Republic of Iraq
Ministry of Higher Education & Scientific research
Al-Mustaqbal University
Science College
Biochemistry Department

Introduction in Chemistry

For

First Year Student/course 2

Lecture 3

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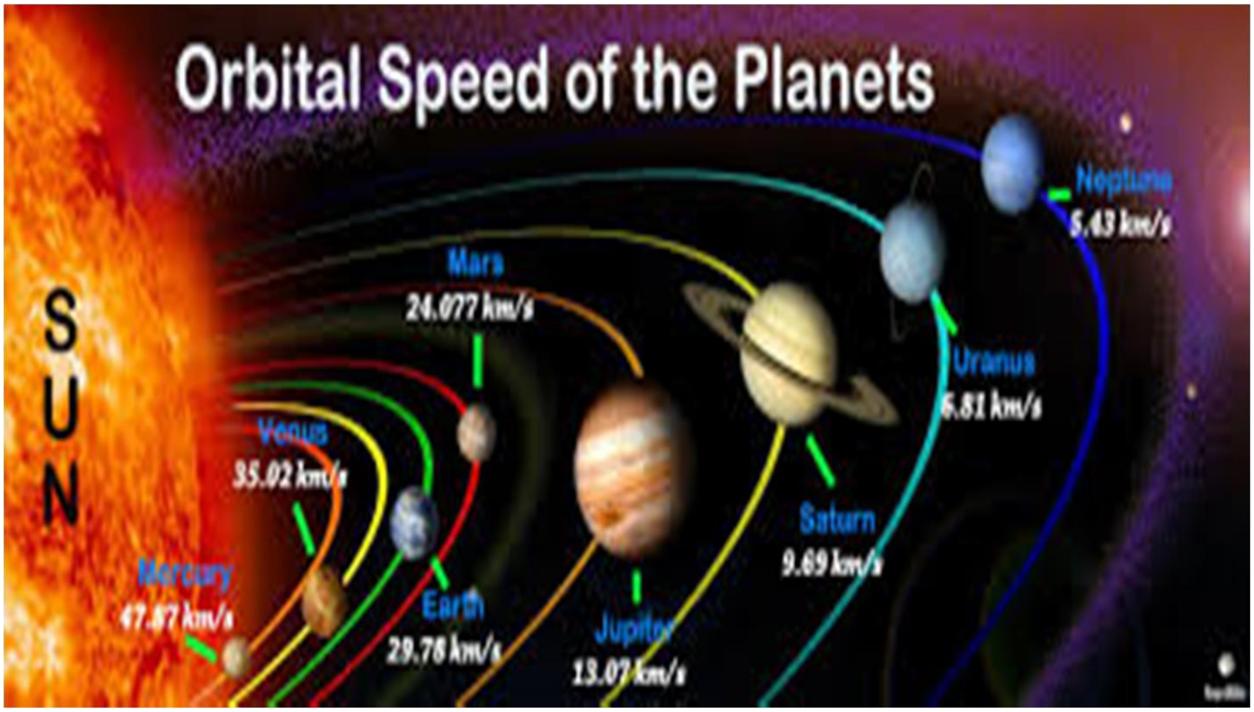
Bohr’s Atom (Bohr Model of the Atom)

The Bohr model is a planetary model that describes an atom consisting of a positively charged nucleus around which negatively charged electrons revolve, similar to planets orbiting the sun (except that the orbits are not planar).



Bohr's Atomic Theory

In 1913, the scientist Niels Bohr attempted to explain the behavior of atoms, particularly hydrogen, using a simple dynamic model of the atom and incorporating hypotheses from quantum theory, which was newly emerging at the time. As a result, Bohr developed a hybrid model that was philosophically unconvincing but, on the other hand, achieved remarkable success in explaining the hydrogen

