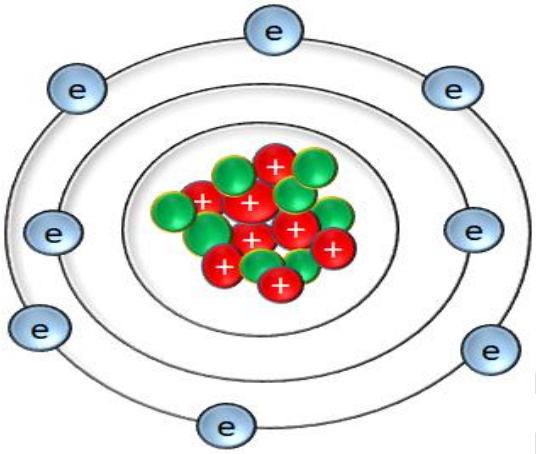
Fundamentals of Chemistry



What is science?

The systemized knowledge which is obtained through observations and experiments is called science.

Explanation

The facts about the material universe are collected through our five senses, which form knowledge.

But when the validity and truthfulness of facts are confirmed by experiments, then it is called science.

Example

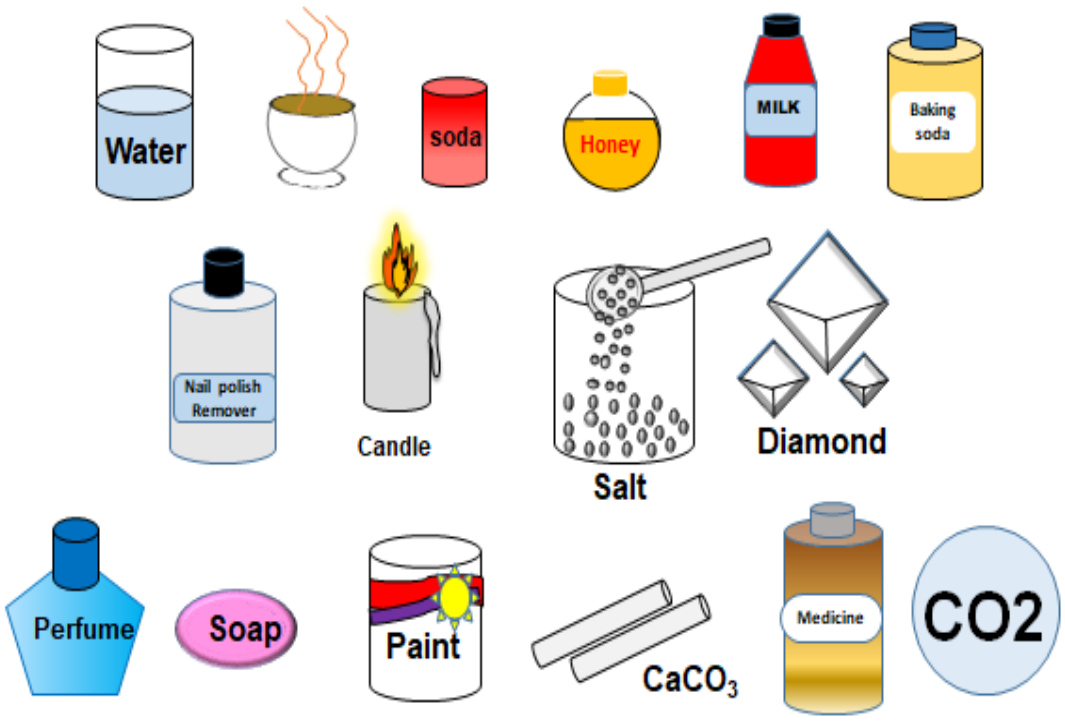
1. Water freezes at 0^0C and boils at 100^0C.
2. When hydrogen and oxygen are chemically combined in a fixed ratio, they form water.

What is Chemistry?

"Chemistry is the branch of science that deals with the study of matter, its composition, structure, properties and their reactions."

In simple words

***Chemistry is the science of* matter.**



Chemistry belongs to every aspect of life

Branches of Chemistry

Organic chemistry

"Organic chemistry is the branch of chemistry that deals with the study of carbon-containing compounds."

Most of the things we come across
in our daily life are organic in nature. e.g.

Food

Carbohydrates **Proteins** **Fats & Oils**

- **The food we eat is mainly organic in nature.**
- **The clothes we wear are also organic e.g. Cotton, Silk, wool, etc.**
- **Natural gas, Petroleum products & coal are organic.**
- **Fuels that run our cars & industries**

e.g. Petrol, Diesel oil, Compressed natural gas (CNG), Coal gas

- All types of allopathy & homeopathy contain organic compounds. e.g. Penicillin, streptomycin

Other uses of organic compounds

- Insecticides like DDT
- Hormones & Steroids
- Vitamins &Enzymes
- Pigments & Dyes
- Paper & Inks
- Perfumes & flavors
- Plastic and Rubber
- Explosives
- Soap & Detergents
- Herbicides e.g. Treflan
- Photographic films & developers etc.

Compounds of carbon with few exceptions

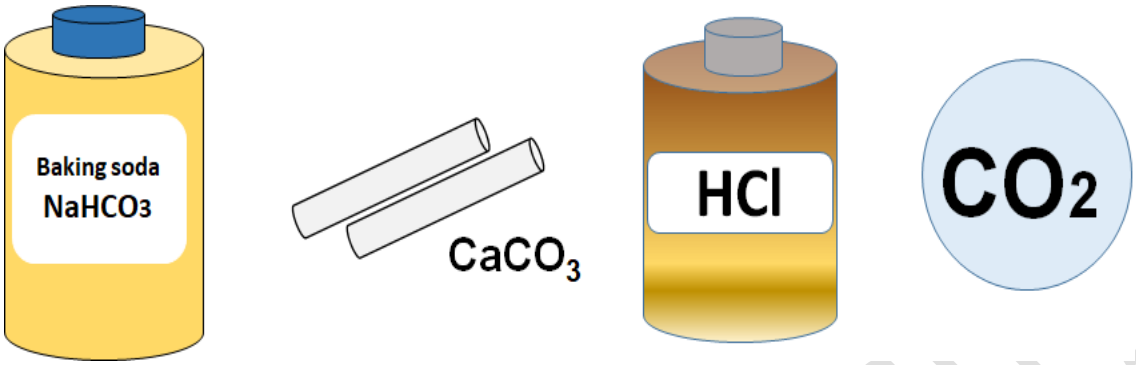
These exceptions are as follow:

1. **Carbon monoxide (CO)**
2. **Carbon dioxide (CO2)**
3. **Carbon disulphide (CS_2)**
4. **Carbonates (CO_3^{2-})**
5. **Bicarbonates (HCO_3^-)**
6. **Cyanides (CN^-)**
7. **Cyanates (CNO^-)**
8. **Metal Carbides (C^{4-}) etc.**

Inorganic Chemistry

"Inorganic chemistry is the branch of chemistry that deals with the study of all elements and their compounds except organic compounds."

Examples of inorganic compounds



Other uses of inorganic compounds

- **Glass**
- **Washing soda ($Na_2CO_3.10H_2O$)**
- **Ceramics etc.**

Analytical Chemistry

"Analytical *Chemistry is the branch of chemistry that deals with the methods and instruments for determining the composition of matter."*

Analytical Chemistry deals with the analysis of substances by using different methods and instrument .

To check

Whether a substance is organic or inorganic

Its percent composition

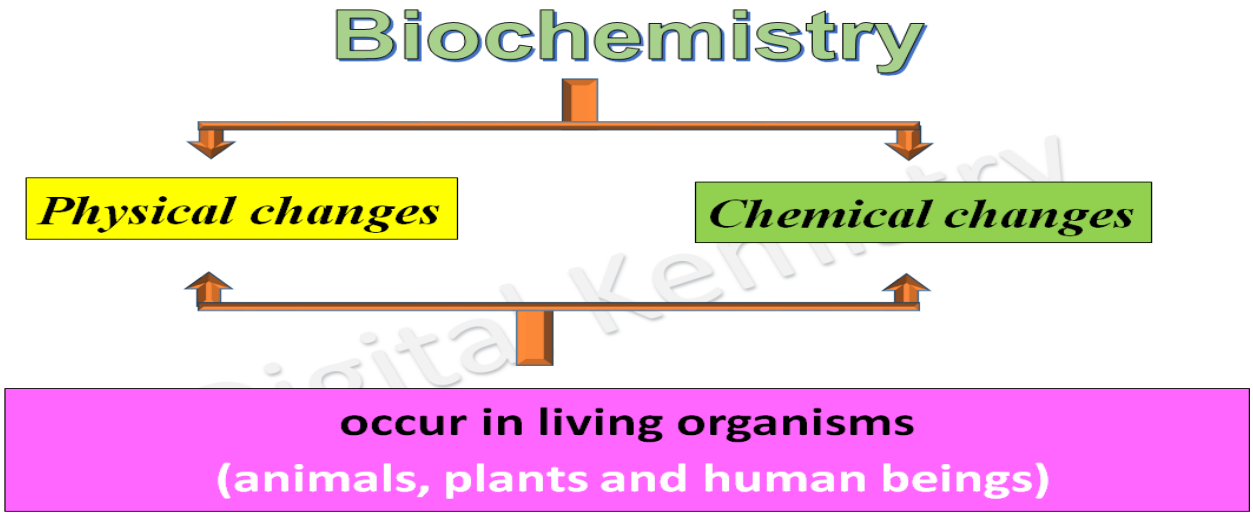
Melting point

Boiling point

Percentage purity of a sample

Biochemistry

"Biochemistry is the branch of chemistry that deals with the physical and chemical changes that occur in living organisms."



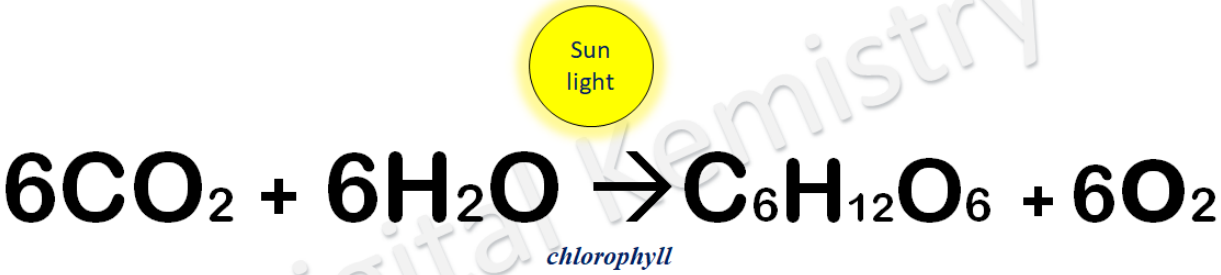
For Example:

Photosynthesis produces glucose and oxygen from CO2 and H2O in the presence of chlorophyll and sunlight.

