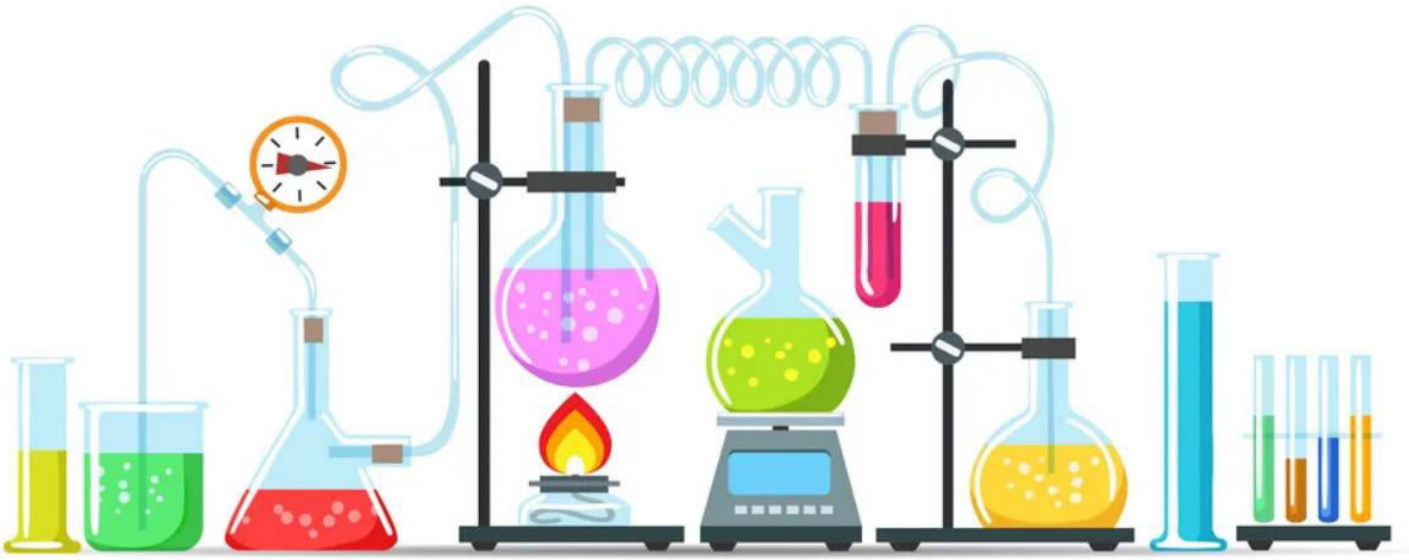
Shiksha CLASSES

CHEMISTRY

Chapter 3: Atoms And Molecules



Atoms And Molecules

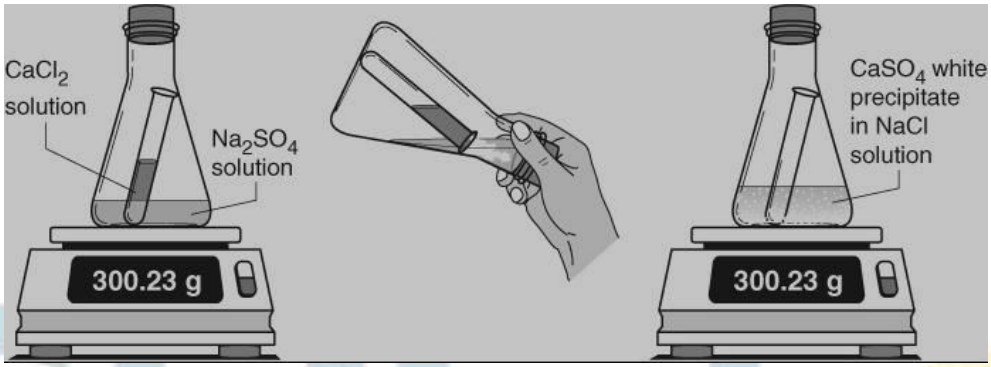
Laws of Chemical Combination

Law of Conservation of Mass

PRINCIPLE: The Law of Conservation of Mass states that mass can neither be created nor destroyed in a chemical reaction.

