IGCSE/GCE O-LEVEL

Nuclear Physics

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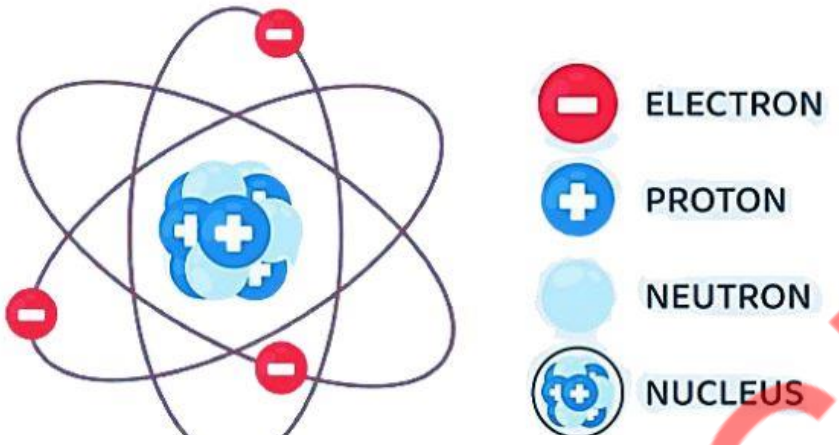
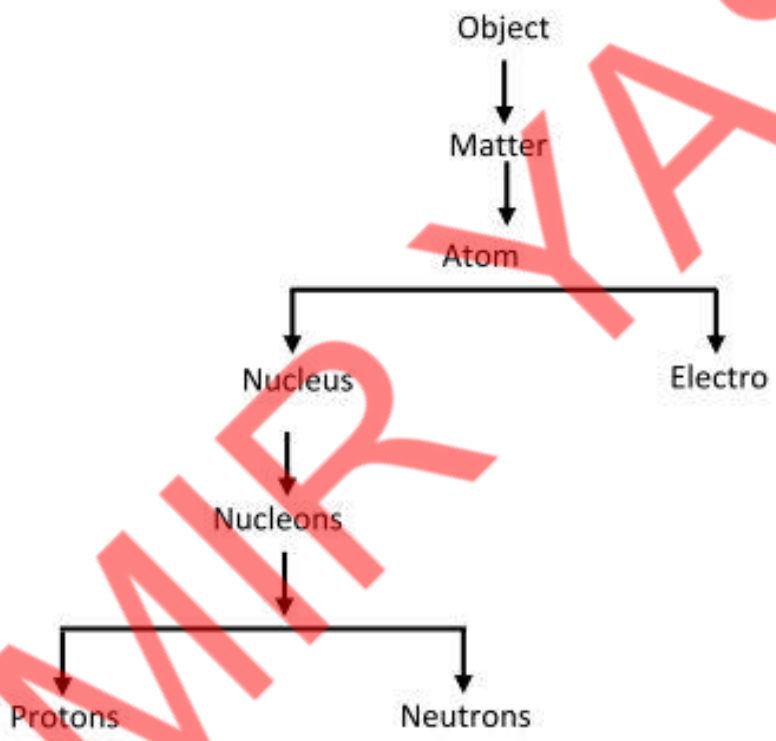

ELECTRON
PROTON
NEUTRON
NUCLEUS


Object
Matter
Atom
Nucleus
Electro
Nucleons
Protons
Neutrons

All the objects are made up of matter and smallest part of matter is atom.

Atom

The smallest part of matter is called atom.

- Atom is further divided into two parts
  - Nucleus
  - Electron

Nucleus

The central part of atom is called nucleus.

- Almost all of mass of atom lies in the nucleus.
- Nucleus consists of two types of particle
  - Proton
  - Neutron

Nucleons

Particles which lie inside the nucleus are called nucleons.
For example proton and neutrons are nucleons.

Proton

A particle which lies inside the nucleus.

- It carries positive charge.
- Its charge is + 1.6×10^{-19}C
- Its mass is 1.66×10^{-27} kg

Neutron

A particle which lies inside the nucleus.

- It has no charge.
- Its mass is equal to mass of proton.
- It mass is 1.66×10^{-27}kg.