Since

Photosynthesis is a chemical reaction that occurs in plants

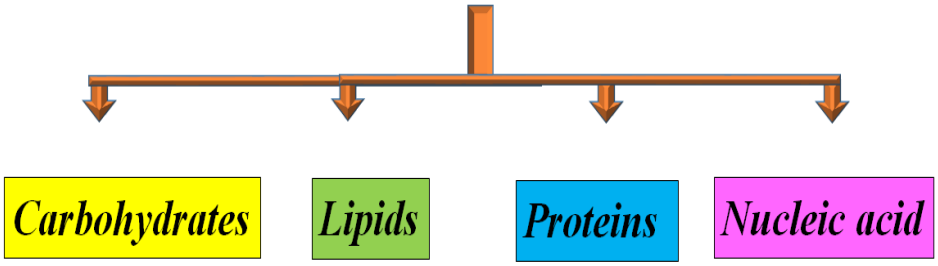
Photosynthesis



Also,

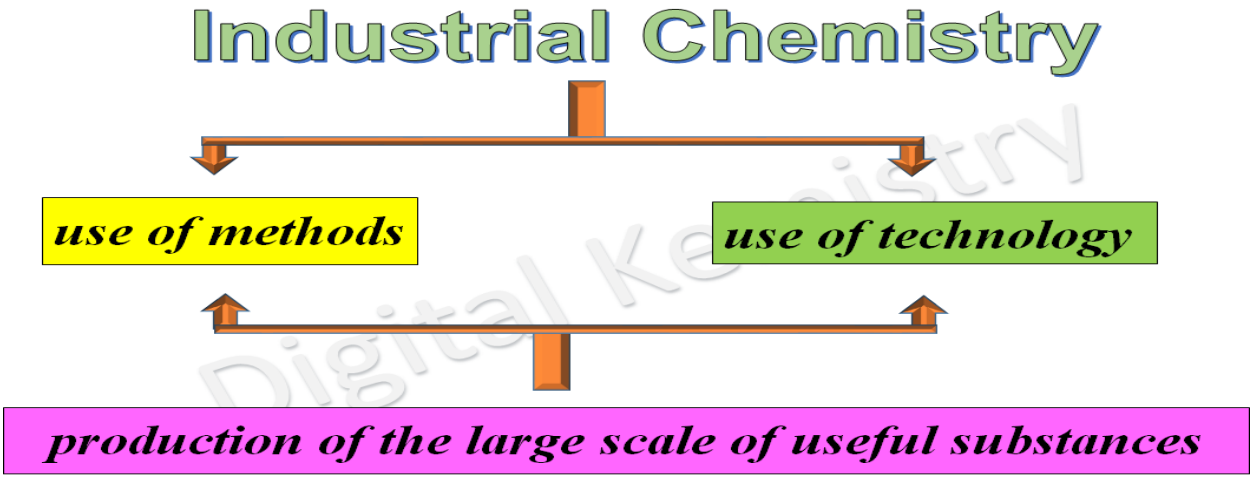
The study of chemical reactions that undergoes the bodies of human beings is biochemistry.

Biomolecules



Industrial Chemistry

"Industrial chemistry is the branch of chemistry that deals with the methods and use of technology in the production of the large scale of useful substances."



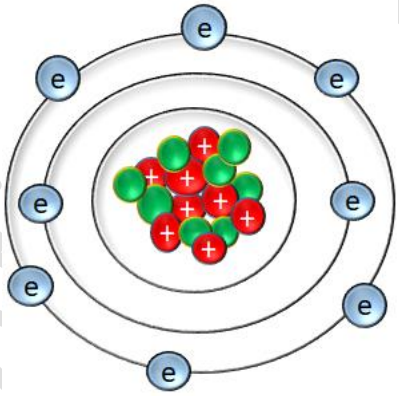
Large scale production of any substance

Haber's process converts large quantities of hydrogen and nitrogen into ammonia.

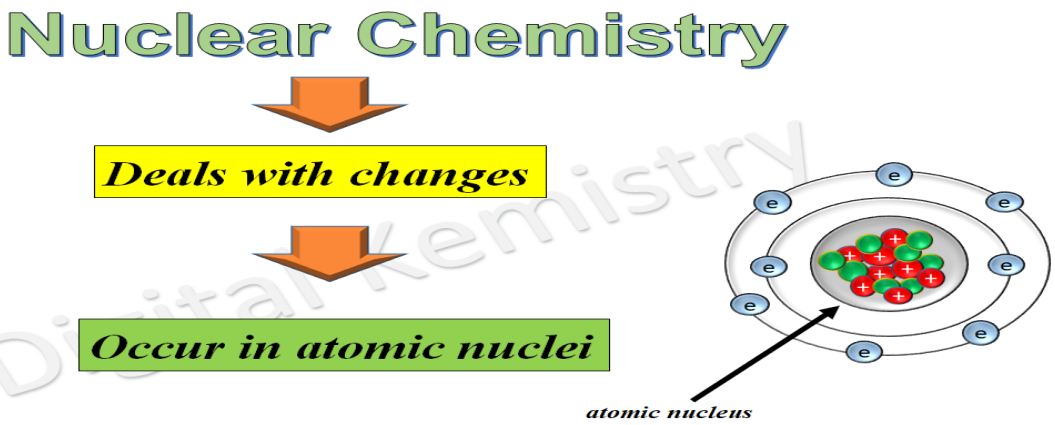
$$N_2 + 3H_2 \rightarrow 2NH_3$$

Nuclear chemistry

"Nuclear chemistry is the branch of chemistry that deals with the changes that occur in atomic nuclei."



The processes of nuclear fission and fusion can be explained by nuclear chemistry



Example:

The study of effects of radioactive radiations or nuclear changes.

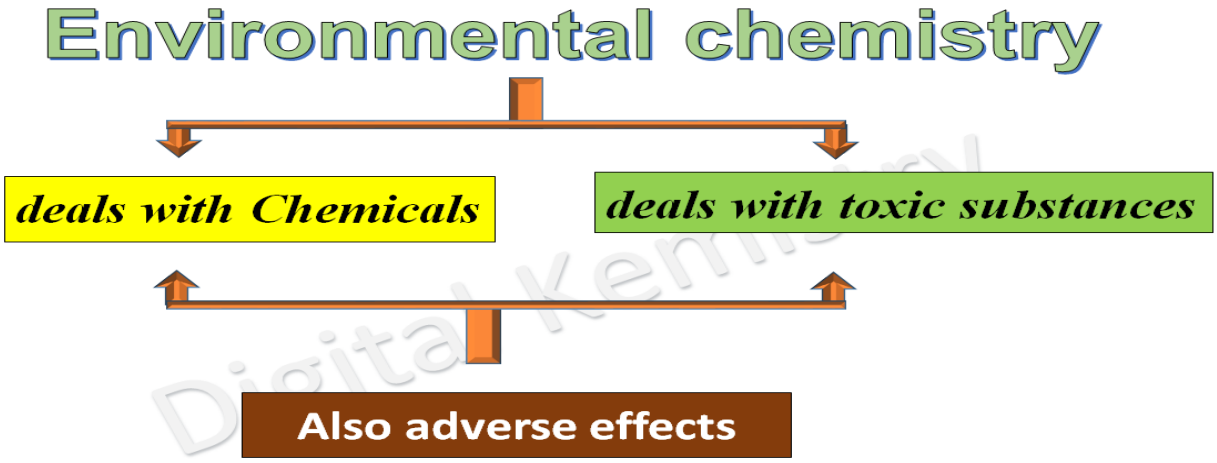
e.g.

Alpha particles when bombarded on nitrogen-14 atom and a proton is emitted, the reaction is written as:

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{14}_{8}O + ^{1}_{1}H$$

Environmental Chemistry

"Environmental Chemistry is the branch of chemistry that deals with the chemicals and toxic substances that pollute the environment and their adverse effects on human beings."



Examples 1

Plantation helps in overcoming Greenhouse effect.

Examples 2

Chlorofluorocarbon compounds are responsible for the depletion of the ozone layer.

Since depletion of the ozone layer is an environmental problem.

Examples 3

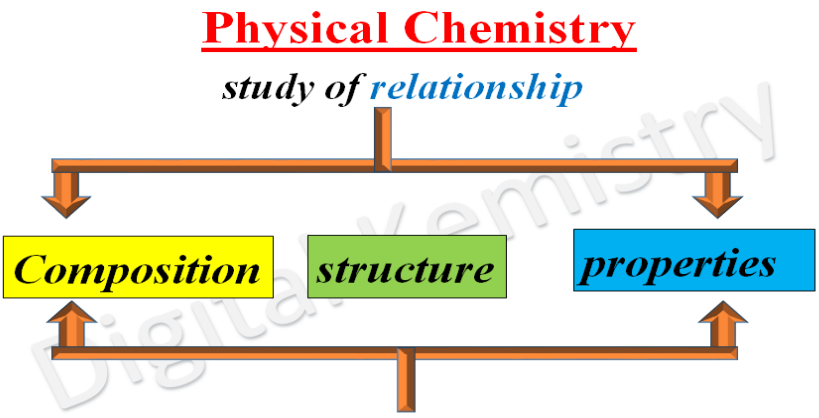
An analyst determines that NO_2 is responsible for acid rain.

Since

acid rain is an environmental problem

Physical Chemistry

"Physical chemistry is the branch of chemistry that deals with the laws and theories to understand the structure and changes of matter."



Changes in matter **on the basis of laws/ principles & theories of physics**

Differentiate between the Branches of Chemistry

Vinegar contains 5% acetic acid.

Acetic acid (CH3COOH) is a colourless liquid that has a characteristic vinegar-like smell. It is used to flavor food. Various types of studies on this compound can help you to differentiate between various branches of chemistry.

Physical Chemistry

Transformation into gaseous state or solid state

Applications of laws and theories to understand its structure

Explanation of its transformation into a gaseous or solid-state, also applications of laws and theories to understand its structure is physical chemistry.

Organic Chemistry

Acetic acid is an organic compounds

Method of preparation

Study of physical and chemical properties

Since it is a carbon-containing compound, so the study of its chemical properties and method of preparation is organic chemistry.

Inorganic Chemistry

Study of component elements

Carbon ,Hydrogen and Oxygen

Inorganic chemistry deals with the elements and their compounds except carbon compounds. However,CO,CO_2,metal carbonates and carbides are studied in inorganic chemistry.

Study of its component elements. i.e. C, H, and O is inorganic chemistry.

Biochemistry

chemical reactions that acetic acid undergoes in the human bodies

The study of chemical reactions that acetic acid undergoes in the human body is biochemistry.

Industrial Chemistry

Use of methods and technology to obtain Acetic acid on large scale

Analytical Chemistry

Use of methods and instruments To determine
Percentage composition
Melting point
Boiling point etc

Environmental Chemistry

Any adverse effect of compound
Or
The compounds that are derived from it on the human

Nuclear Chemistry

Effect of radioactive radiations and neutrons on this Compound or its component elements

Dalton's atomic theory

In 1803, English chemist John Dalton presented a theory on the nature and existence of matter

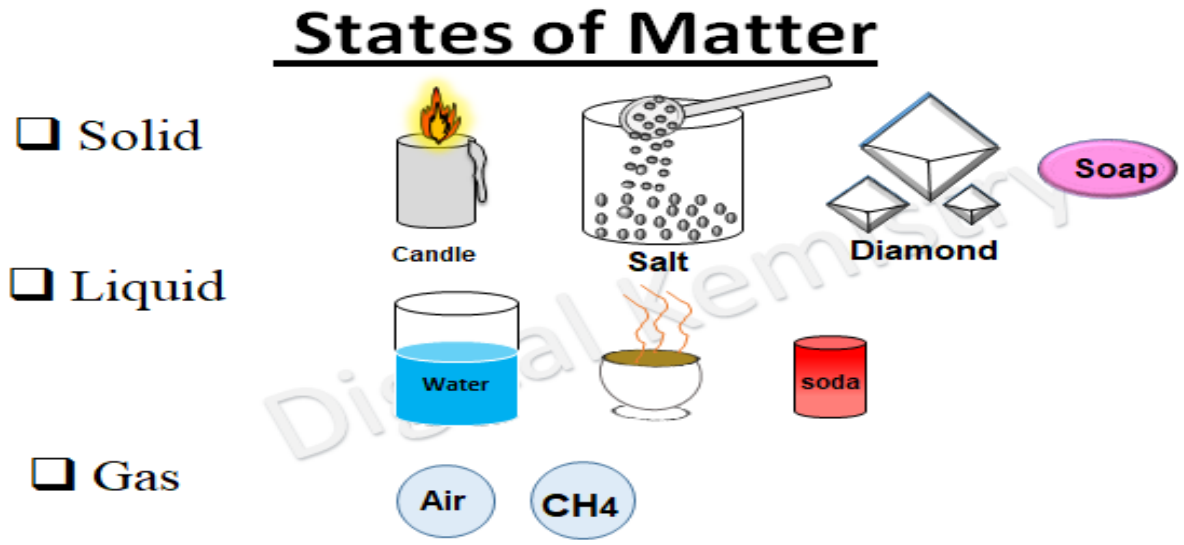
Basic postulates of dalton's atomic theory

- Everything is composed of tiny indestructible particles called atoms
- Atoms of the same element have the same properties
- During chemical reactions, atoms combine in a simple ratio to form compounds
- Atoms can neither be created nor destroyed.

Basic Definitions

What is matter?

"Anything that has mass and occupies space is matter."

