

State Examination Commission – Physics Higher Level, 2005

Question 11

Read the following passage and answer the accompanying questions.

Ernest Rutherford made the following point:

If the particles that come out naturally from radium are no longer adequate for my purposes in the laboratory, then maybe the time had come to look at ways of producing streams of fast particles artificially. High voltages should be employed for the task. A machine producing millions of alpha particles or protons would be required. These projectiles would be released close to a high voltage and would reel away at high speed. It would be an artificial particle accelerator. Potentially such apparatus might allow physicists to break up all atomic nuclei at will.

(Adapted from "The Fly in the Cathedral" Brian Cathcart; 2004)

(i) What is the structure of an alpha particle? (7)

It is a helium nucleus, two protons and two neutrons combined together.

(ii) Rutherford had bombarded gold foil with alpha particles. What conclusion did he form about the structure of the atom? (7)

That an atom is mostly empty space surrounding an extremely dense positive nucleus.

(iii) High voltages can be used to accelerate alpha particles and protons but not neutrons. Explain why. (7)

Neutrons are uncharged and experience no force in electric fields

(iv) Cockcroft and Walton, under the guidance of Rutherford, used a linear particle accelerator to artificially split a lithium nucleus by bombarding it with high-speed protons. Copy and complete the following nuclear equation for this reaction. (7)



(v) Circular particle accelerators were later developed. Give an advantage of circular accelerators over linear accelerators. (7)

Circular accelerators allow particles to be accelerated to higher energies as they go round and round

(vi) In an accelerator, two high-speed protons collide and a series of new particles are produced, in addition to the two original protons. Explain why new particles are produced. (7)

The energy acquired by the protons in the accelerator is converted into the mass of the new particles.

(vii) A huge collection of new particles was produced using circular accelerators. The quark model was proposed to put order on the new particles. List the six flavours of quark. (7)

Up, down, charm, strange, top, bottom

(viii) Give the quark composition of the proton. (7)

Up, up, down