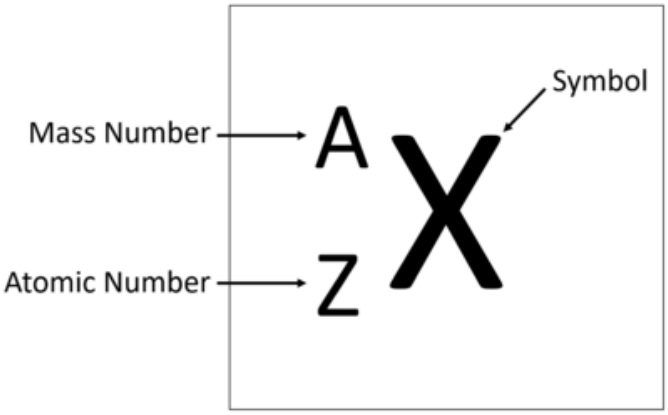
Electron

A particle which revolves around the nucleus.

- It lies outside the nucleus.
- It is negatively charged.
- Its charge is -1.6×10^{-19}C
- Its mass is $\frac{1}{1840}$ (mass of proton) i.e 9.1×10^{-31}kg

	Particle	Position	Charge	Mass
1-	Proton	Inside nucleus	+ve $+1.6X10^{-19}c$	$1.66X10^{-27}kg$
2-	Neutron	Inside nucleus	zero	$1.66X10^{-27}kg$
3-	Electron	out nucleus	-ve $-1.6X10^{-19}c$	$9.1X10^{-31}kg$

Element Representation



Mass Number / Nucleons Number

- It is represented by letter 'A'.
- it represents numbers of protons and neutrons present in the atom / nucleus.
- Since it represents all the particles of nucleus that's why it is called nucleon number. Since almost all the mass of atom is due to the nucleons that's why it is also called mass number.

Atomic Number / Charge Number / Proton Number

- It is represented by letter 'Z'.
- It represents number of protons in the nucleus or number of electrons in the atom.

NOTE

Number of protons and number of electrons in an atom are the same.
That's why all the atoms are neutral.

Example

Helium	$^{4}_{2}He$	A	=	4	(Proton + Neutron)
		Z	=	2	(Proton)
		N	=	A-Z	(Neutrons)
Uranium	$^{235}_{92}U$	A	=	235	
		Z	=	92	
		N	=	143	

Isotope

Atoms of same element having same number of protons but different number of neutrons.

Example

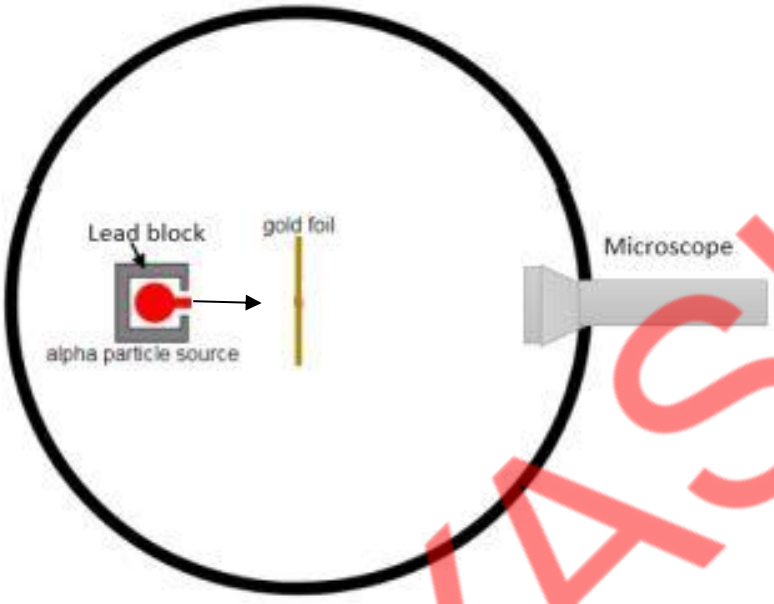
Hydrogen has three isotopes

$$^{1}_{1}H \quad , \quad ^{2}_{1}H \quad , \quad ^{3}_{1}H$$

All the atoms have same number of protons but different number of neutrons

Atom	Number of Protons (Z)	Number of Neutrons(A)
$^{1}_{1}H$	1	1
$^{2}_{1}H$	1	1
$^{3}_{1}H$	1	1
$^{235}_{92}U$	92	143
$^{238}_{92}U$	92	146

Geiger and Marsden Alpha Particle Scattering Experiment



Geiger and Marsden performed an experiment which is called Alpha Particle Scattering. They passed Alpha - particles through thin sheet of Gold (thinner than sheet of paper) to describe structure of atom.