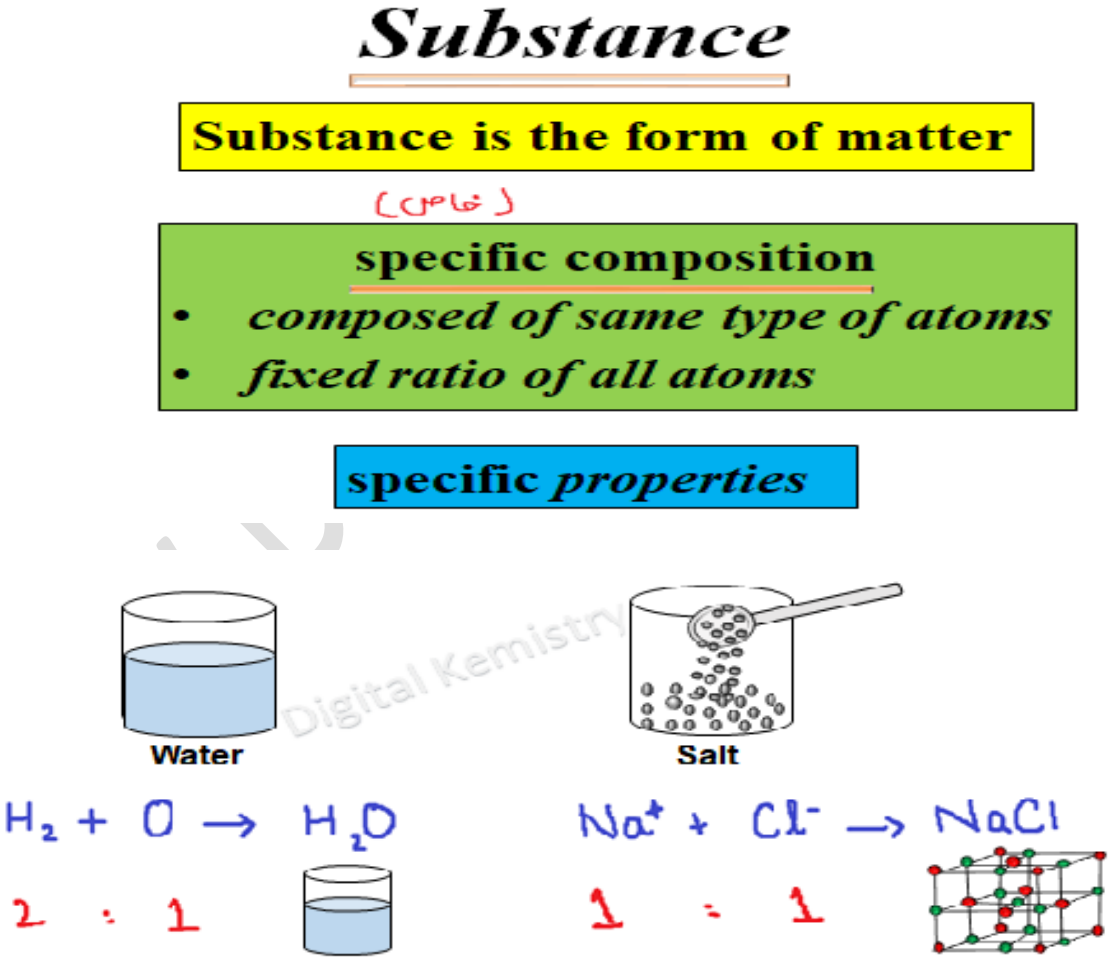


Substance:

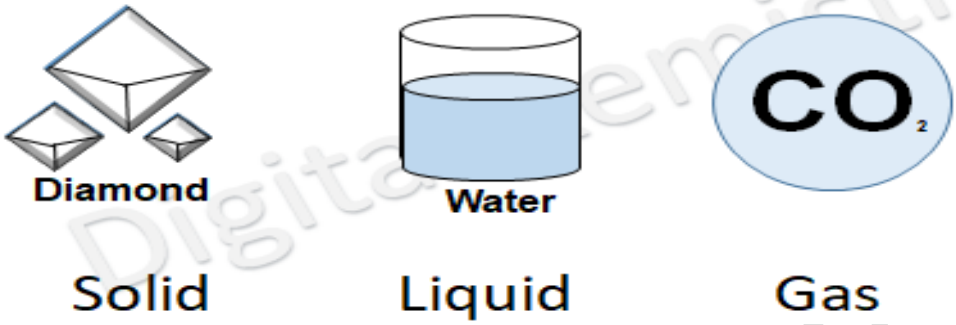
The form of matter which has a specific composition and specific properties is called a substance.

Or

Any matter that has a particular set of characteristics that differ from the characteristics of another type of matter is called a substance.



A substance may be in solid, liquid or gaseous form.



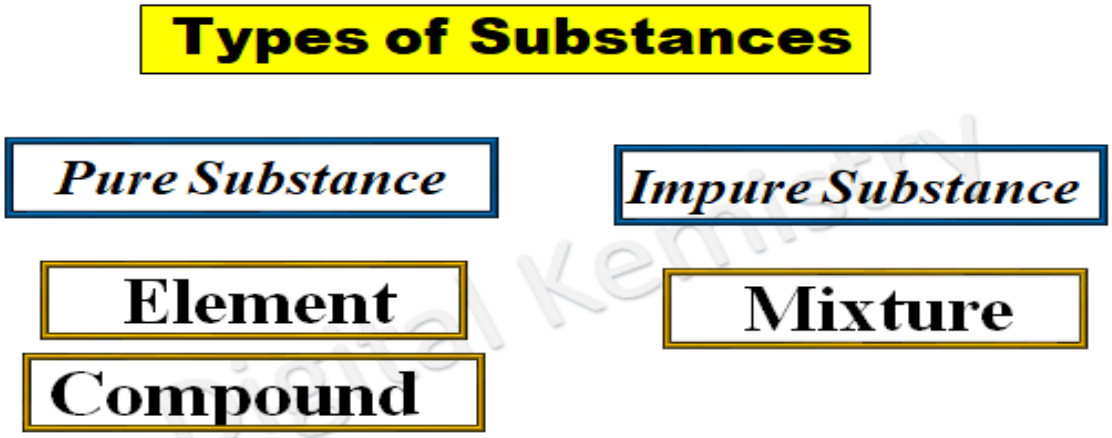
Examples of Substances

- *Water*
- *Carbon dioxide*
- *Oxygen, Hydrogen, Common salt etc.*

Types of Substances

1. Pure Substance

2. Impure Substance

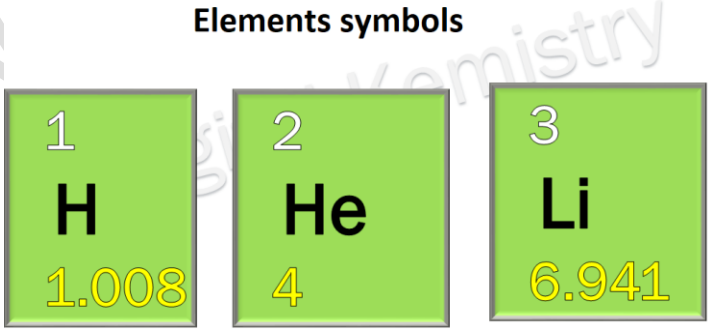


What is an element?

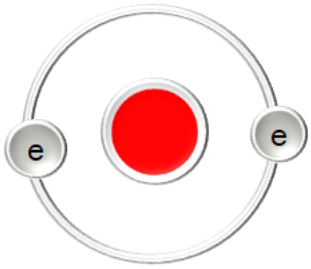
An element is a pure substance that cannot be broken down into smaller substances. Each element's atoms include the same atoms, which have identical structural and chemical properties.

There are 118 naturally occurring elements, of which 92 are found in nature and the remainder are created in laboratories.

An element is represented by a symbol



The smallest particle of an element is an atom



Elements have uniform composition throughout.

Element Examples

Sodium (Na)

Magnesium (Mg)

Oxygen (O)

Argon (Ar)

Some elements are represented by their Latin names e.g

1. Copper Cuprum Cu
2. Silver Argentum Ag
3. Tin Stannum Sn

An element may be in solid, liquid or gas form.

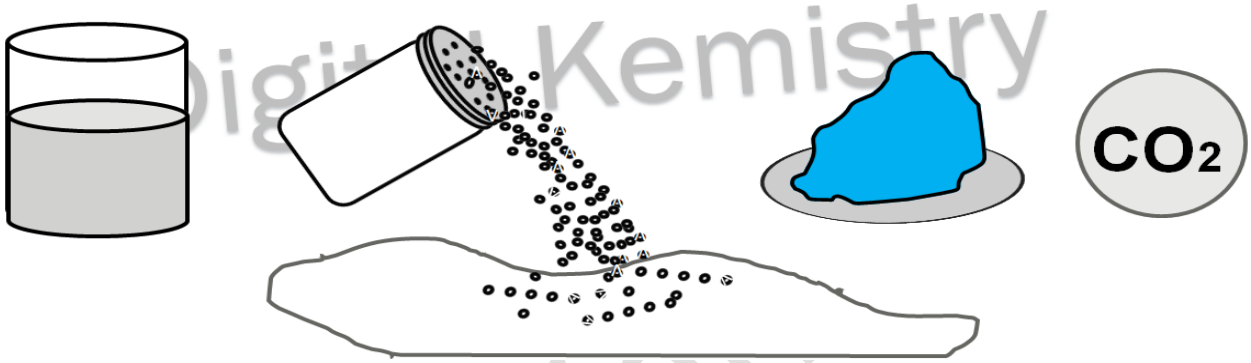
Solid — **majority of elements are in solid state e.g. Cu ,Zn , Na , Fe etc.**

Liquid — **very few elements are in liquid state e.g. Mg (Mercury) , Br (Bromine) etc.**

Gas — **few elements exist in gaseous state e.g. H (Hydrogen) , N (Nitrogen) , O (Oxygen) etc.**

Compound

A compound is a pure substance that consists of two or more elements held together in a fixed proportion by natural forces called chemical bonds.



Compounds are formed by the chemical combination of elements whose properties are entirely distinct from those of their parent elements. As compound is a pure substance, its constituents cannot be separated through physical means.

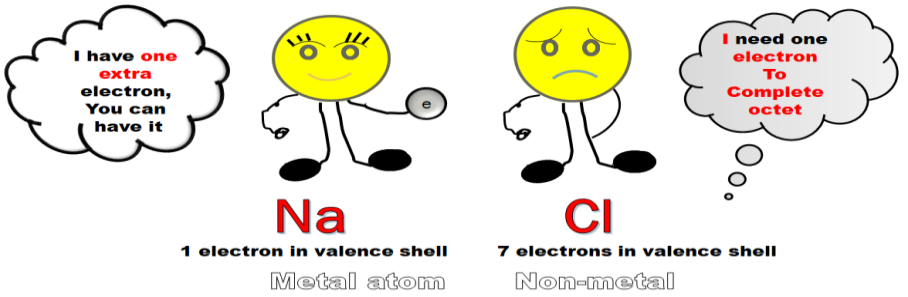
The most essential property of a compound is its constant mass ratio. Hydrogen Peroxide [H2O2] is an example of a compound. Which is applied to the skin as an antiseptic to prevent infection from minor cuts? In hydrogen peroxide, the ratio of hydrogen to oxygen is always 2:2. Changing this ratio will yield an entirely different compound.

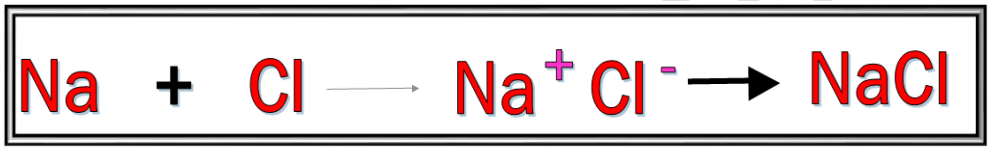
- **The properties of compounds are different from the properties of the elements from which they are formed.**
- **A compound may be ionic or covalent**
- **Compounds have uniform composition throughout**
- **Millions of compounds exist in a universe**
- **Compounds are represented by chemical formulas**

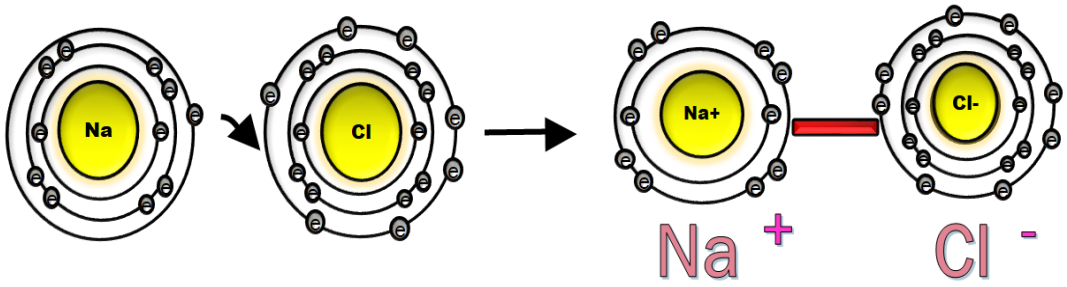
Additional Information:

Ionic bond

The complete transfer of an electron from one atom(metal) to another atom(non-metal)is called an ionic bond.

