

ALMUSTAQBAL UNIVERSITY

College of Health and Medical Techniques Medical Laboratory Techniques Department

Stage : First year students

Subject : General Chemistry 1 - Lecture 1

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Chemistry

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

Major Areas of Chemistry

1. ORGANIC CHEMISTRY

Studies 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**.(e.g: CH_4 , $\text{C}_2\text{H}_5\text{OH}$, $(\text{NH}_2)_2\text{C}=\text{O}$)

2. Inorganic chemistry

Studies the properties and behavior of inorganic compounds(e.g: NaCl , HNO_3 , H_2O_2). It covers all chemical compounds other than organic compounds. It studies minerals, metals, and most elements of the Periodic Table.

3. PHYSICAL CHEMISTRY

Studies 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, and the calculation of structures and properties.

4. BIOCHEMISTRY

Is related to the study of chemical reactions that take place in living beings (animals, plants and micro organisms). It tries to explain them in chemical terms.

5. ANALYTICAL CHEMISTRY

Involves the analysis of a substance to determine its **composition and the quantity** of its components. It is concerned with answering the following questions:

- **What** chemical species are present in a sample ? (Qualitative Analysis)
- **How much** of each component is present? (Quantitative Analysis).

It is done through volumetric, gravimetric or instrumental methods.

There is a huge overlap between Chemistry and other sciences like Engineering, Biology, Medicine, Physics, Geology, and other fields. Chemistry really is a **CENTRAL SCIENCE**.

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 atoms e.g : Carbon is an element contains only one kind of atoms C, also Hydrogen H₂

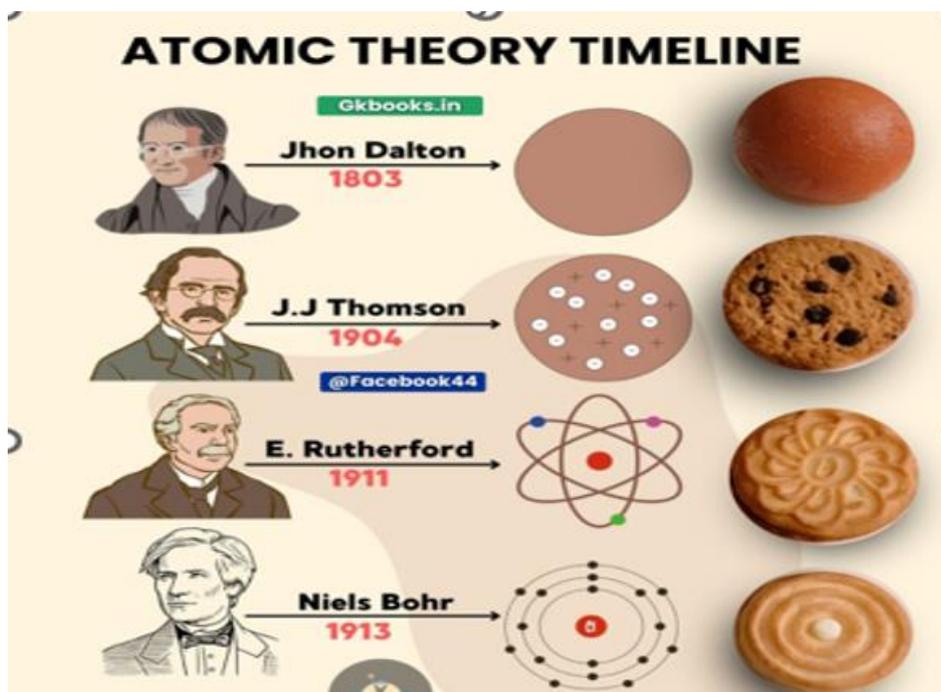
A **compound** is a substance that can be broken down into simple stable substances. Each compound is made from the atoms of two or more elements that are chemically bonded and the properties of the compound are different from its component elements .Water (H₂O)is an example of a compound. It is made of two elements, hydrogen and oxygen. The atoms of hydrogen and oxygen are chemically bonded to form a water molecule. (NH₃ , CO₂ , CH₄ , NaCl , NH₄Cl 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.

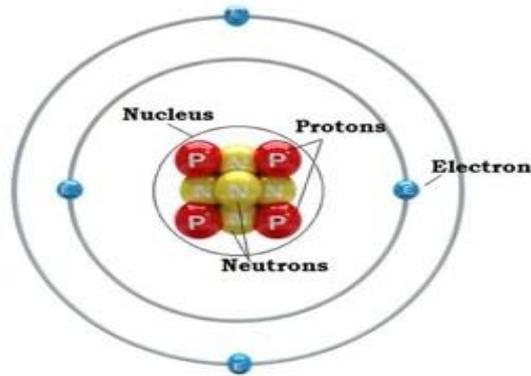


Atoms are composed of tiny **subatomic particles** called *protons, neutrons, and electrons*.

