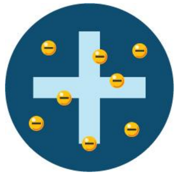
Physics 4: Atomic Structure

Section 1: Key Terms

1 Atom	The **smallest part of an element** that can exist. All substances are made of atoms. **No** overall **electrical charge**. **Very small**, radius of 0.1nm.
2 Element	An element **contains only one type of atom**. Found on the Periodic Table. There are about 100 elements.
3 Isotope	An atom of the **same element** with **different numbers of neutrons**.
4 Radioactive decay	When an **unstable nucleus changes** to **become more stable** and **gives out radiation**. **Random**.
5 Activity	The **rate at which decay occurs**. Measured in **Becquerels (Bq).**
6 Count rate	**Number of decays** recorded **each second** by a Geiger-Muller tube.
7 Half life	The **time it takes** for the **number of nuclei of the isotope in a sample to halve** Or, The **time it takes for the count rate** (or activity) from a sample containing the isotope **to fall to half its initial level**.
8 Contamination	The **unwanted presence of materials containing radioactive atoms** e.g. within liquids, with the body/ on the skin.
9 Irradiation	When an object is **exposed to radiation**. The object does not become radioactive itself.
10 Ionisation	Radiation can ionize by **removing electrons from atoms to form ions**. If this happens in **DNA** it could lead to a **mutation that causes cancer**.
11 Peer review	The **checking of scientific results** by other **scientific experts**.

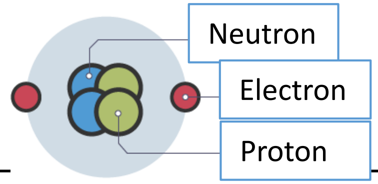
Section 2: Development of Atomic Model

12 Plum Pudding



The plum pudding model shows that the atom is a **ball of positive charge** with **negative electrons embedded** in it. Was **incorrect**.

13 Nuclear Model



Rutherford's scattering experiment found a central area of positive charge. The nuclear model has a **positive nucleus where the majority of the mass is found** and **electrons in shells**. Later, neutrons were discovered and included in the nucleus.

Section 3: Properties of Sub-Atomic Particles

Sub-atomic particle	Mass	Charge	Position in Atom
14 Proton	1	+1	Nucleus
15 Neutron	1	0	Nucleus
16 Electron	Very small	-1	Orbiting in shells

Section 5: Nuclear Radiation

Radiation	Range in air	Absorbed by	Ionizing Power	Product emitted when nuclei decays
20 Alpha	Short **– up to 5cm**	**Paper** and **skin**	**Very High**	**2 protons** and **2 neutrons**
21 Beta	Medium – **about 1m**	About 5mm of **aluminium.**	**Medium**	**Electron**
22 Gamma	**Unlimited –** spreads out in air from the source	**Several centimetres** of **lead.**	**Low**	**Electromagnetic wave**

Section 6: Nuclear Decay Equations

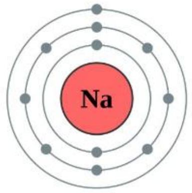
23 Alpha decay	$^{219}_{86}Rn \rightarrow {}^{215}_{84}Po + {}^{4}_{2}He$ In alpha decay a helium nucleus (2 protons and 2 neutrons) is emitted. The new element formed has: - A mass number that has decreased by 4. - An atomic number that has decreased by 2.
24 Beta decay	$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$ In beta decay a neutron turns into a proton. An electron is emitted. The new element formed has: - A mass number that stays the same. - An atomic number increases by 1.
25 Gamma ray	There are no changes to the nucleus when gamma rays are emitted.

Section 4: Atomic Structure

17 **Mass number** – the total number of **protons** and **neutrons**

18 **Atomic number** – the **number of protons** (the number of electrons is the same in an atom)

$^{23}_{11}Na$

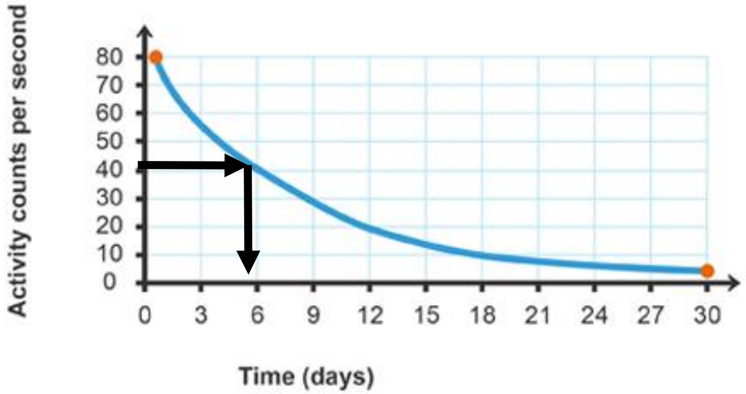


19 **Energy levels:**
Absorption of radiation may lead to electrons moving further from the nucleus (higher energy level). Emission of radiation may lead to electrons moving closer to the nucleus (lower energy level).