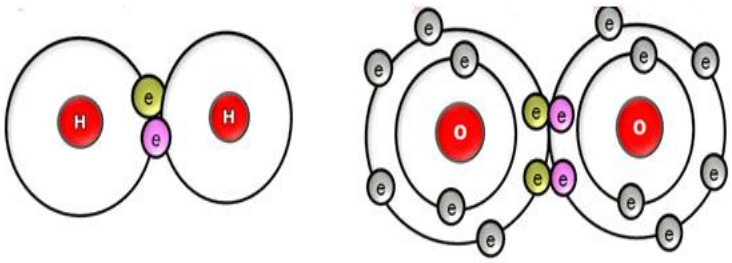






Covalent bond

A covalent bond is formed by the mutual sharing of electrons between the atoms



Representation of compounds

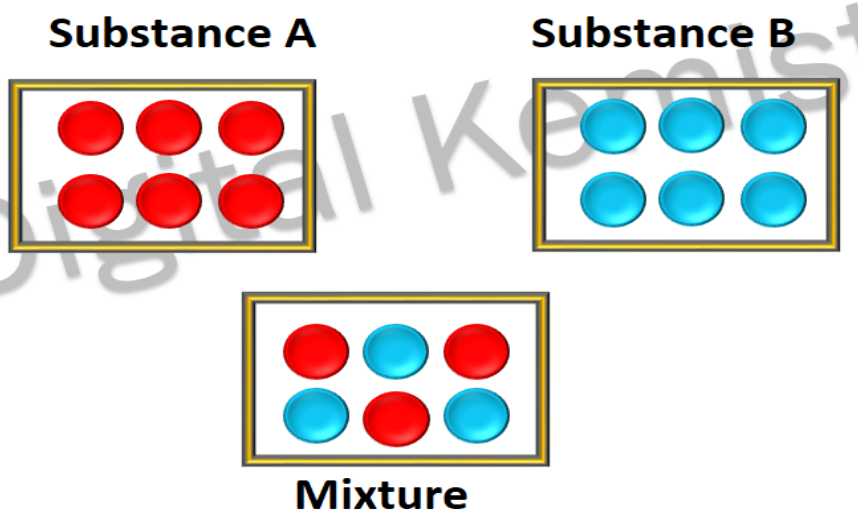
The constituents of a compound are represented through a chemical formula. The formula shows the elements which chemically combined to form that particular compound.

Compound Examples

Hydrogen Peroxide H_2O_2
Water H_2O
Methane [Natural Gas] CH_4

What is a mixture?

A mixture is the physical mixing of two or more substances in any proportion. It is an impure material.



When two or more elements or compounds are mixed in any proportion such that their constituents retain their original properties, a mixture is produced. Various physical procedures, including distillation, filtration, and crystallization, can be used to separate the contents of a mixture.

Components of a Mixture

A mixture consists of two constituents:

1. Solute

2. Solvent

1. Solute

Solute refers to the small component of a solution that is dissolved in the solvent.

2. Solvent

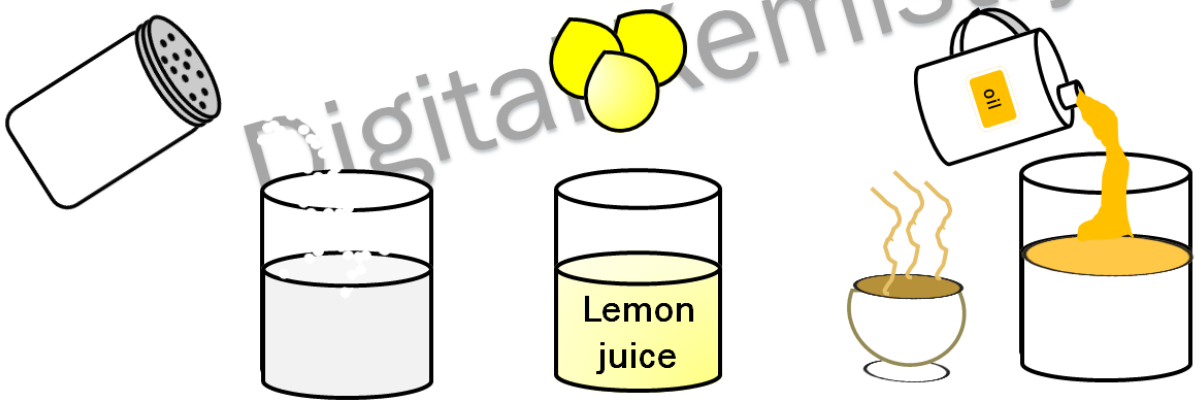
A solvent is the primary component of a solution that dissolves the solute. Also referred to as a dissolving media.

Examples

- Salt in water
- Petrol in water
-

A mixture is an impure substance.

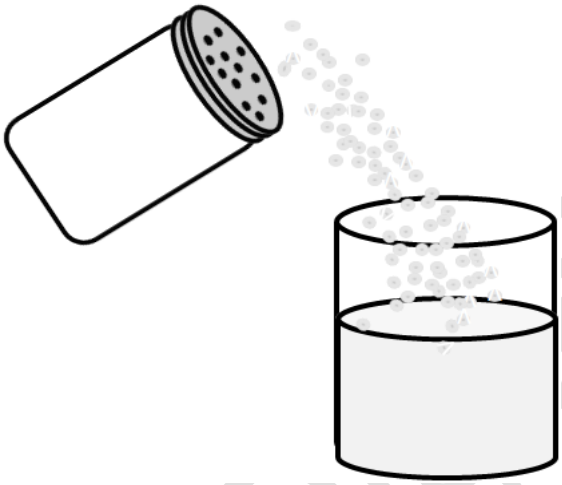
Mixture



Examples of Mixture

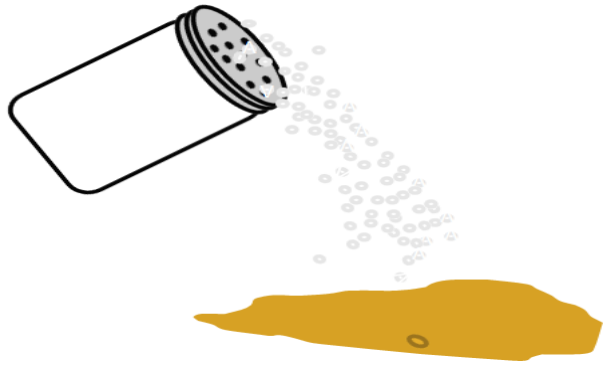
Air is a mixture of oxygen, nitrogen, carbon dioxide, noble gases and water vapors.

A mixture of salt and water.



Soil is a mixture of sand,clay,mineral salt,water and air

A mixture of salt and sand.



Types of Mixture

2 types of mixture

- ***Homogeneous mixture***
- ***Heterogeneous mixture***

Homogeneous Mixture

A mixture that consists of only one phase is called a homogeneous mixture.

A homogeneous mixture has throughout the uniform composition

Examples of homogeneous mixture

- **A mixture of salt and water.**
- **Air is a mixture of oxygen, nitrogen, carbon dioxide,**
- **Noble gases and water vapors.**

Heterogeneous Mixture

A mixture consisting of two or more visible different components is called a heterogeneous mixture.

Heterogeneous mixtures do not have uniform composition

Examples of the heterogeneous mixture

- **Oil floating on water.**
- **A mixture of salt and sand.**

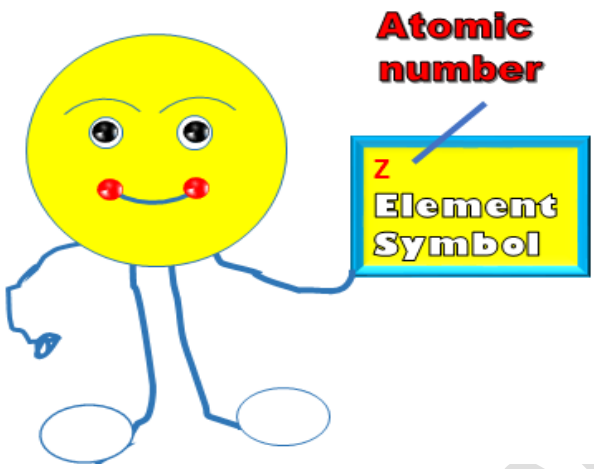
For additional information

Bad breath may have certain advantages. Garlic's chemical composition is highly complex. Garlic has around 200 chemical components. People who consume a lot of garlic have a reduced risk of stomach cancer, heart disease, and stroke compared to those who consume little or no garlic.

Difference between Compound and Mixture

Compound	Mixture
Compound is formed by the chemical combination of two or more elements.	Mixture is formed by the physical combination of two or more pure substances (elements and compounds)
The constituents (elements)lose their identity and form a new substance (compound) having entirely different properties from them.	Mixture shows the properties of constituents. (Each pure substance retain their properties in a mixture)
Compounds always have fixed composition by mass.	Mixture do not have fixed composition.
Compounds have homogeneous composition.	Mixture may be homogeneous or heterogeneous in composition.
Compound is represented by chemical formula.	Mixture is not represented by chemical formula. (It consists of two or more components)
The constituents (elements) can not be separated by physical methods	The constituents can be separated by physical methods.
Compounds have sharp and fixed melting points.	Mixture do not have sharp and fixed melting points.

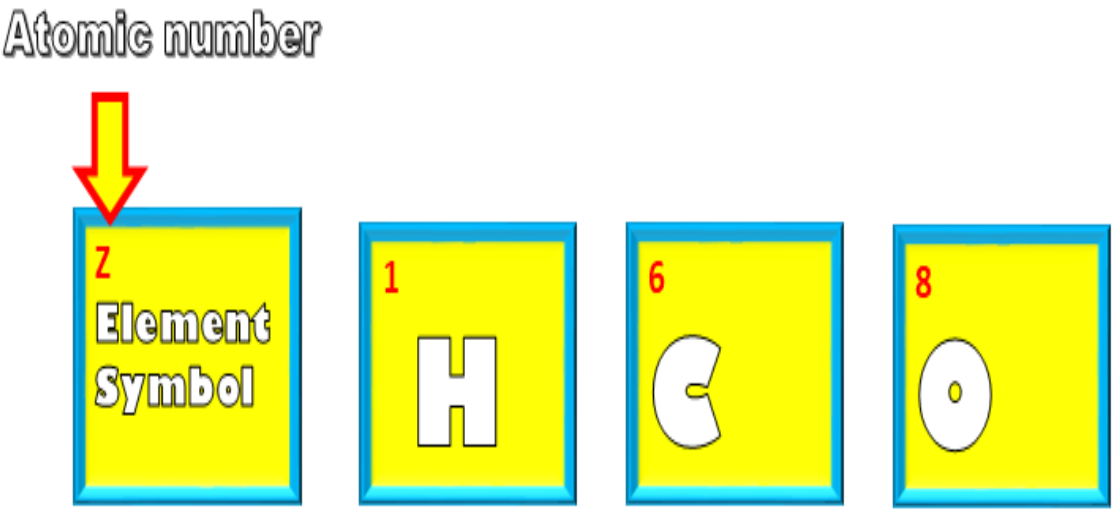
What is an Atomic Number?



An atomic number is defined as the total number of protons present in the nucleus of an atom.

