RADCOMMGB

RADCOMM RADIATION DETECTION SYSTEMS

Introduction to radioactivity

RADCOMM
RADIATION DETECTION SYSTEMS
AUTHORIZED DISTRIBUTOR

You may wonder…

What is radioactivity?
Where does it come from?
How do we know it is there?
How harmful is it?

Where does radioactivity come from?

Radiation is a **natural phenomenon.** It is all around us, contained in the materials that surround us.

This gives us a **background** of radiation.

The most common source of radiation is **not** radioactive. This makes up the visible light we use to see, as well as microwaves and radio waves.

Where does radioactivity come from?

Radiation can be found:

- in the ground;
- in materials in the environment, such as building materials e.g. granite;
- gases in the air around us such as radon;
- cosmic radiation which is dependent on your altitude, latitude, solar activity and the amount of time you spend outside;

…continued….

Where does radioactivity come from?

…continued….

- when we have X-Rays and other medical scanning procedures either in hospital or at the dentist; and
- when we carry out certain industrial activities such as processing scrap metal.

So why is radiation dangerous?

To understand radioactivity we need to revisit some science lessons from school.

All materials are made of one or more of the 118 known elements. Each element is given a letter or pair of letters to identify it, such as:

Uranium = U

Oxygen = O

Iron = Fe (Ferrous)

Hydrogen = H

So why is radiation dangerous?

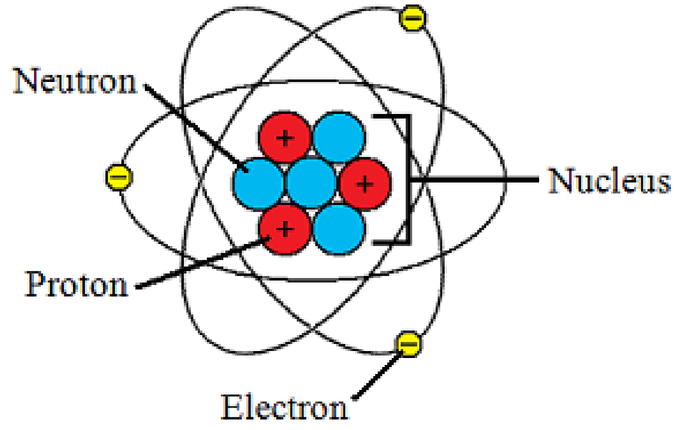
Different materials are made of different specific element combinations (compounds), for example:

- water is a compound of the elements hydrogen & oxygen joined (bonded) together - H_2O.
- carbon dioxide is made of carbon and oxygen bonded together - CO_2
- sugar is $C_6H_{12}O_6$ and ethanol C_2H_5OH.

What is an atom?

All elements are made of atoms. The atom of each element is different.

The number of **protons** in the **nucleus** *defines* the properties of the element. They are usually equal in number to the **electrons** surrounding the atom.



The number of neutrons may vary.

What is radioactivity?

Some elements have atoms with different numbers of **neutrons**, whilst maintaining the same number of protons and electrons, for example:

Cobalt 55 (Co-55) has 27 protons, 27 electrons and 28 neutrons
Cobalt 60 (Co-60) has 27 protons, 27 electrons but 33 neutrons

Atoms with different numbers of neutrons are called **isotopes**.

Remember: the number of *protons* defines the element so an element made of atoms with 27 protons in the nucleus will always be Cobalt.

What is radioactivity?

