CHM 101

ELECTRONIC THEORY OF ATOMS AND ELECTRONIC CONFIGURATION

BY

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Properties of Atoms and the Periodic Table

Structure of the Atom Elements are abbreviated in scientific shorthand.

- Symbols on the periodic table are short or abbreviated ways to write the name of an element.
- All symbols consist of one capital letter or a capital letter and 1 or 2 lower case letters.
- Some symbols are from the element's name (H, He, B, Be, I, F, Br, etc).
- Sometimes the symbol is from the old Greek or Latin name (silver is Ag for Argentum).
- Some elements are named after some scientists. (Es for Einsteinium, Lr for Lawrencium)

Atom—smallest piece of matter that still has the properties of the element.

- Atoms are made up of subatomic particles—protons, neutrons and electrons.

  Protons and neutrons are in the nucleus of an atom.

  Electrons occupy orbitals or electron clouds that surround the nucleus.

- Protons are found in the nucleus of atoms and have an electric charge of +1.
- Neutrons are found in the nucleus of atoms and do not have an electric charge. They are electrically neutral.
- Electrons are located in electron clouds, called orbitals, and have an electric charge of -1.
- The number of protons in the nucleus of an atom is its atomic number o It identifies which element you have.

The number of neutrons plus protons in an atom is its mass number.

- In an atom, the number of protons equals the number of electrons.

Atoms that have lost or gained electrons are called ions.

• The atomic weight or atomic mass is the average of the mass numbers of all of the isotopes of an element.

• Isotopes are atoms of the same elements that have different numbers of neutrons. Each isotope of an element has a different mass number.

• Electrons can spin in any direction; scientists cannot tell exactly where an electron is at a given moment or where it is going.

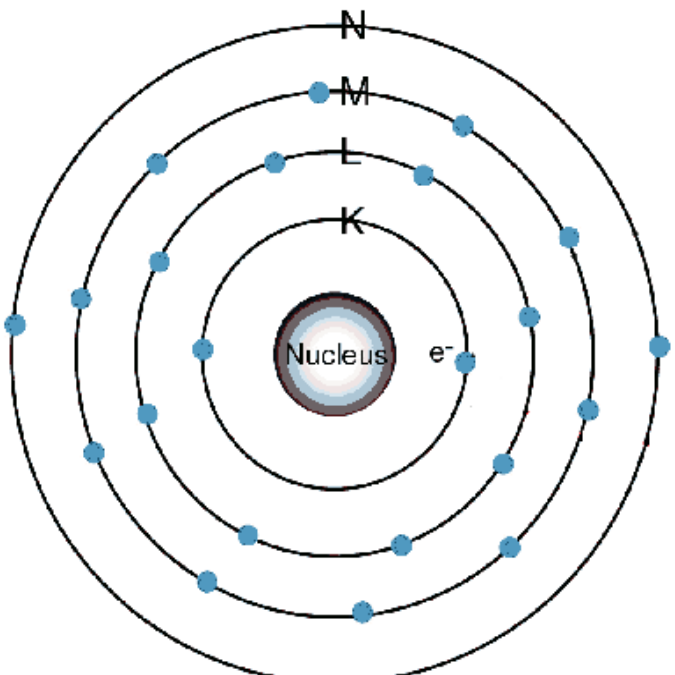
They calculate the probability that an electron will be found in a given space.

These calculations determine the location and shape of the electron clouds (orbitals) where the electrons reside

The distance from the nucleus and the electron spins is called energy shell, energy level, or orbital.

Each energy level can only hold a certain number of electrons

- i The first shell (K level) can hold 2 electrons
- ii. The second shell (L level) can hold 8 electrons
- iii. The third level (M level) can hold 18 electrons
- iv. The fourth level (N level) can hold 32 electrons
- v. The fifth level (O level) can hold 50 electrons
- vi. The sixth level (P level) can hold 72 electrons o Each energy level is completely filled before electrons fill the next level.
- The number of electrons in the outermost level are called valence electrons.
- $2[n]^2$


N
M
L
K
Nucleus
e⁻

Protons and neutrons are made up of smaller particles called quarks.

- Six different quarks have been discovered so far.
- Each proton and neutron is composed of 3 quarks.
- To find quarks, scientists smash charged particles into protons using electric and magnetic fields

Models—used by scientists to represent things that are difficult to visualize.

- **Scaled-up models** help you visualize things too small to see.
- **Scaled-down models** help you see something too large to see all at once.

