ALMUSTAQBAL UNIVERSITY

College of Engineering and Engineering Techniques

Biomedical Engineering Department

Stage : Second year students

Subject : Chemistry 1 - Lecture 1

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General Chemistry - Introduction

Chemistry

Chemistry is the study of matter, its chemical and physical properties, the chemical and physical changes it undergoes, and the energy changes that accompany those processes.

Branches of Chemistry:

Chemistry includes many different branches of study and research.

1. Organic chemistry:

Involves the study of the structure, properties, and preparation of chemical compounds of diverse substances such as plastics, drugs, solvents, industrial chemicals that **consist primarily of carbon and hydrogen.**

2. Inorganic chemistry:

The study of non-organic substances. It is concered with the study of the properties and behavior of inorganic compounds. It covers all chemical compounds except organic compounds.

3. Physical chemistry:

The study of the properties and changes of matter and their relation to energy. It deals with the study of the effect of chemical structure on the physical properties of a substance, the rate of a chemical reaction, the interaction of molecules with radiation.

4. Analytical chemistry:

The identification of the components and composition of materials . Involves the analysis by Qualitative and Quantitative methods to determine its composition and the quantity of its components through volumetric, gravimetric or instrumental methods.

5. Biochemistry:

The study of substances and processes occurring in living things. It is related to the study of chemical reactions that take place in animals, plants and micro organisms and tries to explain them in chemical terms.

6. Theoretical (Computational) chemistry:

The use of mathematics and computers to understand the principles behind observed chemical behavior and to design and predict the properties of new compounds

In all areas of chemistry, chemicals are used.

A chemical is any substance that has a definite composition and properties.

Knowing the properties of chemicals allows chemists to find suitable uses for them.

Basic Building Blocks of Matter

Materials → Molecules → Atoms

The fundamental building blocks of matter are atoms and molecules. These particles make up elements and compounds.

An atom is the smallest unit of an element that maintains the chemical identity of that element.

An element is a pure substance that cannot be broken down into simpler, stable substances and is made of one type of atom e.g : Carbon is an element contains one kind of atom

A compound is a substance that can be broken down into simple stable substances. Each compound is made from the atoms of two or more elements that are chemically bonded and the properties of the compound are different from its component elements .Water is an example of a compound. It is made of two elements, hydrogen and oxygen. The atoms of hydrogen and oxygen are chemically bonded to form a water molecule. (NH_3 , CO_2 , CH_4 , NaCl , NH_4Cl and other are also examples)

Molecule is the smallest unit of compound that retains all of the properties of that compound.

A mixture consists of two or more substances mixed together, not chemically combined. The components retain their individual properties, can be present in any proportion, and can be separated by physical changes.

All matters exists either as elements, compounds, or mixtures.

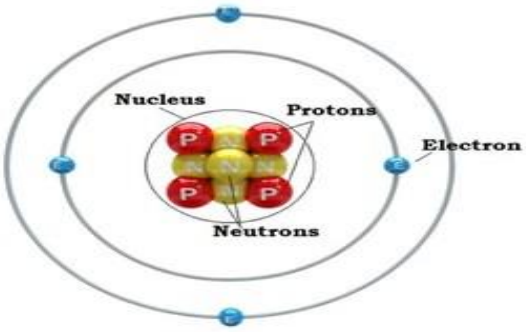
An atom is the smallest and simplest particle of an element. It is the basic structure from which all matter is composed.

Atoms are composed of tiny **subatomic particles** called ***protons, neutrons , and electrons.***

An atom is an electrically neutral, spherical entity composed of a positively charged central nucleus surrounded by one or more negatively charged electrons

An **atom** is composed of two regions:
- The nucleus, which is in the center of the atom and contains protons and neutrons, and
- The outer region of the atom, which holds its electrons in orbits around the nucleus.

