7th Science Lesson 4 Notes in English

4] Atomic Structure

Introduction

- The molecules are combination of atoms of different elements or the same element.

How small is an atom?

- An atom is one and thousand times smaller than the thickest human hair. It has an average diameter of 0.0000000001m or 1×10^-9 m.
- To understand atom's size with the familiar things we know, now let us find what is the size of pencil, red blood cell, virus and dust particle.

  1×10^-2 m 1×10^-4 m 1×10^-6 m

  1×10^-7 m 1×10^-10 m

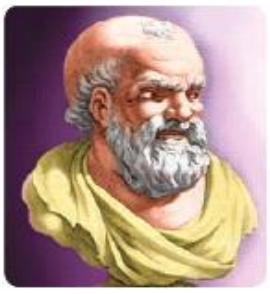
- Now you could imagine how small an atom would be.

Evolution of idea of an atom

- Many scientists have studied the structure of the atom and advanced their theories about it.
- The theories proposed by Dalton, Thomson and Rutherford are given below.

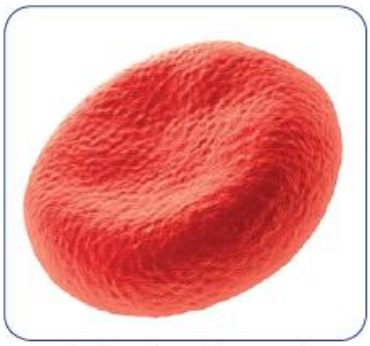
Dalton's atomic theory

- **John Dalton proposed the atomic theory in the year 1808.**
- He proposed that matter consists of very small particles which he named atoms. An atom is smallest indivisible particle, it is spherical in shape.
- His theory does not propose anything about the positive and negative charges of an atom.
- Hence, it was not able to explain many of the properties of substances.

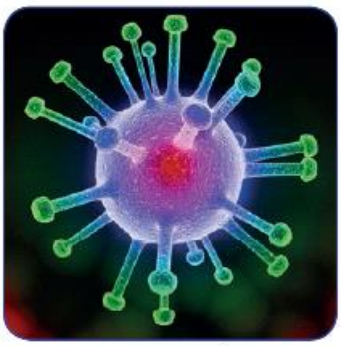


John Dalton

Pencil 1×10^{-2} m

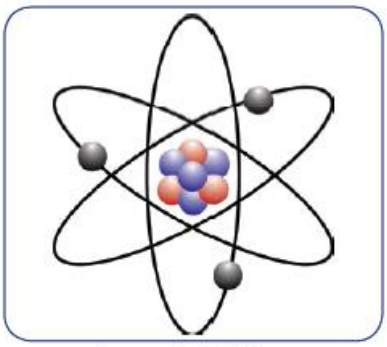


Red Blood Cell 1×10^{-4} m



Virus 1×10^{-6} m

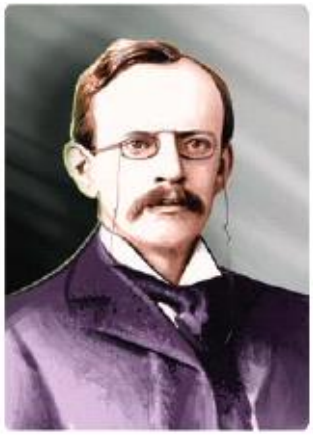
Dust Particle 1×10^{-7} m



Atom 1×10^{-10} m

Thomson's theory

- In 1897 J.J Thomoson proposed a different theory. He compared an atom to a watermelon.
- His theory proposed that the atom has positively charged part like the red part of the watermelon and in it are embedded, like the seeds, negatively charged particles which he called electrons.
- According to this theory as the positive and negative charges are equal, the atom as a whole does not have any resultant charge.
- Thomson's greatest contribution was to prove by experimentation the existence of the negatively charged particles or electrons in an atom.
- For this discovery, he was awarded the **Nobel Prize in 1906**. Although this theory explained why an atom is neutral, it was an incomplete theory in other ways.