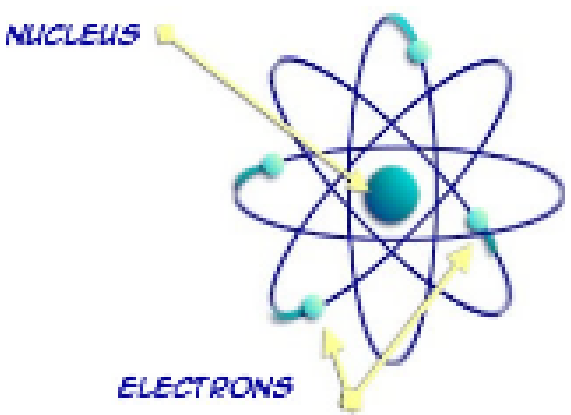
Scientists use scaled-up models to represent atoms.

Our models have changed as our understanding of atomic structure has grown.

- Democritus and John Dalton thought that an atom was a sphere of matter that was the same throughout. (The “uncuttable” atom)
- J.J. Thomson discovered that all atoms contain electrons, which are tiny, negatively charged particles. Thomson proposed that an atom is a sphere of positive charge with the electrons mixed uniformly in the sphere. Electron was first referred to as Corpuscles.(The “plum pudding” model). He used cathode ray tube technology in his discovery.

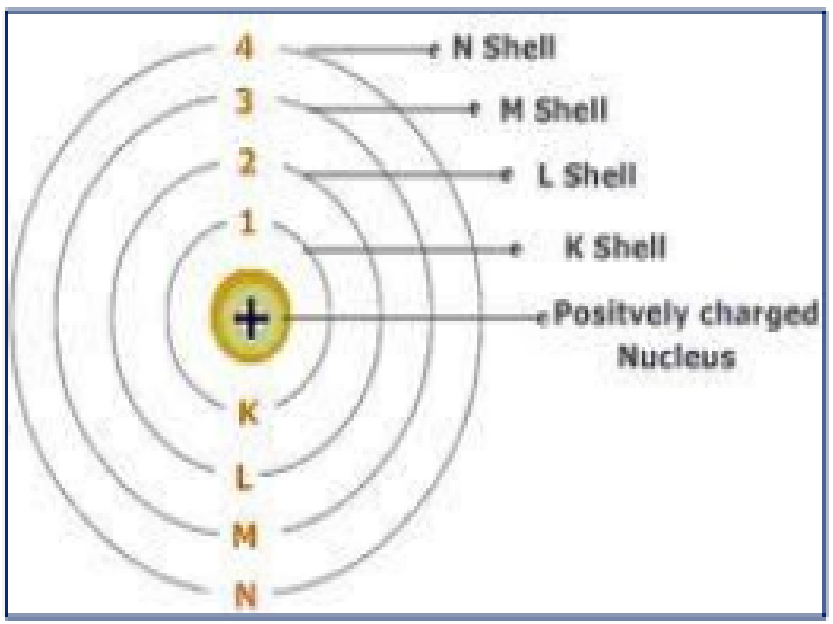
Rutherford updated the model of the atom. He hypothesized that almost all the mass and all the positive charge of an atom is concentrated in an extremely tiny nucleus at the center of the atom with the electrons occupying mostly empty space around the nucleus. He carried out his experiment using gold foil.

- Bohr described the atom as a planetary arrangement: electrons orbiting the nucleus.



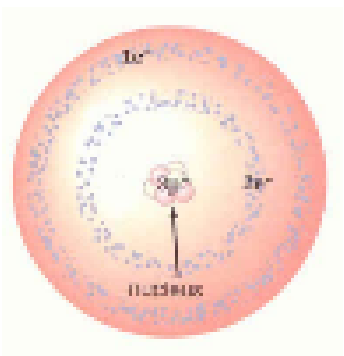
←Bohr Model

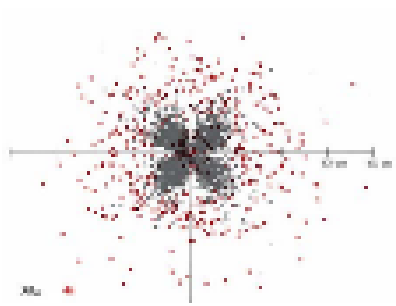
Bohr model


4
3
2
1
K
L
M
N
N Shell
M Shell
L Shell
K Shell
Positvely charged
Nucleus

The current electron cloud model shows electrons traveling in specific energy levels around a nucleus of protons and neutrons.

- These “clouds” or orbitals have different shapes





← e- Cloud Model

Erwin Schrödinger

Erwin Schrödinger used Heisenberg's uncertainty principle to come up with the atomic model that we still use today.

SCHRÖDINGER'S ATOMIC MODEL (THE CLOUD MODEL)

- An electron does not travel in an exact orbit
- We can predict where it will probably be
- We cannot say for certain where it is, but only where it ought to be.
- The type of probability orbit is dependent on the energy level described by Bohr

Masses of Atoms

Atomic mass—composed mostly of the protons and neutrons in the nucleus.

