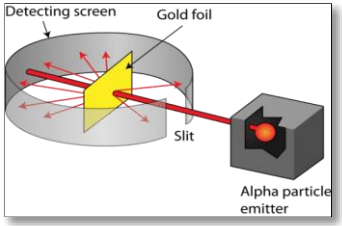
P6: Radioactivity Knowledge Organiser

Lesson sequence

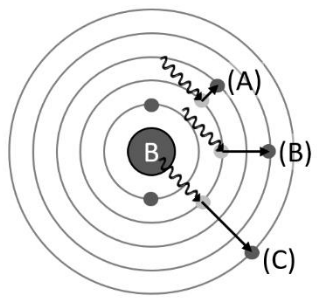
1. Atomic structure
2. Subatomic particles
3. Electron orbits
4. Radiation from unstable atoms
5. Nuclear reactions
6. Half-life
7. Background radiation
8. Dangers of radioactivity

1. Atomic structure	
***Atom**	Smallest stable particle of matter.
****Size of atoms**	2.5 x10^{-10} m in diameter
***Element**	Pure substance made of a single type of atom.
***John Dalton**	Pictured atoms as tiny hard round balls, with different elements having atoms of different sizes.
***J.J Thomson**	Discovered negative particles smaller than atoms called electrons.
****Plum-pudding model**	Atoms as a sphere of positively charged matter with negative electrons scattered throughout it.
****Rutherford's experiment**	Fired alpha particles at very thin gold leaf and used a special screen to record where they went.
****Rutherford's results**	Most alpha particles went straight through, some scattered (changed path).
****Rutherford's explanation**	Scattered particles hit a nucleus. Nucleus must be small because most went straight through without hitting it.

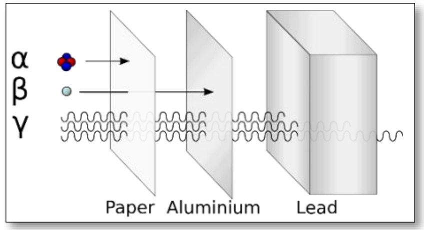


2. Subatomic particles	
***Subatomic particle**	Particles smaller than atoms: protons, neutrons and electrons.
***Protons**	+1 charge, mass = 1, located in the nucleus
***Neutrons**	0 charge, mass = 1, located in the nucleus
***Electrons**	-1 charge, mass = 1/1835, located around nucleus in shells
****Relative mass**	Not the actual mass because no units. Protons and neutrons have same relative mass: their mass is 1.
***Nucleons**	Subatomic particles found in the nucleus: protons and neutrons.
***Determining the element**	The number of protons determines which element an atom is.
***Atomic number**	The number of protons in an atom. Also electrons.
***Mass number**	The number of nucleons (protons and neutrons) in an atom.
***Number of neutrons**	Mass number – atomic number
****Isotopes**	Versions of an element with the same number of protons, but different number of neutrons.
****Naming isotopes**	Name followed by mass, e.g. carbon-13, or symbol preceded by mass, e.g. ^{13}C.

3. Electron orbits	
****Orbits**	The shells of electrons around an atom.
****Orbits and energy**	Higher orbit = higher energy
****Excited electrons**	When an electron has absorbed energy and jumped to a higher orbit.
*****How to excite electrons**	- When atoms absorb light - When electricity is passed through gases - Strongly heating a material
*****Emitting light**	Electrons emit light when they drop back down an orbit. A bigger drop down releases higher energy light.
*****Absorbing light**	Light absorbed at specific wavelengths corresponds to energy gap in orbits: jumping up one orbit = redder light, jumping up several orbits = bluer light.
*****Emission spectrum**	Pattern of bands of light at specific wavelengths caused by exciting a gaseous element with electricity.
*****Absorption spectrum**	Pattern of dark band in a 'rainbow' spectrum caused by a gaseous element absorbing some of the light passed through it.
*****Forming ions**	When an electron is given so much energy it leaves the atom entirely creating a positive ion.
****Ionising radiation**	Radiation that causes ionisation: (high energy) UV, x-rays, gamma rays.



