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**Knowledge Rich Curriculum Plan**

Science – Physics

Year 12



| **Science**  **Year 12 Physics** | **Unit: Particle Physics** |  |  |
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| **Lesson/Learning Sequence** | **Intended Knowledge:**  *Students will know that…* | **Tiered Vocabulary** | **Prior Knowledge:**  *In order to know this students, need to already know that…* |
| **Lesson:**  **Constituents of the Atom** | * Students will know that atomic mass unit is defined as a mass equal to one twelfth the mass of an atom of carbon-12 * Students will know that protons and neutrons have a mass of 1 amu * Students will know that specific charge is calculated using the equation:   specific charge = charge ÷ mass   * Students will know that specific charge has the unit coulomb per kg * Students will know that proton number has the symbol Z, and nucleon number has the symbol A * Students will know that protons and neutrons are nucleons * Students will know how to calculate specific charge * Students will know how to determine the mass and charge of subatomic particles and ions using data from the data booklet * Students will know how to use AZ notation to represent atoms | Atomic mass unit: mass equal to one twelfth the mass of an atom of carbon-12 | * ***Students need to already know that the simple model of an atom has a nucleus (containing protons and neutrons) and electrons orbiting the nucleus. Students need to also already know that protons have a relative charge of +1, neutrons have no charge and electrons have a relative charge of -1*** * ***Students need to already know that isotopes are atoms that contain the same number of protons but different number of neutrons*** |
| **Lesson:**  **Stable and Unstable Nuclei** | * Students will know that within the nucleus there is strong nuclear force, which is a force that helps to keep the nucleus stable * Students will know that the strong nuclear force is attractive up to 3 fm, and repulsive below 0.5 fm * Students will know that unstable nuclei undergo alpha and beta decay * Students will know that during alpha decay a nucleus loses 2 protons and 2 neutrons, resulting in the nucleon number decreasing by 4 and the atomic number decreasing by 2 * Students will know how to write equations representing alpha decay * Students will know that during Beta minus decay a neutron turns into a proton, an electron and an anti-electron neutrino * Students will know how to write equations representing beta minus decay |  | * ***Students need to already know that repulsive forces would exist between protons*** * ***Students need to already know that unstable nuclei undergo decay*** |
| **Lesson:**  **Particles, antiparticles and photons** | * Students will know that for every type of particle there is a corresponding antiparticle * Students will know that an antiparticle has the same mass and opposite charge to its corresponding particle * Students will know the following examples of antiparticles:   -positron (antiparticle to an electron)  -antiproton (antiparticle to a proton)  -antineutron (antiparticle to a neutron)  -antineutrino (antiparticle to a neutrino)   * Students will know that photons are packets of electromagnetic waves. * Students will know that the energy carried by a photon is given by the equations:   E = hf or E = hc/lambda   * Students will know that when a particle and its antiparticle meet they annihilate each other. * Students will know that during annihilation mass is converted into energy, the particle and antiparticle are transformed into two photons of energy * Students will know that mass and energy interchangeable, as stated in the equation E = mc(squared) * Students will know that during pair production energy is converted into mass. * Students will know that during pair production a single photon of energy is converted into a particle-antiparticle pair. * Students will know how to calculate energy involved in interactions using the equations stated above * Students will know how to determine if pair production can take place from a single photon * Students will know how to determine the wavelength or frequency of a photon that is released during annihilation | Antiparticle: a particle that has the same mass and opposite charge to its corresponding particle | * ***Students need to already know that the particles proton, electron, neutron and neutrino exist.*** * ***Students need to already know how to convert between eV and Joules*** |
| **Lesson:**  **Hadrons** | * Students will know that hadrons are not fundamental particles, as they are made from smaller particles * Students will know that there are two categories of Hadrons; Baryons and Mesons * Students will know that Baryons are made from three quarks (they will find more out about this next lesson) * Students will know that Antibaryons are made from three antiquarks * Students will know that the only stable Hadron is the proton, all other Hadrons eventually decay into a proton * Students will know that Mesons are made from a quark and an antiquark | Fundamental particle: a particle that is not made form smaller particles | * ***Students need to already know that the nucleons are protons and neutrons*** |
| **Lesson:**  **Quarks** | * Students will know that quarks are fundamental particles. * Students will know that fundamental particles are particles that aren't made of anything smaller * Students will know that there are three quarks (up, u, down, d, and strange, s) all which have their own antiquark * Students will know that quarks have 3 properties; charge, baryon number and strangeness. These properties are detailed in the data booklet * Students will know how to determine the quark composition of baryons, antibaryons and mesons * Students will know that the quark composition of a neutron is dud * Students will know that the quark composition of a proton is duu * Students will know that when a neutron decays to a proton, a d quark turns into an u quark * Students will know how to determine changes in quark composition during particle interactions | Quark: a fundamental particle that makes up hadrons | * ***Students need to already know that baryons are made of 3 quarks, antibaryons are made of 3 antiquarks and mesons are made of 2 quarks*** |