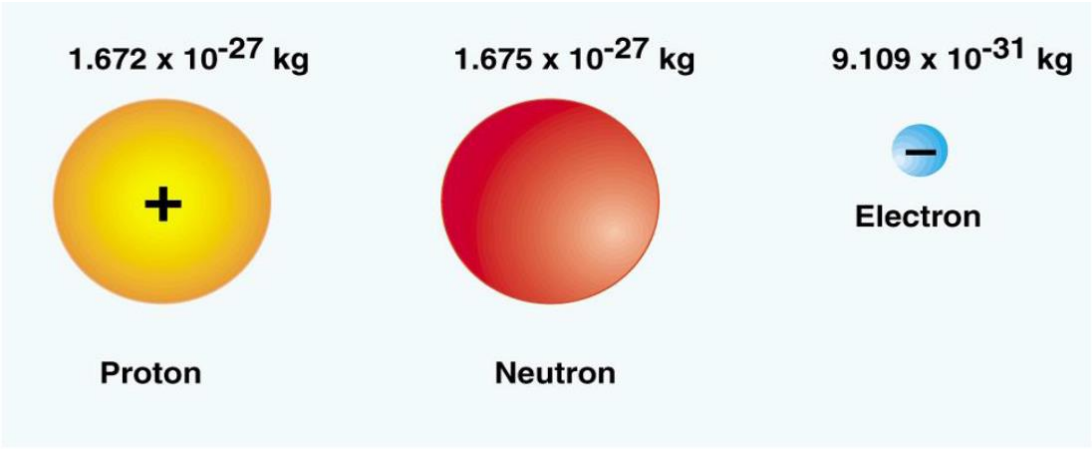
* A **proton** is a positively charged particle in an atom
* An **electron** is a negatively charged particle in an atom
* A **neutron** is a neutral (neither negative nor positive) particle in an atom



- Atoms = protons (p) + neutrons (n) + electrons (e)

	Mass (kg)	Charge (coulomb)
Proton	1.673×10^{-27}	$+1.602 \times 10^{-19}$
Neutron	1.675×10^{-27}	0
Electron	9.109×10^{-31}	-1.602×10^{-19}

- Fundamental charge = 1.602×10^{-19} C (Coulomb)



Model of Proton, Neutron and Electron

The proton and neutron have roughly the same mass and have approximately 1837 times the mass of the electron. The proton and electron have equal, but opposite, electrical charges. A neutron does not have an electrical charge (with a zero charge).

Atomic Number, Mass Number, and Atomic Symbol

Atoms of different elements differ from one another, according to how many protons they contain, the number of protons in the nucleus of each of its atoms Is called the **atomic number** (***Z***).

Thus, if we know the number of protons in an atom, we can identify the element. Any atom with 6 protons, for example, is a carbon atom because carbon has Z = 6. All carbon atoms (Z = 6) have 6 protons, all oxygen atoms (Z = 8) have 8 protons, and all uranium atoms (Z =92) have 92 protons.

Atoms are neutral overall and have no net charge because the number of positively charged protons in an atom is the same as the number of negatively charged electrons . Thus, the atomic number also equals the number of electrons in every neutral atom of a given element .

Atomic Number (Z) = No. of protons = No. of electrons

The **Atomic Number (Z)** is the number of protons in an atom

The Mass Number (A) is the total number of protons and neutrons in atom

Thus, a carbon atom with 6 protons and 6 neutrons in its nucleus has a mass number of 12, and a uranium atom with 92 protons and 146 neutrons in its nucleus has a mass number of 238.

Mass number (A) = atomic number (Z) + No. of neutrons(N)

Mass number (A) ≈ Z + N

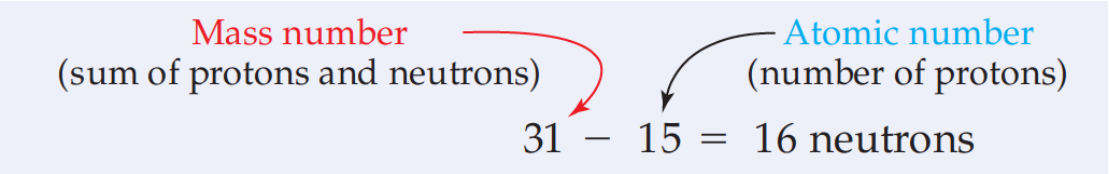
element	Atomic number(Z)	No. of protons	No. of electrons	No. of neutrons	Mass Number(A)
H	1	1	1	0	1
C	6	6	6	6	12
Na	11	11	11	12	23
F	9	9	9	10	19
Cl	17	17	17	18	35

Example:
Phosphorus has atomic number (Z= 15) How many protons, electrons, and neutrons are there in phosphorus atoms, which have mass number (A= 31).

