Eduqas Physics – Component 3

Module 7: Particles and nuclear structure

This topic covers the nuclear atom and the idea that matter is composed of quarks and leptons. Learners study the quark composition of the neutron and the proton and the idea that quarks and antiquarks are never observed in isolation. The properties of the four interactions experienced by particles are discussed and learners are shown how to apply the conservation of charge, lepton number and quark number to given reactions.

<table>
<tr><th rowspan="2">You should be able to demonstrate and show your understanding of:</th><th colspan="4">Progress and understanding:</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><td>The significance of the results of the Rutherford alpha particle scattering experiment</td><td></td><td></td><td></td><td></td></tr>
<tr><td>How to approximate the maximum size of the Coulomb repulsion force between an alpha particle and a gold atom / nucleus for both the plum pudding model and the Rutherford model</td><td></td><td></td><td></td><td></td></tr>
<tr><td>The idea that matter is composed of quarks and leptons and that there are three generations of quarks and leptons, although no questions will be set involving second or third generations</td><td></td><td></td><td></td><td></td></tr>
<tr><td>
<table>
<tr><td></td><td colspan="2">Leptons</td><td colspan="2">Quarks</td></tr>
<tr><td>Particle (symbol)</td><td>Electron (e^-)</td><td>Electron neutrino (ν_e)</td><td>Up (u)</td><td>Down (d)</td></tr>
<tr><td>Charge (e)</td><td>1</td><td>0</td><td>$+\frac{2}{3}$</td><td>$-\frac{1}{3}$</td></tr>
</table>
The idea that antiparticles exist for the particles given in the table above, that the properties of an antiparticle are identical to those of its corresponding particle apart from having opposite charge, and that particles and antiparticles annihilate
</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Symbols for a positron and for antiparticles of quarks and hadrons</td><td></td><td></td><td></td><td></td></tr>
<tr><td>The idea that quarks and antiquarks are never observed in isolation, but are bound into composite particles called hadrons, or three types of baryon (combinations of 3 quarks), or antibaryons (combinations of 3 antiquarks) or mesons (quark-antiquark pairs)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>The quark compositions of the neutron and proton</td><td></td><td></td><td></td><td></td></tr>
<tr><td>How to use data in the table above to suggest the quark make-up of less well known first generation baryons and of charged pions</td><td></td><td></td><td></td><td></td></tr>
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<tr><td colspan="2">The properties of the four forces or interactions experienced by particles as summarized in the table below</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2"><table>
<tr><th>Interaction</th><th>Experienced by</th><th>Range</th><th>Comments</th></tr>
<tr><td>gravitational</td><td>all matter</td><td>infinite</td><td>very weak – negligible except between large objects such as planets</td></tr>
<tr><td>weak</td><td>all leptons, all quarks, so all hadrons</td><td>very short</td><td>only significant when the e-m and strong interactions do not operate</td></tr>
<tr><td>electromagnetic (e-m)</td><td>all charged particles</td><td>infinite</td><td>also experienced by neutral hadrons, as these are composed of quarks</td></tr>
<tr><td>strong</td><td>all quarks, so all hadrons</td><td>short</td><td></td></tr>
</table></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">How to apply conservation of charge, lepton number and baryon number (or quark number) to given simple reactions</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">The idea that neutrino involvement and quark flavour changes are exclusive to weak interactions</td><td></td><td></td><td></td><td></td></tr>
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