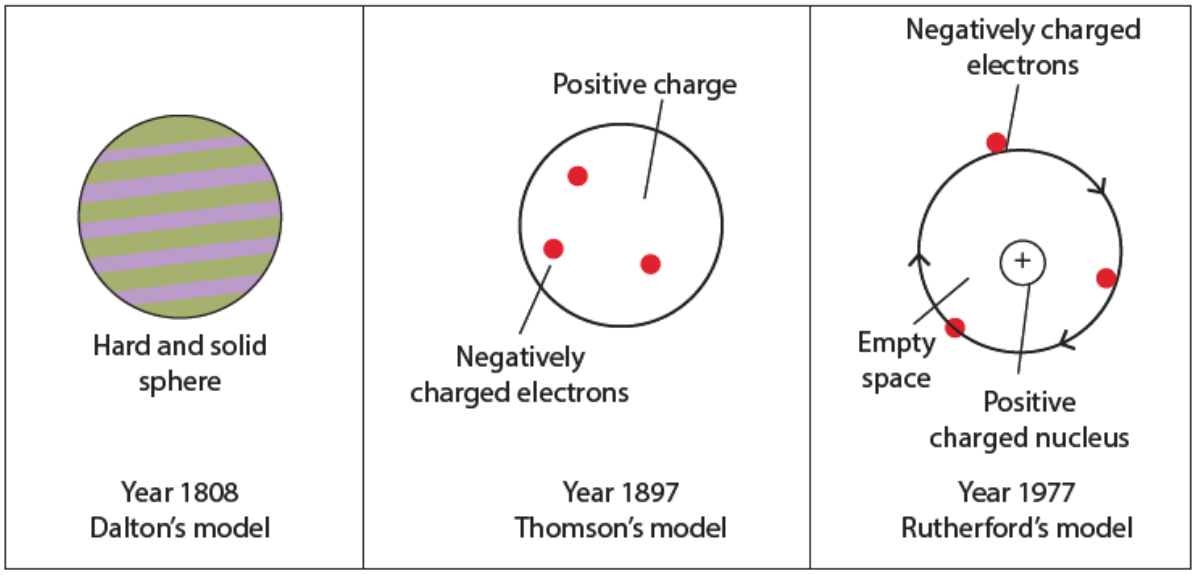
J.J. Thomson

Rutherford's theory

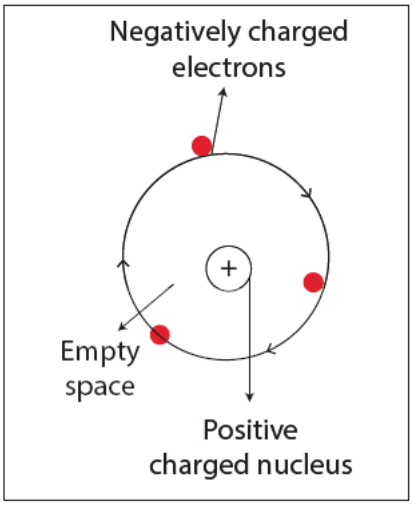
- There were short coming in Thomson's theory, Earnest Rutherford gave a better understanding. Earnest Rutherford conducted an experiment.
- He bombarded a very thin layer of gold with positively charged alpha rays.
- He found that most of these rays which travel at a great velocity passed through the gold sheet without encountering any obstacles.
- A few are, however, turned back from the sheet.
- Rutherford considered this remarkable and miraculous as if a bullet had turned back after colliding with tissue paper.
- Based on this experiment, Rutherford proposed his famous theory.
- In his opinion, – 1. The fact that most alpha particles pass through the gold sheet means that the atom consists mainly of empty space. 2.
- The part from which the positively charged particles are turned back is positively charged but very small in size as compared to the empty space.

Rutherford

Stages of discovery of the constituents of an atom



- From these inferences, Rutherford presented his theory of the structure of atoms. For this theory, he was awarded the Nobel Prize for chemistry.