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:

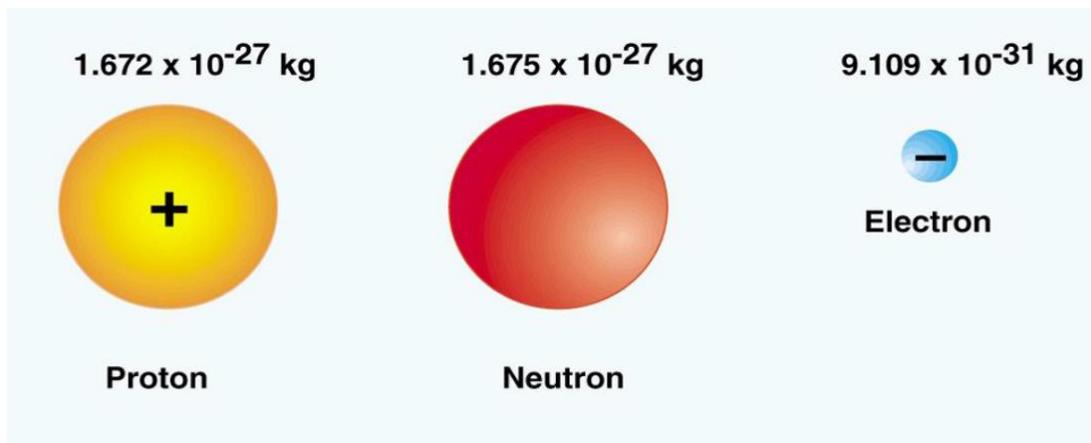
- The nucleus, which is in the center of the atom and contains protons and neutrons, and
 - The outer region of the atom, which holds its electrons in orbits around the nucleus.
- * A **proton** is a positively charged particle in an atom
 - * An **electron** is a negatively charged particle in an atom
 - * 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 the 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) \approx 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 ($Z= 15$) and mass number ($A= 31$).

How many protons, electrons, and neutrons are there in phosphorus atoms.

Answer:

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

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

The diagram shows the calculation of the number of neutrons in an atom. It features the equation $31 - 15 = 16$ neutrons. Above the number 31 is the text "Mass number (sum of protons and neutrons)" in red. Above the number 15 is the text "Atomic number (number of protons)" in blue. A red arrow points from the mass number text to the number 31, and a blue arrow points from the atomic number text to the number 15.

$$\begin{array}{l} \text{Mass number} \\ \text{(sum of protons and neutrons)} \end{array} \quad 31 - \begin{array}{l} \text{Atomic number} \\ \text{(number of protons)} \end{array} 15 = 16 \text{ neutrons}$$

Excercise :

The Nickel element has an atom with atomic number ($Z = 28$) and has Mass Number of ($A = 58$) 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.

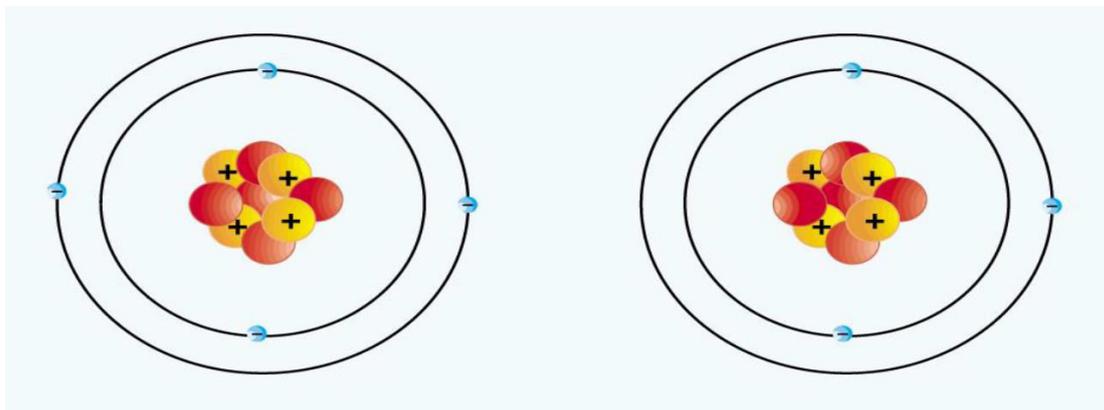
The electrostatic attractive force between the positively-charged protons in the nucleus and the negatively-charged electrons around the nucleus holds the atom together.

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 others of opposite charge by electrical attraction.