ANSWER

Atomic Number (Z) = 15 = No. of protons = No. of electrons

Mass number (A) = 31= No. of protons (Z) + No. of neutrons(N)



Excercise :
The Nickel element has an atom with atomic number (Z = 28) and has Mass Number of (A= 60) Give the number of electrons and neutrons in the atom.

Excercise:
The cobalt used in cancer treatments has atomic number (Z= 27) and mass Number (A = 60) . How many protons, neutrons, and electrons are in these cobalt atoms?

In an atom, the protons and neutrons gather in the center position that called the **Nucleus**. Because the protons are positively charged, the nucleus has a positive electric charge.
The electrons of the atom move rapidly around the nucleus.

The electrons are much more likely be located in certain regions of space surrounding the nucleus than in other regions of space.
Assuming that the electron is rapidly moving around the nucleus .
The probability of finding the electron in any region of space can then be described by a cloud .The density of the cloud at any point is the probability of finding the electron at that point.
The electrostatic attractive force between the positively-charged protons in the nucleus and the negatively-charged electrons around the nucleus holds the atom together.

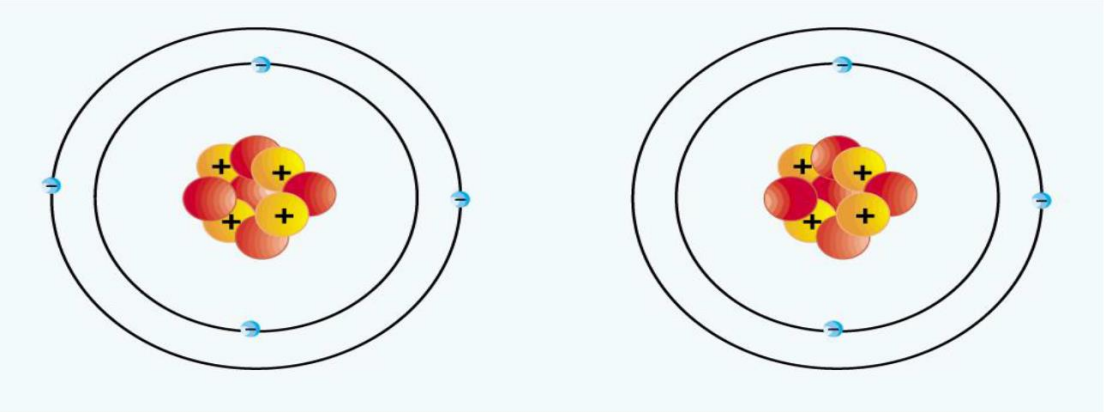
IONS:

Atoms containing the same number of protons and electrons have no net charge (**Neutral atoms**).

Atoms that have extra or missing electrons have a net electrical charge and are called **ions.**

Ions can interact with other of opposite charge by electrical attraction.

e.g: $Na^+ \leftrightarrow Cl^- \rightarrow$ Na-Cl



Beryllium atom (Be)
4 protons , 4 electrons

Beryllium ion (Be^+)
4 protons , 3 electrons

Diagram Comparing a Beryllium atom (Be) and a Positively-Charged Beryllium Ion(Be^+)

Atoms interact with others by sharing or transferring electrons that are farthest from the nucleus. These electrons are called **valence electrons** .

***The Valence electrons determine the chemical properties of the element .**

Value of atomic number (Z) is constant for each element and differ from other elements .

e.g : H (Z = 1) , O (Z = 8) , Fe (Z = 26) , Ag (Z= 47)

*** The Number of protons describe the identity of the element**

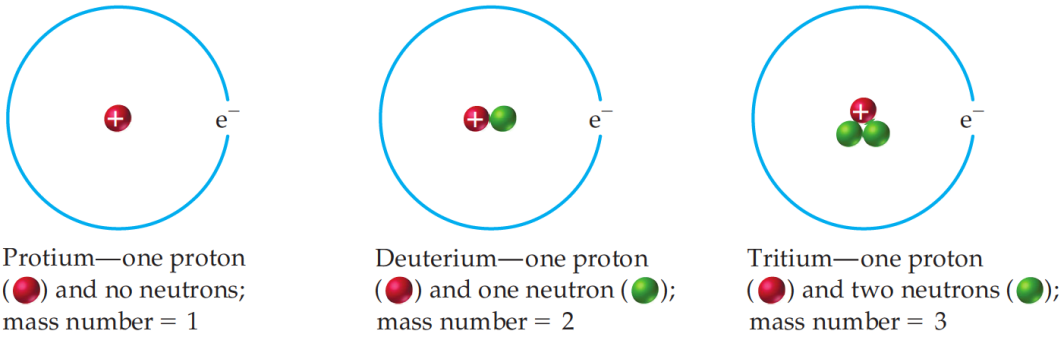
Excercise :