Apparatus

- A thin sheet of gold is placed exactly at the middle.
- A source of Alpha - particle is placed to one side of Gold sheet.
- A moveable microscope is placed to other side of gold sheet.
- Lens of microscope is coated with Zinc sulphide to detect the presence of Alpha particles.
- Alpha particle consists of two protons and two neutrons and carries positive charge.
- When charge particle hits zinc sulphide, a spot of light is produced.

Observations

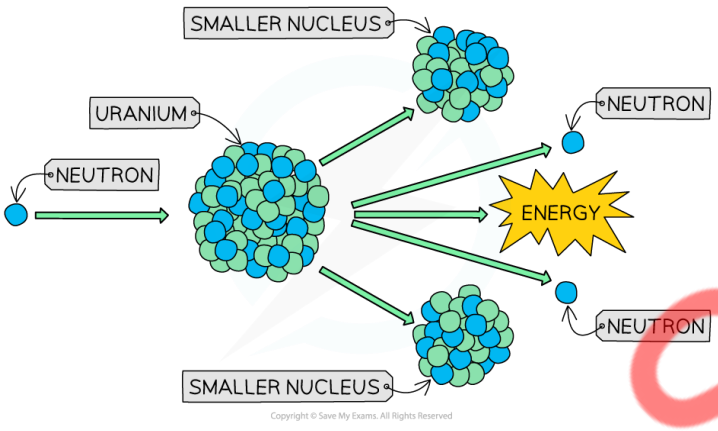
1. Most of Alpha - particles passed un-deflected through the gold sheet.
2. Some of Alpha - particles were deflected through the gold sheet.
3. Few Alpha - particles were deflected in almost backward direction.

Conclusion about structure of atom

1. Most part of atom is empty
2. Positive charge is present inside the atom
3. Size of matter (Nucleus) inside the atom is very small.

Nuclear Fission

A process in which a heavy nucleus splits into two light nuclei with release of energy is called nuclear fission.



There are two types of fission reactions.

- Spontaneous Fission
- Neutron Induced Fission

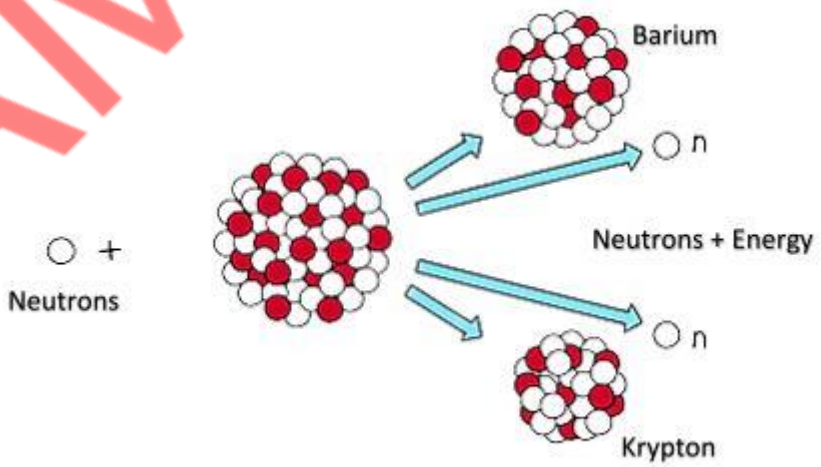
Spontaneous Fission

When an unstable heavy nucleus splits into two light nucleus with release of energy automatically then it is called spontaneous fission.

