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ATOMIC STRUCTURE MODEL AND REVIEW OF ATOMS : A STUDY

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ABSTRACT :

Data obtained from the Rutherford scattering experiment are used to present a simple picture of the structure of the atom. On the assumption that the particles which make up the nucleus (neucleons) are neutrons and protons, a "building-up" of the various atoms is explained and a system of nuclear nomenclature is developed. The model of an atom as a central nucleus of neutrons and protons surrounded by outer shells of electrons is found to fit in with the results of many physical and chemical experiments. In particular, the results of experimental spectroscopy yield quantitative agreement with certain calculations made on this atomic model. Bohr's theory of the hydrogen atom is developed in simple terms and the equation for energy level in the H-atom is derived. Excitation and ionization of atoms are described in terms of the Bohr model of the atom. The total electron density distribution of an isolated atom or an atom in a molecule does not reveal an atomic shell structure. Many localization functions, such as the radial averaged electron density, the Laplacian of the electron density, or the electron localization function have been proposed to visualize and analyze the shell structure of atoms. It was found that for light main group elements the correct number of shells is revealed by such functions. Later it was recognized that for heavy main group elements and for transition metals many of these diagnostic tools fail to reveal the full set of electronic shells as expected from the periodic table.

INTRODUCTION

Atomic theory and atomic structure is an essential student learning topic that is an example of fundamental conceptual understanding of science as a subject matter. If it is based on the historical development and contribution of philosophers and scientists (Leucippus, Democritus, Dalton, Thomson, Rutherford, Bohr, Schrödinger and Heisenberg) it can be used as a supporting approach for helping students to better understand the abstract nature around us (Justi & Gilbert, 2000; Niaz et al., 2002; Park & Light, 2009). A main aim of science educators all around the world should be to teach their students to gain knowledge based on the scientific ideas and content of the contemporary atomic structure theory .

A smallest unit of element which consists of a dense, central positively charged nucleus surrounded by negatively charged electrons is called as atom.

Atom is divided into two parts – Atomic structure and extra nucleus part. Atomic structure consists of positively charged proton (P^+) and neutral neutron (n°). Extra nucleus part contains negatively charged electrons(e^-).

Atoms have mass as all elements and compounds have mass. The mass of atom is

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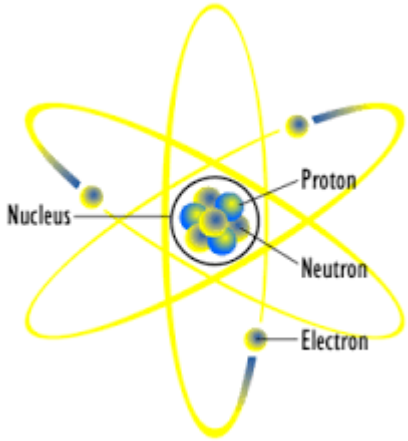
mainly concentrated in its nucleus because of protons. Protons has highest mass as compare to electrons and neutrons.

Hydrogen is the lightest of all elements and the nucleus of hydrogen atom contains one proton surrounded by one electron.

The nucleus of every atom contains fixed number of protons which attracts same number of electrons and an atom becomes electrically neutral. Ions can be formed either by adding or by removing electrons from the atom.



Atomic Mass

Protons and neutrons have approximately the same mass, about 1.67×10^{-24} grams. Scientists define this amount of mass as one atomic mass unit (amu) or one Dalton. Although similar in mass, protons are positively charged, while neutrons have no charge. Therefore, the number of neutrons in an atom contributes significantly to its mass, but not to its charge.

Electrons are much smaller in mass than protons, weighing only 9.11×10^{-28} grams, or about 1/1800 of an atomic mass unit. Therefore, they do not contribute much to an element's overall atomic mass. When considering atomic mass, it is customary to ignore the mass of any electrons and calculate the atom's mass based on the number of protons and neutrons alone.

Electrons contribute greatly to the atom's charge, as each electron has a negative charge equal to the positive charge of a proton. Scientists define these charges as "+1" and "-1." In an uncharged, neutral atom, the number of electrons orbiting the nucleus is equal to the number of protons inside the nucleus. In these atoms, the positive and negative charges cancel each other out, leading to an atom with no net charge.

Protons, Neutrons, and Electrons			
	Charge	**Mass (amu)**	**Location**
Proton	+1	1	nucleus
Neutron	0	1	nucleus
Electron	–1	0	orbitals

Volume of Atoms

Accounting for the sizes of protons, neutrons, and electrons, most of the volume of an atom—greater than 99 percent—is, in fact, empty space. Despite all this empty space, solid objects do not just pass through one another. The electrons that surround all atoms are negatively charged and cause atoms to repel one another, preventing atoms from occupying the same space. These intermolecular forces prevent you from falling through an object like your chair.

