

17 A cosmic ray, consisting of a fast-moving proton, collides with a proton within the nucleus of an atom in the upper atmosphere. Three particles, a proton, a neutron and a pion result from the collision.

(a) Write a particle equation for this collision.

(2)

(b) The table shows the properties of two quarks.

Quark	Charge/ e
u	$+2/3$
d	$-1/3$

Give the quark structure for each of the particles produced by this collision.

(3)

(c) The mass of a pion is $140\text{MeV}/c^2$.

Calculate the mass of the pion in kg.

(3)

Mass = kg

(d) The mass of a neutron is about the same as the mass of a proton. A student suggests that the minimum kinetic energy the cosmic ray proton would need to create the pion in this collision is 140 MeV.

Discuss whether this suggestion is correct. Your answer should include reference to the laws of conservation of momentum and conservation of energy.

(4)

(Total for Question 17 = 12 marks)