Total Mass of the Reactant = Total Mass of the Product

DIAGRAM:



TECHNIQUE:

- Take a solution of calcium chloride in a flask labelled A and a solution of sodium sulphate in a test tube labelled B.
- Tie a thread to the test tube and carefully lower it into the flask. Seal the flask with a cork to make it airtight.
- Weigh the flask on a balance. It weighs around 300.23 grams.
- Tilt and swirl the flask and allow the contents of the test tube to come in contact with the contents of the flask.

OBSERVATION:

- Calcium chloride reacts with sodium sulphate to form a white precipitate of calcium sulphate and a solution of sodium chloride.
- Weigh the flask again. There will be no change in the weight of the flask. It is found to weigh 300.23 grams.

CONCLUSION:

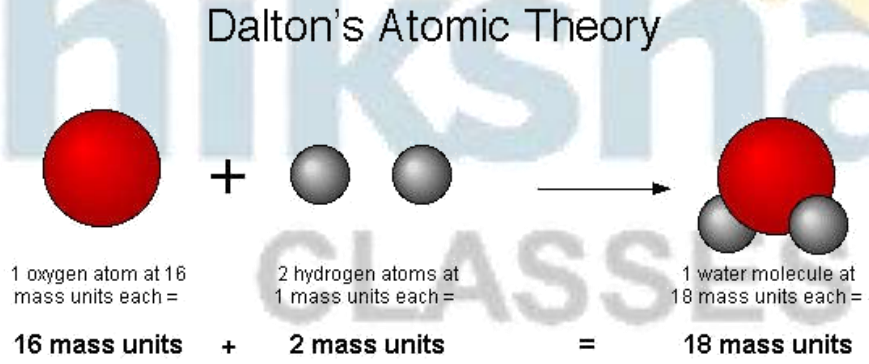
- Scientists noticed that if chemical reactions were carried out in a closed container, there was no change in the mass.

- The total mass of the reactants was equal to the total mass of the products.

Law of Constant Proportion

- According to the Law of Constant Proportion, in a chemical substance, elements are always present in a definite proportion by mass.
- For example, water obtained from any source will have the same two elements, namely hydrogen and oxygen present in it.
- 2 grams of hydrogen and 16 grams of oxygen form a molecule of water. The proportion of hydrogen and oxygen is 1 : 8 by mass. This proportion will always remain the same, irrespective of the source of water.
- Similarly, carbon dioxide obtained from any source will contain the same two elements, carbon and oxygen.
- 12 grams of carbon and 32 grams of oxygen form a molecule of carbon dioxide. Carbon dioxide obtained from any source will always have the proportion of masses of carbon and oxygen as 3 : 8.

Dalton's Atomic Theory



Dalton's theory is the basic theory about the nature of matter. According to his theory, all matter, whether a solid, liquid or gas or an element, compound or mixture, is composed of small particles called atoms.

The Postulates of Dalton's Atomic Theory

- All matter is made up of very tiny particles called atoms.
- Atoms are indivisible particles, which can neither be created nor destroyed in a chemical reaction.
- The atoms of a given element are identical in mass and chemical properties.
- Atoms of different elements have different masses and chemical properties.

- Atoms combine in the ratio of small whole numbers to form compounds.
- The relative number and types of atoms are constant in a given compound.

The Atom: Its Size, Mass and Symbol

- An atom is very small in size and consists of subatomic particles protons, neutrons and electrons.
- About one million atoms stacked up one over the other would roughly equal the thickness

> Atomic radius is measured in nanometers.
> $\frac{1}{10^9}$ m = 1 nm
> 1 m = 10^9 nm

of a sheet of a paper.

Modern Day Symbols of Atoms of Different Elements

- Dalton was the first scientist to use symbols for elements. He used circles to represent elements.
- Berzelius suggested that the symbols of the elements can be made from one to two letters of the name of the element.
- Now, we use names and symbols as stated by IUPAC i.e. the International Union of Pure and Applied Chemistry.
- Many symbols are the first letter or the first two letters of the name of the element.

