Department of Mathematics and Natural Sciences

CHE 101: Introduction to Chemistry

Lecture -01

Content: Structure of atom, isotopes, isobar & isotones

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What is Chemistry

Matter

Matter is anything that has a mass and occupies space. Matter can be distinct substances or mixtures. The distinct substances are either **elements or compounds**.

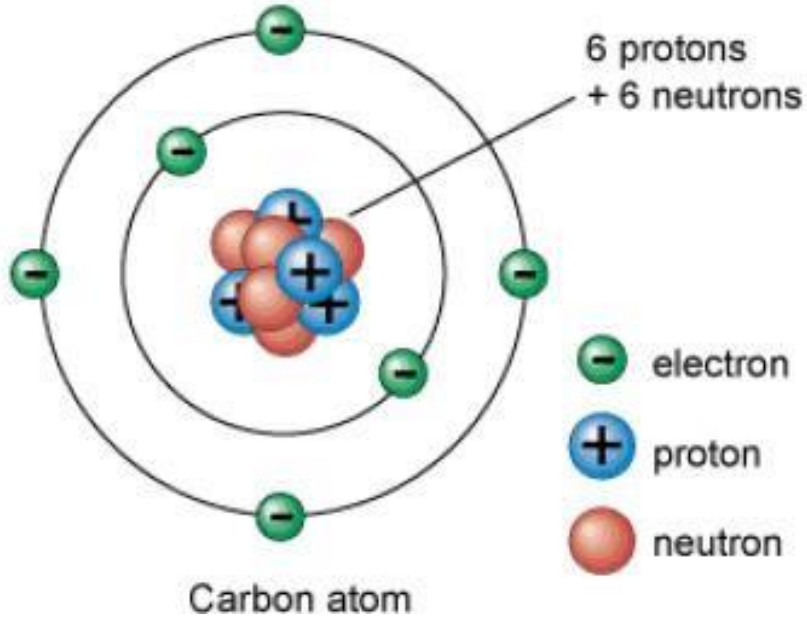
If a substance is made up of only one kind of atoms, it is called **element.**

If, however it is made up of two or more kinds of atoms joined together in a definite proportion, it is called a **compound.**