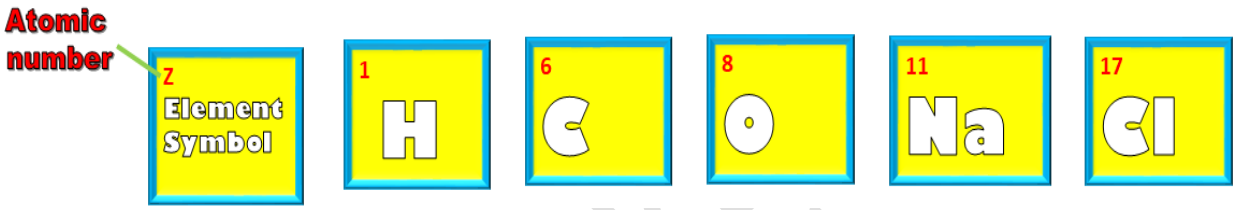
Atomic number (Z) = Number of Protons

Atomic Number Representation



ATOMIC NUMBER (Z)

	Element	Atomic Number (Z)
1	Hydrogen	1
2	Carbon	6
3	Oxygen	8
4	Sodium	11
5	Chlorine	17

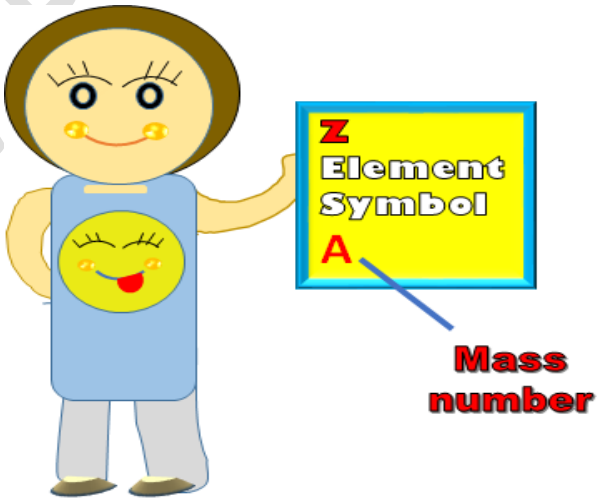


Mass Number (A)

The mass number is defined as the total number of protons and neutrons in the nucleus of an atom.

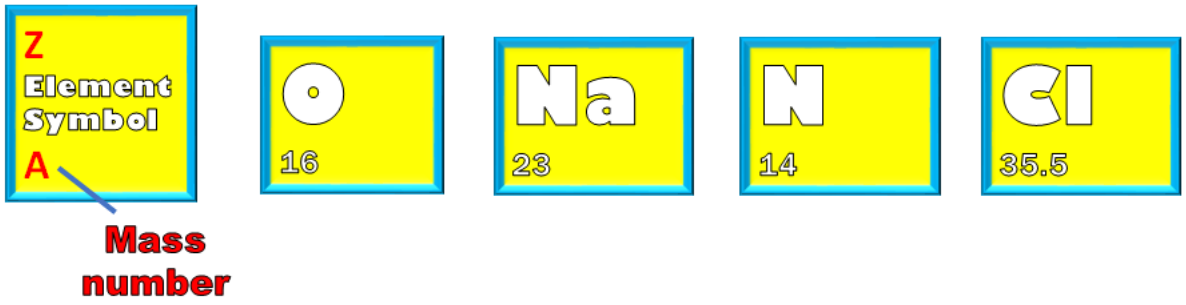
Mass number (A) = Number of Protons + Number of Neutrons

Mass number is represented by the symbol A



Mass number is represented by symbol A

Elements	Mass number
Oxygen (O)	16 amu
Sodium (Na)	23 amu
Nitrogen (N)	14 amu
Chlorine (Cl)	35.5 amu



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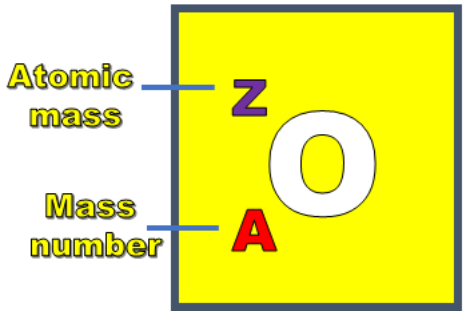
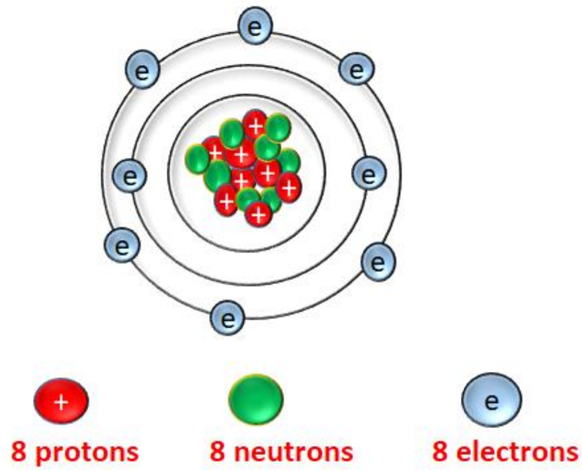
Finding atomic number (Z) & Mass Number (A) of Oxygen atom?

Atomic number (Z) = Number of Protons

Mass number (A) = Number of Protons (Z) + Number of Neutrons (n)

Atomic number (Z) & Mass Number (A) of Oxygen





Atomic Number (Z) = 8

No of protons= 8

Mass Number (A) = 16

No of protons= 8

+

No of neutrons = 8

****

<u>How do you find the number of neutrons in an atom?</u>

<u>Atomic Number (Z) = 8</u>

<u>Mass Number (A) = 16</u>

Number of neutrons (n) = Mass number (A) – Atomic number (Z)

Number of neutrons (n) = 16 – 8

Number of neutrons (n) = 8

****

Determining the number of protons and neutrons in an atom

The atomic number of an element is 17 and the mass number is 35. How many protons and neutrons are present in the nucleus of an atom of this element?

Atomic number (Z) = 17 **No of protons= 17**

Mass Number (A) =35

Mass number = **No of protons + No of neutrons = 35**

$$\text{Number of neutrons } (n) = \text{Mass number } (A) - \text{Atomic number } (Z)$$

Number of neutrons (n) = 35 – 17

Number of neutrons (n) = 18

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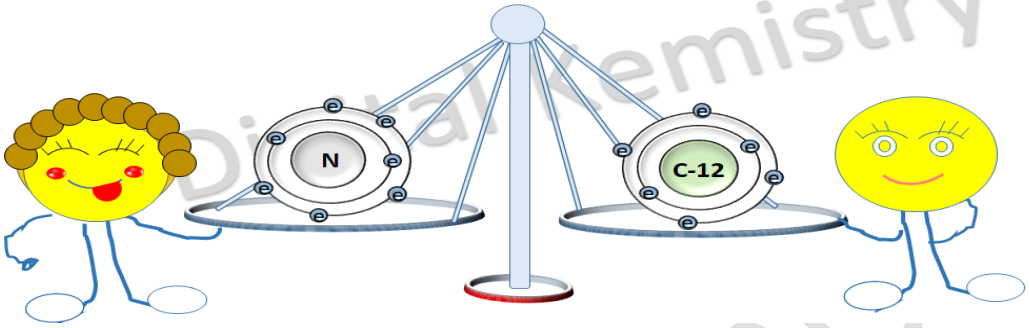
Relative Atomic Mass & Atomic Mass Unit



What is Relative atomic mass?

Relative atomic mass is defined as the mass of an atom of an element compared to the mass of a C-12 atom.

It is measured in either grams or amu. Consequently, the mass of one gram of an element represented in grams is known as the relative atomic mass.

Since an atom is an incredibly small particle, it is impossible to determine the precise mass of an element using a delicate balance. The chosen standard is carbon with a precise mass of 12g or 12amu.

Mass of one Carbon-12 atom=12amu

1 amu=mass of one C-12 atom/12

Now finding the relative atomic mass of hydrogen

8.4/100×12

=1.008 amu

EXAMPLE

One atom of sodium = 23 amu

One atom of chlorine = 35.5 amu

One atom of calcium = 40 amu

Why?

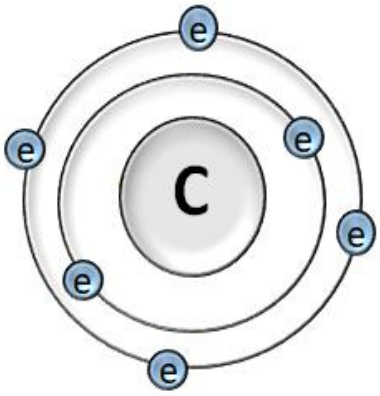
Comparing the mass of an atom of an element with the mass of a C-12 atom.

Reason

The mass of an atom in grams or kilograms is an extremely small value, so measuring such a small mass is not possible.

For that purpose atomic masses are expressed by comparing with the mass of C-12 (standard atom).

Nowadays, the atom chosen as the standard for comparison is the C-12.



As

Mass = Kilogram

Length=meter

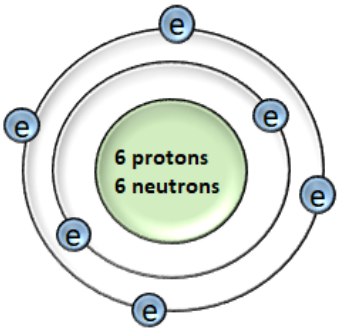
Temperature = Kelvin

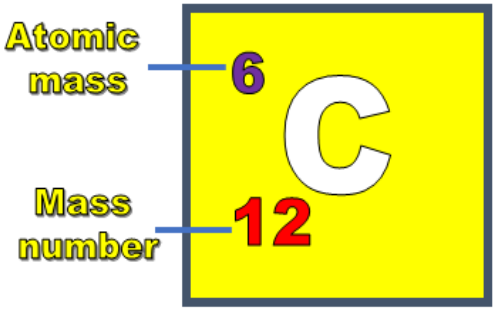
Time = second

Nowadays ,C-12 atom choosen as the standard for the measurement of mass of an atom of an element.

Why is it called Carbon-12?

C-12 has exactly **6 protons** and **6 neutrons** so the **atomic mass is equal to 12** . Therefore, it is called carbon-12.





Unit of Relative atomic mass

Atomic mass unit (amu)

Definition

One atomic mass unit (amu) is defined as a mass exactly equal to one-twelfth the mass of one C-12 atom.

Mass of one C-12 atom = 12 amu

$$\text{amu} = \frac{\text{mass of one C-12 atom}}{12}$$

Relative atomic masses of some elements.

Elements	Relative Atomic mass
Hydrogen (H)	1.008 amu
Oxygen (O)	15.9994 amu
Sodium (Na)	22.9898 amu
Nitrogen (N)	14.0067 amu
Sulphur (S)	32.06 amu
Chlorine (Cl)	35.453 amu
Iron (Fe)	55.847 amu

AVERAGE ATOMIC MASS

The weighted average of atomic masses of naturally occurring isotopes of an element is known as average atomic mass.