Name	Symbol
Carbon	C
Nitrogen	N
Calcium	Ca
Aluminium	Al

- The symbols of some elements are formed from the first letter of the name and a letter appearing later in the name.

Name	Symbol
Chlorine	Cl
Magnesium	Mg

- The symbols for some elements were derived from their Latin, German or Greek names.

English name of the element	Latin name of the element	Symbol
Sodium	Natrium	Na

Potassium	Kalium	K
Iron	Ferrum	Fe
Copper	Cuprum	Cu
Silver	Argentum	Ag
Gold	Aurum	Au
Mercury	Hydrargyrum	Hg
Lead	Plumbum	Pb
Tin	Stannum	Sn

Modern Symbols of Elements

The modern symbols of elements are derived from their English or Latin names, which are made up of either the first letter, the first and second letter or the first letter and a letter appearing later in the name of the element.

Name of element	Symbol	Latin Name	Name of element	Symbol	Latin Name
Hydrogen	H	—	Nickel	Ni	—
Oxygen	O	—	Manganese	Mn	—
Boron	B	—	**Ca**lcium	Ca	—
Carbon	C	—	**Ch**lorine	Cl	—
Fluorine	F	—	**Br**omine	Br	—
Iodine	I	—	**Ch**romium	Cr	—
Nitrogen	N	—	**Co**balt	Co	—
Phosphorus	P	—	Lead	Pb	**Plumb**um
Sulphur	S	—	Mercury	Hg	**Hydrarg**yrum
Barium	Ba	—	Phosphorus	P	—
Iron	Fe	**Fe**rrum	Sodium	Na	**Na**trium
Gold	Au	**Au**rum	Potassium	K	**K**alium
Silver	Ag	**Ar**gentum	Tin	Sn	**Stan**num
Tungsten	W	**W**olfram (German name)	**U**ranium	U	—
Lithium	Li	—	Zinc	Zn	—

Significance of Symbol of an Element

The symbol of an element signifies

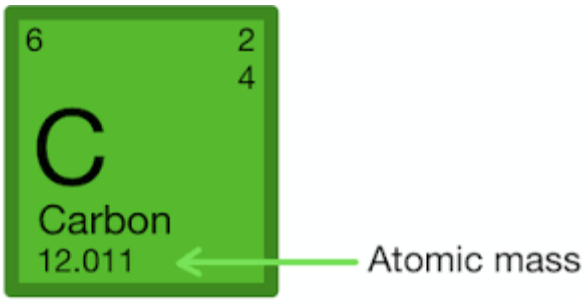
1. The name of the element.
2. An atom of the element.

For example-

The symbol N stands for,

1. The element nitrogen.
2. An atom of the element nitrogen.

Atomic Mass



- Earlier, hydrogen was taken as a standard for measuring the atomic masses of elements.
- Later, carbon-12 isotope was chosen as a standard for measuring the atomic masses of elements.
- Similarly, the relative atomic mass of the atom of an element is defined as the average mass of the

  atom, as compared $\frac{1}{12}$th the mass of one carbon-12 atom.
- The masses of all other atoms are determined relative to the mass of an atom of carbon–12 as the standard.
- Carbon–12 atom has been assigned an atomic mass of exactly 12 atomic mass units, abbreviated as amu, i.e. 12 amu. Recently, the unit of atomic mass, amu was replaced by u, meaning unified mass.
- Now, since carbon–12 atom has been assigned an atomic mass of 12 amu, therefore, the atomic mass unit should be equal $\frac{1}{12}$th (one twelfth) of the mass of a carbon–12 atom.

