Name:

Periodic Table and Atomic Structure	**Objectives**
8. Radioactivity	-define radioactivity -describe the nature and penetrating ability of alpha, beta and gamma radiation -give one example each of the following: an α emitter, a β emitter and a γ- emitter -explain how radiation is detected having seen a demonstration / video (principles of a geiger muller tube not required) -define radioisotopes -define and explain half life (non-mathematical treatment) -give a historical outline of: • Becquerel's discovery of radiation • Marie and Pierre Curie's discovery of radioactivity -comment on the widespread occurrence of radioactivity **-distinguish between a chemical reaction and a nuclear reaction (simple equations required, confine to α and β emissions)** -state three uses of radioactivity, including food irradiation and the use of 60Co for cancer treatment -explain how 14C is used for age determination (calculations not required)

In certain isotopes of some elements, the nucleus is held together in a very unstable way. This can result in the nucleus giving off energy to make itself stable, or even breaking up and shooting small pieces of itself off. This giving off of energy or small pieces of itself is called **radioactivity.**

Def^n: **Radioactivity** is the spontaneous breaking up of unstable nuclei with the emission of one or more types or radiation.

Def^n: A **radioisotope** is a radioactive isotope.

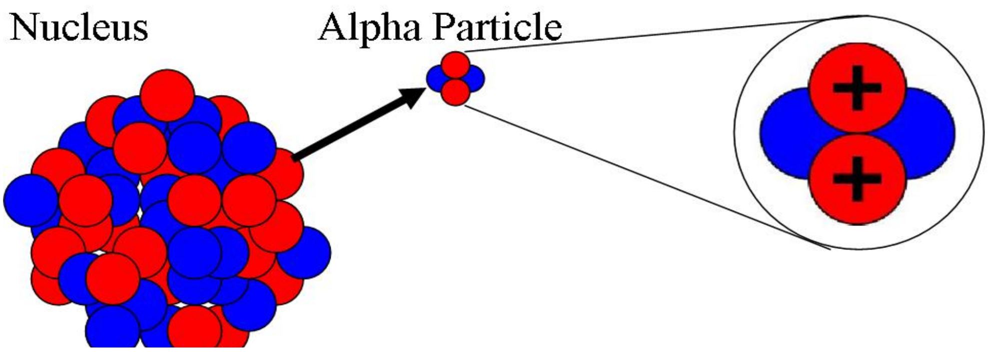
History:

1. Henri **Bequerel** discovered radioactivity by noticing that uranium salts caused shadows to appear on photographic plates.
2. Pierre and Marie **Curie** were the first people to isolate and purify (effectively discovering) the radioactive elements Polonium and Radium.

Types of Radiation:

There are 3 types of radiation given off by radioactive elements:

1. Alpha Particles (α):
   An alpha particle consists of 2 protons and 2 neutrons (no electrons at all). It is effectively the nucleus of a Helium atom, or a Helium atom with its 2 electrons removed, so we can show an α particle as He^{2+}.



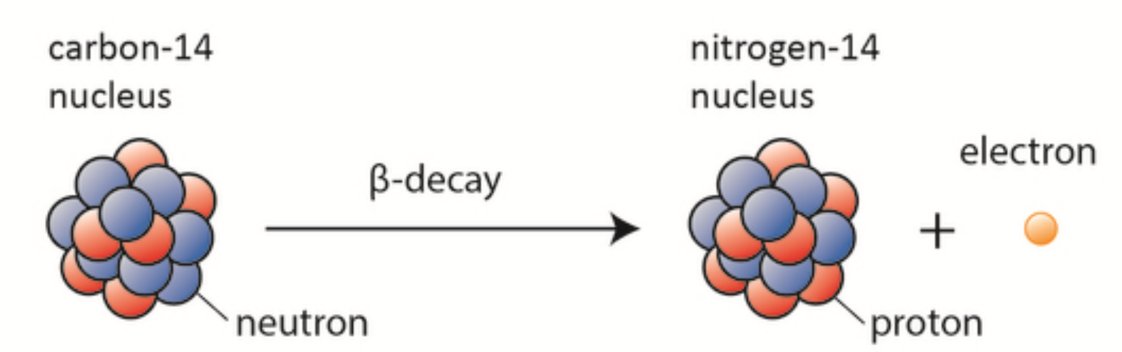
An example of an equation involving α emission is shown below:

$$^{208}_{84}Po \longrightarrow {}^{4}_{2}He + {}^{204}_{82}Pb$$

Notes:

- The totals of the mass numbers and the atomic numbers on the left and right hand sides are always equal for equations involving radioactivity.
- The He atom is the α particle.
- Alpha particles have a mass of 4 and an atomic number of 2 (2 protons, 2 neutrons).
- In this reaction, the Po changes to Pb, a different element. This ONLY happens in nuclear reactions.

2. Beta Particles (β):
A beta particle is simply a quickly-moving electron. In elements that have β particle emission, what happens is that a neutron in the nucleus of the element turns into a proton and an electron. The proton stays in the nucleus, but the electron is shot off out of the nucleus.
We show a β particle as $^{0}_{-1}e$. The e stands for electron, which has a mass of 0 and an atomic number of -1.