- The unit of measurement for atomic particles is atomic mass unit (amu).
- Protons and neutrons have a mass equal to 1 amu.
- Electrons are 1/2000th the size of a proton or neutron. (This means that electrons are 2000 times smaller than protons or neutrons so an atom would need 2000 electrons to increase in mass by 1 amu.)
- Atomic number—the number of protons in an atom; number of protons also identifies the element. The sum of the number of protons and neutrons in the nucleus of an atom is the mass number. (The electrons are too small to count).

Isotopes— are atoms of the same element with different numbers of neutrons.

• Isotopes of the same element have similar chemical properties because they have the same atomic number and arrangement of valence electrons.

• The number of neutrons is equal to the mass number minus the atomic number.

• The name of the element followed by the mass number identifies the isotope.

Examples: Oxygen-18, Oxygen-16

Examples: Oxygen-18, Oxygen-16

These can also be written ^{18}O; ^{16}O

Average atomic mass is the weighted-average mass of an element's isotopes.
• Average atomic mass is closest to its most abundant isotope. Thus, you should be able to determine the most abundant isotope of an element by rounding the average atomic mass found on the periodic table to the nearest whole number.

Sample Problem (Calculating Average Atomic Mass): 80% of boron atoms are boron-11 while 20% are boron-10. Calculate the weighted atomic mass of boron atoms. Mass of boron-11 = 11 amu

Mass of boron-10 = 10 amu

To calculate the average atomic mass, convert the percentage to a decimal and calculate the weighted average: (0.80) 11 + (0.20) 10 = 0.88 + 0.20 = 10.8 amu (Notice that the weighted average is 10.8 amu which is very close to 11 amu. This indicates that boron-11 is the most abundant isotope.

Examples

E.g.2; A sample of copper contains 70% of copper-63 and 30% of copper-65 atoms. Calculate the relative atomic mass of the sample of copper.

$$\frac{(63 \times 70) + (65 \times 30)}{70 + 30} \qquad \frac{4410 + 1950}{100} = \quad 63.6$$

SUMMARY OF ATOM

The smallest part of an element is called an atom,

Each atom (of an element) is different in structure from other atoms (of other elements),

An atom can be divided in smaller subatomic particles: Protons, Electrons and Neutrons,

The nucleus is the centre of an atom. It contains protons and neutrons. Electrons orbit the nucleus.

As we go up the periodic table, electrons and protons are added.

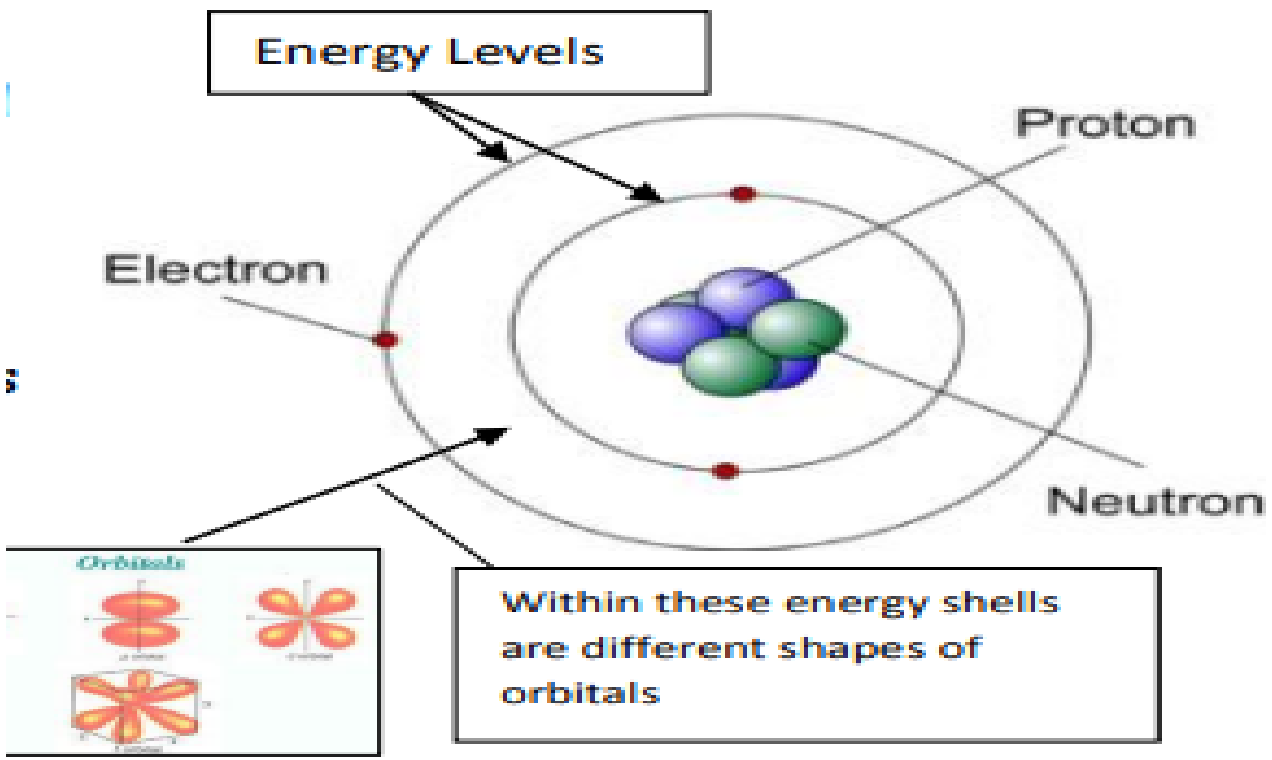
Electrons occupy a certain energy level (of a certain size)

