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ATOMS, MOLECULES AND CHEMICAL ARITHMETIC'S

Scopeof Chemistry

- Chemistry is the study of matter and the changes it undergoes and considers both macroscopic and microscopic information. Matter is anything that has mass and occupies space. The five main disciplines of chemistry are *physical chemistry, organic chemistry, inorganic chemistry, analytical chemistry and biochemistry.*
- **Atom:** It is the smallest particle of an element that takes place in a chemical reaction. It may or may not be capable of free existence.
- **Molecule:** It is the smallest particle of an element or a compound that is capable of free existence.
- **(i)** The term molecule was given by *Avogadro.*
- **(ii)** The term element was given by *Robert Boyle.*
- **Precision:** If refers to the closeness of various measurements for the same quantity.
- **Accuracy:** It refers to the agreement of a particular value to the true value of the result
- **Mass and weight:** Mass of a substance is the amount of matter present in it while **weight** is the force exerted by gravity on an object. The mass of a substance is constant whereas its weight may vary from one place to another due to change in gravity.
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- **Standard Temperature Pressure (STP):** 0°C (273.15 K) temperature and 1 pressure.
- **Normal Temperature Pressure (NTP):** 20°C (293.15 K) temperature and 1 atm pressure.

Scientific Notation

- Expressing a number in the form $N \times 10^n$, and N can vary b/w 1 to 10.
- **Mole:** A **mole** is defined as that amount of substance which has mass equal to gram atomic mass if the substance is atomic or gram molecular mass if the substance is molecular. 1 **mole** of carbon atoms =12 grams.

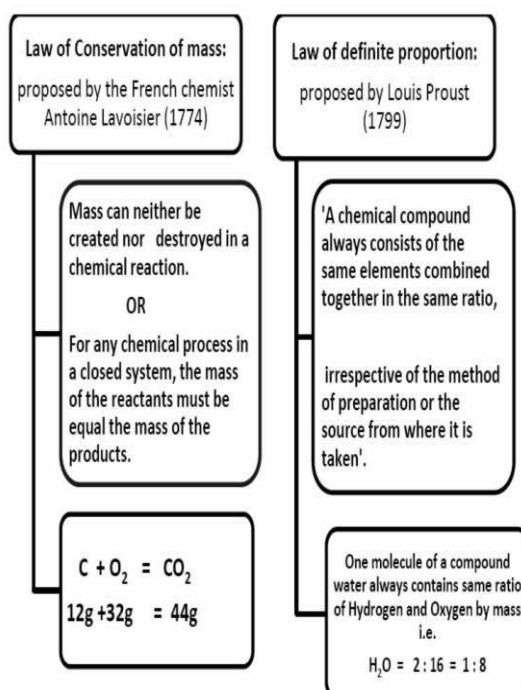## Laws Of Chemical Combinations

- In every chemical reaction, total masses of all the reactants are equal to the masses of all the products. This law is known as the law of conservation of mass.

Dalton's Atomic Theory

- **Dalton's Atomic Theory (1803):** This theory was based on laws of chemical combinations. It's basic postulates are:
- All matter is made up of tiny, indivisible particles called atoms.
- **Atoms** can neither be created nor destroyed.
- **Atomic Mass:** It is the average relative atomic mass of an atom.
- Properties. However, atoms of different element exhibit different.
- All atoms of a specific element are identical in mass, size, and other properties and vary in mass and size.

- **Gram Atomic Mass (GAM)**: Atomic mass of an element expressed in gram is called its gram atomic mass or gram-atom or mole-atom.
- **Molecular Mass**: It is the mass of a molecule, i.e., number of times a molecule is heavier than
- 1 / 12th mass of C-12 atom.
- **Limiting reagent** It is the reactant which is completely consumed during the reaction.

S. No	Compound	No. of atoms/g of carbon	No atoms/g of Oxygen	Ratio of masses C : O
1.	CO	One -12g	One-16g	12:16 or 1: 1.333g
2.	CO_2	One-12g	Two- 32g	12:32 or 1: 2.666g

Law of Conservation of mass: proposed by the French chemist Antoine Lavoisier (1774)

Mass can neither be created nor destroyed in a chemical reaction.

OR

For any chemical process in a closed system, the mass of the reactants must be equal the mass of the products.

$$C + O_2 = CO_2$$
$$12g + 32g = 44g$$

Law of definite proportion: proposed by Louis Proust (1799)

'A chemical compound always consists of the same elements combined together in the same ratio,

irrespective of the method of preparation or the source from where it is taken'.

One molecule of a compound water always contains same ratio of Hydrogen and Oxygen by mass i.e.

$$H_2O = 2 : 16 = 1 : 8$$

Test Yourself

Q. Draw all the atomic models given in your textbook and compare which one is the correct explanation for the atomic structure.