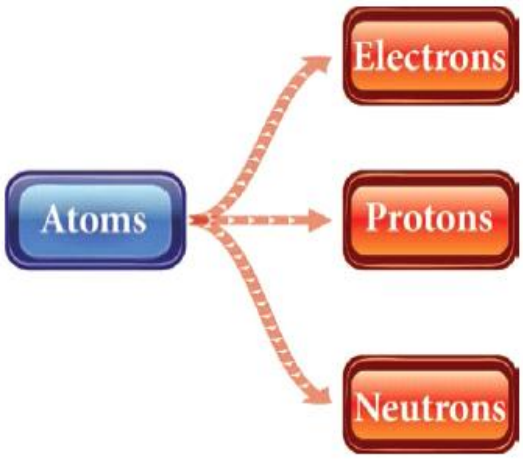


Rutherford's theory proposes that

- The nucleus at the centre of the atom has the positive charge. Most of the mass of the atom is concentrated in the nucleus.
- The negatively charged electrons revolve around the nucleus in specific orbits.
- In comparison with the size of the atom, the nucleus is very very small.

The subatomic particles

- The discoveries made during the twentieth century proved that atoms of all elements are made up of smaller components - **electron, proton and neutron.**
- An electron from hydrogen atom is no different from electron of a carbon atom.
- In the same manner, protons and neutrons of all elements also have same characteristics.
- These particles that make up the atom are called Subatomic Particles.



Proton (p)

- The proton is the positively charged particle and it's located in the nucleus. Its positive charge is of the same magnitude as that of the electron's negative charge.

Neutron (n)

- Neutron is inside the nucleus. The neutron does not have any charge. Excepting hydrogen (protium), the nuclei of all atoms contain neutrons.

Electron (e)

- This is a negatively charged particle. Electrons revolve around the nucleus of the atom in specific orbits.
- The mass of an electron is negligible as compared to that of a proton or neutron. Hence, the mass of an atom depends on the number of protons and neutrons in the nucleus.
- Protons and Neutrons are the two types of particles in the nucleus of an atom. They are called nucleons.
- The total negative charge of all an electrons outside the nucleus is equal to the total positive charge in the nucleus.
- That makes the atom electrically neutral.

Charge and mass of the sub atomic particles:

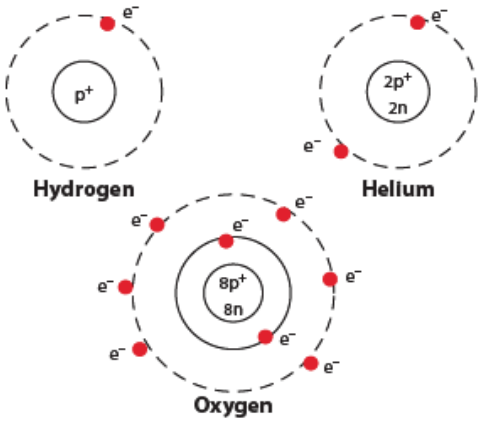
Particle	Discoverer	Symbol	Charge	Mass (kg)
Proton	Ernest Rutherford	p	+1	1.6726×10^{-27}
Electron	Sir John Joseph Thomson	e	-1	9.1093×10^{-31}
Neutron	James Chadwick	n	0	1.6749×10^{-27}

Atomic number and Mass number

- Further investigations led to the discovery that the number of the protons inside the nucleus of an atom determines what element it is.
- For Example if the nucleus has only one proton, then all such atoms are hydrogen atom. If there are eight protons then that atom is oxygen.

Atomic number (z)

- The number of electrons or protons in an atom is called the atomic number of that atom. It is represented by the letter Z.
- If we know the atomic number of an atom, we know the number of electrons or protons in it.



- The hydrogen nucleus has one proton around which revolves one electron. It means that its atomic number z=1.
- In the helium atom there are two protons and two electrons in orbit around the nucleus, so the atomic number of helium is z=2.

Mass number (A) or Atomic mass:

- We have seen that the mass of an atom is concentrated in its nucleus. From this, we can get the atomic mass number.

- Mass number (A) is equal to the sum of the number of protons (p) and neutrons (n) in the nucleus.

  Atomic mass or mass number = Number of Protons + Number of Neutrons

  A = p+n

- A lithium atom contains 3 Protons and 4 neutrons. Its atomic mass number A = 3+4 = 7.
- In a sodium atom, there are 11 Protons and 12 neutrons. Hence, its atomic mass number A = 11 + 12 = 23.
- When writing the symbol of an element, its atomic number and atomic mass number are also written.
- For example, the symbols of hydrogen, carbon and oxygen are written as 1H1, 6C12, 8O16 respectively.

