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INORGANIC CHEMISTRY

Chemistry:

Chemistry is the branch of science which deals with the properties, characteristics and physical and chemical changes of the matter.

Inorganic chemistry:

Inorganic chemistry is the study of the structure, properties, composition, reactions, and preparation of inorganic compounds, which include metals and minerals

Atom:

An Atom is a small part of element that takes part in chemical reactions. The concept of an atom is originated from Greek philosophers like Democritus and John Dalton.

Democritus studied the nature of matter and the constituents of all the substances. This is **Democritus' atomic theory exactly:**

1. All matter consists of invisible particles called atoms.

2. Atoms are indestructible.

3. Atoms are solid but invisible.

4. Atoms are homogenous.

5. Atoms differ in size, shape, mass, position, and arrangement.

    ->Solids are made of small, pointy atoms.

    ->Liquids are made of large, round atoms.

    ->Oils are made of very fine, small atoms that can easily slip past each other.

John Dalton (1766-1844):

John Dalton developed an atomic theory in the 1800s. He did experiments, worked out some atomic weights and invented symbols for atoms and molecules. His most important conclusions are summarised below:

1. All matter is made of atoms.
2. Atoms cannot be broken down into anything simpler.
3. All the atoms of a particular element are identical to each other and different from the atoms of other elements.
4. Atoms are rearranged in a chemical reaction.
5. Compounds are formed when two or more different kinds of atoms join together

Dalton's theory was developed and changed as new evidence was discovered.

JJ Thomson's discovery of the electron:

JJ Thompson discovered the electron in 1897. This showed that the atom contained smaller pieces, whereas Dalton had thought that atoms could not be broken down into anything simpler.

Rutherford's nuclear atom:

In 1911 Ernest Rutherford used experimental evidence to show that an atom must contain a central nucleus. This was further evidence that an atom contained smaller pieces.

Bohr's electron orbits:

Niels Bohr further developed Rutherford's nuclear atom model. He used experimental evidence to support the idea that electrons occupy particular orbits or shells around the nucleus of an atom.

Structure of the atom

- Every atom is made of a nucleus consisting of protons and neutrons. The nucleus is surrounded by electrons.
- Protons and electrons are oppositely charged. Neutrons have no charge. This means the nucleus of an atom is always positively charged.
- An atom has a neutral overall charge because it has the same number of electrons as protons.

- Protons and neutrons have the same mass. Electrons have such a small mass that this can usually be taken as zero.

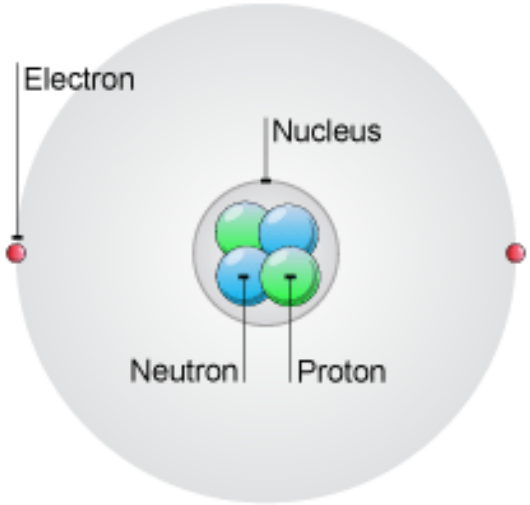

Figure: Structure of an atom

Fundamental particles of an atom

Elements of atom	Charge	Mass (g)	Mass (amu)	Discovered by	Charge in Coulomb
Proton	+1	1.6727×10^{-24}	1.007316	E. Goldstein	1.602×10^{-19}
Neotron	0	1.6750×10^{-24}	1.008701	James Chadwick	no charge i.e. neutral
Electron	-1	9.110×10^{-28}	0.000549	J.J Thomson	1.602×10^{-19}

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How does the structure of the atom relate to its properties?

Chemical reactions involve either the transfer or the sharing of electrons between atoms. Therefore, the chemical reactivity/ properties of an element is primarily dependent upon the number of electrons in an atom of that element. Protons also play a significant role because the tendency for an atom to either lose, gain or share electrons is dependent upon the charge of the nucleus.

Therefore, we can say that the chemical reactivity of an atom is dependent upon the number of electrons and protons, and independent of the number of neutrons.

