

15

The discovery of the Higgs particle was an important contribution to our understanding of particle physics.

(a)

Describe the standard model for subatomic particles. You should identify the fundamental particles and the composition of the particles we can observe.

(5)

(b)

The mass of the Higgs particle is 2.2×10^{-25} kg.
Calculate this mass in GeV/c².

(3)

(c)

The Higgs particle was discovered using the Large Hadron Collider (LHC) in 2012. Two beams of very high energy protons, moving in opposite directions, were made to collide.

(i)

Explain the need for such high energy collisions.

(3)

(ii)

The beams of protons are contained within a ring of superconducting magnets.
Calculate the momentum of a proton in a beam.

(3)

(iii)

State the total momentum of the products of the collision between the two beams of protons.

(1)

(d)

The LHC accelerates protons until they gain energies of about 7 TeV.
A student used the equation $E_k = \frac{p^2}{2m}$ to predict the energy of a proton in the beam, using the momentum calculated in (c)(ii), but found the energy was far higher than 7 TeV.
Explain why.

(2)

(Total for Question 15 = 17 marks)