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The Shell Model and The Periodic Table

The Rutherford-Bohr model of the atom shed light on the arrangement of the periodic table of the elements. The orbits which electrons were allowed to occupy around atomic nuclei were in groups of a similar radii called shells. There was a maximum number of electrons which each shell could hold given by the formula $2n^2$, where n = 1, 2, 3, 4,… So the first shell nearest to the nucleus had only $2(1^2) = 2$ electrons. The second shell had $2(2^2) = 8$ electrons and the third shell had $2(3^2) = 18$ electrons.

The Atomic Number or Proton Number

An atom is normally electrically neutral and since the proton (positive) and the electron (negative) each have the same number of charge, there must normally be equal number of protons and electrons in an atom. However atoms can gain or lose electrons and become ions without changing into a different substance or element. So the number of electrons is not a reliable guide to the type of atom. The number of protons in the nucleus of an atom is the only factor which determines which element an atom belongs. The atomic or proton number, Z of an element is the number of protons in the nucleus of all atoms of that element.

Neutron Number (N) and Mass Number (A)

The nucleus of the atom contains protons and neutrons. These are both referred to as nucleons, that is, particles that belong in the nucleus of an atom. The number of neutrons known as the neutron number, N in a nucleus is similar to the number of protons Z but is often greater than Z particularly for large atoms. The number of nucleons in the nucleus of an atom is called its nucleon number or mass number, A.

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RADIOACTIVITY

Isotopes

These are atoms with the same number of protons but different number of neutrons, that is, atoms with same atomic number but different mass number. Alternatively, isotopes can be defined as atom of the same element with different mass numbers.

Radioactive Emissions

There are 3 types:-

1. Alpha Radiation (α)
2. Beta Radiation (β)
3. Gamma Radiation (γ)

Nature of Radiation

An alpha particle is identical in structure to the nucleus of a helium atom, that is, it consists of 2 protons and 2 neutrons. Its symbol is written as ${}^{4}_{2}\alpha$.

The beta particle is a high energy electron. Its symbol therefore, ${}^{0}_{-1}\beta$. Since the beta particle is an electron, the mass number is considered to be zero while the proton number is -1.

Gamma radiation is in the form of electromagnetic waves therefore they possess all the properties of electromagnetic spectrum.

These properties include:

1. Can travel through a vacuum
2. Could be reflected, refracted and diffracted
3. Has a speed of $3 \times 10^{8} m/s$ in a vacuum.
4. Can be emitted and absorbed
5. They are transverse waves
6. They undergo interference

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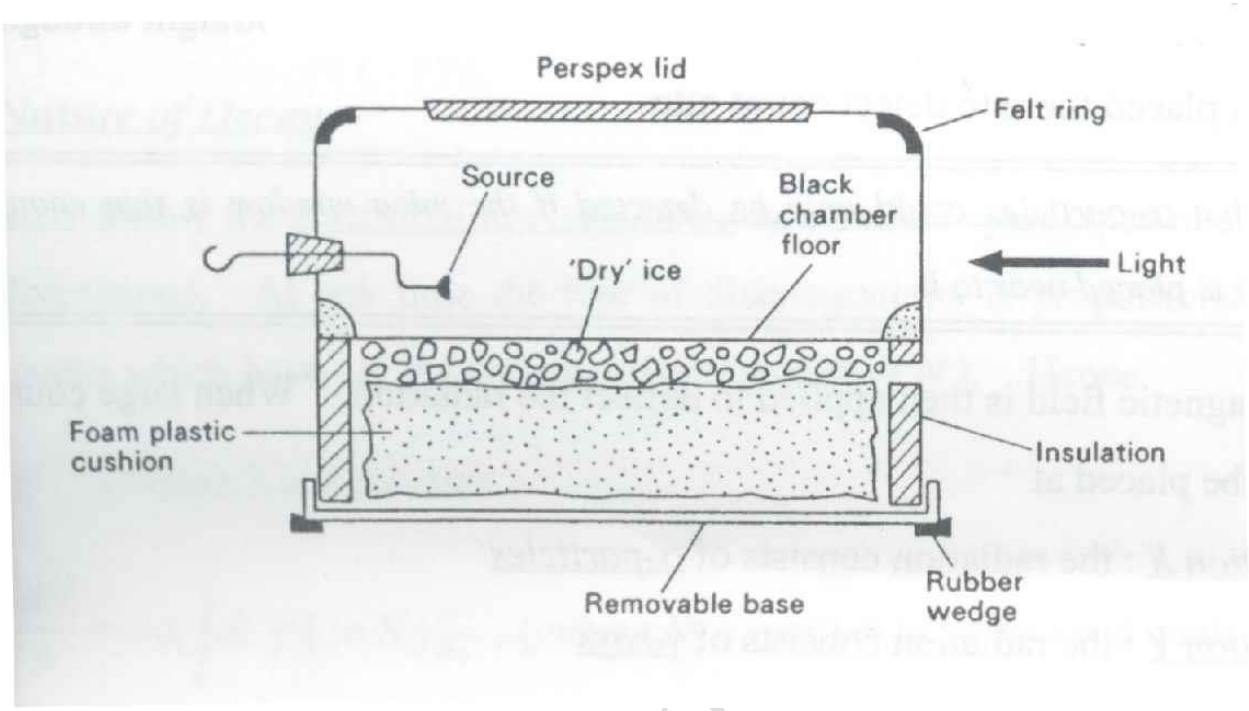
The Cloud Chamber



In the cloud chamber, alcohol and water vapour are cooled to very low temperatures so that they remain in vapour form. If this vapour is cooled any more or it is touched then the vapour condenses into liquid form. When radioactive emissions pass through the super cooled vapour they touch the vapour particles causing condensation along its path. The condensed vapour (liquid) remains suspended and therefore the pathway taken by the radioactive emissions can be seen. This pathway is made more visible by shining light through it.

