KNOWLEDGE

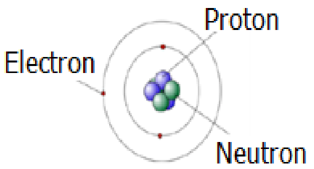
Physics Topic P7
Particles at work – Atomic structure

ORGANISER

Section 1: Key Terms

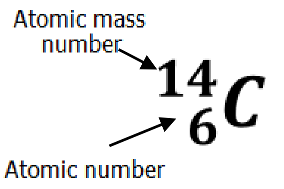
Atom	The **smallest part of an element** that can exist. All substances are made of atoms. **No** overall **electrical charge**. **Very small**, radius of 0.1nm.
Element	An element **contains only one type of atom**. Found on the Periodic Table. There are about 100 elements.
Isotope	An atom of the **same element** with **different numbers of neutrons**.
Radioactive decay	When an **unstable nucleus changes** to **become more stable** and **gives out radiation. Random.**
Activity	The **rate at which decay occurs**. Measured in **becquerels (Bq).**
Count rate	**Number of decays** recorded **each second** by a Geiger-Muller tube.
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.**
Contamination	Is when **radioactive particles get into objects** e.g. within liquids, with the body or on the skin.
Irradiation	When an object is **exposed to radiation.** The object does not become radioactive itself.
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**.
Peer review	The **checking of scientific results** by other **scientific experts.**

Section 2: Development of Atomic Model

Plum Pudding 	Thompson's plum pudding model shows that the atom is a **ball of positive charge** with **negative electrons embedded** in it. Was **incorrect.**
Nuclear Model 	**Rutherford's** alpha particle scattering experiment found a **central area of positive charge.** The nuclear model has a **positive nucleus** and **electrons in shells.** Later, neutrons were discovered and included in the nucleus.

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 3: Atomic mass number and atomic number



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

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

Section 4: Properties of Sub-Atomic Particles

Sub-atomic particle	Mass	Charge	Position in Atom
Proton	1	+1	Nucleus
Neutron	1	0	Nucleus
Electron	$\frac{1}{2000}$	-1	Orbiting in shells

Section 5: Nuclear Radiation

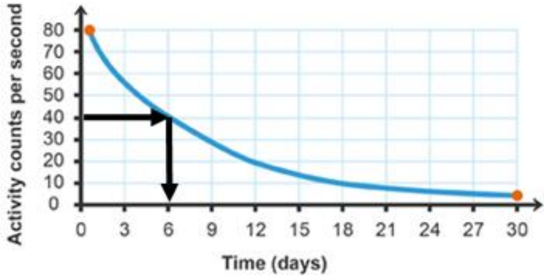
Radiation	Range in air	Absorbed by	Ionizing Power	Product emitted when nuclei decays
Alpha	Short **– up to 5cm**	**Paper** and **skin**	**Very High**	**2 protons** and **2 neutrons**
Beta	Medium – **about 1m**	About 5mm of **aluminium.**	**Medium**	**Electron**
Gamma	**Unlimited –** spreads out	**Several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

Section 6: Nuclear Decay Equations

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** and **atomic number** that has **decreased** by **2.**
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** and an **atomic number** which **increased by 1.**
Gamma ray	There are **no changes to** the **nucleus** when gamma rays are emitted.

Section 7: Activity & half-life

Halve the initial activity (80 ÷ 2 = 40)
Draw a line across on the graph until you reach the curve
Draw a line down (half-life = 6 days)
Half life **never** drops to zero.