Explanation

In the majority of cases, the atomic mass of any element is rarely found to be in whole numbers. It is because most of the elements contain different isotopes and the relative atomic mass takes into account the natural abundance of each isotope

Average atomic mass = Atomic mass of 1st isotope × its % abundance/100 + Atomic mass of 2nd isotope × Its % abundance /100

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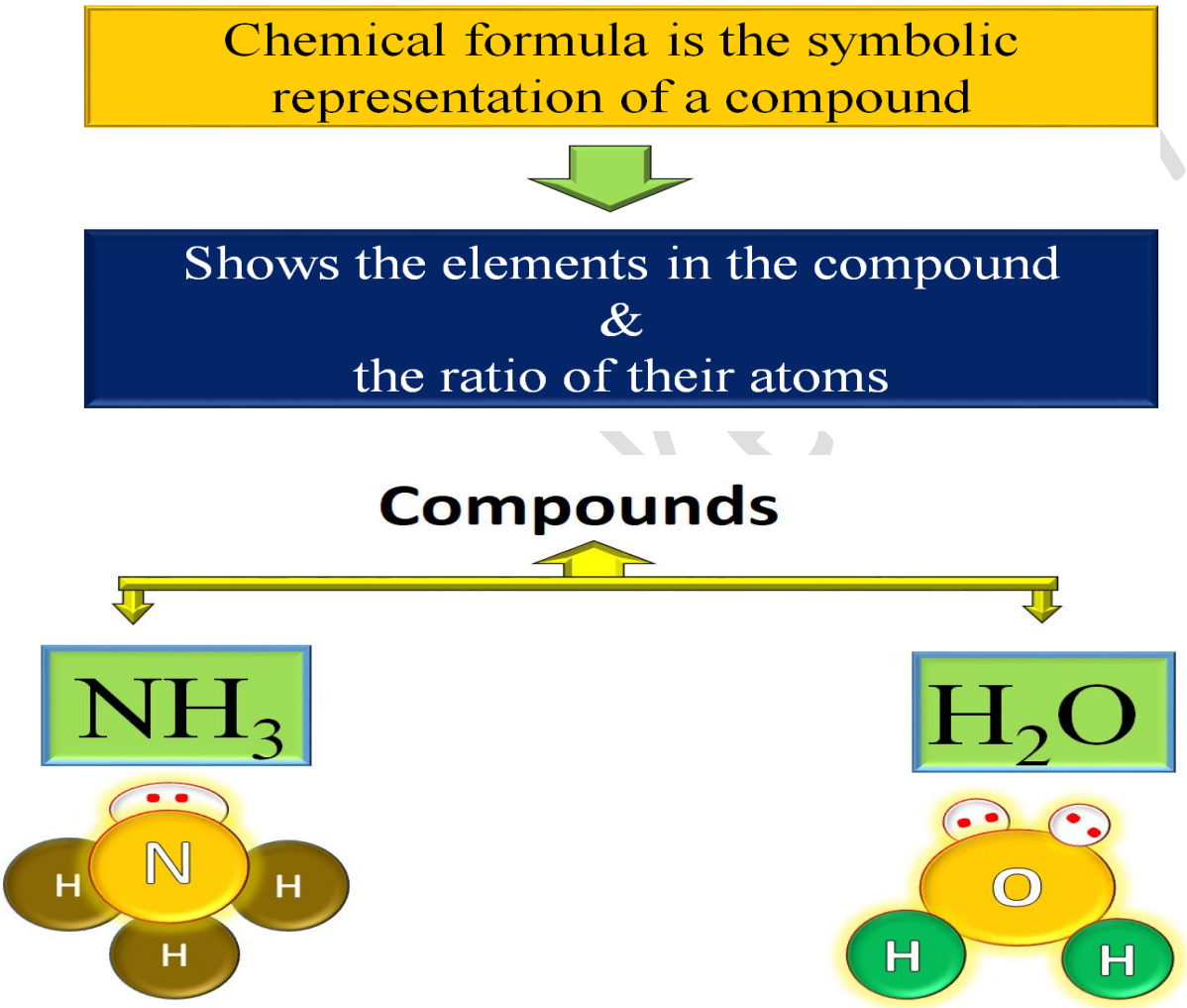
Chemical Formula

The symbolic representation of a compound that shows elements in the compound and also the ratio of their atoms is called the chemical formula.



CHEMICAL FORMULAS Examples

Calcium Carbonate = $CaCO_3$

Water = H_2O

Sulphuric acid = H_2SO_4

Benzene = C_6H_6

Types of Chemical Formulas

- Empirical Formula
- Molecular Formula

Empirical Formula

The chemical formula that gives the simplest or the most reduced whole number ratio of atoms present in a compound is called the empirical formula.

e.g.
Chemical formula of Benzene is C_6H_6

Benzene = CH
(Empirical Formula)

Benzene = C_6H_6

C : H

6 : 6

6 6

~~6~~ : ~~6~~

~~6~~ ~~6~~

1 : 1

Empirical Formula of H_2O_2

The actual formula for hydrogen peroxide is H_2O_2 which shows that there is one hydrogen atom for every oxygen atom. Therefore the simplest ratio of hydrogen to oxygen is 1:1.So the empirical formula of hydrogen peroxide is HO.

Molecular Formula

The chemical formula that gives the actual number of atoms present in one molecule of a compound is called the molecular formula.

The molecular formula could be derived from the empirical formula in the following way i.e

Molecular formula = n(Empirical formula)

where n could be equal to 1,2,3,4,5...

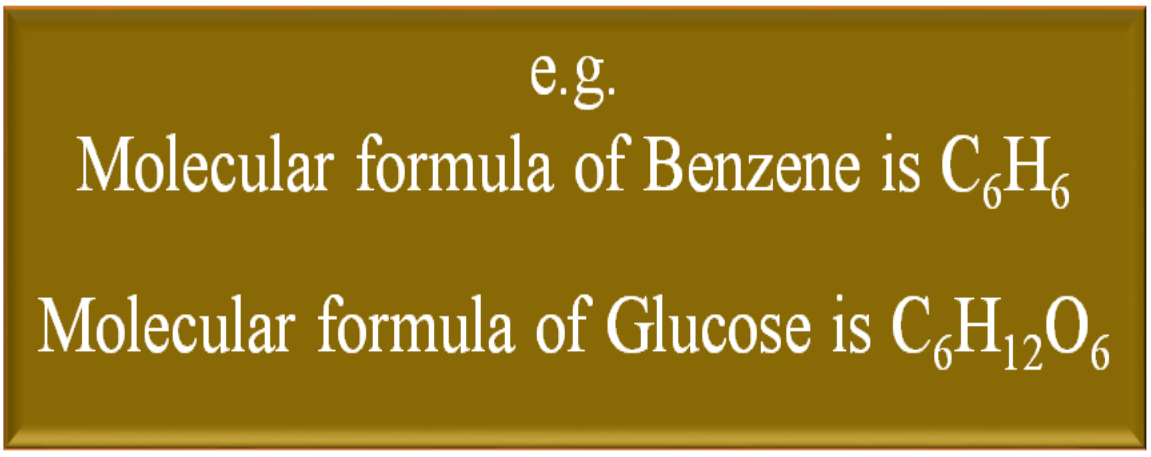
For example

The empirical formula of benzene is CH so its Molecular Formula could be derived in the following way i.e

The molecular formula of Benzene =n(CH)

Here the value of n = 6

So Molecular formula of benzene=C_6H_6



COMPOUND	*EMPIRICAL FORMULA*	*MOLECULAR FORMULA*
GLUCOSE	CH_2O	$C_6H_{12}O_6$
ETHENE	CH_2	C_2H_4

****

Vinegar is 5% acetic acid. This contains 2 carbon atoms, four hydrogen atoms, and 2 oxygen atoms. Write its empirical and molecular formulas.

Given:

Number of carbon atoms = 2

Number of hydrogen atoms = 4

Number of oxygen atoms = 2

Find out its empirical and molecular formulas

Solution:

C: H: O

2: 4: 2

Molecular formula = $C_2H_4O_2$

C	:	H	:	O
$\frac{2}{2}$	:	$\frac{4}{2}$	:	$\frac{2}{2}$
1	:	2	:	1

Empirical formula = CH_2O

****

Caffeine ($C_8H_{10}N_4O_2$) is found in tea and coffee. Write its empirical formula.

Given:

Molecular formula = $C_8H_{10}N_4O_2$

Find out its empirical formula

Solution:

$$\underset{8}{C_8} : \underset{10}{H_{10}} : \underset{4}{N_4} : \underset{2}{O_2}$$

$$\frac{8}{2} : \frac{10}{2} : \frac{4}{2} : \frac{2}{2}$$

$$4 : 5 : 2 : 1$$

Empirical formula = $C_4H_5N_2O$

****

Why do some compounds have the same empirical and molecular formula?

If the chemical formula cannot be further reduced, the empirical formula and molecular formula are same.

Compound	Empirical formula	Molecular formula
Ammonia	NH_3	NH_3
Carbon dioxide	CO_2	CO_2
Water	H_2O	H_2O

****

Molecular mass

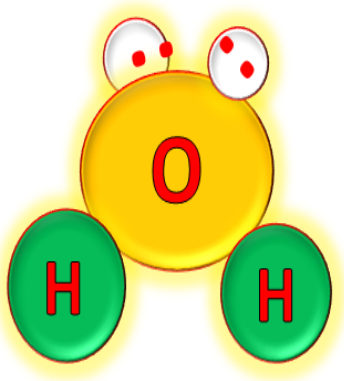
Molecular mass is defined as " the sum of atomic masses of all the atoms present in the molecule ".

To find the molecular mass of a compound, you have to add up the atomic masses of all the atoms

In the compound.

For Example

Molecular mass of H_2O



H_2O

=2(atomic mass of H) + atomic mass of O

Molecular mass of H_2O

=2(atomic mass of H) + atomic mass of O

=2 (1) + 16

=2 + 16

=18 amu

Molecular mass of NH_3

NH3

=14 + 3 (1)

=14 +3

=17 amu

****

1. Determine the molecular mass of glucose $C_6H_{12}O_6$ which is also known as blood sugar.

Problem solving strategy

Multiply the atomic mass of carbon, hydrogen and oxygen by their subscripts and add.

SOLUTION

Molecular mass of $C_6H_{12}O_6$ = 6(12.00) + 12(I.008) + 6(16.00)

= 180.096 amu

****

Determine the molecular mass of naphthalene $C_{10}H_8$ which is used in mothballs

Problem solving strategy

Multiply the atomic mass of carbon, and hydrogen by their subscripts and add.

SOLUTION

Molecular mass of $C_{10}H_8$ = 10 (12)+ 8 (1)

= 120 + 8

= 128 amu

.....

Difference between Molar mass and Molecular mass

	Molar mass	Molecular mass
Definition	Molar mass refer to the mass of one mole of a substance (atoms , molecules or formula units)	Molecular mass refer to the mass of a single molecule
Unit	Measured in g/mol	Measured in amu
Components	Measurement is given to atoms, molecules and compounds	Measurement is given to molecules only
Examples	For example : Mass of 1 mole of oxygen atom = 16 g Molar mass of O-atom= 16 g/mol	For example : Molecular mass of Ca(OH)2 = 74 amu
	Mass of 1 mole of water molecule =18 g Molar mass of H_2O = 18 g/mol	Mass of 1 mole of water molecule =18 g Molecular mass of H_2O = 18 amu

****

Formula unit

The smallest repeating unit of an ionic compound which shows the simplest ratio between its ions is called the formula unit.

Example

The simplest ratio between Mg and Cl in the crystal lattice of MgCl is 1:1 hence the formula unit of magnesium chloride is MgCl

****

ION

When an atom loses or gains an electron it becomes a charged particle known as an ion.

EXPLANATION

The most of the time, an atom is electrically neutral, but when it takes or loses an electron, it acquires a charge and becomes an ion.

Types of Ions

There are two types of ions

- Cation
- Anion

CATION

The charged specie that is formed by the loss of electrons is known as a cation.

The number of protons are greater than electrons in a cation

EXAMPLE

Mg^{+2} , H^{+1}

ANION

The charged specie that is formed by the gain of electrons is known as an anion.

the number of electrons are greater than protons in anions.e.g Cl^{-1},O^{-2}

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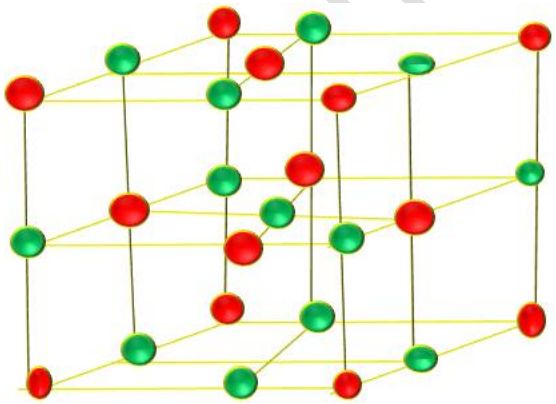
Formula Mass

The sum of atomic masses of all the atoms in the formula unit of a compound is called formula mass.

NaCl



NaCl

=23 + 35.5

=58.5 amu

The simplest ratio between cations & anions in an ionic compound is called formula unit.

Formula mass of C_3H_6O

= 12 x 3 + 1 x 6 + 16

= 36 + 6 + 16

= 58 amu

Formula mass of $MgSO_4$

= 24 + 32 + 16 x 4

= 24 + 32 + 64

= 120 amu

Molecular Ion

When a molecule gains or loses electrons, the resulting species is called a molecular ion.