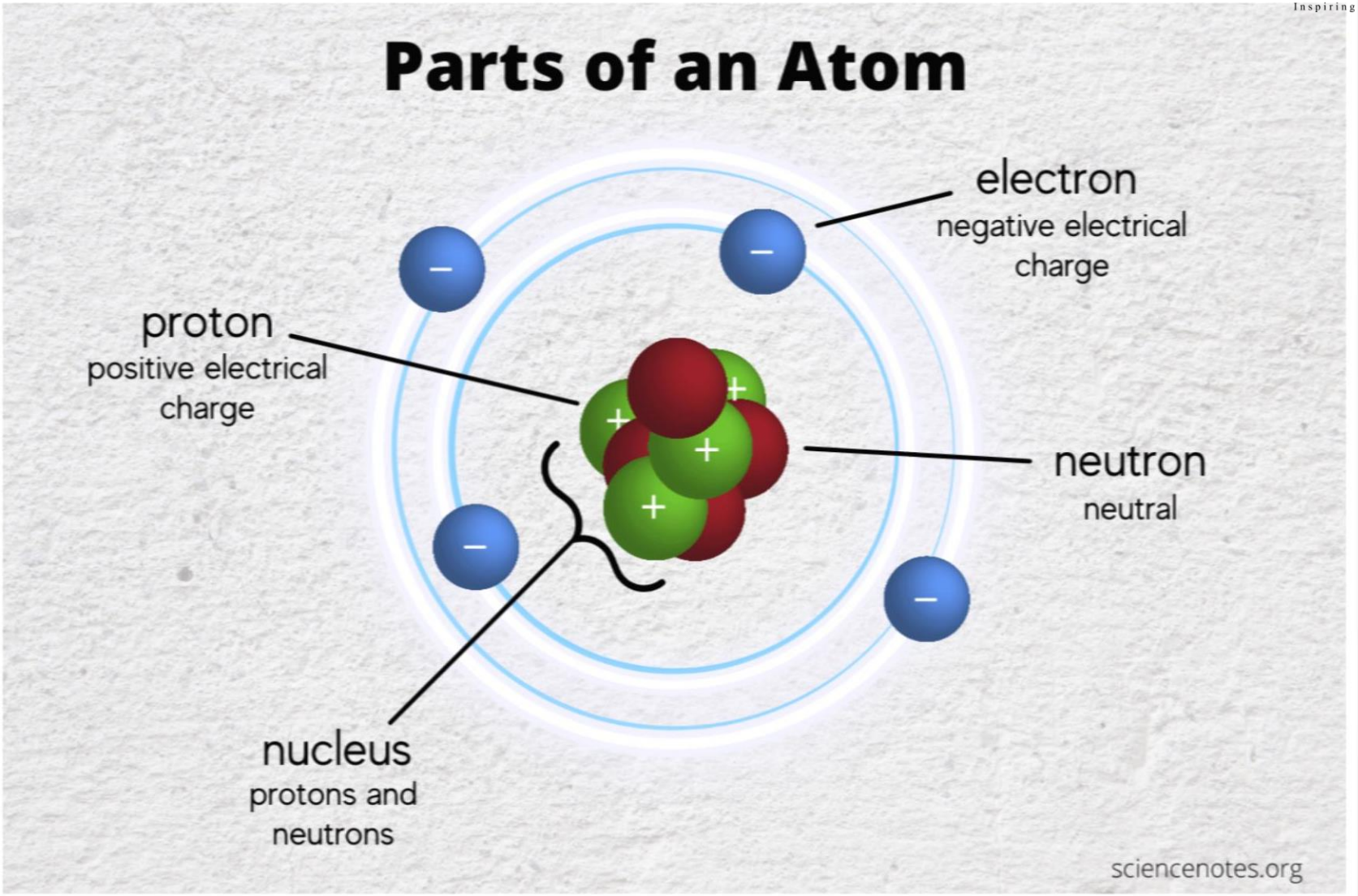
Atom

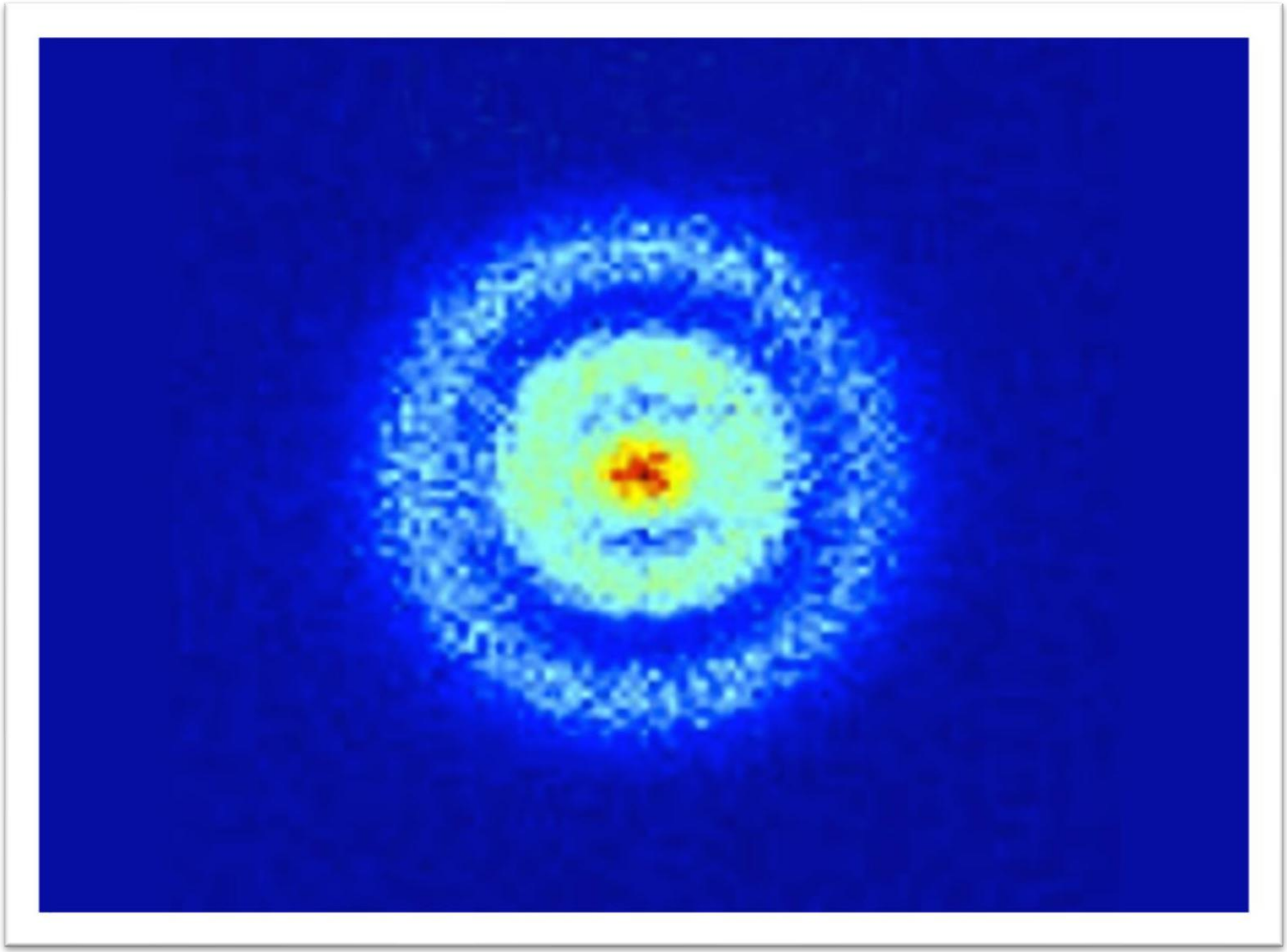
All matter – whether element, compound or mixture is composed of extremely small particles of matter that retains its identity during chemical reactions called atoms.

A table, a chair, even you are made up of atoms!



Carbon atom


Parts of an Atom
electron
negative electrical charge
proton
positive electrical charge
neutron
neutral
nucleus
protons and neutrons
sciencenotes.org



- All atoms are made of three subatomic particles

- **Electrons, protons and neutrons**

Particle	Actual Charge	Actual Mass	Position	Discovered by
Electron	-1.6×10^{-19} C	9.1x10-28 g	Orbit	J.J Thomson -1897
Proton	$+1.6\times10^{-19}$ C	1.673x10-24 g	Nucleus	Ernest Rutherford -1919
Neutron	0	1.675x10-24 g	Nucleus	James Chadwick-1932

What does an atom look like?

Protons and neutrons are held together rather closely in the center of the atom. Together they make up the nucleus, which accounts for nearly all of the mass of the atom.
Electrons move rapidly around the nucleus and constitute almost the entire volume of the atom. Atoms have sizes on the order of 10^{-10} m.(angstrom (Å), unit of length, **equal to 10^{-10} metre**, or 0.1 nanometre)

What holds an atom together?

The negatively charged electron is attracted to the positively charged nucleus by a Coulombic attraction.
The protons and neutrons are held together in the nucleus by the strong nuclear force (Binding energy).

