A Level Physics

Particles

Name:

Total Marks: /30

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1. This question explores the fundamental forces that are invoked in the standard model and that act at the quantum level.

(a) State the three fundamental interactions that are described by the Standard Model. \[2\] 

(b) Describe the nature of the strong nuclear force and sketch a graph to show its variation with distance. \[4\]
(c) Explain the repulsion between two positively charged particles in terms the quantum-scale interactions and exchange particles.

(d) Calculate the wavelength of a 5.0 MeV photon.
2. This question will assess your knowledge of the classification of particles and of the transformations that can take place between these classes.

(a) In the Standard Model, all particles can be classified as either leptons, mesons, baryons or photons. Give an example of a lepton and a baryon and, if either are not fundamental particles, state what they are made of. \[3\]

(b) Express the $\beta^+$ decay equation in terms of the transformation of hadrons and leptons. \[2\]

(c) Express the $\beta^-$ decay equation in terms of the transformation of fundamental particles. \[2\]
(d) State the charges on the following quarks and their antiparticles.

i. Up

ii. Strange

iii. Down

(e) By considering the charge of the individual quarks involved, show that the net charges of a proton and an anti-proton are of equal magnitude but opposite polarity.

(f) Muons are created by cosmic rays high in the atmosphere (at altitudes of about 15000 m) and should have a lifetime of approximately 2 µs. Briefly explain why a muon, with a velocity of 29.8 cm s\(^{-1}\), can be observed at sea level.
3. Reactions and interactions can be represented by both equations and diagrams. Just as in classical Newtonian mechanics, there are conservation laws that can be used to ascertain whether a certain reaction can take place.

(a) State the quarks that a K$^+$ particle is made from. [1]

(b) K$^+$ decays via the weak interaction to produce three pions. Which pions are produced? [1]

(c) Show that strangeness is not conserved in this reaction. [1]

(d) Sketch a Feynman diagram to illustrate the reaction below. The exchange particle for this reaction is the W$^-$ particle. [3]

$$\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$$