1 atomic mass unit (amu) or 1 u = $\frac{1}{12}$th the mass of carbon–12 atom

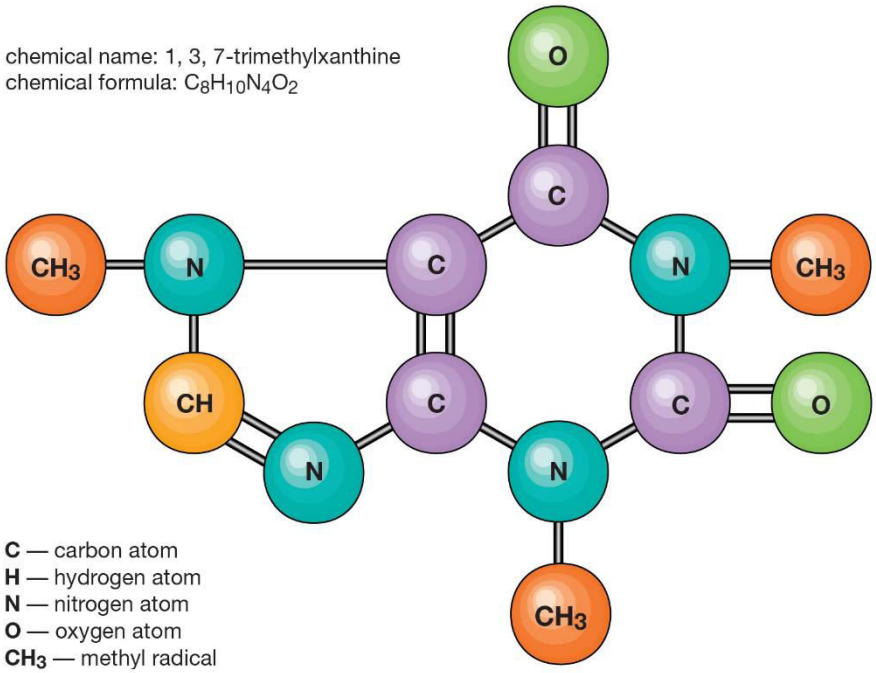
Definition of the atomic mass unit (amu or u):
One atomic mass unit is a mass unit equal to exactly one twelfth $\frac{1}{12}$th the mass of one atom of carbon–12.

How do Atoms Exist?

- Atoms of a few elements such as noble gases like helium, neon, argon and krypton etc. exist in the free state, that is as single atoms.

- But most elements, being chemically reactive, do not exist in the free state. They either exist as molecules or ions.
- For example, an iodine crystal is a collection of many iodine molecules. These molecules are so tiny that they are not visible to the naked eye. But, what is visible is the entire iodine crystal.
- Similarly, in sodium chloride, the sodium ions and chloride ions being very tiny are not visible. But, we see the compound sodium chloride as a white powder which is made up of several sodium and chloride ions.

Molecule



- A molecule is a group of two or more atoms chemically bonded together. A molecule is the smallest particle of an element or a compound which has properties of the element or the compound and can exist in a free state.
- Molecules can be formed either by the combination of atoms of the same element or of different elements.
- Thus, there are two types of molecules — molecules of elements and molecules of compounds.

Molecules of Elements

- A molecule of an element contains two or more similar atoms combined together.
- They are classified as diatomic, triatomic, tetra-atomic and poly-atomic molecules, depending on the number of atoms present in them.

Atomicity

Atomicity is the total number of atoms present in one molecule.

Table showing atomicity of some elements

Name	Formula of molecule	Atomicity	
Helium	He	1	Monoatomic
Hydrogen	H_2	2	Diatomic
Nitrogen	N_2	2	Diatomic
Ozone	O_3	3	Triatomic
Phosphorous	P_4	4	Tetra-atomic
Sulphur	S_8	8	Poly-atomic

Molecules of Compounds

- A molecule of a compound contains two or more different types of atoms, chemically combined together.
- The atoms of different elements join together in definite proportions to form the molecules of compounds.

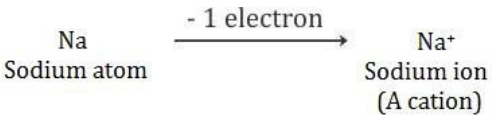
Compound	Molecular Formula	Combining Elements	Simplest ratio
Water	H_2O	Hydrogen, oxygen	1 : 8
Ammonia	NH_3	Nitrogen, hydrogen	14 : 3
Carbon dioxide	CO_2	Carbon, oxygen	3 : 8

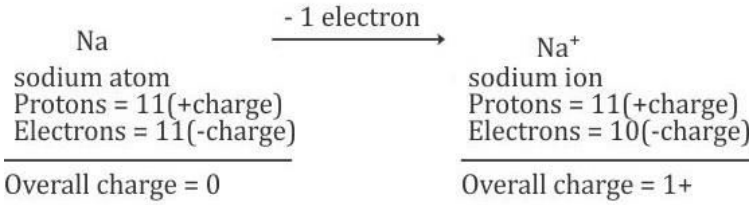
Ions and Radicals

An atom or a group of atoms can exist independently with charge(s). These are formed by the loss or gain of electron(s). They are called radicals or more commonly ions.

