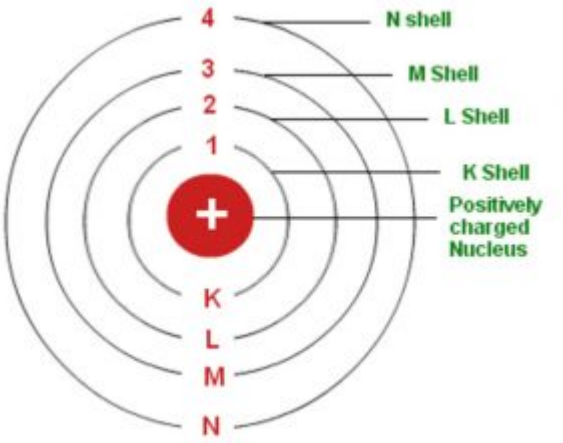
Bohr’s Model Of An Atom

Introduction

The general features of the structure of a hydrogen atom and its spectrum were quantitatively first explained by a Danish physicist Neil's Bohr in the year 1913. So it is known as Bohr’s Model of An Atom in general. He used Plank’s concept of quantization of energy in his model. He came to this model after applying some modifications to Rutherford’s model of an atom.

Postulates of Bohr’s Model Of An Atom



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According to Bohr’s model, an atom consists of a positively charged nucleus surrounded by negatively charged electrons. And on that basis, he explained a hydrogen atom structure with the following postulates,

1. In an atom, the negatively charged electron revolves around the positively charged nucleus in a circular path of fixed radius and energy. These paths are called orbits or stationary states or allowed energy states.
2. The orbits are arranged around the nucleus in a concentrated manner and numbered with positive integers (n=1, 2, 3, …) from the center to outwards. These numbers are called Principle Quantum Numbers. The first stationary state (n=1) is called the Bohr Orbit.
3. An electron circulating in an orbit holds a specific amount of energy in that particular orbit. The amount of energy an electron can hold in a particular orbit is called a shell, which is denoted by alphabetic characters (K, L, M, …) starting from the center to outwards. Thus, the alphabet K represents the lowest energy level, which is the first orbit (n=1).

4. The energy of an electron does not change with time. But if an electron absorbs a certain amount of energy, it shifts up from its current energy level to a higher energy level. Similarly, if an electron releases a certain amount of energy, it shifts down from its current energy level to a lower energy level.
5. The frequency *(v)* of the radiation absorbed or released by an electron when it shifts between a higher and a lower energy levels, is denoted as E_2 and E_1 respectively. It is given by the following equation that is known as Bohr's Frequency Rule.

$$v = \frac{\Delta E}{h} = \frac{E_2 - E_1}{h}$$

6. The angular momentum of an electron is quantized and is expressed in a given stationary state as,

$$m_e vr = n\frac{h}{2\pi}; (n = 1, 2, 3, ...)$$

where m_e is the mass of the electron, v is its velocity, and r is the radius of the orbit (n).

Limitations of Bohr's Model of an Atom

One of the major limitations of Bohr's model was that it could only account for the stability and line spectra of hydrogen and hydrogen-like atoms that contain only one electron in their orbit. For example, H^+, Li^{2+}, Be^{3+}, and so on. Moreover, Bohr's model couldn't account for the following points.

1. Bohr's model fails to account for the finer details of the hydrogen atom spectrum which can be observed using spectroscopic methods.
2. It is unable to explain the spectrum of atoms other than hydrogen, for example, the helium atom.
3. Bohr's theory couldn't explain the splitting of spectral lines in the presence of a magnetic field (Zeeman effect) or an electric field (Stark effect).
4. It also couldn't account for the 3-dimensional model of an atom, the shape of molecules, and the spectra obtained from larger atoms.
5. It could not explain the atoms' ability to form molecules by chemical bonds.

Reasons for the Failure of the Bohr's Model

In addition to the limitations explained above, the following reasons led to the failure of Bohr's model of an atom.

1. The wave character of electrons or the dual nature of matter was not considered in Bohr's model.

2. The exact position and velocity of an electron can't be determined at the same time, as per Heisenberg's Uncertainty Principle. This statement contradicts Bohr's theory of an orbit of a fixed radius for an electron.

Frequently Asked Questions

1. How does an electron move as per Bohr's model of an atom?

As per Bohr's model of an atom, a negatively charged electron moves around the positively charged nucleus in a circular path of a fixed radius called orbits.

2. How was Bohr's model of an atom useful?

Bohr was the first to discover that electrons revolve around the nucleus in an atom, and an element's properties can be determined by the number of electrons moving in the outer orbit.

3. What does Bohr's model of an atom say about protons, neutrons, and electrons?

As per Bohr's model of an atom, the nucleus holds most of an atom's mass and contains neutrons and positively charged protons. While, electrons hold a very little mass and a negative charge equivalent to the positive charge of the nucleus.

4. How did Sommerfeld modify Bohr's model of an atom?

Sommerfeld suggested that the electrons move around the nucleus in elliptical orbits and not in circular orbits as said by Bohr in his atomic model.