Section 7: Finding Half Life

26

1. Find the initial count rate.
2. Half that value.
3. Draw a line across and then down.
4. This is the half life of the isotope.



27. Finding the age of a sample using the half life

- Half the initial count rate until you get down to the current count rate.
- Multiply the number of times you had to half the count rate by the half life to find the age.

Example Question : - Strontium has a half life of 28 years. The initial count rate was 2000. how old is the sample if the new count rate is 250.

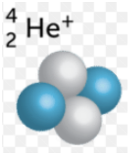
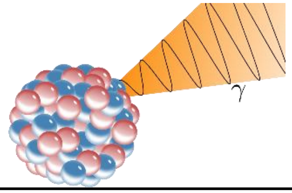
2000/2 = 1000/2= 5000/2= 250

3 x 28 = 84years

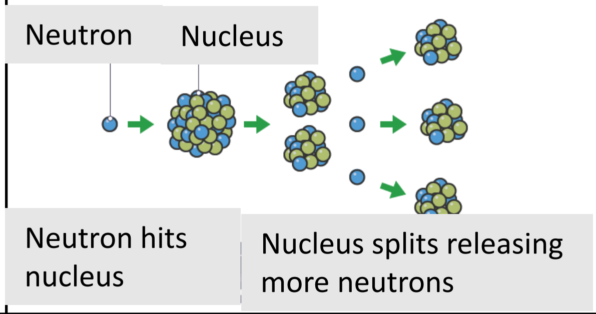
Section 9: Background Radiation – SEPARATES ONLY

31 What is background radiation	Low level radiation which is around us all the time. The amount you are exposed to is called the **radiation dose** and is measured in **Sieverts (Sv).** The risk of harm is related to the amount of exposure and can vary depending on where you live and your lifestyle, job etc.
32 Natural Sources	- The air - Food - Building materials - Granite rock - Space (cosmic rays)
33 Artificial Sources	- Medical treatments - Nuclear waste and power plants - Nuclear fall out from nuclear disasters.

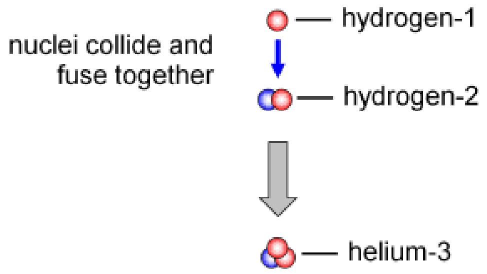
Section 8: Types of Radiation

28 Alpha α	- Two protons and two neutrons bound together (identical to a helium nucleus) - Symbol $_2He^4$ - Mass 2 - Charge 2+ 
29 Beta β	**Formed when a neutron splits to form a proton, which is left in the nucleus and and high speed electron, which is fired out of the nucleus.** **- Symbol $_{-1}\beta^0$** - **Mass 0** - **Charge -1**
30 Gamma γ	An electromagnetic wave of radiation given out by the nucleus. - Symbol $_0\gamma^0$ - Mass 0 - Charge 0 