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^+)

Cation (Positive Ion) Formed by losing electrons Size is smaller than its neutral atom Reason: Fewer electrons → less repulsion + higher effective nuclear pull Example: Na (neutral) > Na^+ (cation)	Anion (Negative Ion) Formed by gaining electrons Size is larger than its neutral atom Reason: More electrons → more repulsion → bigger size Example: Cl^- (anion) > Cl (neutral atom)
<p>Cation: Atomic Radius > Ionic Radius</p> <p>Na 190 pm Na^+ 116 pm Mg 145 pm Mg^{2+} 66 pm</p>	<p>Anion: Atomic Radius < Ionic Radius</p> <p>Cl 79 pm Cl^- 167 pm S 88 pm S^{2-} 184 pm</p>

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**

Example :

The Calcium 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.

Answer:

Atomic number($Z=20$) = No. of protons=No. of electrons (Neutral atom)= 20
In Ca^{2+} we have 2 electrons loss then No. of electrons is 18

Exercise:

The Ferrous ion (Fe^{2+}) has an atom with atomic number ($Z = 26$) and Mass Number of ($A = 56$) Give the number of protons ,electrons and neutrons in the ion.

Exercise:

The chloride ion (Cl^-) has an atom with atomic number ($Z = 17$) and Mass Number of ($A = 35$) Give the number of protons ,electrons and neutrons in the ion.

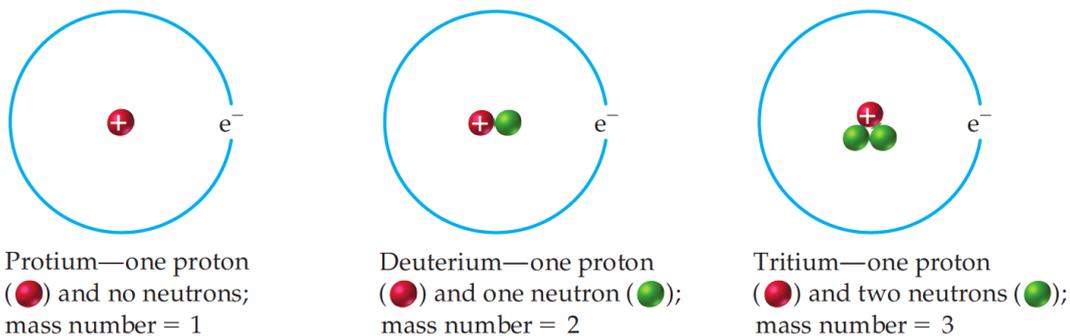
ISOTOPES

When an element has atoms that differ in the number of neutrons in the nuclei, these atoms are called different isotopes of the element.

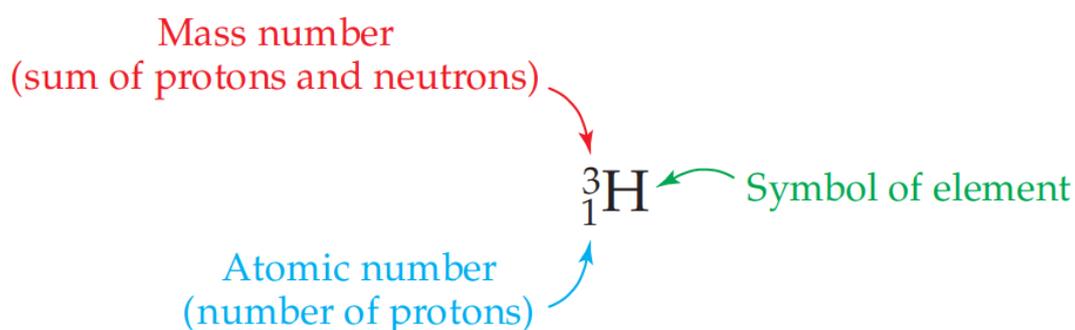
All isotopes of one element have identical chemical properties.

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.



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.

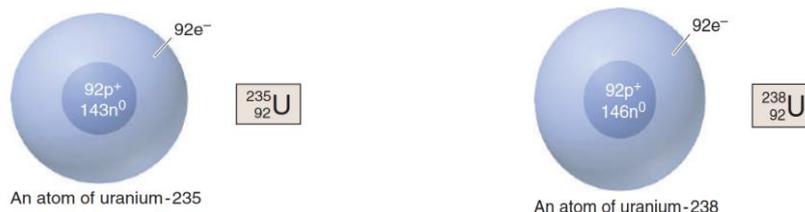
Isotopes are :

1. Atoms of the same element with the same number of protons
2. Have different numbers 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



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

${}_{92}\text{U}^{238}$ 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 ${}_{92}\text{U}^{235}$. 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.

Number of neutrons = mass number - atomic number

$$235 \text{ (protons + neutrons)} - 92 \text{ protons} = 143 \text{ neutrons}$$

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

While uranium-238 nucleus is made up of 92 protons and 146 neutrons.

Exercise:

Find the number of neutrons , protons and electrons in chlorine isotope ${}_{17}\text{U}^{37}$ with atomic number of 17 and mass number of 37.