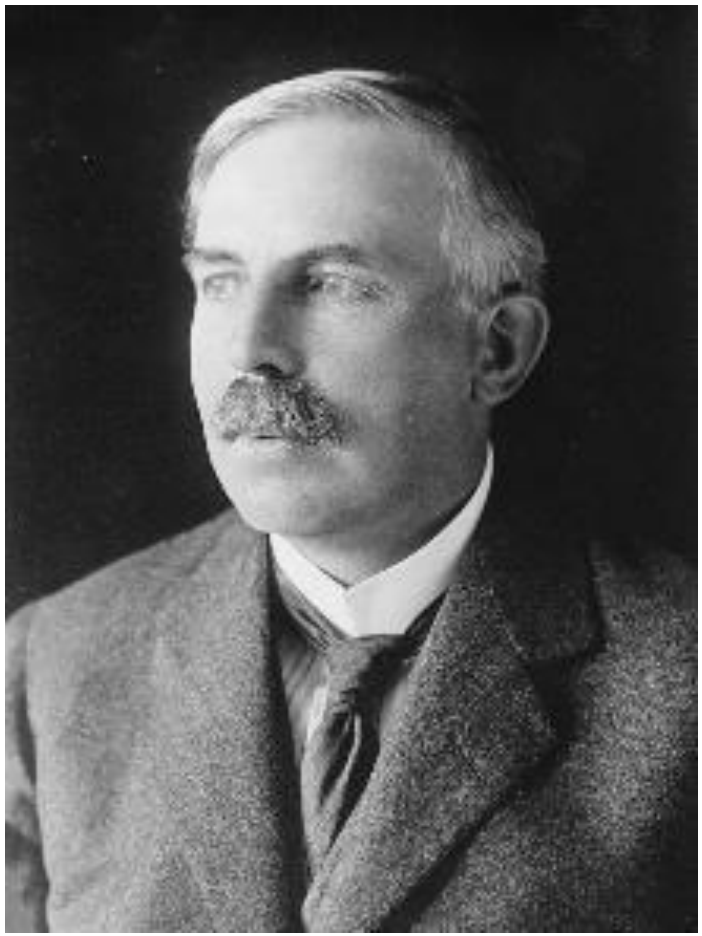
J J Thomson 1856-1940

Nobel Prize in Physics 1906

"in recognition of the great merits of his theoretical and experimental investigations on the conduction of electricity by gases. Cathod Ray Experiment

Earnest Rutherford
1871-1937

BRAC UNIVERSITY
Inspiring Excellence



Nobel Prize in Chemistry 1908

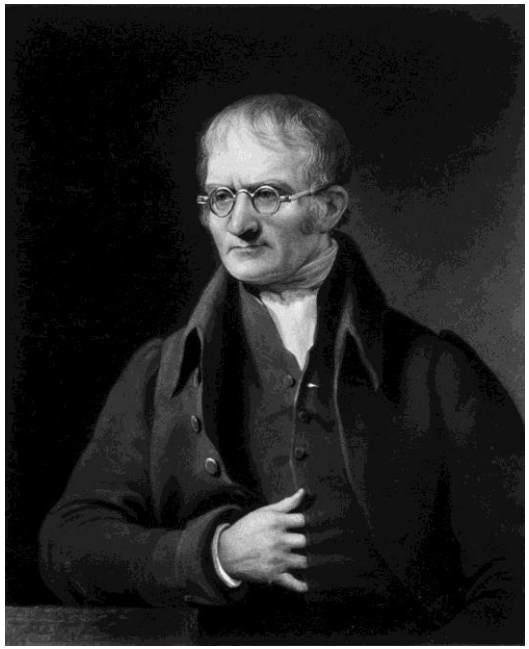
"for his investigations into the disintegration of the elements, and the chemistry of radioactive substances."

James Chadwik
1891-1974

Nobel Prize in Physics
1935

"for the discovery
of the neutron."

John Dalton1766-1844



Royal Medal in Physics
1826

"For his development of the Atomic Theory and his other important labours and discoveries in Physical Science."

Postulates of Dalton's Atomic Theory

British Chemist **John Dalton** (1766-1844) proposed a theory to explain the structure of
matter in terms of different combinations of very small particles.