The mass and radioactive properties of an atom are dependent upon the number of protons and neutrons in the nucleus.

Symbolism

There is a symbolism or shorthand for describing atoms which is universally used across all scientific disciplines

Atomic Number (Z) = no of proton

Mass Number (A) = no of protons + no of neutrons

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Isotopes

Isotopes are atoms which have the same atomic number but different mass numbers. They have the same number of protons but different numbers of neutrons. The number of neutrons in a nucleus determines the isotope of that element. The fact that they have varying numbers of neutrons makes no difference whatsoever to the chemical reactions of the carbon.

Example 1: Hydrogen has three known isotopes: protium, deuterium and tritium. Protium, symbolized as 1H, is just ordinary hydrogen; it has one proton and one electron and no neutrons. Deuterium (D or 2H) has one proton, one electron and one neutron. Tritium (T or 3H) has one proton, one electron and two neutrons.

Example 2: There are three kinds of carbon atom 12C, 13C and 14C. They all have the same number of protons, but the number of neutrons varies.

protons	neutrons		mass number
carbon-12	6	6	12
carbon-13	6	7	13
carbon-14	6	8	14

Isobars

Isobar, in nuclear physics, any member of a group of atomic or nuclear species all of which have the same mass number that is, the same total number of protons and neutrons. Thus, chlorine-37 and argon-37 are isobars. Chlorine-37 has 17 protons and 20 neutrons in its nucleus, whereas argon-37 has a nucleus comprising 18 protons and 19 neutrons.

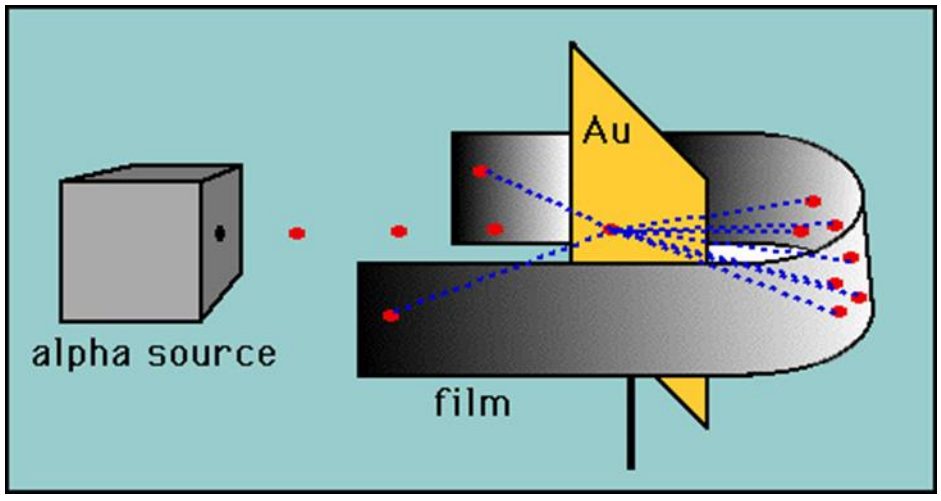
Isotone

Isotone, any of two or more species of atoms or nuclei that have the same number of neutrons.

Thus, chlorine-37 and potassium-39 are isotones, because the nucleus of this species of chlorine consists of 17 protons and 20 neutrons, whereas the nucleus of this species of potassium contains 19 protons and 20 neutrons.

Rutherford model:

Ernest Rutherford, a British scientist conducted an experiment and based on the observations of this experiment he proposed the atomic structure of elements and gave Rutherford's Model of Atoms. He conducted an experiment by bombarding a thin sheet of gold with α-particles and then studied the trajectory of these particles after their interaction with the gold foil.