Once the energy level is full, a new level begins

Within each of these levels are specials types of orbitals.

Depending on the energy level, Each orbital can contain two electrons

ATOMIC STRUCTURE



Electron configuration

This is arrangement of electrons distributed among the orbitals, shells and subshells.

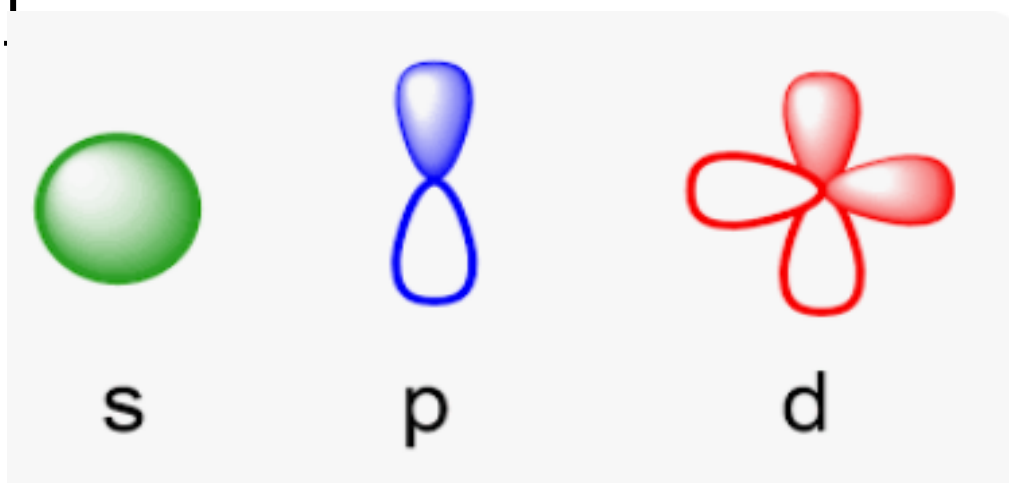
In writing electronic configuration, three rules/principles are followed namely;

- **Aufbau principle** ;- Electrons always go into orbitals with lowest possible energy that is orbitals are filled with electrons in their order of increasing energy. This is also known as building up principle.
- **Hund's rule** ;- Electrons enter into the degenerate orbitals singly to the maximum extent possible before pairing.
- **Pauli exclusion principle** ;- Only electron with opposite spin can occupy the same orbital.

Shapes of orbitals

- S – orbitals ;- spherically symmetrical
- P – orbitals ;- dumb-bell
- D – orbitals ;- double dumb-bell with directional characteristics

$2[2L + 1]$



Example of electronic configuration of some elements

Element	Electron Configuration	Element	Electron Configuration
H	$1s^1$	Na	$1s^2 2s^2 2p^6 3s^1$
He	$1s^2$	Mg	$1s^2 2s^2 2p^6 3s^2$
Li	$1s^2 2s^1$	Al	$1s^2 2s^2 2p^6 3s^2 3p^1$
Be	$1s^2 2s^2$	Si	$1s^2 2s^2 2p^6 3s^2 3p^2$
B	$1s^2 2s^2 2p^1$	P	$1s^2 2s^2 2p^6 3s^2 3p^3$
C	$1s^2 2s^2 2p^2$	S	$1s^2 2s^2 2p^6 3s^2 3p^4$
N	$1s^2 2s^2 2p^3$	Cl	$1s^2 2s^2 2p^6 3s^2 3p^5$
O	$1s^2 2s^2 2p^4$	Ar	$1s^2 2s^2 2p^6 3s^2 3p^6$
F	$1s^2 2s^2 2p^5$	K	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
Ne	$1s^2 2s^2 2p^6$	Ca	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

Thank

you

for

listening