1. All matter is composed of minute particles called atoms. An atom is an extremely small particles of matter that retains its identity during chemical reaction. These atoms are indivisible and indestructible.

2. An element is a type of matter composed of only one kind of atom, each atom of a given kind having the same properties. Mass is one such property. Thus, the atoms of a given element have a characteristic mass.

3. The properties and masses of atoms of different substances are different.

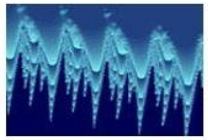
4. A compound is a type of matter composed of atoms of two or more elements chemically combined in fixed proportions. Water, for example, a compound of the elements hydrogen and oxygen, consists of hydrogen and oxygen atoms in the ratio of 2 to 1.(Law Of Constant Composition)

A chemical reaction consists of the rearrangement of the atoms present in the reacting substance to give new chemical combinations present in the substances formed by the reaction. So only atoms take part in chemical reaction.(Law Of Conservation Of Mass)

1. Atoms are not created, destroyed, or broken into smaller particles during a chemical reaction.

Law of definite proportions

Law Of Constant Composition



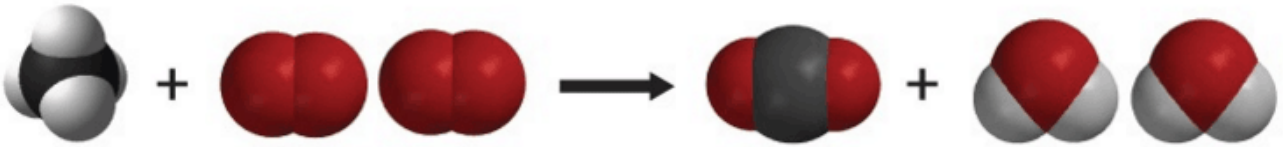
Ice water H_2O 1 : 8

River water H_2O 1 : 8

Sea water H_2O 1 : 8

A **chemical compound** always contains **same elements** combined together in **same proportion** of mass.

Law Of Conservation Of Mass



CH_4	+	$2O_2$	→	CO_2	+	$2H_2O$
methane		oxygen		carbon dioxide		water
16 g		2*32 g		44 g		2*18 g

Limitations of Dalton's Atomic Theory

1. According to Dalton theory atoms are indivisible. Now it is established that atoms are divisible into fundamental particles-proton, neutron and electron.

2. Atoms of same elements have same mass according to Dalton. But isotopes show that atoms of same element can have different masses. Hydrogen has three isotopes having masses of 1, 2 and 3 units.

3. Dalton said that atoms of different elements will have different masses. After the discovery of isobars, we see that atoms of different elements can have same masses. Example: Tellurium (atomic number 52) and iodine (atomic number 53) have same atomic mass 127.

4. Dalton called atom to be the smallest part of both element and compound. But now it is known that atoms are smallest part of an element that can exist in free state and molecules are smallest part of compound. Dalton did not show any difference between an atom and a molecule.

