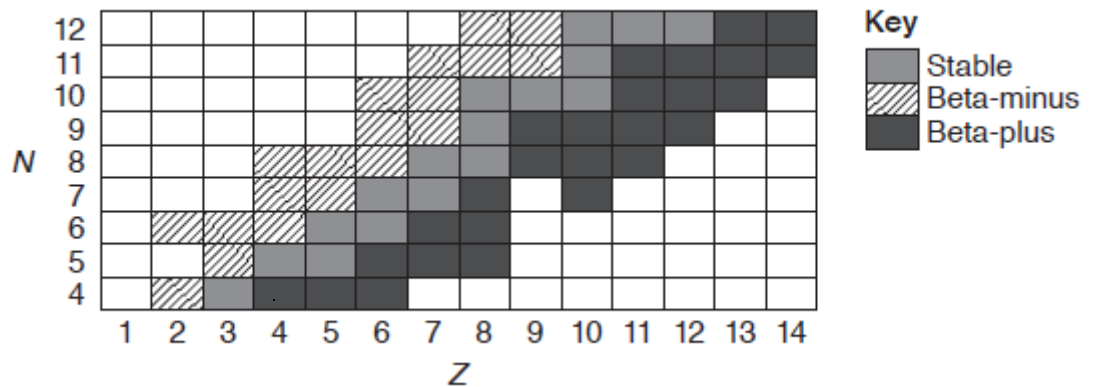


Fig. 21

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

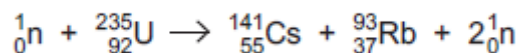
- (i) a beta-minus particle

If  $N$  is  $> 7$ , 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 ( $^{235}_{92}\text{U}$ ) is illustrated below.



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**.

Where one individual reaction triggers the next, producing a self-sustaining cascade of reactions. [2]

(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 0.19u.

A fuel rod in a nuclear reactor contains 3.0% of uranium-235 by mass.

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

molar mass of uranium-235 = 0.235 kg mol<sup>-1</sup>

1u = 1.66 × 10<sup>-27</sup> kg

0.03 kg of U-235

$$\frac{0.03}{0.235} \times 6.02 \times 10^{23} = 7.7 \times 10^{22} \text{ U-235 particles}$$

$$\Delta \text{mass} = 7.7 \times 10^{22} \times 0.19 \times 1.661 \times 10^{-27} = 2.4 \times 10^{-5}$$

$$E = \Delta \text{mass } c^2 = 2.4 \times 10^{-5} \times (3 \times 10^8)^2 = 2.18 \times 10^{12} \text{ J}$$

energy = ..... 2.2 × 10<sup>12</sup> ..... J [4]

**Total Marks for Question Set 28: 10**

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