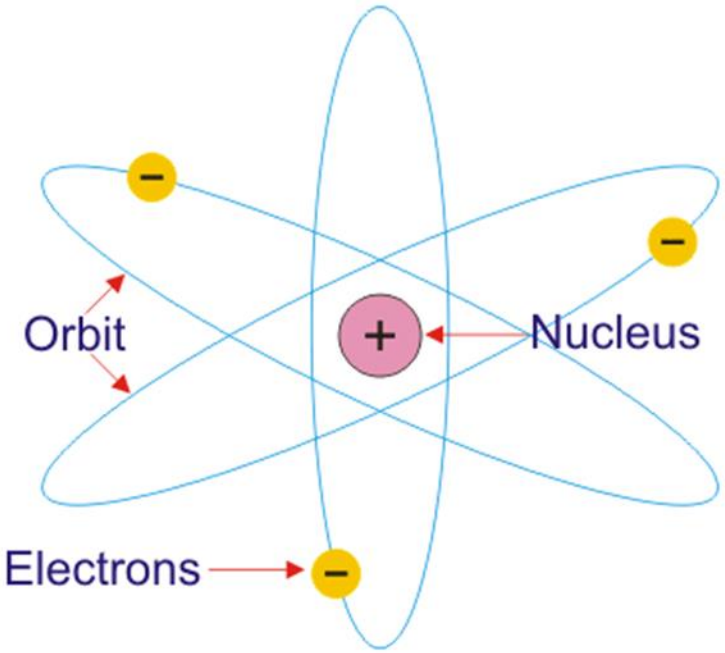
Rutherford, in his experiment, directed high energy streams of α-particles from a radioactive source at a thin sheet (100 nm thickness) of gold. In order to study the deflection caused to the α-particles, he placed a fluorescent zinc sulphide screen around the thin gold foil. Rutherford made certain observations that contradicted Thomson's atomic model. The observations made by

Rutherford led him to conclude that:

- A major fraction of the α-particles bombarded towards the gold sheet passed through it without any deflection, and hence most of the space in an atom is empty.
- Some of the α-particles were deflected by the gold sheet by very small angles, and hence the positive charge in an atom is not uniformly distributed. The positive charge in an atom is concentrated in a very small volume.
- Very few of the α-particles were deflected back, that is only a few α-particles had nearly 180o angle of deflection. So the volume occupied by the positively charged particles in an atom is very small as compared to the total volume of an atom.

Based on the above observations and conclusions, Rutherford proposed the atomic structure of elements. According to Rutherford's atomic model:

1. The positively charged particles and most of the mass of an atom were concentrated in an extremely small volume. He called this region of the atom as a nucleus.
2. Rutherford's model proposed that the negatively charged electrons surround the nucleus of an atom. He also claimed that the electrons surrounding the nucleus revolve around it with very high speed in circular paths. He named these circular paths as orbits.



Rutherford's Atomic Model

3. Electrons being negatively charged and nucleus being a densely concentrated mass of positively charged particles are held together by strong electrostatic force of attraction.

Limitation of Rutherford's atomic model:

- According to The Ernest Rutherford's atomic model, the electrons are not attached to the mass of atom. The electrons are either stationary in space or rotate in circular paths around the nucleus. But if the electrons are stationary they must be fallen to nucleus due to attraction force between electron and nucleus.
- On the other hand if the electrons are moving in a circular path, then according to electromagnetic theory, the accelerated charge of electron would have continuously lost its energy and would have down into the nucleus as shown in figure below Rutherford Atomic Model fails to explain why electrons are not fallen into positively charge nucleus.

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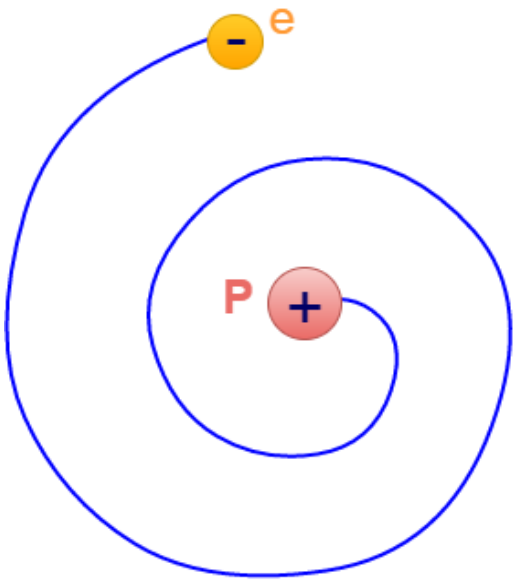

Thus, the deficiencies of Rutherford's Atomic model can be described as below-

1. The Rutherford's atomic model does not explain the distribution of electrons in the orbits.
2. The Rutherford's atomic model does not explain the stability of the atom as a whole.