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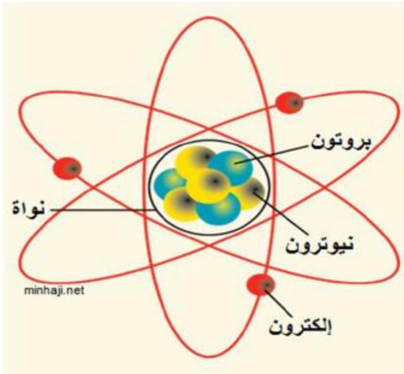
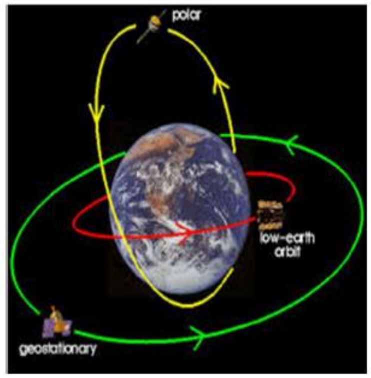
1. Electrons revolve around the nucleus in circular orbits.
2. Each of these orbits has a specific radius.
3. Each of these orbits has a specific energy.
4. Only orbits where the electron has an angular momentum are allowed. The product of the electron's momentum and the radius of its orbit (the circumference of the circle) is equal to a numerical value derived from Planck's constant. This can be written as: $mv \times 2\pi r = nh$
5. The atom either loses or gains energy in discrete quanta when the electron moves from one energy level to another.

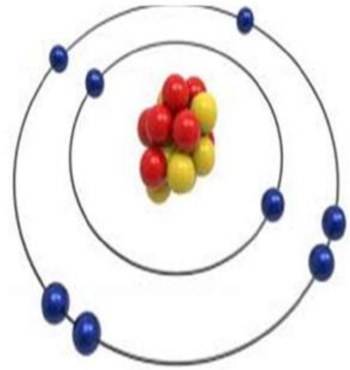
Bohr's theory failed in several aspects, particularly in explaining the behavior of atoms more complex than hydrogen. The main reasons for the failure of Bohr's theory include:

The First Difficulty: Explaining the Fine Structure of the Hydrogen Line Spectrum

One of the challenges of Bohr's theory was explaining the **fine structure** in the hydrogen line spectrum. Using modern precise instruments, it was found that some of the spectral lines are not singular, but rather consist of a group of closely spaced lines. This phenomenon was later explained by the scientist **Sommerfeld**, who proposed the idea of **elliptical (elliptic) orbits** in addition to the circular orbits for the electron.







Thus, we have the principal quantum number **n**, and each value of the secondary quantum number **l**. For example, if **l** takes values from 0 to **n-1**, and if **L= 1**, then for **n = 2**, the allowed values of **L** would be 0 and 1.

The Second Difficulty: Explaining the Splitting of Atomic Spectral Lines in a Magnetic Field (Zeeman Effect)

A second difficulty of Bohr's theory was its inability to explain the splitting of atomic spectral lines when placed in a magnetic field, known as the **Zeeman effect**. The solution to this phenomenon was to introduce a third quantum number called the **magnetic quantum number**, denoted by **m**, which defines the orientation of the electron's orbit relative to the external magnetic field.

The magnetic quantum number **m** takes integer values from **-l** to **+l**, where **l** is the orbital angular momentum quantum number. For example, if **l = 2**, the values of **m** would range from **m = -2** to **m = +2**, including the values: **m = -2, -1, 0, +1, +2**.

The Third Difficulty: The Presence of Double Lines in the Emission Spectrum of Alkali Elements (Lithium Group)

Another observation in the emission spectrum of alkali elements (such as lithium) is the presence of **double lines**. Scientists were able to explain this phenomenon by suggesting that, in addition to the electron's circular motion around the nucleus, the electron also undergoes **spinning** (or intrinsic angular momentum) around its own axis. This spin results in two types of motion within the magnetic field:

1. One spin direction aligns with the magnetic field (clockwise, **+1**).
2. The other spin direction opposes the magnetic field (counterclockwise, **-1**).

This led to the introduction of a **fourth quantum number**, called the **spin quantum number**, denoted by **s**, which describes the electron's spin.