Molecular ions that contain a positive charge are formed by the loss of an electron from neutral molecules.

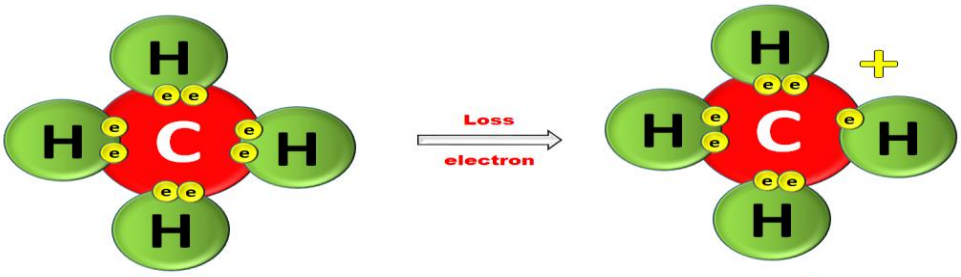
Molecular ions having a negative charge are formed by the gain of an electron from neutral molecules

Examples

Positive molecular ions are known as molecular cations E.g

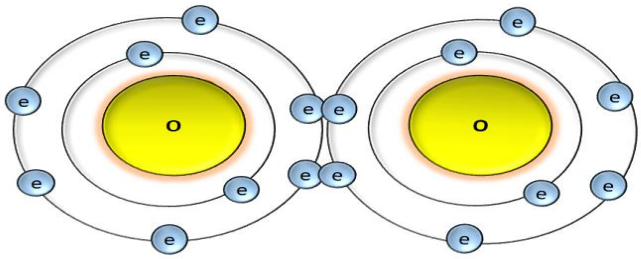
O_2^+ ,CH_4^+ , H_3O^+ , NH_4^+

CH_4^+ Formation



$$CH_4 \longrightarrow CH_4^+ + 1e^-$$

O_2^+ Formation

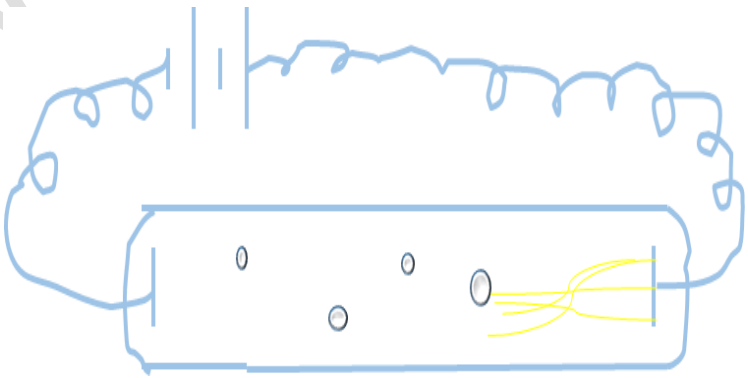


$$O_2 \longrightarrow O_2^+ + 1e^-$$

Negative molecular ions are known as molecular anions E.g

$SO4^{-2}$, OH^-

How molecular ions are formed?

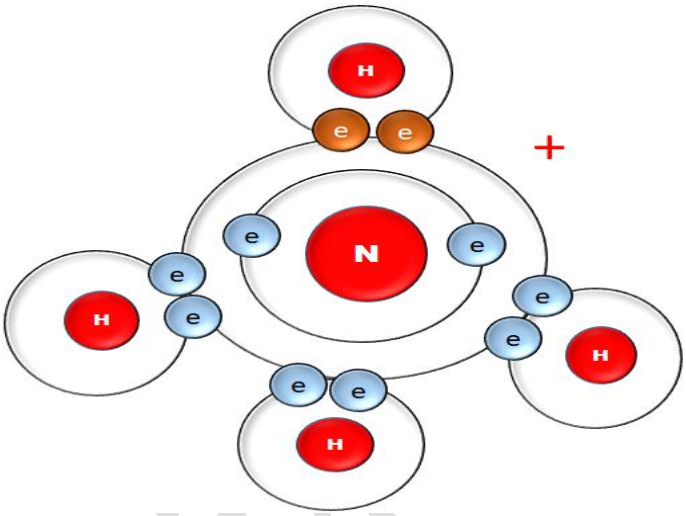


Molecular ions are formed by bombarding high-energy radiations such as **alpha particles** or **X-rays** on gas molecules.

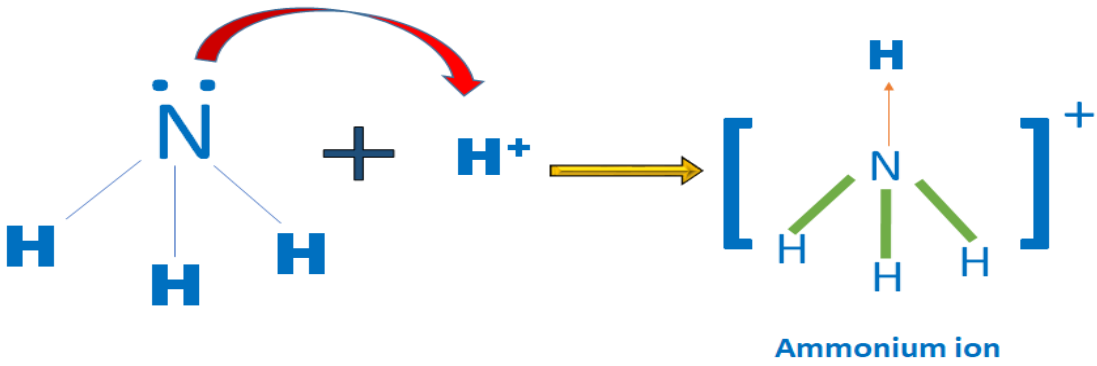
These Radiations knocked out the electrons from gas molecules, resulting in the formation of cationic molecular Ions.

Cationic molecular ions are more common than anionic molecular ions.

Why Ammonium ion is not a molecular ion?



The ammonium ion is formed by the coordinate covalent bond between ammonia (NH3) and hydrogen ion (H+).



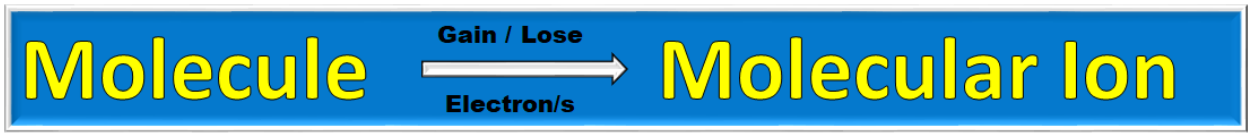
Ammonium ion

Note:

A coordinate covalent bond is a type of covalent bond where only one atom(donor) donates the electron pair to another atom(acceptor).

whereas:

When a molecule gains or loses electrons, the resulting species is called a molecular ion.



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Free Radical

An atom or molecule having an unpaired electron in its valence shell is termed a free radical.

$^{\bullet}H$ $^{\bullet}Cl$ $^{\bullet}Br$ $^{\bullet}CH_3$

Chemical specie (atom/molecule)
Having
unpaired(single)
Valence electron

EXPLANATION

A free radical is formed by the homolytic fission of a molecule such that each atom in the molecule obtains an unpaired electron. A free radical has no charge and is represented by a [.] on the symbol of the element. It is a highly reactive specie and cannot exist independently.

Reaction involving free radicals

$Cl2 \rightarrow 2Cl^{\cdot}$

The chlorine-free radical will react with methane CH4 to form methyl free radical.

$CH4 + Cl^{\cdot} \rightarrow CH3^{\cdot} + HCl$

Now the methyl free radical reacts with another Cl2 molecule to form chloromethane and chlorine free radical

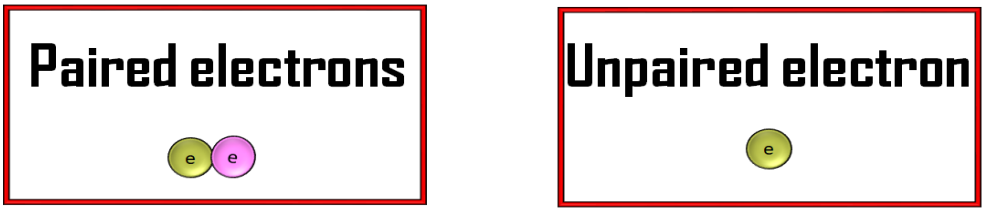
$CH3^{\cdot} + Cl2 \rightarrow CH3Cl + Cl^{\cdot}$

The reaction goes on until the formation of a stable product.

Free Radical Representation

$^{\cdot}H$ $^{\cdot}Cl$ $^{\cdot}Br$ $^{\cdot}CH_3$

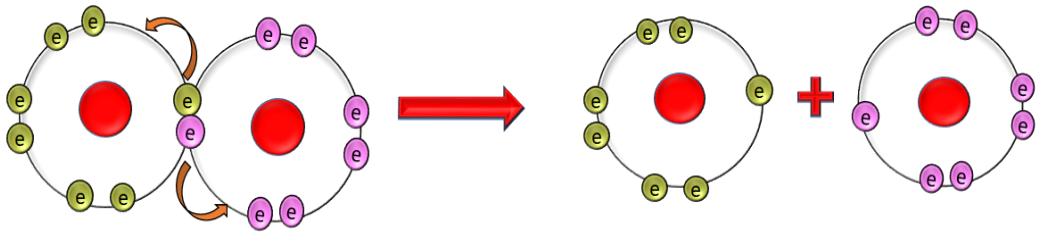
Chemical specie (atom/molecule)
Having
unpaired(single)
Valence electron



Free radical having odd no of valence electrons i.e. 1,3,5,7…..

How does free radical form?

In the presence of heat /light, homolytic breakage of the molecule occurs resulting in the formation of free radicals.



Free radicals have incomplete valence shell electrons. Due to this, they are unstable & short-lived.

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Mole

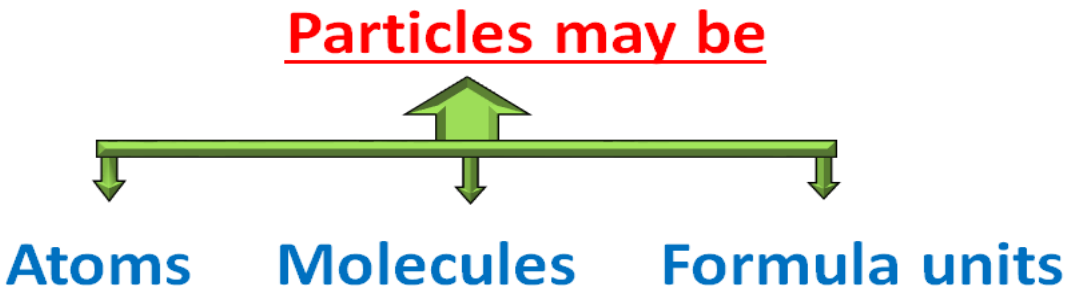
A mole is the mass of a substance that includes 6.023 x 10^{23} of the substance's particles. The mole is the SI unit used to measure substance amounts.

mol is its symbol for mole

One mole of carbon-12 weighs 12 grams and contains 6.022140857 x 10^{23} carbon atoms.

OR

Relative atomic mass, Formula mass, and Molecular mass expressed in grams is called a mole.