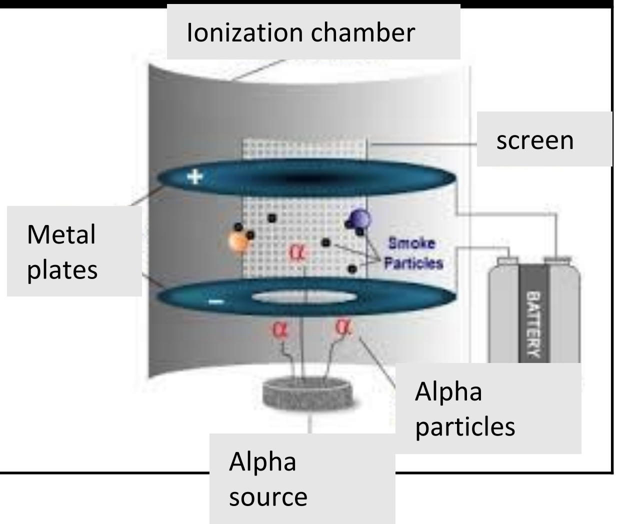
Section 10: Fission - SEPARATES ONLY

34 Fission power stations	- **Nuclear fission** is the splitting of a large atomic nucleus into smaller nuclei. At which point large amounts of energy are released. - The energy can be used to heat water and turn it into steam. - This drives a turbine, which turns a generator, making electricity.	
35 Pros and cons of Fission	Pros - Low green house gas emission. - High energy output. - Reliable and can respond to demand - Cheap electricity one up and running	Cons - Expensive build cost - Produced radioactive waste which is difficult and expensive to store. - Isn't renewable - Potential for a nuclear disaster.

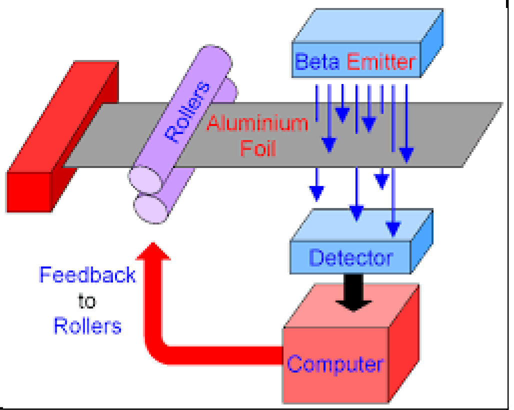
Section 11: Fusion – SEPARATES ONLY

36 How nuclear fusion works	-Nuclear fusion involves two atomic nuclei joining to make a large nucleus. - Energy is released when this happens. - This could be used to **generate electricity**. - **The Sun** and other **stars** use nuclear fusion to release energy. - **Hydrogen nuclei** join to form **helium nuclei**.	
37 Pros and cons of Fusion	Pros - No greenhouse gases. - Virtually limitless fuel available. (The deuterium can be distilled from seawater and the tritium can be “bred” in the reactor.) - No chain reaction. Easier to control or stop than fission. - Little or no nuclear waste. Core remains radioactive for only 100 years. Possibly radioactive structural elements. - Very low fuel cost	Cons - Unproven at anything resembling commercial scale. - No full scale production expected till at least 2050 - Commercial power plants would be extremely expensive to build - Current energy consumption to get up and running almost equals output.

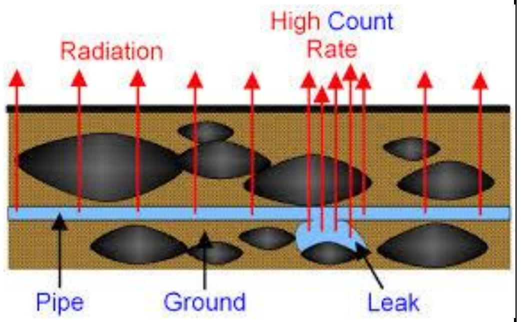
Section 12 Uses of Alpha Radiation

38 Smoke detectors	Ionisation is useful for smoke detectors. - Radioactive americium releases **alpha radiation**, which ionises the air inside the detector. - Smoke from a fire absorbs alpha radiation, altering the ionisation and triggering the alarm.	

Section 13 Uses of Beta Radiation

39 Monitoring the Thickness of paper or sheet metal	- Beta radiation is used to monitor the thickness of materials such as paper, plastic and aluminium. - The thicker the material, the more radiation is absorbed and the less radiation reaches the detector. - It then sends signals to the equipment that adjusts the thickness of the material.	

Section 14 Uses of Beta Radiation

40 Leak testing	- To find a leak or blockage, the radioactive material is put into one end of the pipe. - A radiation detector outside the pipe or above ground is used to track its progress through the pipe. - The leak or blockage is discovered by finding where amount of radiation detected decreases.	
41 Cancer treatment	High-powered gamma rays are used to kill **cancer cells** inside the body. As the gamma rays strong enough to kill cancer cells would also kill healthy cells around the tumour, several weaker sources are used and arranged so the gamma rays are focused on the tumour. This **concentrates** the gamma rays on the cells that need to be killed.