KNOWLEDGE

Physics Topic P7
Particles at work – Atomic structure (triple)

ORGANISER

Section 8: Key Terms

Background radiation	Background radiation **is around us all of the time**. It comes from: • **natural sources** such as **rocks** and **cosmic rays** from space • **man-made sources** such as the **fallout f**rom **nuclear weapons testing** and **nuclear accidents**.
Radiation dose	A measure of the **amount of exposure** to **radiation**, measured in **sieverts (Sv)**.
Radioactive isotopes	Isotopes **used in medicine** for **medical imaging**, **treatment of cancer** and as **tracers** to monitor organs.
Radioactive tracers	**Trace** the **flow of a substance** through an organ.
Nuclear Fission	**Splitting of** an atom's **nucleus** into **two smaller nuclei** and the release of two or three neutrons and energy.
Nuclear Fusion	is the **joining** of **two light nuclei** to form a **heavier nucleus**. In this process some of the **mass** may be **converted** into the **energy of radiation**.

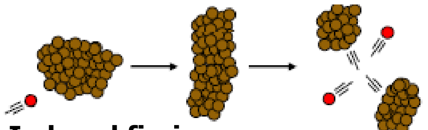
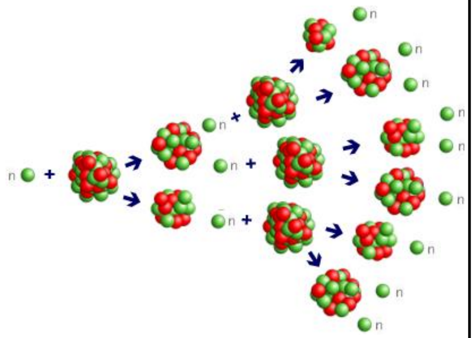
Section 9: Radioactive isotopes and medicine

Used in medicine **for medical imaging**, **treatment of cancer** and **tracers** to monitor/explore internal organs. How useful the radioactive isotope is depends on it's half life and the type of radiation given out.

Radioactive tracers	Radioactive Tracers (like radioactive Iodine) contain a **radioactive isotope** that **emits gamma** radiation. **Radioactive Iodine** is used because: • Half life of 8 days (lasts lone enough for test but decays completely after a few weeks). • Emits gamma so can be detected outside the body. • Decays into a stable product.
Gamma Cameras	Take **images** of **internal body organs**. Before image is taken, patient is injected with solution containing a gamma-emitting radioactive isotope. The solution is absorbed by the organ and the camera detects the gamma radiation. The half life of the radioactive isotope **should not be** too **long** (to avoid unnecessary risks) **or too short** (so a useful image produced).
Gamma beams	**Gamma** beams (or radioactive implants) can **destroy cancer cells** in a tumour.

Section 10: Nuclear Fission

Nuclear fission is the **splitting of a large and unstable atom's nucleus** (e.g. uranium or plutonium) into two smaller nuclei and the release of neutrons and energy.

Induced fission	Energy is released in a nuclear reactor because of nuclear fission. In induced fission, the nucleus of an atom is struck by a neutron, causing the nucleus to split into two smaller fragment nuclei. Energy is also released.	 **Induced fission**
Nuclear fission in **Power Stations**	• Unstable nuclei are **bombarded with neutrons**. • The nuclei undergo fission and split. • **Two smaller nuclei are formed** plus neutrons. • **Energy is released**. • Released neutrons cause more nuclei to split which produces a **chain reaction**. • The reaction is **controlled** using **control rods** which **absorb the neutrons** (slowing down the chain reaction). • A coolant removes the heat energy, usually to produce steam.	 **Chain reaction** (extremely dangerous if not controlled). The explosion caused by a nuclear weapon is caused by an **uncontrolled** chain reaction.

Section 11: Nuclear fusion

Process of forcing the nuclei of two atoms close together forming a single larger nucleus. The two nuclei collide at high speed. Energy is released when the nuclei fuse together. The **suns core releases energy** due to the **nuclear fusion** reaction of **hydrogen nuclei into helium nuclei**.

Nuclear fission	Nuclear fusion
Been used for over 50 years.	A **developing technology**. Needs to be at a **high temperature** and **pressure** for reaction take place and generate energy.
Uses uranium (only found in some parts of world)	Hydrogen fuel easily available as present in sea water
Produces radioactive waste which has to be stored safely and securely.	Reaction product helium is stable.