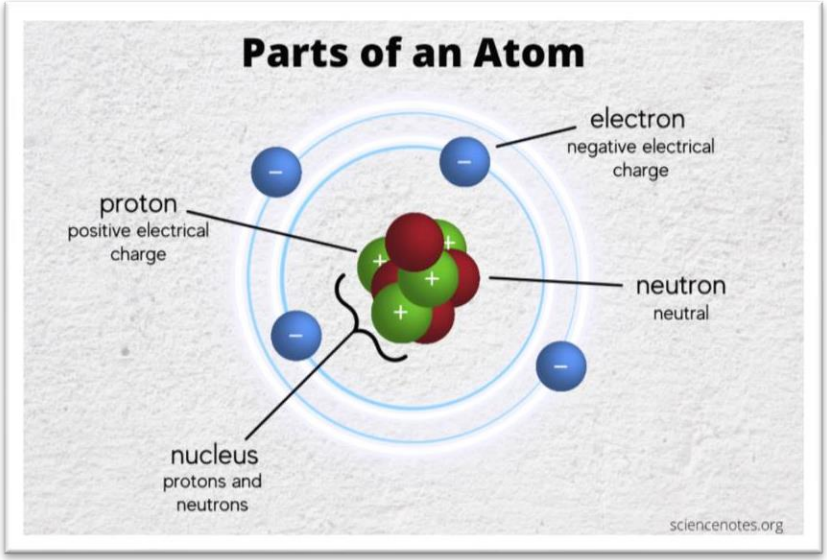
The structure of atom

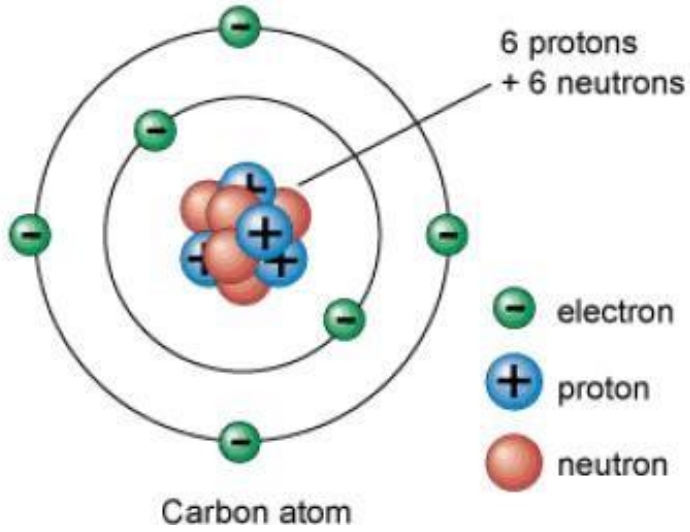
- Several experiments showed that an atom consists of two kinds of particles: a **nucleus**- the atom's central core, which is positively charged and contains most of the atoms mass, and **one or more electrons.**

Electron

An electron is a very light, negatively charged particle that exists in the region around the atom's positively charged nucleus.

Charge of electron: 1.602 X 10^{-19} coulombs (C)
Mass of Electron: 9.109 X 10^{-31} kg (more than 1800 times smaller than the mass of the lightest atom (hydrogen)





Proton: A proton is a nuclear particle having a positive charge equal to that of the electron and a mass more than 1800 times that of electron.
The proton in a nucleus give the nucleus its positive charge.
Mass of proton is 1.672×10^{-27} Kg and charge is 1.602×10^{-19} C

Neutron: The neutron is a nuclear particle having a mass almost identical to that to that of the proton but no electrical charge.
Mass of neutron is 1.674×10^{-27} Kg and charge is 0 C

Composition of the nucleus: The nuclei of atoms contain protons and neutrons except hydrogen which consists of a single proton. The proton and the neutrons in the nucleus are held together by a force known as nuclear force.