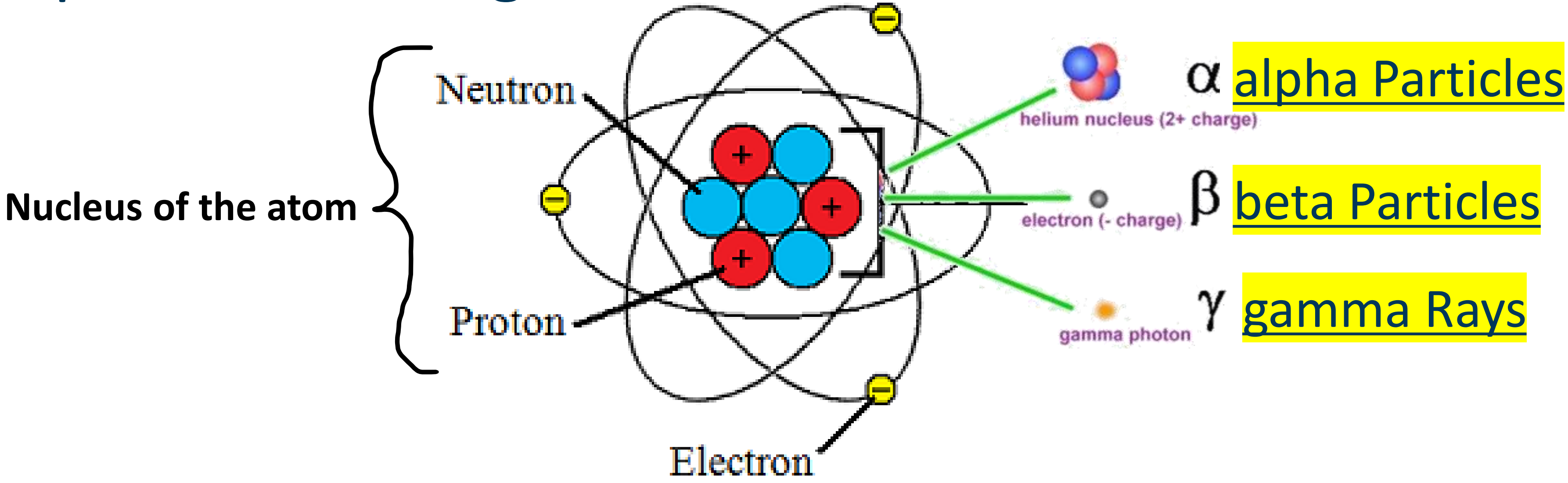
Some of isotopes of an element may be stable, but some will be unstable or **radioactive**, e.g. Co-60.

These unstable atoms **decay** until they become stable. This is what we call **radiation**.

As they decay they will lose **particles** and/or **energy**. This may change them to a new element or to a stable isotope of the same element.

What types of radiation are there?

During the decay of the unstable isotope, different types of radiation can be **emitted** (given out) by the *nucleus* of the atom commonly:
alpha, beta and gamma radiation.



In addition there are also X-rays and neutron rays.

What types of radiation are there?

Alpha and beta radiation occur in atoms that have an unstable ratio of protons to neutrons in the nucleus.

Alpha particles are a helium nucleus made of 2 neutrons and 2 protons.

Beta particles are electrons. However they come from *inside* the *nucleus:* a neutron splits into a proton and an electron. The electron is emitted.

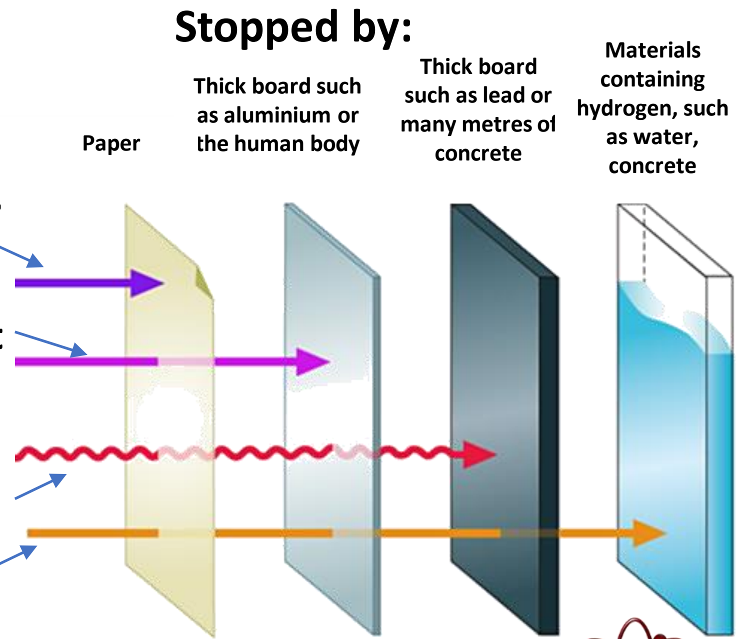
What types of radiation are there?

