

13 The Proton-Antiproton Collider ($S\bar{p}\bar{p}S$) was a large particle accelerator. An experiment using the $S\bar{p}\bar{p}S$ proved the existence of a particle called a Z boson.

(a) The mass of the Z boson is $91 \text{ GeV}/c^2$.

Show that the mass of the Z boson is nearly 100 times greater than the mass of a proton.

(4)

(b) Protons and anti-protons were accelerated in the $S\bar{p}\bar{p}S$ to very high energies before they collided.

Explain why the protons and anti-protons needed high energies to produce the Z boson.

(3)



- (c) Z bosons produced by high energy collisions can have a range of lifetimes.
The Z bosons with the longest lifetimes are those that were moving very fast.

Explain this observation.

(2)

(Total for Question 13 = 9 marks)