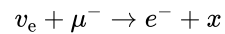


HL Paper 3

This question is about the standard model.

- a. State what is meant by the standard model. [3]
- b. Use the conservation of lepton number and charge to deduce the nature of the particle x in the following reaction. [1]



- c. State what is meant by deep inelastic scattering. [1]

Markscheme

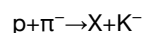
- a. the theory that describes the electromagnetic and weak (and strong) interaction of quarks and electrons/particles;
- b. ν_μ / muon neutrino;
- c. scattering (of leptons by hadrons) in which large amounts of energy is transferred (to the hadrons);

Examiners report

- a. A significant number of candidates left the question unanswered. Of those candidates who did attempt the question very few knew anything about deep inelastic scattering.
- b. A significant number of candidates left the question unanswered. Of those candidates who did attempt the question very few knew anything about deep inelastic scattering.
- c. A significant number of candidates left the question unanswered. Of those candidates who did attempt the question very few knew anything about deep inelastic scattering.

This question is about linear accelerators.

- b. A moving proton is incident on a stationary pion, producing a kaon (K meson) and an unknown hadron X according to the reaction given below. [2]



- (i) State, with a reason, the electric charge of X .
- (ii) State, with a reason, if X is a baryon or a meson.

- c. In a deep inelastic scattering experiment, protons of momentum $2.70 \times 10^{-18} \text{ N s}$ are scattered by gold nuclei. [3]
- Given that the diameter of nucleons is of the order 10^{-15} m and the diameter of quarks is less than 10^{-18} m , determine if these protons will be able to resolve
- (i) nucleons within the gold nuclei.
 - (ii) quarks within the gold nuclei.
- d. Outline how deep inelastic scattering experiments led to the conclusion that gluons exist. [2]

Markscheme

- b. (i) positive in order to satisfy electric charge conservation;
- (ii) baryon in order to satisfy baryon number conservation/contains 3 quarks;
- c. (i) the de Broglie wavelength is $\lambda = \frac{6.63 \times 10^{-34}}{2.7 \times 10^{-18}} = 2.5 \times 10^{-16} \text{ m}$;
- this is less than the nucleon size so nucleons can be resolved;
- Argument required for second mark.*
- (ii) but it is greater than the quark size so quarks cannot be resolved;
- d. deep inelastic scattering experiments measure the (fraction of) momentum carried by electrically charged constituents of hadrons;
- this is less than the total momentum of the hadron indicating the presence of neutral constituents;

Examiners report

- b.
- c.
- d.