Meden School Curriculum Planning							
Subject	Physics	**Year Group**	13	**Sequence No.**	2	**Topic**	3.8 Nuclear Physics

Retrieval	Core Knowledge	Student Thinking
What do teachers need **retrieve** from students before they start teaching **new content**?	What **specific ambitious knowledge** do teachers need to teach students in this sequence of learning?	What real life examples can be applied to this sequence of learning to **development of our students thinking, encouraging them to see the inequalities around them** and 'do something about them!'
GCSE Physics P4 Atomic Structure. The history of the atomic story, including Dalton, Thompson, Rutherford, Bohr and ChadwickThe alpha scattering experiment, alpha, beta and gamma radiation and their properties. Half-life calculations and decay equations. Nuclear Fission and electricity generation. Risks and precautions of suing radioactive materials.	**3.8.1.1 Rutherfords Scattering** Alpha particles fired at a thin film of gold foil, most particles went straight through suggesting that most of the atom is empty space. Some particles were deflected, this suggested that the positive alpha particle had encountered another positive charge, this was the protons in the nucleus. A very tiny number were reflected back, this suggested that most of the mass of the atom was concentrate at the centre, in the nucleus. This disproved the current model of the atom proposed by JJ Thompson and is an example how new evidence leads to ideas and theories changing over time. **3.8.1.2 Alpha, beta, and Gamma radiation** Alpha is 2+ particle made from 2 protons and 2 neutrons, can only travel a few centimetres in air and is highly ionizing. It is absorbed by paper and skin Beta a negatively charge electron emitted from the nucleus when a neutron decays. Can travel about a metre in air, is moderately ionizing and is stopped by a few mm of aluminium.	

Gamma is a high frequency, high energy wave, weakly ionizing, infinite distance in air. Absorbed by lead/concrete.

; applications eg to relative hazards of exposure to humans.

Applications also include thickness measurements of aluminium foil paper and steel.

Inverse-square law for γ radiation: $I = \frac{k}{x^2}$

Experimental verification of inverse-square law. Applications eg to safe handling of radioactive sources.

Background radiation; examples of its origins and experimental elimination from calculations.

Appreciation of balance between risk and benefits in the uses of radiation in medicine.

Required practical 12: Investigation of the inverse-square law for gamma radiation.

3.8.1.3 Radioacitve Decay

Random nature of radioactive decay; constant decay probability of a given nucleus;

$\frac{\Delta N}{\Delta t} = -\lambda N$

$N = N_0 e^{-\lambda t}$

Use of activity, $A = \lambda N$

Modelling with constant decay probability. Questions may be set which require students to use

$A = A_0 e^{-\lambda t}$

Questions may also involve use of molar mass or the Avogadro constant.

Half-life equation: $T_{½} = \frac{\ln 2}{\lambda}$

Determination of half-life from graphical decay data including decay curves and log graphs.

	Applications eg relevance to storage of radioactive waste, radioactive dating etc. **3.8.1.4 Nuclear Instability** Graph of N against Z for stable nuclei. Possible decay modes of unstable nuclei including α, β^+, β^- and electron capture. Changes in N and Z caused by radioactive decay and representation in simple decay equations. Questions may use nuclear energy level diagrams. Existence of nuclear excited states; γ ray emission; application eg use of technetium-99m as a γ source in medical diagnosis. **3.8.1.5 Nuclear Radius** Estimate of radius from closest approach of alpha particles and determination of radius from electron diffraction. Knowledge of typical values for nuclear radius. Students will need to be familiar with the Coulomb equation for the closest approach estimate. Dependence of radius on nucleon number: $R = R_0 A^{1/3}$ derived from experimental data. Interpretation of equation as evidence for constant density of nuclear material. Calculation of nuclear density. Students should be familiar with the graph of intensity against angle for electron diffraction by a nucleus. **3.8.1.6 Mass and Energy** Appreciation that $E = mc^2$ applies to all energy changes, Simple calculations involving mass difference and binding energy. Atomic mass unit, u.	

	Conversion of units; 1 u = 931.5 MeV. Fission and fusion processes. Simple calculations from nuclear masses of energy released in fission and fusion reactions. Graph of average binding energy per nucleon against nucleon number. Students may be expected to identify, on the plot, the regions where nuclei will release energy when undergoing fission/fusion. Appreciation that knowledge of the physics of nuclear energy allows society to use science to inform decision making. **3.8.1.7 Induced Fission** Fission induced by thermal neutrons; possibility of a chain reaction; critical mass. The functions of the moderator to slow down neutrons to the have the correct kinetic energy for absorption , control rods to absorb excess neutrons to control the speed of the reactor, and coolant to transfer the thermal energy to the water for steam production in a thermal nuclear reactor. Details of particular reactors are not required. Students should have studied a simple mechanical model of moderation by elastic collisions. Factors affecting the choice of materials for the moderator, control rods and coolant. Examples of materials used for these functions. **3.8.1.8 Safety Aspects** Fuel used uranium or plutonium, remote handling of fuel, shielding, emergency shut-down. Production, remote handling, and storage of radioactive waste materials. Appreciation of balance between risk and benefits in the development of nuclear power.	Should we be using nuclear power to generate electricity. How green is it? What are the risks and what are the options available to mitigate the risks? Should western nations dicatate to other countries their nuclear policy?