InkPhysics

ANSWER BOOK

Particle interactions and exchange particles

Particles · Year 12

AQA 3.2.1.4 · OCR A 6.4.2

10 questions · 30 marks

NAVY EDITION

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SECTION A · Warm-up

A1 The strong (nuclear) interaction, the weak (nuclear) interaction, the electromagnetic interaction and gravity. [2]

A2 The (virtual) photon. [2]

A3 The W^+, W^- and Z bosons. [2]

SECTION B · Standard

B1 Strong: gluons (pions between nucleons). Electromagnetic: virtual photons. Weak: W and Z bosons. Gravity: gravitons (proposed). [3]

B2 An exchange particle (a virtual particle) is emitted by one particle and absorbed by another. In transferring energy and momentum between them it produces the effect we observe as a force; the type of exchange particle determines the interaction. [3]

B3 A neutron changes into a proton, emitting a W^- boson. The W^- then decays into an electron and an electron antineutrino. So $n \rightarrow p + W^-$, then $W^- \rightarrow e^- + \text{anti-}\nu_e$. [4]

B4 A proton changes into a neutron, emitting a W^+ boson, which decays into a positron and an electron neutrino: $p \rightarrow n + W^+$, then $W^+ \rightarrow e^+ + \nu_e$. [3]

SECTION C · Stretch

C1 The interaction is mediated by a W^+ boson (a proton emits a W^+ and becomes a neutron; the W^+ is absorbed by the electron). Overall: $p + e^- \rightarrow n + \nu_e$. [4]

C2 The range of an interaction is linked to the mass of its exchange particle. The W and Z bosons are very massive, so they can only exist as virtual particles for an extremely short time and travel a tiny distance, giving the weak force its very short range. The photon is massless, so the electromagnetic force has, in principle, infinite range. [4]

C3 Similarity: both are mediated by exchange particles (bosons). Difference: the electromagnetic force uses the massless photon (long range), whereas the weak force uses the massive W and Z bosons (very short range). [3]