Physics

Question	Maximum Mark	Mark Awarded
#1	6	
#2	6	
#3	8	
#4	9	
#5	9	
#6	11	
#7	20	
Total	69	

#1

7. *(a)* Explain briefly what is meant by conservation of mass-energy. [2]

(b) It is suggested that a collision between two protons, each of kinetic energy 3 GeV produces the following interaction:

$$p + p \longrightarrow 5p + 3\bar{p} + n + \bar{n} + 2\pi^{+} + 2\pi^{-} + 4\nu_{e}$$

Determine which, if any, of the conservation laws are violated (the rest mass-energy of a proton or a neutron ≈ 1 GeV). [4]

Question taken from Eduqas examination paper 842103, June 2018

#2

Discuss the make-up and properties of the following particles e^-, e^+, n, $\overline{p}$, π^-. [6 QER]

Question taken from Eduqas examination paper 842103, November 2020

#3

6. *(a)* The anti-Δ^{++} is an anti-baryon and a first-generation particle which has a charge of $-2e$. Explain why the only possible quark make-up of the anti-Δ^{++} is $\bar{u}\bar{u}\bar{u}$. [1]

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(b) The anti-Δ^{++} has a lifetime of approximately 6×10^{-24} s and decays into a π meson and another anti-baryon. Deduce the quark make-up of the π meson and the anti-baryon and name them. [2]

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(c) State which force is responsible for the decay of the anti-Δ^{++} into a π meson and anti-baryon, giving a reason for your answer. [2]

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(d) In 2011, a highly respected international research collaboration reported that they had measured neutrinos travelling at speeds greater than that of light. This report was met by caution from the scientific community and then the result was disproved. Explain briefly why the result was met with caution and how the results might have been disproved. [3]

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Question taken from Eduqas examination paper 842103, June 2019

#4

When colliding two protons at very high energy the following interaction has been observed at the large hadron collider in CERN.

$$p + p \rightarrow {}^{2}_{1}H + e^{+} + x$$

(a) Use the conservation of lepton number and conservation of charge to identify the particle x. [3]

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(b) State which force is responsible for this interaction. Give your reasoning. [2]

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(c) State which of the above particles can be classed as: [2]

(i) a baryon;

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(ii) an antiparticle.

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(d) At present, countries in Europe contribute to funding research at CERN. Evaluate whether or not the money could be better spent on humanitarian aid. [2]

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Question taken from Eduqas examination paper 842001, June 2017

#5

7. *(a)* Quarks and electron neutrinos are fundamental particles whereas protons and neutrons are not. Explain this statement. [2]

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(b) (i) State why it is that electron neutrinos are very difficult to detect. [2]

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(ii) Electron neutrinos can be detected when they interact with deuterium nuclei, ${}^{2}_{1}\mathrm{H}$, that are present in heavy water. The following reaction is observed.

$$\nu_e + {}^{2}_{1}\mathrm{H} \rightarrow \mathrm{p} + \mathrm{p} + \mathrm{x}$$

Identify particle x and justify your answer using the conservation laws. [3]

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(c) When a positron and an electron meet they annihilate to produce two gamma ray photons.

$$e^{+} + e^{-} \rightarrow \gamma + \gamma$$

State which force is responsible for this interaction, giving your reasoning. [2]

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Question taken from Eduqas examination paper 842001, June 2019

#6

5. *(a)* Subatomic particles can be classified as either hadrons or leptons. Giving examples of each, fully describe the differences and similarities between these two groups. Include the types of interaction they undergo and how one of the groups can be further sub divided. [6 QER]

(b) Electron capture occurs when an electron interacts with a proton in the nucleus of an atom. The following interaction occurs:

$$p + e^- \longrightarrow n + x$$

(i) Identify the particle, x, explaining how you used the relevant conservation laws. [3]

(ii) Describe the change in quark flavour during electron capture. [1]

(iii) State and explain which interaction is responsible for this decay. [1]

Question taken from Eduqas examination paper 842001, June 2018

#7

(a) A carbon-14 nucleus decays as shown:

$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + e^{-} + \bar{\nu}_e$$

(i) Show how charge, baryon number and lepton number are conserved in this decay. [3]

(ii) Give two reasons why this must be a weak nuclear force interaction. [2]

(b) The decay constant of carbon-14 is $3.83 \times 10^{-12}\ s^{-1}$.

(i) Calculate its half-life in years. [3]

(ii) The natural ratio of carbon-14 to carbon-12 is 1.00×10^{-12} i.e.

$$\frac{\text{number of } ^{14}_{6}C \text{ nuclei}}{\text{number of } ^{12}_{6}C \text{ nuclei}} = 1.00 \times 10^{-12}$$

Calculate the activity of 12 g of naturally occurring carbon. [3]

(iii) In an old tree found preserved in a peat bog in Ireland, much of the carbon-14 has decayed but the carbon-12 all remains. The ratio of carbon-14 to carbon-12 in this old tree has dropped to 0.34×10^{-12}. Calculate the age of the old tree. [3]

(c) Carbon-11 ($^{11}_{6}C$) is proton rich and undergoes positron decay to a stable isotope of boron (B). Complete the following decay equation for carbon-11. Space is provided should you require analysis of lepton number, baryon number and charge. [3]

$$^{11}_{6}C \longrightarrow$$

(d) On the 14 March 2013, the discovery of the Higgs boson was first announced by CERN. Some physicists were convinced that they had discovered the Higgs boson, others believed that there are many different types of Higgs bosons while others claim that this was just another particle and not the Higgs boson. Explain how it may or may not be decided which, if any, of these claims is correct. [3]

Question taken from Eduqas examination paper 842103, June 2017