All the elements in the periodic table have the following combination of protons, electrons and neutrons:

Elements	Symbols	Number of proton, electron, neutron,
Carbon	$_6C^{12}$	6p,6e,6n
Beryllium	$_4Be^{12}$	4p,4e,5n
Nitrogen	$_7Be^{14}$	7p,7e,7n
Boron	$_5B^{11}$	5p,5e,6n

Elements and their symbols with their atomic number and mass number.

Element	symbol	Atomic number	Protons (p)	Neutrons(n)	Mass number(p+n)
Hydrogen	H	1	1	0	1
Helium	He	2	2	2	4
Aluminium	Al	13	13	14	27
Oxygen	O	8	8	8	16
Sodium	Na	11	11	12	23

Valency

- Imagine there are various people having different pattern of hands. Some have no hands and some have one, some two and others three.
- Few have four and no one has more than four.
- The person with four hands can hold hands of four others at a same time, while the one with no hands can never hold any hand. In this manner some atoms can hold one electron, some can hold two, some can hold three, some can hold four and some cannot hold any electron.
- This combining property of an atom is called as Valency. It is a measure of how many hydrogen atoms it can combine with.
- For example: oxygen can combine with two hydrogen atoms and create water molecule, the valency of oxygen atom is two.
- In case of chlorine, it can combine with only one hydrogen to create HCl (hydrochloric acid) here the valency of chlorine is one.
- Methane has one carbon atom combining with four hydrogen atoms to form carbon molecule is methane (CH4).
- Valency is defined as the combining capacity of an element. Atoms of different elements combine with each other to form molecules.
- **Valency determines the number of atoms of an element that combines with atom or atoms of another type.**
- The element having valency one is called monovalent.
- For example: Hydrogen and Sodium.
- The elements having valency two are called divalent. For example: Oxygen and Beryllium.
- The elements having valency three are called trivalent. For example: Nitrogen and Aluminum.
- Some elements exhibit more than one valency. For example: Iron combines with oxygen to form two types ferrous oxide (exhibits valency 2) and ferric oxide (exhibits valency 3), however we will study about them later.
- When atoms of different elements combine with each other then molecules of compounds are formed.
- In these instances, it is necessary to know the valancies of those elements. For example:

$2Na + Cl_2$ ---------- 2NaCl

Valency 1 + 1

- Here, the valancies of both sodium and chlorine are 1.
- Remember The valency of element Na is 1
- The valency of element Cl is 1
- Then, the molecular formula will be Symbol of Elements Na Cl Molecular Formula

Radicals and ions 1 1 NaCl

$2\ Mg + Cl_2$ ---------- $Mg\ Cl_2$

Valency 2 1

- Here, the valency of magnesium is 2 and that of Cl is 1.

Elements and their symbols with their atomic number and mass number and valency

Element	Symbol	Atomic Number	Mass Number	Valency
Hydrogen	H	1	1	1
Carbon	C	6	12	4
Oxygen	O	8	16	2
Sodium	Na	11	23	1
Calcium	Ca	20	40	2

More to know:

- Nanometer is the smallest unit used to measure small lengths. One metre is equal to 1×10^{-9} nm or one nanometer is equal to 1×10^{-9} m
- You have around 7 billion atoms in your body, yet you replace about 98% of them every year!
- Is the structure of the atom the same as the structure of the solar system? Yes! It is similar to the solar system. It has a core center called nucleus and it has paths called orbits around the nucleus.

Isotopes:

- Atoms of the same element can have different number of neutrons. Such atoms will have same atomic number but different mass numbers.
- These atoms are called isotopes. For example Hydrogen has three isotopes --- Hydrogen ($_1H^1$), Deuterium ($_1H^2$), and Tritium ($_1H^3$).

Isobars:

- Atoms that have the same mass number but different atomic numbers. for example Calcium – 40 and Argon - 40

What makes atoms stick together?

Electrons carry a negative electric charge, and protons carry a positive charge. The attraction between them holds electrons in orbits.

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