Some related terms

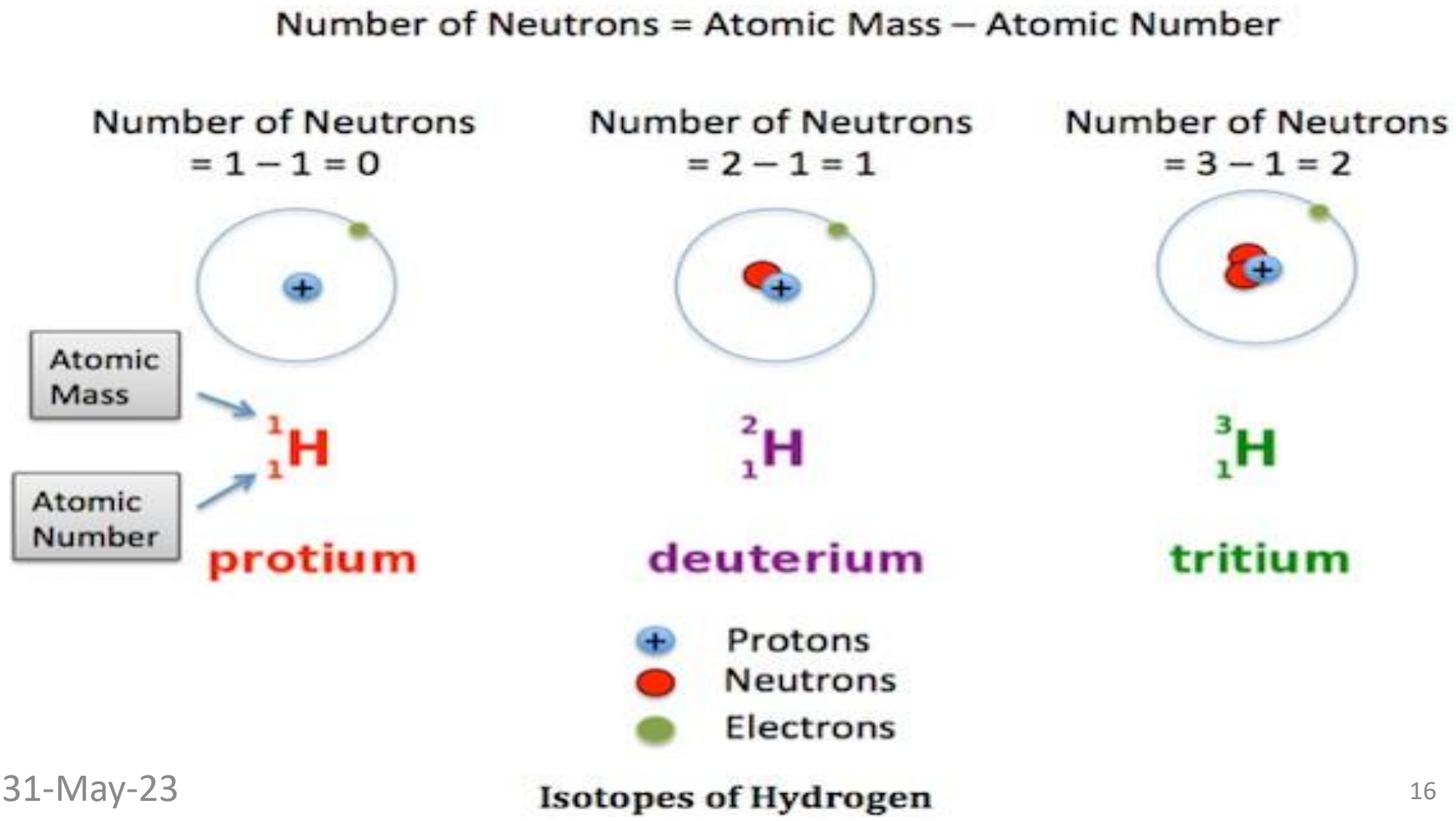
Atomic number: It is the number of protons in the nucleus of an atom.
The number of protons and electrons are equal in an atom as they are electrically neutral. So it can also be defined by the total number of electrons in the atom.

Atomic mass or mass number: It is the total number of protons and neutrons in a nucleus.

Nuclide: Nuclide is an atom characterized by definite atomic number and mass number.
The symbol for naturally occurring sodium nuclide is as follows:

Here, the atomic number is written as subscript and mass number is written as superscript. Atomic number of Na is 11, that is Na has 11 proton.
As the number of proton and electron in an atom is equal, so Na has 11 electron.
The number of neutron in Na is = 23 – 11 = 12

The atoms having same atomic/proton number but different atomic mass number are called **isotopes**. (iso= Same)



Isotopes of Hydrogen

Isotones

Atoms of different elements having different mass number and different atomic number but same neutron number are called **Isotones.**