The Calicum ion (Ca^{2+}) has an atom with atomic number (Z = 20) and has Mass Number of (A= 40) Give the number of protons ,electrons and neutrons in the ion.

ISOTOPES

When an element has atoms that differ in the number of neutrons in the nuclei, these atoms are called different isotopes of the element. ***All isotopes of one element have identical chemical properties*.** This means that :

1. It is difficult to separate isotopes from each other by chemical processes.
2. The physical properties of the isotopes, such as their masses, boiling points, and freezing points, are different.
3. Isotopes can be most easily separated from each other using physical processes.

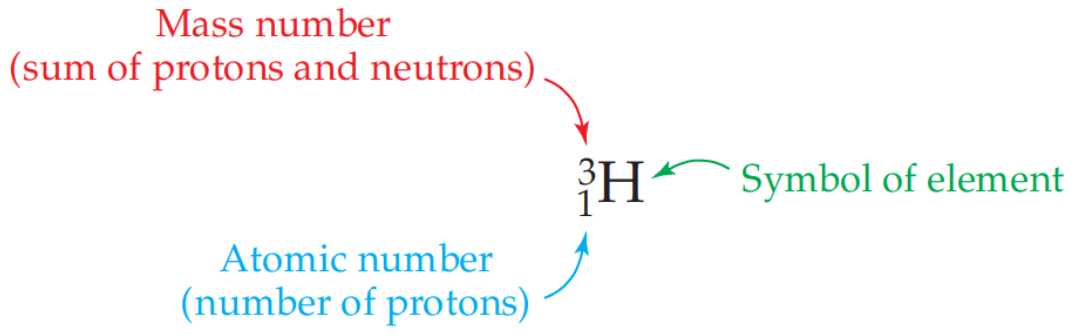


Protium—one proton (●) and no neutrons; mass number = 1

Deuterium—one proton (●) and one neutron (●); mass number = 2

Tritium—one proton (●) and two neutrons (●); mass number = 3

Tritium is represented by the following symbol and other elements are represented in the same manner



Since different isotopes of an element contain different numbers of neutrons in the nuclei of their atoms, isotopes of the same element will have different mass numbers. This was shown above for the three isotopes of hydrogen.

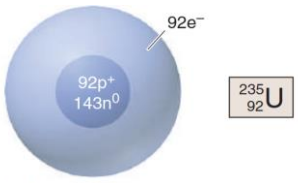
Isotopes are :

1. Atoms of the same element with the same number of protons
2. Have different number of neutrons.
3. Have the same number of electrons and the same chemical behavior.

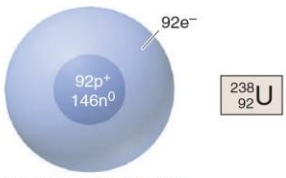
Hydrogen isotopes :

"protium" H^1 ; "deuterium" H^2 or D and "tritium" H^3 or T

Uranium isotopes



An atom of uranium-235



An atom of uranium-238

$_{92}U^{235}$ contains 92 protons +143 neutrons

$_{92}U^{238}$ contains 92 protons + 146 neutrons

There are two methods for specifying isotopes. In the first method, the mass number is written with a hyphen after the name of the element. The uranium isotope used as fuel for nuclear power plants has a mass number of 235 and is therefore known as (Uranium – 235) .

The second method is written as $_{92}U^{235}$. The 235 superscript indicates the mass number and the 92 subscript indicates the atomic number.

The number of neutrons is found by subtracting the atomic number from the mass number.

mass number - atomic number = number of neutrons

235 (protons + neutrons) - 92 protons = 143 neutrons

Thus, a uranium-235 nucleus is made up of 92 protons and 143 neutrons.