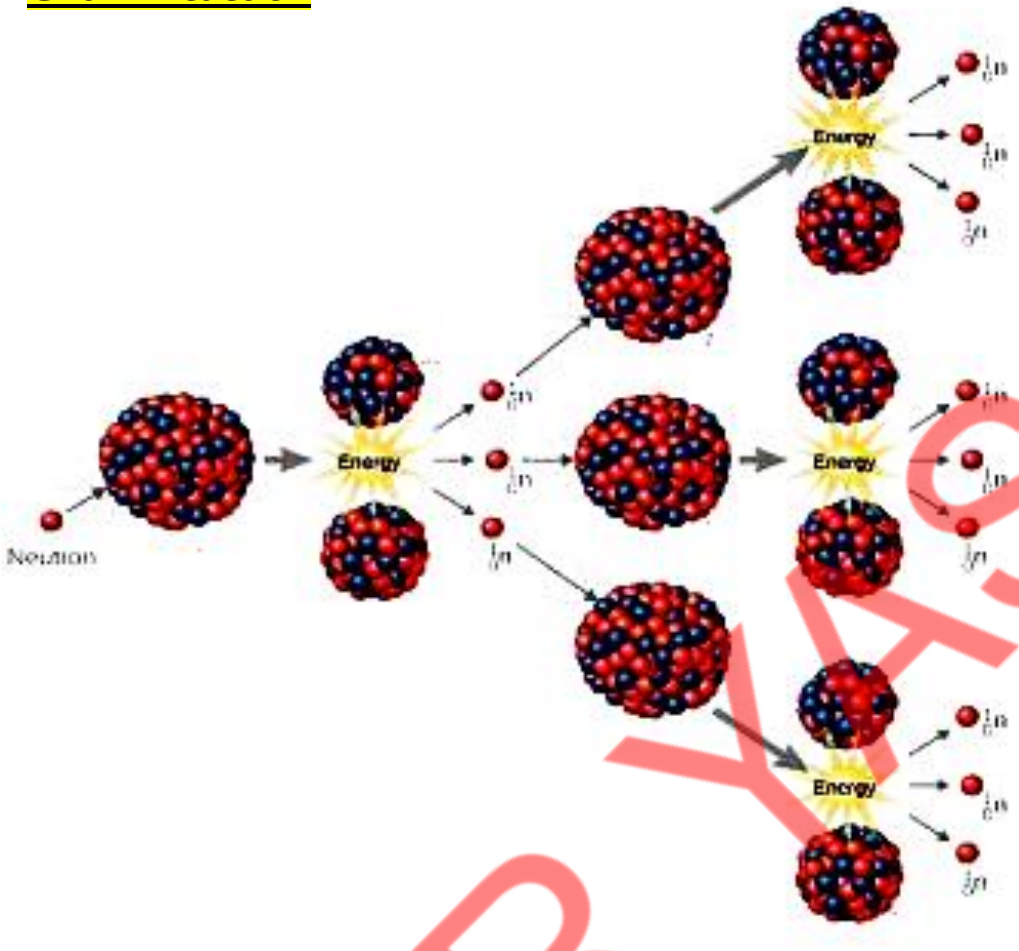
Neutron Induced Fission

When a heavy nucleus absorbs a slow moving neutron and then splits into two light nuclei with release of energy then it is called neutron induced fission.

- In nuclear reactor and nuclear bomb, neutron induced fission is used.
- Uranium nucleus is called Parent nucleus
- Barium and Krypton nuclei are called daughter nuclei.
- Energy is released in fission reaction inform of Kinetic energy of Barium and krypton and neutron plus Gamma rays.



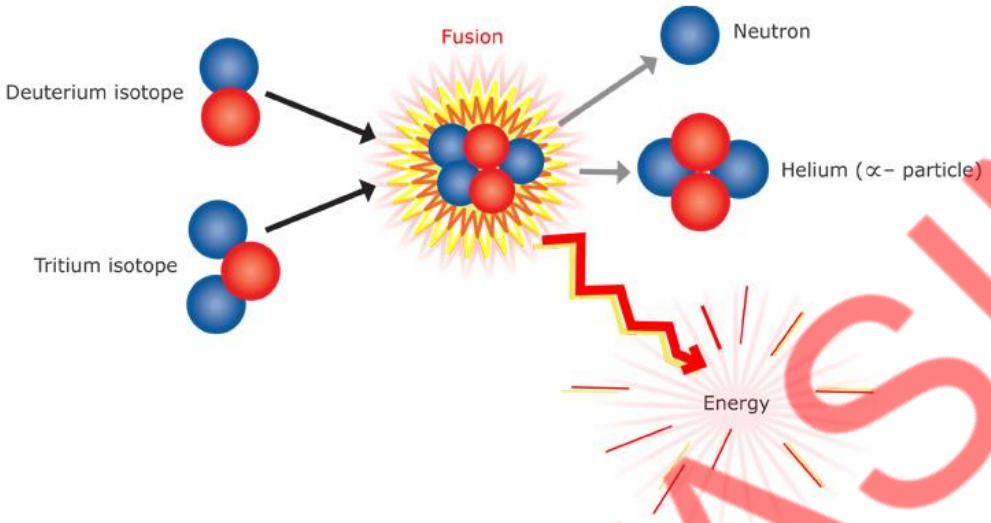
Chain Reaction



- When a slow moving neutron is absorbed by a uranium nucleus it splits into two light nuclei with release of energy and two more neutrons are produced.
- These two neutrons produce fission reaction in two further uranium nucleus and as a result four neutron are produced.
- These four neutrons collide with further four uranium nucleus and as a result eight neutrons are produced, then sixteen, then thirty two and so on.
- This process of continuous fission is called chain reaction.
- In nuclear reactor, controllable chain reaction is produced.
- In nuclear bomb, an uncontrollable chain reaction is used.
- The idea is to get as many uranium nucleus as possible to undergo fission in short time. The nuclear reaction escalates out of control and vast amount of energy is produced in fraction of second.