Gamma radiation is pure energy. It is emitted from atoms that are in an ‘excited’ state, i.e. it has too much energy to be stable.

An atom is often ‘excited’ after alpha or beta decay has occurred.

What types of radiation are there?

Each type of radiation has a different amount of energy and mass. This means they each *penetrate* distances (travel) into a material before they ‘lose’ their energy. (Technically, the energy is not ‘lost’ but absorbed by other atoms)



Alpha particles, travel a few centimetres in air High energy and harmful if they enter the body.

Beta particles, travel a few metres in air. Less energy but more penetrating than alpha particles.

Gamma rays (and X-Rays), travel hundreds of meters in air. Harmful no matter whether source is internal or external.

Neutron particles usually from nuclear fission or fusion reactions.

What are alpha particles?

- Alpha particles are high energy radiation.
- In particle terms they are heavy.
- They are stopped by a few cm of air, a single sheet of paper or dead cells on the skin's surface, so **pose little risk when external to the body**.
- Alpha radiation is **very harmful** if ingested or enters the body through a wound. It can do a lot of damage to a concentrated area of cells.

It may help to have an analogy to visualise what happens, albeit in simple terms…

What is alpha radiation?

Imagine alpha particles as a bus in a busy street.

As the bus (alpha particle) moves forwards it 'interacts' with the other vehicles that are in its path (atoms).
As the bus is large but has lots of energy (alpha particles are high energy particles) it will interact with a lot of vehicles in a short distance as it tries to move up the street. Each interaction slows down the bus until it stops after a short distance (the particle's energy is absorbed by each interaction).

What are Beta particles?

- Beta particles have less energy but are more penetrating than alpha particles.
- They are can penetrate up to 10m in air, and up to 2cm of plastic or wood.
- Beta particle sources can **cause harm from outside the body**, to skin and eyes for example.
- If the particles enter the body (by inhalation, ingestion or through an open wound) they are harmful as they can penetrate further into body tissue and interact with atoms making up cells.

What is beta radiation?

Beta particles are much smaller and have less mass than an alpha particle (about 8000 times lighter).

You could consider beta particles to be a motor cyclist in the same busy street 'dodging' around the traffic. They will still have 'interactions' with other 'vehicles' (atoms) but far fewer for the same distance travelled compared with the alpha particles. They will travel further that a bus (alpha particles) before all their energy has been 'lost' (absorbed) in interactions.

What are Gamma Rays?

- Gamma rays are electromagnetic radiation rather than particles. They have less energy than alpha or beta particles but are much more penetrating.
- They can *almost* be stopped by several metres of concrete or lead.
- Gamma rays are **very harmful no matter where the source is located** because of their penetration ability. They will affect the whole body rather than a localised area.

What is gamma radiation?

Gamma radiation is pure energy. It does not have any mass.   It can penetrate much further than either alpha or beta radiation into a material.

Gamma radiation on the same street, would behave more like light and not be stopped by other vehicles (atoms). Just as light can be reflected and change direction, so can the gamma ray if it interacts with an vehicle (atom) in the street. Whilst this is less likely to happen than with other radiation types, it does occur. They travel a long way before they have 'spent' their energy.

Is one type of radiation more dangerous?

When considering these actions of radiation, all ionising radiation can be dangerous.