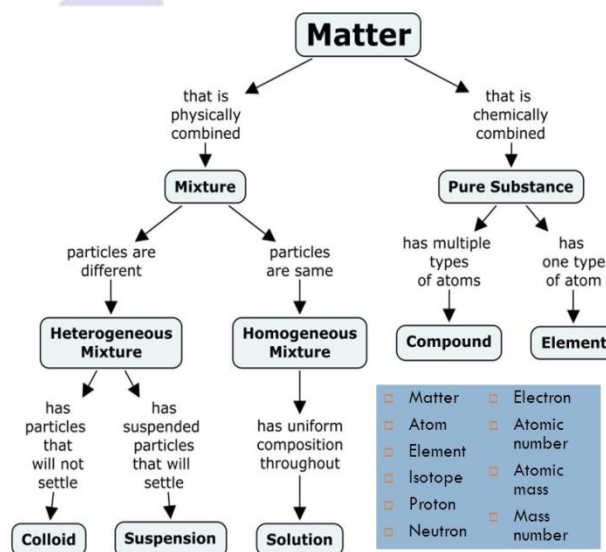Also discuss the Drawbacks of some atomic models.

- **Excess reagent** It is the reactant which is not completely consumed and remains unreacted during the reaction.
- **Empirical formula:** is the simplest formula of a compound giving simplest whole number ratio of atoms
- Present in one molecule, e.g., CH is empirical formula of benzene (C_6H_6).
- **Molecular formula** is the actual formula of a compound showing the total number of atoms of constituent elements, e.g., C_6H_6 is molecular formula of benzene.

Check Yourself

1. C-O bond length is minimum in

   (A) CO_2 (B) CO_3^{2-}

   (C) $HCOO^-$ (D) CO

2. Molecules are held together in a crystal by

 (A) Hydrogen bond

 (B) Electrostatic attraction

 (C) Van der Waal's attraction

 (D) Dipole-dipole attraction

3. Sp^3d^2 hybridization is present in

[$Co(NH_3)_6^{3+}$], find its geometry

 (A) Octahedral geometry

 (B) Square planar geometry

(C) Tetragonal geometry

 (D) Tetrahedral geometry

4. Find the molecule with the maximum dipole moment

   (A) CH_4 (B) NH_3

   (C) CO_2 (D) NF_3

5. MX_6 is a molecule with octahedral geometry. How many $X - M - X$ bonds are at 180°?

   (A) Four   (B) two

   (C) Three   (D) Six

Stretch Yourself

1. In SF_4 molecule, the lp electrons occupies an equatorial position in the trigonal bipyramidal arrangement to an axial position. Give reason.

2. Write electron dot structure (Lewis structure) of Na, Ca, B, Br, Xe, As, Ge, N^{3-}. Out of p-orbital and sp-hybrid orbital which has greater directional character and Why?

3. Explain the shape of BrF_5.

4. Explain why PCl_5 is trigonal bipyramidal whereas IF_5 is square pyramidal.

5. In both water and dimethyl ether (CH_3— Ö — CH_3), oxygen atom is central atom, and has the same hybridization, yet they have different bond angles.
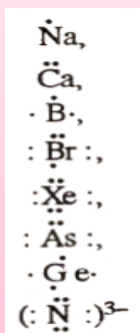
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Answers

 Check Yourself

Answer: 1(D);   2(C);   3(A);   4(B);   5(C)

Stretch Yourself

1. The lp - bp repulsions are less if it occupies equatorial position than if it occupies axial position. As a result, energy is less and stability is more.

2.

$\dot{N}a,$
$\ddot{C}a,$
$\cdot \dot{B}\cdot,$
$: \ddot{B}r :,$
$:\ddot{X}e :,$
$: \dot{A}s :,$
$\cdot \dot{G} e\cdot$
$(: \ddot{N} :)^{3-}$

3. **BrF₅:** Br is surrounded by 5 bonded pairs and one lone pair. Shape is square pyramidal.

4. In PCl₅, P has 5 valence electrons in orbital. To make 5 bonds with 5 Cl atoms, it will share one of its electrons from 3s to 3d orbital; therefore the hybridization will be sp^3d. And with sp^3d hybridization, the geometry will be trigonal bipyramidal. IF₅, the Iodine atom has 7 valence electrons in molecular orbital.

5. Dimethyl ether will have larger bond angle. There will be move more repulsion between bond pairs of −CH₃ groups attached in ether than between bond pairs of hydrogen atoms attached to oxygen in water. The carbon of −CH₃. In ether is attached to three hydrogen atoms through bond and electron pair of these bonds add to the electronic charge density on carbon atom. Hence, repulsion between two −CH₃ groups will be more than that between two hydrogen atoms.