1. The chamber is transparent for easy viewing.
2. The crushed dry ice is to cool the vapour.
3. The foam sponge provided insulation
4. The lamp provides light which makes the tracks more visible.

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Range of Radioactive Emissions

The distance travelled by the radiation emissions is dependant upon the following:

1. Size of Particle
2. Charge of Particle

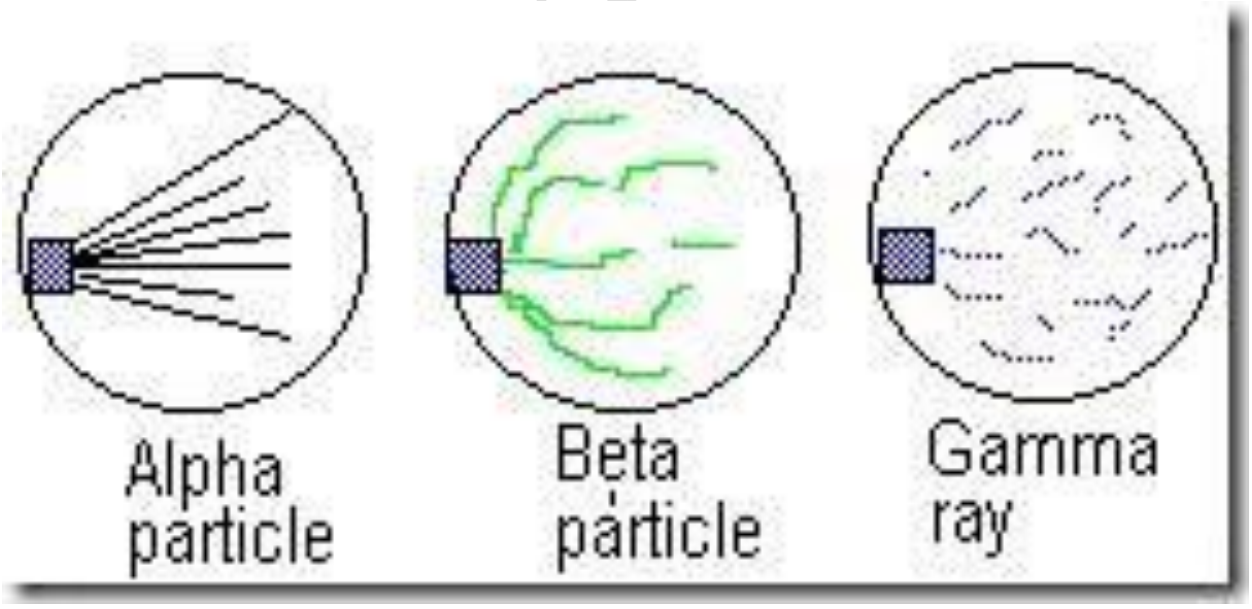
The alpha particle has the largest size, that is, a mass number of 4 and also the largest charge (+2). Since it is a large particle, it readily bombards other molecules, hence its range is short (only a few centimetres). When the alpha particle passes through a medium, it takes up two electrons to form a helium atom.

A beta particle being an electron has a mass of $^{1}/_{1840}$ and a charge of -1. The beta particle travels a longer distance than the alpha particle, that is, a few metres.

The gamma ray, being part of the electromagnetic spectrum, can travel a distance measured in kilometres.

Depth of Penetration

1. An alpha particle can travel through very thin metal foil but stopped by paper
2. Beta particles can pass through thin aluminium no thicker than 3mm
3. Gamma rays are able to penetrate through lead sheets 2cm in thickness



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Explanation of Tracks Created in The Cloud Chamber

1. The alpha particle has a large mass (4) therefore when it passed through the cloud chamber it touches many vapour molecules. This results in thick tracks. Since they bombard so many vapour particles, they are readily stopped, hence they produce short tracks.
2. The beta particle being a high energy electron has a mass of $^1/_{1840}$ therefore will touch few particles along its path hence the pathways are thin. Due to their small size also they are easily deflected hence their paths are curved.
3. Gamma rays (radiation) possesses large amounts of energy when they pass through the super cooled vapour, they bombard electrons within the vapour particles. These electrons absorb energy from the gamma radiation. The electrons become high energy electrons. These high energy electrons produce tracks which are seen as scattered, thin, short, curved lines. The high energy electrons quickly return to their low energy state hence the reason short tracks are produced. The gamma rays themselves do not produce tracks.