4. Radiation from unstable atoms	
***Unstable atom**	An atom whose nucleus contains too much energy becomes unstable.
***Decay**	When an unstable atom releases its excess energy by changing. Releases ionising radiation.
***Alpha radiation**	Made of alpha particles: two protons and two neutrons. Symbol: α or $^{4}_{2}He$.
***Beta-minus radiation**	Made of beta particles: a fast-moving electron. Symbol: β^- or $^{0}_{-1}e$.
***Beta-plus radiation**	Made of positrons: particles with same mass as electrons but a positive charge. Symbol: β^+ or $^{0}_{1}e$.
***Gamma radiation**	Extremely short wavelength / high frequency / high energy electromagnetic radiation. Symbol: γ.
***Neutron radiation**	Fast-moving neutrons. Symbol: n.
***Ionising power**	From most to least is alpha, beta gamma.
***Penetrating power**	From most to least is gamma, beta, alpha.
****Ionising vs penetrating power**	When the radiation ionises an atom it loses some of its energy. Alpha ionises particles most easily so loses it energy most quickly, and vice versa for gamma.

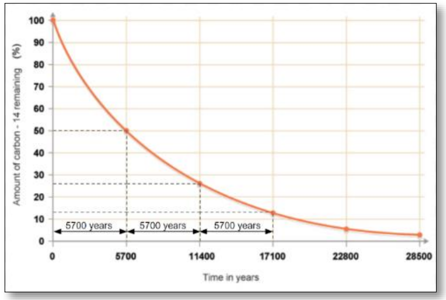


5. Nuclear reactions	
****Alpha decay**	Atomic number decreases by two, mass number decreases by four.
****Beta-decay**	Atomic number increases by one, mass number stays the same.
****Beta+ decay**	Atomic number decreases by one, mass number stays the same.

****Gamma decay**	Atomic number and mass number unchanged.
****Neutron decay**	Atomic number stays the same, mass number decreases by one.
*****Writing nuclear equations**	- Write in what you know - Balance the mass and atomic number - Work out the symbols to match the numbers

6. Half-life

***Half-life**	The time taken for half of the undecayed atoms in a sample to decay. Stays constant for each isotope.
***Half-life and stability**	Less stable → shorter half-life More stable → longer half-life
***Half-life and radioactivity**	Shorter half-life → more active Longer half-life → less active
***Becquerels, Bq**	The unit of radioactivity: 1 Bq = one decay per second.
****Half-life graph**	x-axis = time, y-axis = radioactivity. The line curves downwards but never touches the x-axis.
****Determining half-life from a graph**	Pick two points on the y-axis, one half of the other, trace along to the line and down to the time. Half-life is the difference in the time.
****Calculations with half-life**	- Divide time by half-life to give a number of half-lives - Forwards in time: halvings - Back in time: doublings



7. Background radiation

***Background radiation**	Low levels of ionising radiation that we are constantly exposed to.
***Radon gas**	The biggest source of background radiation: a radioactive gas produced by some rocks in the ground
***Other sources**	Food, hospitals, nuclear power industry, space (cosmic rays)
***Artificial sources**	15%: 14% hospitals, 1% nuclear industry
****Geiger-Müller (GM) tube**	Used to measure radioactivity, produce a click each time radiation passes through it.
****Count-rate**	The number of time a GM tube detects radiation each second.
****Measuring background radiation**	Use a GM tube to take several readings and then calculate the average (mean).
****Measuring the activity of a source**	Measure the source, subtract the background radiation.
***Dosimeter**	A badge that changes colour in response to radiation exposure.
***Dose**	The amount of radiation received.

8. Dangers of radioactivity

***Mutations**	DNA damage caused by ionising radiation, can lead to cancer.
****Repairing damage**	Cells contain proteins that can repair DNA damage as long as the radiation dose is low enough.
****Minimising radiation risk**	- Wear protective clothing - Handle with tongs - Don't point at people - Limit time - Use protective shielding - Wear dosimeter badges
****Nuclear power risks**	There is a small chance of accidents causing radioactive sources to escape
****Irradiation**	Exposure to radiation, stops when the source of radiation is removed.
****Contamination**	When particles of radioactive substances are on or in the body.
****Risks in perspective**	Using radioactivity carries serious risks, but so do many other things, so it is safe to use as long as it is treated with caution.