Combined Science - Physics

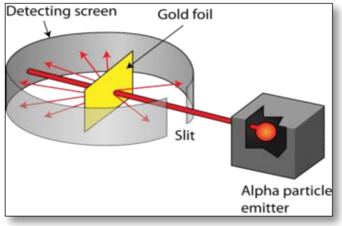
CP6 Knowledge organiser

P6: Radioactivity

Lesson sequence

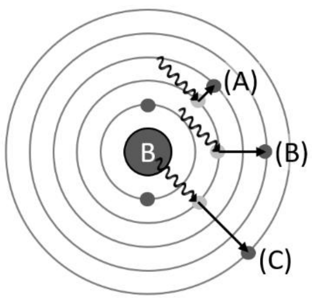
1. Atomic structure
2. Subatomic particles
3. Electron orbits
4. Radiation from unstable atoms
5. Nuclear reactions
6. Half-life
7. Background radiation
8. Dangers of radioactivity

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.

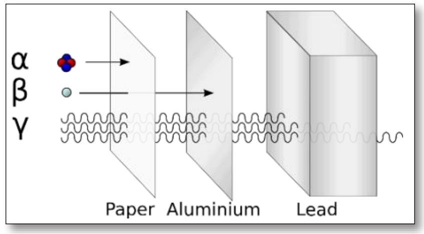


2. Subatomic particles	
***Subatomic particle**	Particles smaller than atoms: protons, neutrons and electrons.
***Protons**	+1 charge, mass = 1, located in the nucleus
***Neutrons**	0 charge, mass = 1, located in the nucleus
***Electrons**	-1 charge, mass = 1/1835, located around nucleus in shells
****Relative 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.



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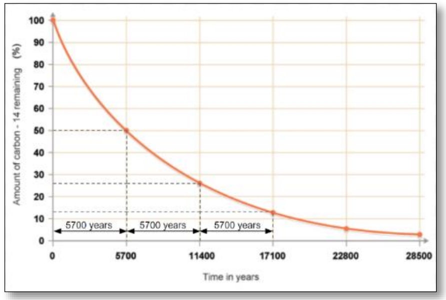
5. Nuclear reactions	
****Alpha decay**	Atomic number decreases by two, mass number decreases by four.
****Beta- decay**	Atomic number increases by one, mass number stays the same.
****Beta+ decay**	Atomic number decreases by one, mass number stays the same.
****Gamma decay**	Atomic number and mass number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