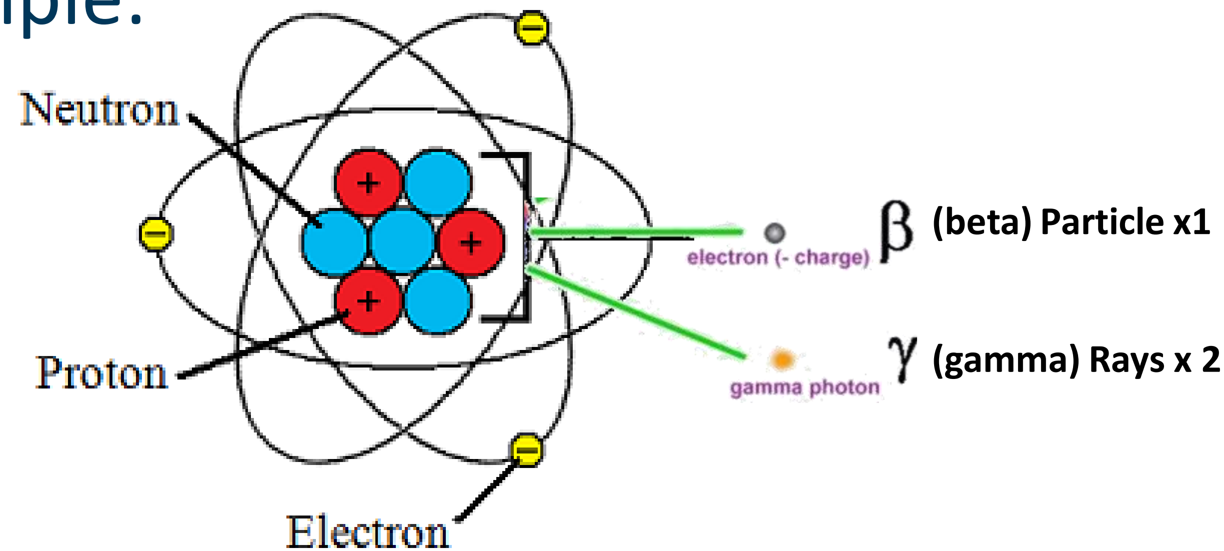
Alpha and beta radiation will be most harmful when *inside* the body as they interact with other atoms in close proximity.

Gamma radiation is harmful no matter where it is because it is so penetrating, spreading its interactions over a wide area.

Is all radioactivity the same?

Each radioactive isotope will emit a characteristic type or mix of radiation from the nucleus when it decays. For example:

Cobalt 60 emits: one beta particle & two gamma rays.



Caesium 137 emits one beta particle but only one gamma ray.

Is all radioactivity the same?

Radioactive isotopes also differ in how long they emit radiation for. They decay at a characteristic rate, called a **half-life**, until they are stable.

Each half life, *half* the atoms will decay:
1 half life - $^{1}/_{2}$ the atoms will have decayed.
2 half lives - half of the remaining of radioactive atoms left will decay, i.e. $^{3}/_{4}$ of the atoms will have decayed.
3 half lives - $^{7}/_{8}$ of the atoms will have decayed and so on.

Is all radioactivity the same?

Some examples of half lives are:

• Iodine-131	8 days
• Cobalt-60	5.3 years
• Cesium-137	30 years
• Americium-241	241 years
• Uranium-238	4.5 billion years
• Thorium-232	14 billion years

Obviously a short half life renders the isotope ‘safe’ (stable) much more quickly.

What is radioactivity?

In summary:

- Radiation is *energy* released by unstable atoms (*isotopes*) of certain elements.
- Radioactive isotopes *decay* in order to become stable elements.
- Different types of radiation can penetrate different distances into different materials and so be stopped by some materials.
- All *ionising* radiation is dangerous as it interacts with the atoms in the cells of our body.
- Different radioactive isotopes emit radiation for different *half lives*.
- Different types of radiation are emitted by different isotopes.