Nuclear Fusion

A process in which two light nucleus combine to produce a heavy nucleus with release of energy is called nuclear fusion.

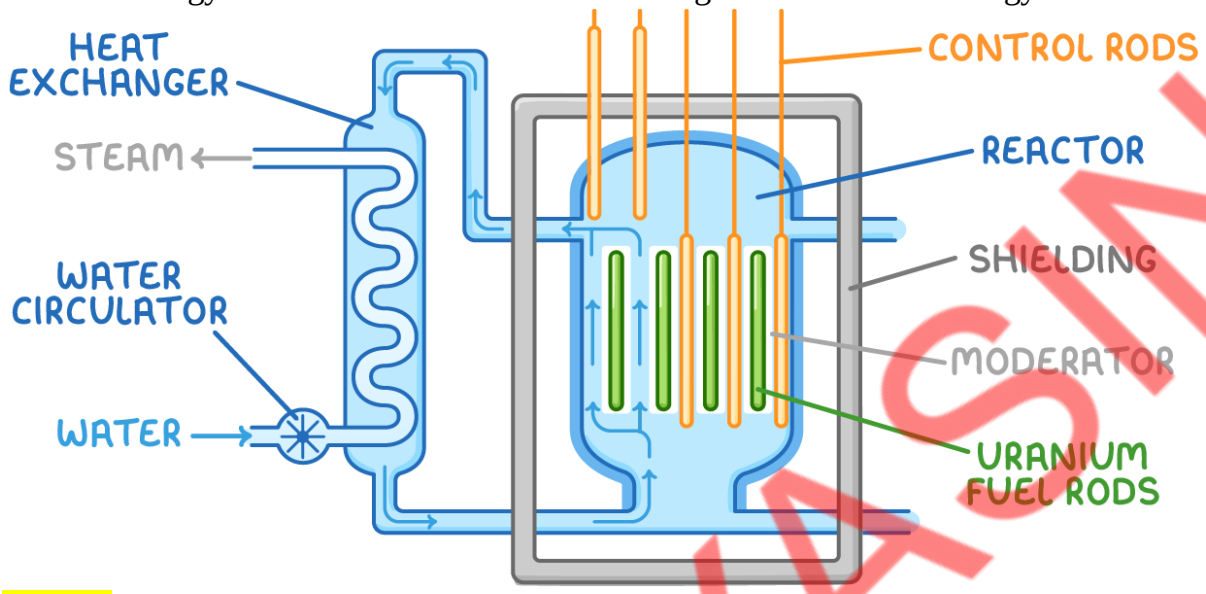


$$^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He + {}^{1}_{0}n + \text{Energy}$$

- High temperature is required for nuclear fusion.
- At high temperature two deuterium nuclei have enough Kinetic energy to overcome the repulsive force due to their positive charge and fuse to form heavy nucleus.
- Nuclear fusion is produced in stars because they have very high temp.
- In nuclear reactor, high temperature is produced by fission and then fusion is made possible.

Nuclear Reactor

It is used to produce thermal energy by using controlled fission reaction.
Thermal energy is then used to run turbine which generates electric energy.



Parts

There are four essential parts of nuclear reactor.

- Fuel rod
- Moderator
- Control rod
- Coolant

Fuel Rod

They contain uranium – 235 and used to produce fission reaction.
A spent rod can be removed and replaced while reactor is running.

Moderator

Graphite blocks are used to slow down the neutron and are called moderator.
They are placed between the fuel rods.

Control Rod

They are used to control the rate of fission reaction.
They are made up of boron. Boron is a good absorber of neutrons.
They are lowered in the core to slow or stop the reaction.
They are raised to increase the rate of fission.

Coolant

Carbon dioxide is used as coolant it heats up due to thermal energy produced in reactor.
The hot gas converts water into steam.
Steam is then used to run the turbines.