An example of an equation involving β emission is shown below:

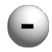
$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

Notes:

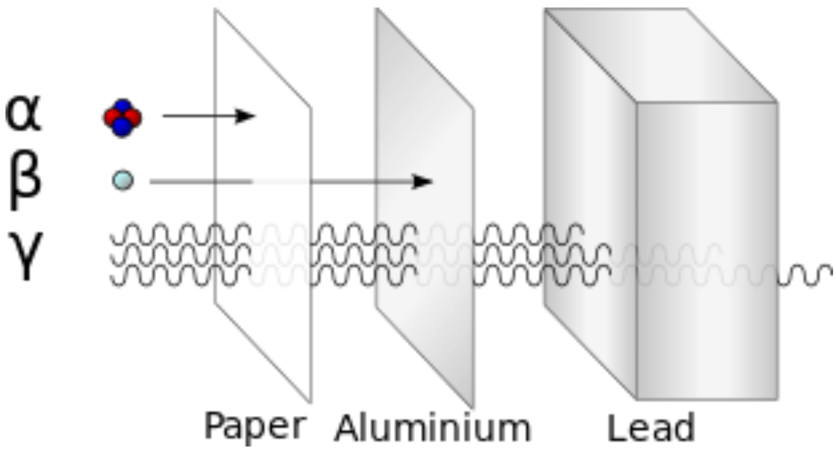
- The totals of the mass numbers and atomic numbers on both sides of the equation are always equal.
- The atomic number of 6 increases by 1 to 7 during β decay. This is because one of the neutrons has turned into a proton. (Remember, atomic number is the number of protons, or positive charges in the nucleus)
- The mass number of 14 stays the same, because neutrons and protons both have the same mass. This means that even though a neutron has turned into a proton, it still weighs the same.
- When giving a symbol to your element, (C, N, for example) always use the atomic number to match it to its symbol on the periodic table, not its mass number.

3. Gamma Radiation (γ):
   Gamma radiation is a very strong form of electromagnetic radiation (like light or x-rays) and travels at the speed of light. Gamma rays are extremely dangerous because of their high energy and speed. No changes to the numbers of protons or neutrons in the nucleus happen when gamma radiation is given off.

Properties of Radioactive Particles and Radiation:

	Alpha Particles	**Beta Particles**	**Gamma Radiation**
Nature	Helium Nuclei 	Electrons 	Waves of High Energy 
Charge	Positive	Negative	None
Penetrating Power	Weak – stopped by paper	Medium – stopped by 4mm of Aluminium	Strong – stopped by several cm of lead
Example Radioisotope	Americium-241. Used in smoke detectors.	Carbon-14. Used for radiocarbon dating.	Cobalt-60. Used for cancer treatment.

A useful diagram to remember the penetrating power of each type of radiation:



Nuclear Reactions:

Def[n]*:* A **nuclear reaction** is a process that alters the composition, sturcture or energy of an atomic nucleus.

Chemical reactions involve changes in the sharing and trandfer of *electrons*, whereas nuclear reactions involve changes in the *nucleus*. The main differences between chemical and nuclear reaction are:

	Chemical Reaction	**Nuclear Reaction**
1.	Involves electrons	Involves nucleus
2.	No new elements formed	New elements formed
3.	No release of nuclear energy	Release of nuclear energy
4.	Bonds are broken and formed	No bonds are broken or formed

Half-Life of a Radioisotope:

Def^n: The **half-life** of an element is the time taken for half the nuclei of a radioactive sample to decay.

Radioactive materials decay using a half life. This means that half the sample has decayed after 1 half life. Half of what remains (1/4 of the original sample) remains after 2 half lives, etc.

Example:

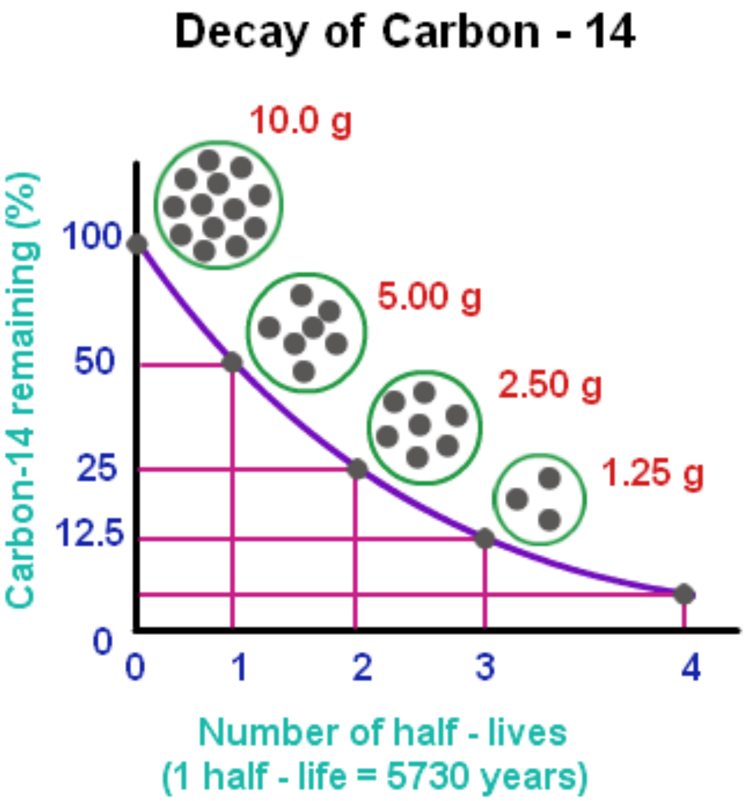
The half-life of Carbon-14 is 5730 years.

If we begin with 10g of ^{14}C, after 5730 years, half that amount will have decayed to nitrogen, leaving only 5g of ^{14}C.

After another 5730 years, half of the 5g sample will have decayed to nitrogen, leaving us with 2.5g of ^{14}C.

After yet another 5730 years, half of the 2.5g of ^{14}C will have decayed to nitrogen, leving us with 1.25g of ^{14}C.

So, half of the sample decays with each half-life.



Note on Radiocarbon Dating:

Def^n: **Radiocarbon Dating** is a technique used to find the age of an object containing carbon. It is based on the ratio of ^{14}C to ^{12}C in the object.