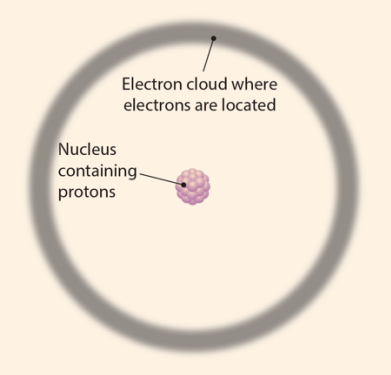
Chapter 6: Atomic theory

Many models of the atom have been put forward by scientists over the centuries. You must be able to describe and compare three atomic models, and give their assumptions and limitations.

1. The nuclear model



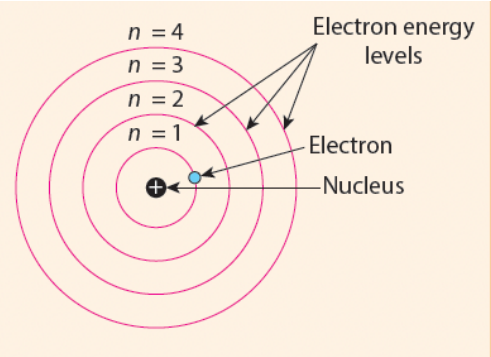
Assumptions

- The nucleus contains most of the atom's mass
- Electrons orbit around the nucleus in a relatively empty space

Limitations

- Lacks detail about electron behaviour and doesn't clearly explain electron arrangement

2. The Bohr model – The planetary model of the atom



Assumptions

- Bohr proposed that **electrons in an atom have a specific, fixed amount of energy** (a quantum of energy), and so can move around the nucleus only in **certain specific orbits** with a fixed radius, depending on the fixed amount of energy they have.
- Bohr's theory states that electrons are found in **energy levels**. Electrons in the first energy level – the closest to the nucleus – have the same amount of energy as each other, and that amount of energy is less than the energy of electrons in the second energy level (further from the nucleus). Bohr represented energy levels using the letter n: n=1 for the first, n=2 for the second.

An energy level is the fixed amount of energy of an electron in an atom.

However, although Bohr's model of the atom worked well for hydrogen, **it didn't work so well for atoms containing more than one electron** (multi-electron atoms). This was due to some limitations of his theory.

Limitations

- Bohr's theory didn't take into account wave-particle duality
- We now know that electrons don't travel in fixed orbits, but rather are found in orbitals (due to Heisenberg's uncertainty principle we can only refer to the probability of finding an electron)
- Bohr's theory didn't account for sublevels

3. The orbital model

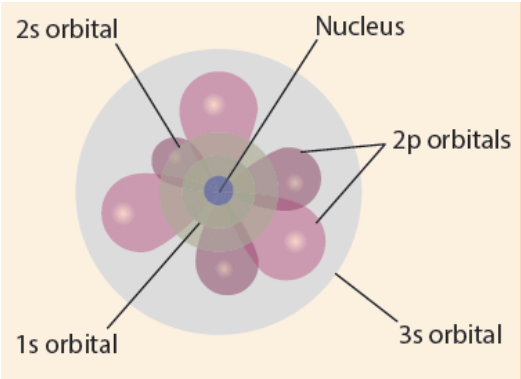
The orbital model shows electrons in 3-D orbitals (rather than Bohr's 2-D orbits).

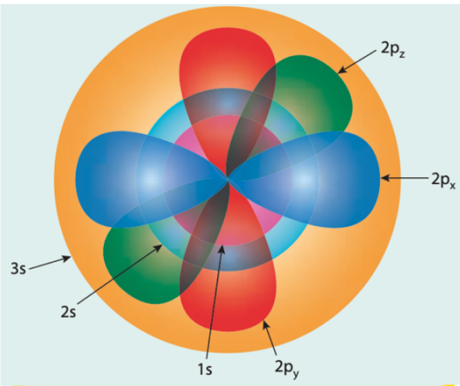
An orbital is a region of space around the nucleus of an atom within which there is a high probability of finding an electron.

S orbitals are spherical, with the nucleus at their centre. Each energy level has an s orbital – e.g. 1s, 2s – and the size of the orbital is dependent on the energy level to which it belongs.

P orbitals are dumb-bell shaped, arranged around the central nucleus. There are three kinds of p orbitals – p_x, p_y and p_z.

When s and p orbitals are mapped together, along with d and f orbitals, the orbital model of the atom is shown. These orbitals surround the nucleus, which is tiny but very dense, and is home to both protons and neutrons.





The orbital model of the atom is actually much less specific than some of the previous models proposed – we can't state exactly both the position and speed of electrons, and we cannot even state the exact size of an atom.

Assumptions

- Electrons are found in orbitals – regions of space where there is a high probability of finding an electron.
- Electrons have wave-particle duality.

Limitations

- We can predict only the likelihood of where electrons are – we do not know their exact positions.