METHODOLOGY :

Dalton's atomic theory. Greek philosophers first introduced a primitive atomic theory in the 5th century BCE. After Renaissance,

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Scientists such as Boyle and Hooke picked up atomic theory or p-what again and used it to explain natural phenomena. Dalton first detailed his atomic theory in 1803. Two major differences between his theory and the previous ones are: 1) different elements are composed of different atoms, 2) different atoms have different weight. In the early 19th century, Dalton's theory was widely accepted by chemists, advancing the development of chemistry at the theoretical level.

Bohr's quantum atom. In 1913, Bohr proposed a new quantum atomic model, which was one of the most revolutionary theoretical models in the history of science. Bohr's quantum atom is similar to a microscopic solar system, with a series of electron orbitals circulating the positively charged nucleus in the center. Every orbital is characterized by a specific energy, with lower-energy orbitals closer to the nucleus and higher-energy orbitals further away from the nucleus. Bohr's model provided perfect explanation to the hydrogen atomic spectrum .

Atomic orbitals of quantum mechanics.

Although Bohr's quantum model successfully explained some properties of hydrogen atoms and other single electron ion such as He ion, it was very limited for multi-electron atoms. From 1920 to 1930, de Broglie, W. Heisenberg, I. Schrodinger, and other physicists established quantum mechanics, which became the fundamental theory for understanding the atomic and molecular world. In quantum mechanics, an atomic orbital is interpreted as the possibility of finding an electron around a nucleus, which can be calculated using the elegant Schrodinger equation. To make these abstract mathematical concepts more intuitive, chemists usually use graphics to represent atomic orbitals. For the orbitals above, the 3D surfaces are selected based on isosurfaces, inside which the possibility of electron occurrence is 90%. (Figure reference: the three-dimensional atomic orbit models by Dr. S. Immel from Darmstadt Applied Science and Technology University)

Rutherford Atomic Theory

Rutherford, a student of J. J. Thomson modified the atomic structure with the discovery of another **subatomic particle called "Nucleus"**. His atomic model is based on the Alpha ray scattering experiment.

Based on the above observations and conclusions, Rutherford proposed his own atomic structure which is as follows.

- The nucleus is at the center of an atom, where most of the charge and mass are concentrated.
- Atomic structure is spherical.
- Electrons revolve around the nucleus in a circular orbit, similar to the way planets orbit the sun.

Thomson Atomic Model

The English chemist Sir Joseph John Thomson put forth his model describing the atomic structure in the early 1900s.

He was later awarded the Nobel prize for the **discovery of "electrons"**. His work is based on an experiment called cathode ray experiment. The construction of working of the experiment is as follows:

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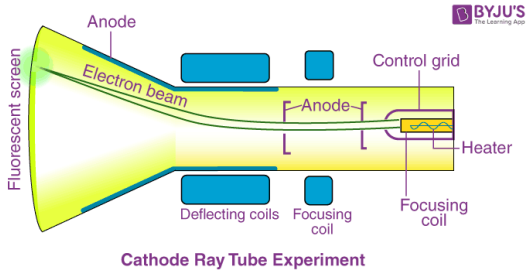
Cathode Ray Experiment

It has a tube made of glass which has two openings, one for the vacuum pump and the other for the inlet through which a gas is pumped in.



Cathode Ray Tube Experiment

The role of the vacuum pump is to maintain "partial vacuum" inside the glass chamber. A high voltage power supply is connected using electrodes i.e. cathode and Anode is fitted inside the glass tube.

Based on conclusions from his cathode ray experiment, Thomson described the atomic structure as a positively charged sphere into which negatively charged electrons were embedded. Thomson's atomic model does not clearly explain the stability of an atom. Also, further discoveries of other subatomic particles, couldn't be placed inside his atomic model.

CONCLUSION :

Atomic structure refers to the structure of atom comprising a **nucleus** (center) in which the **protons** (positively charged) and **neutrons** (neutral) are present. The negatively charged particles called electrons revolve around the **center** of the nucleus. Though the word *atom* originally denoted a particle that cannot be cut into smaller particles, in modern scientific usage the atom is composed of various subatomic particles. The constituent particles of an atom are the electron, the proton and the neutron. . Based on conclusions from his cathode ray experiment, Thomson described the atomic structure as a positively charged sphere into which negatively charged electrons were embedded.

It is commonly referred to as the **"**plum pudding model" because it can be visualized as a plum pudding dish where the pudding describes the positively charged atom and the plum pieces describe the electrons.

Thomson's atomic structure described atoms as electrically neutral, i.e. the positive and the negative charges were of equal magnitude.

- Since most rays passed through, Rutherford concluded that most of the space inside the atom is empty.
- Few rays got reflected because of the repulsion of its positive with some other positive charge inside the atom.
- 1/1000th of rays got strongly deflected because of a very strong positive charge in the center of the atom. He called this strong positive charge as "nucleus".
- He said most of the charge and mass of the atom resides in the Nucleus

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