| **Lesson:**  **Leptons** | * Students will know that Leptons are fundamental particles * Students will know that fundamental particles are particles that aren't made of anything smaller * Students will know that leptons are much lighter than Baryons and Mesons * Students will know that Leptons don't feel the strong nuclear interaction * Students will know that electrons, muons and tauons are examples of charged Leptons * Students will know that electrons, muons and tauons have their own corresponding neutrino. * Students will know that neutrinos are charge less, almost massless particles. * Students will know that Leptons have a Lepton number of +1, whilst Antileptons have a Lepton number of -1 | Lepton: a type of fundamental particle | * ***Students need to already know that fundamental particles are particles that can't be made any smaller*** |
| **Lesson:**  **Particle Interactions** | * Students will know that there are four fundamental interactions: gravity, electromagnetic, weak nuclear, strong nuclear * Students will know that exchange particles are used to explain force interactions between particles * Students will know that electromagnetic forces and gravitational forces have unlimited range * Students will know that the relative strength of the interactions are ordered, from strongest to weakest, as: Strong nuclear, electromagnetic, weak nuclear, gravitational * Students will know that strong nuclear force acts between nucleons (hadrons), and the exchange particles are Gluons (between quarks) and Pions (between baryons) * Students will know that the electromagnetic force acts between charged particles, and has the exchange particle Virtual Photon * Students will know that the weak nuclear forces acts between all particles, and the exchange particles are W+, W- and Z * Students will know that gravitational forces act between particles with masses, and the exchange particle is the Graviton | Exchange particle (boson): particles that are used to explain force interactions between particles. They conserve energy and charge | * ***Students need to already know that strong nuclear forces act between nucleons*** |
| **Lesson:**  **Conservation Laws** | * Students will know that for particle interactions to occur the following conservation laws must be obeyed:   Charge - must be conserved  Baryon number - must be conserved  Lepton number - must be conserved  Strangeness - conserved in electromagnetic and strong interactions. Doesn't have to be conserved in Weak interaction   * Students will know that during beta plus decay an up quark turns into a down quark * Students will know that during beta minus decay a down quark turns into an up quark * Students will know how to apply conservation laws to determine whether a particle interaction will take place |  | * ***Students need to already know that baryons have a baryon number of 1*** * ***Students need to already know that leptons have a lepton number of 1*** |
| **Lesson:**  **The Weak Interaction** | * Students will know that beta decay is an example of weak interaction * Students will know that beta minus decay occurs in a neutron rich nuclei. * Students will know that beta minus decay sees a neutron decay into a proton, electron and an anti electron neutrino * Students will know that charge, Baryon number and Lepton number are conserved during this interaction * Students will know that beta plus decay occurs in proton rich nuclei * Students will know that during beta plus decay a proton decays into a neutron, positron and an electron neutrino * Students will know that Baryon number, Lepton number and charge are all conserved during beta plus decay * Students will know how to apply the conservation laws to weak interaction |  | * ***Students need to already know that during interactions Baryon number, Lepton number and charge need to be conserved*** * ***Students need to already know that during weak interactions strangeness doesn't have to be conserved*** |
| **Lesson:**  **The Strong Interaction** | * Students will know that strong nuclear force acts alongside electromagnetic force within the nucleus * Students will know that the combination of electromagnetic force and strong nuclear force results in their being repulsive forces less than 0.7 fm, attractive forces up to 2 fm and then repulsive forces above 2 fm * Students will know that larger nuclei tend to include more neutrons to help counteract the repulsive electromagnetic forces between the protons. |  | * ***Students need to already know that strong nuclear force takes place between hadrons and quarks*** |
| **Lesson:**  **Particle Diagrams** | * Students will know that Feynman diagrams are used to represent particle interactions * Students will know that the arrows in Feynman diagrams tell us which particles are present before and after the interaction * Students will know that the exchange particle is represented using a wavy arrow * Students will know that the type of particle can't change either side of the diagram * Students will know how to draw Feynman diagrams to represent different particle interactions |  | * ***Students need to already know that in particle interactions Baryon number and Lepton number must be conserved*** * ***Students need to already know that strong nuclear force acts between nucleons (hadrons), and the exchange particles are Gluons (between quarks) and Pions (between baryons)*** |