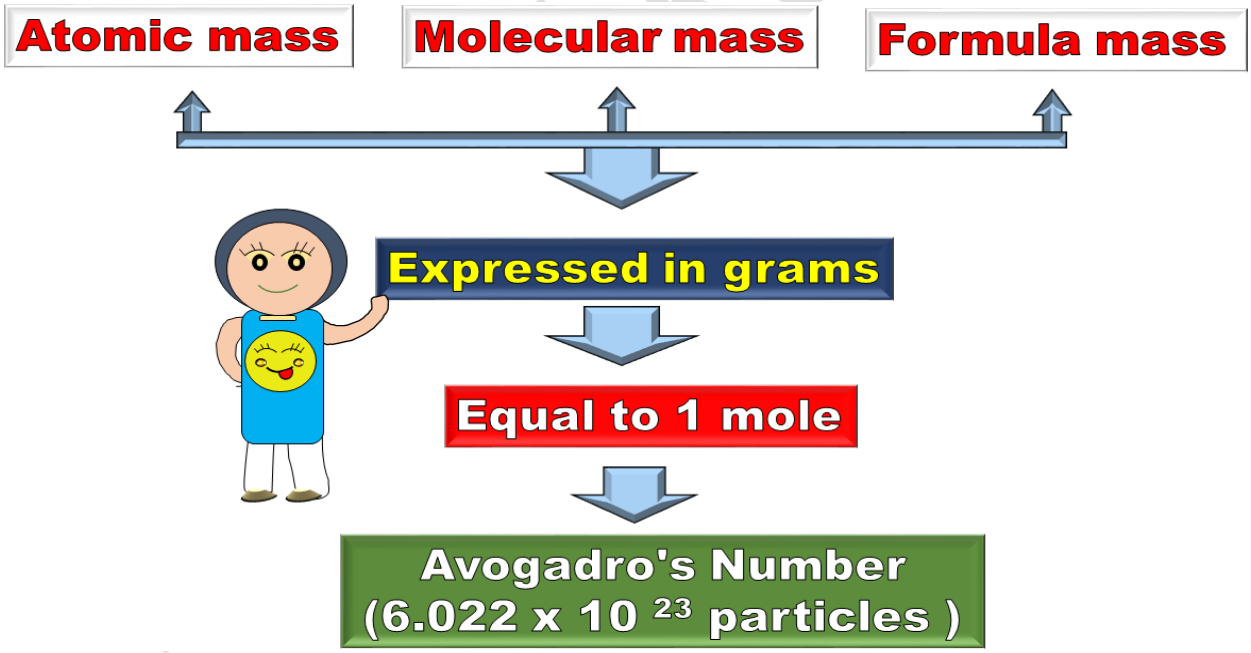


Examples

1 Mole of Oxygen =16g=6.023×10^{23} atoms

1 Mole of NaCl =58.5g=6.023×10^{23} formula units

1 Mole of water =18g=6.023×10^{23} molecules



Molar mass

The mass of one mole of particles (atoms, molecules, or formula units) expressed in grams is called molar mass.

1 mole = 6.022×10^{23} particles

For Example:

Mass of I mole of C- atom (**6.022×10^{23} atoms**) = **12 g**

Molar mass of carbon atom = **12 g/ mol**

Mass of I mole of H2O molecule (**6.022×10^{23} molecules**) = **18g**

Molar mass of water molecule = **18g / mol**

Mass of I mole of NaCl formula unit (**6.022×10^{23} formula units**) = **58.5g**

Molar mass of NaCl formula unit = **58.5g /mol**

****

Avogadro's number

The quantity of units contained in a mole of any material is known as Avogadro's number or Avogadro's constant. The value is $6.022140857 \times 10^{23}$. In accordance with the characteristics of the reaction and the material, the units might be electrons, ions, atoms, or molecules.

Therefore, the value would be as follows if you wanted to know how many particles there are in 3 moles of a substance:

= $3 \times 6.023 \times 10^{23}$

= 1.81×10^{24} particles

REPRESENTATION

It is represented by N_A

****

How to Calculate molar mass:

HCl

=1 + 35.5
=36.5 g/mol

Ca(OH)2

=40 + 2 (16) +2(1)

=40 +32 +2
=74 g/mol

NH3

=14 + 3 (1)

=14 +3
=17 g/mol

CO2

=12 + 2 (16)

=12 +32
=44 g/mol

NaCl

=23 + 35.5
=58.5 g/mol

****

The mass of 5 moles of an element X is 60g. Calculate the molar mass of this element . Also name the element.

Given data:

Mole of element X = 5 mol

Mass of element X = 60g

Required:

Molar mass of element X = ?

Solution:

Using formula to find the molar mass :

$$\text{No of moles} = \frac{\text{mass}}{\text{molar mass}}$$

Putting values in formula :

so

$$\text{molar mass} = \frac{\text{mass}}{\text{No of moles}} = \frac{60\ \text{g}}{5\ \text{mol}} = 12\ \text{g / mol}$$

Thus the molar mass of element X is **12 g/mol**

&

the element X is carbon .

How do you calculate moles from molar mass?

1st Method

A technician weighs 40g of Sodium chloride (NaCl) . How many moles of formula units are in a sample?

Given data:

Mass of NaCl = 40 g

Required:

Moles of NaCl formula units =?

Solution:

Molar mass of NaCl = 23 + 35.5 = 58.5 g/mol

We know that:

$$\text{No of moles} = \frac{\text{mass}}{\text{molar mass}}$$

$$\textbf{No of moles} = \frac{\textbf{mass}}{\textbf{molar mass}} = \frac{\textbf{40 g}}{\textbf{58.5 g/mol}}$$

= **0.684** mol of NaCl formula units

2nd Method

A technician weighs 40g of Sodium chloride (NaCl) .

How many moles of formula units are in a sample.

Given data:

Mass of NaCl = 40 g

Required:

Moles of NaCl formula units = ?

Solution:

Molar mass of NaCl = 23 + 35.5 = 58.5 g/mol

We know that :

58.5 g NaCl = 1 mole of NaCl formula units

$$40 \text{ g NaCl} = \frac{40}{58.5} \text{ mole of NaCl formula units}$$

= 0.684 mol of NaCl formula units

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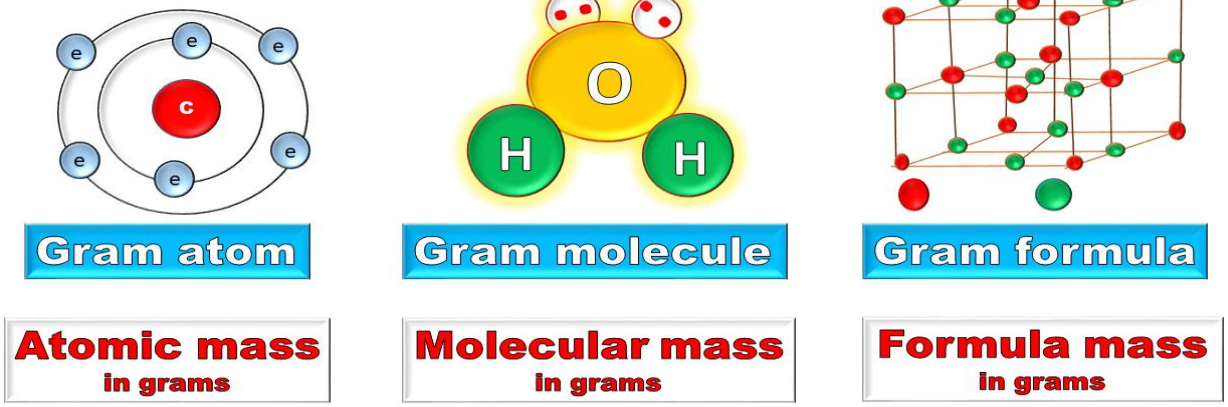
Gram Atomic Mass ,Gram Molecular Mass and Gram Formula Mass



GRAM ATOMIC MASS

Gram atomic mass is the term used to describe an element's atomic weight when stated in grams. An element's molar mass is defined as the mass of one mole in grams.

EXAMPLE

Helium, for instance, has a gram atomic mass of 4 g . Similarly sodium (Na), has a gram atomic mass of 22.99 grams and an atomic weight of 22.99 u. A mole of sodium thus weighs 22.99 g of atoms.

GRAM FORMULA MASS

Formula mass of an ionic compound expressed in grams is called gram formula mass

It can be explained with the help of following example

Formula mass of NaCl = 23 + 35.5

= 58.5amu

Therefore, gram formula mass of NaCl = 58.5g = mole of NaCl formula units.

Formula mass of KCl = 39 + 35.5

= 74.5amu. So, gram formula mass of KCl = 74.5g

GRAM MOLECULAR MASS

The mass in gram of one mole of a molecule is known as the gram molecular mass. Molar mass and gram molecular mass are equivalent. The sole distinction is that the mass unit to be utilized is specified by gram molecular mass. The mass of a molecule can be expressed in either grams or grams per mole (g/mol).

EXAMPLES

Molecular mass of H_2O = 2 x 1.008 + 16 = 18.016amu

so, gram molecular mass of H2O = 18.016g Molecular mass of C6H12O6 = 6 x 12 + 12 x 1.008 + 16 x 6 = 180.096amu So, gram molecular mass of C6H12O6 = 180.096g.

****

Differentiate between gram atomic mass, gram molecular mass, and gram formula mass.

ANSWER

Statements

1. In contrast to gram formula mass, which represents one mole of ionic formula units of a compound, gram atomic mass denotes one mole of atoms of an element. Gram molecular mass denotes one mole of molecules of a compound or an element that exists in a molecular state.
2. Gram atomic mass contains 6.022 x 10^{23} atoms, gram molecular mass contains 6.022 x 10^{23} molecules whereas gram formula mass contains 6.022 x 10^{23} formula units
3. *Therefore one mole can be defined as formula mass, atomic mass, or molecular mass expressed in grams.*

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Chemical Calculations

Determine the molar masses of sodium, nitrogen, sucrose

Solution

Molar masses of sodium Na

1 mole of Na = 23g

b) Nitrogen occurs as diatomic molecules.

Molar mass of Nitrogen N2

= 14 x 2

= 28amu

Therefore, mass of 1 mole of N2 = 28 g

Molecular mass of Sucrose $C_{12}H_{22}O_{11}$

= 12x12 + 1x22 + 16x11

= 144 + 22 + 176

Therefore, mass of 1 mole of sucrose = 342g

****

2. **Oxygen is converted to ozone O_3 during thunderstorms. Determine the mass of ozone if 9.05 moles of ozone is formed in a storm.**

Ozone is a molecular substance. Determine its molar mass and use it to convert moles to mass in grams.

9.05 moles of O_3 ⟶ ? g of O_3

Solution:

1 mole of O3 = 16 x 3 = 48 g

1 mole of O3 = 48 g

So, 9.05 moles of O3 = 48 g x 9.05

= 434.4g of O_3

****

3. When methane burns CO2 is formed is 0.25 moles of CO2 is formed what mass of CO2 is produced?

SOLUTION

Molar mass of CO2 = 12 + 16 x 2 = 44g

1 mole of CO2 = 44g of CO2

So, 0.25 moles of CO2 = 44 x 0.25 = 11g of CO2

****

4. Calculate the moles of each of the following

A. Balloon filled with 5g of hydrogen

B. A block of ice that has a mass of 100g

SOLUTION

a) Molar mass of H2 = 1.008 x 2 = 2.016g

1 mole of H2 = 2.016g

So, 2.016g of H2 = 1 mole of H2

1g of H2 = 1/2.016 moles of H2

5 gram of H2 =1÷2.016×5

5 gram of H2 = 2.48 Moles of H2

b. 1 Mole Of H2O =2×1.008+16

1 Mole of H2O =2.016+16

1Mole of H2O=18.016g

So 1 gram of H2O = 1÷18.016 moles

100 Gram of H2O= 1÷18.016×100 moles

100 grams of H2O=5.55 Moles of H2O

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4. ***Zn is a metal that is used to galvanize steel to prevent corrosion. How many atoms are there in 1.25moles of Zn?***

SOLUTION

1 mole of Zn contains = 23 6.022 x 10^{23} atoms

1.25 moles of Zn contains = 6.022 x 10^{23} x 1.25 = 7.53 x 10^{23} Zn atoms

6. Methane is one of the main components of natural gas . Calculate how many moles are in 0.5 moles of a pure sample of methane.

SOLUTION

1 mole of CH4 contains = 6.022×10^{23} molecules

So, 0.5 moles of CH4 will contain = $6.022 \times 10^{23} \times 0.5 = 3.011 \times 10^{23}$ molecules

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7. Titanium is a metal that is used in rockets. Calculate the number of moles in a sample containing 3.011×10^{23}atoms

SOLUTION

6.022×10^{23} atoms = 1 mole

3.011×10^{23}Atoms→ ? mole

6.022×10^{23} atoms = 1 mole of Ti

1 Ti atom =$1 \div 6.022 \times 10^{23}$ moles of Ti

3.011×10^{23} Ti atoms = $1 \div (6.022 \times 10^{23}) \times 3.011 \times 10^{23}$ moles of Ti

=0.5 moles of Ti

The End