Oxygen $^{16}_{8}O$ **(p=8; n=8)**

Nitrogen $^{15}_{7}N$ **(p=7; n=8)**

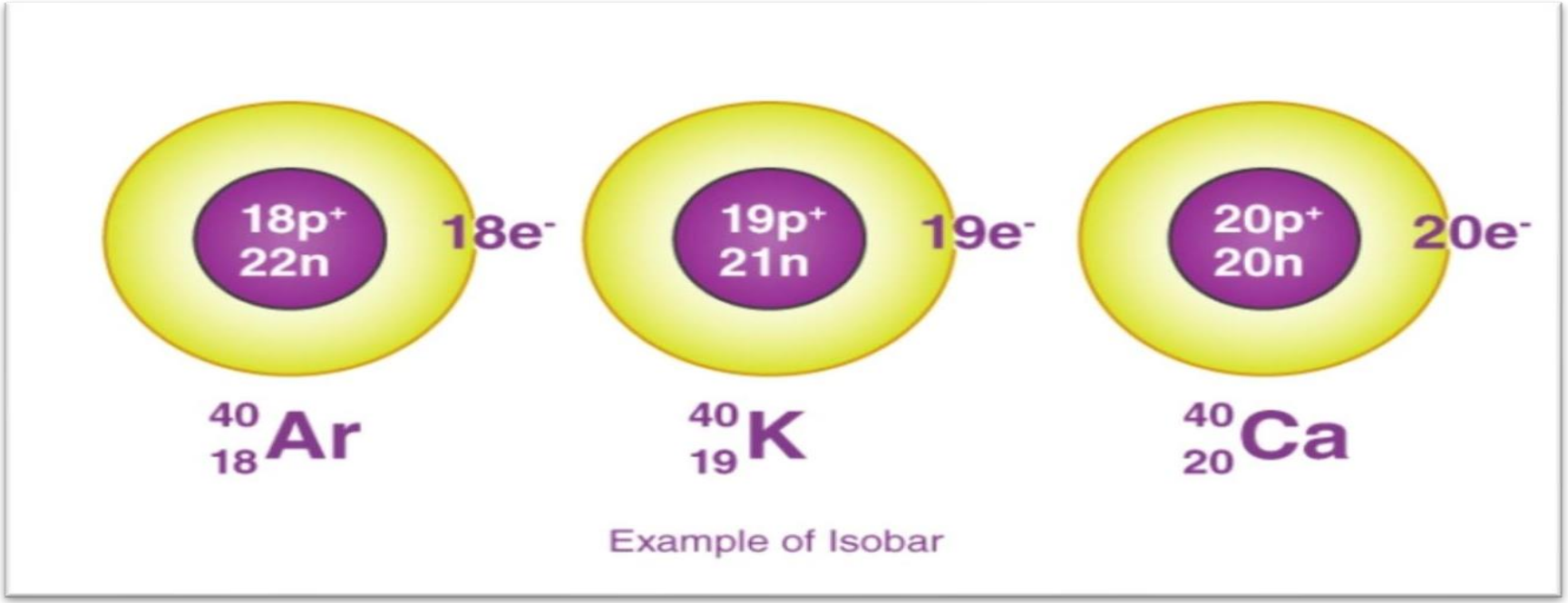
Carbon $^{14}_{6}C$ **(p=6; n=8)**

Are isotones because of having same number of neutron (8)

Isobars

Atoms of different elements having same mass number but different proton/atomic number are called **Isobars.**

Example:



Example of Isobar

Example Chart

Isotopic Symbol	Isotopic Name	Atomic Number	Mass Number	# of protons	# of neutrons	# of electrons
$^{7}_{3}Li$	Lithium-7	3	7	3	4	3
$^{37}_{17}Cl$	Chlorine-37	17	37	17	20	17
$^{137}_{56}Ba$	Barium-137	56	137	56	81	56

Thank You All

Keep Safe