Types of Ions or Radicals

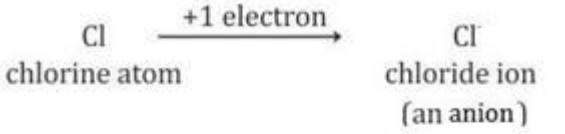
Ions are either positively charged or negatively charged.
Positively charged ions are called cations. Example: Sodium ion (Na+)

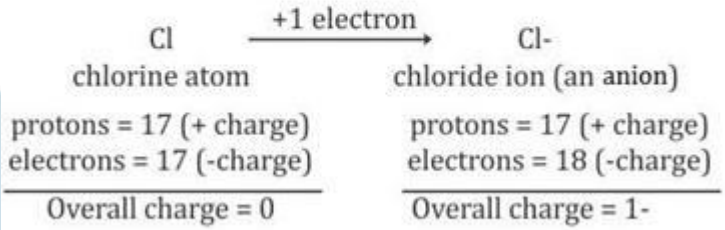




Formation of a Sodium ion

Negatively charged ions are called anions. Example: Chloride ion (Cl-)





Formation of a Chloride ion

- Sometimes, groups of atoms also give or accept electrons forming positive or negative groups of ions. Such groups of atoms having a positive or negative charge are called radicals

What does the charge indicate?

The charge indicates the valency of an ion.

Magnesium ion is written as Mg^{2+}, where the 2+ charge indicates that its valency is +2.

Sulphate ion is written as SO_4^{2-}, where the 2- charge indicates that its valency is -2.

The valencies of ions and radicals are useful in writing the chemical formulae of the compounds.

Variable Valency

Sometimes, the same element may exhibit one valency in one compound and another valency in some other compound. This property is called variable valency.

Example

Element	Symbol	Valencies exhibited (variable valencies)	
Copper	Cu	1, 2	Cu^{+1}, Cu^{+2}
Silver	Ag	1, 2	Ag^{+1}, Ag^{+2}
Gold	Au	1, 3	Au^{+1}, Au^{+3}
Iron	Fe	2, 3	Fe^{+2}, Fe^{+3}

Writing Chemical Formulae

Step 1 : Write the symbol of a basic radical (element with a positive valency) on the left hand side and that of the acidic radical (element with a negative valency) on the right hand side.

Step 2 : Write the valency number/charge of each of the respective ions at the bottom of its symbol.

Step 3 : Interchange the valency number. Ignore the (+) and (-) sign.

Step 4 : Write the interchanged number.

Step 5 : Write the compound's formula.

Step 6: Cross the reduced valencies. If 1 appears, ignore it. And if a group of atoms receives a valency number more than 1, enclose it within brackets.

Formulae of Simple Compounds

Using the valency of ions, we can write the formulae of compounds.

Formula of Aluminum chloride

Symbols	Al	Cl
Valency	3+	1-
Formula	**$AlCl_3$**	

Formula of Carbon dioxide

Symbols	C	O
Valency	4+	2-
Formula	C_2O_4 = **CO_2**	

Formula of Sodium phosphate

Symbols	Na	PO_4
Valency	1+	3-
Formula	Na_3PO_4	

Formula of Magnesium sulphate

Symbols	Mg	SO_4
Valency	2+	2-
Formula	$Mg_2(SO_4)_2$ = **$MgSO_4$**	

Formula of Ammonium bicarbonate

Symbols	NH_4	HCO_3
Valency	1+	1-
Formula	**NH_4HCO_3**	

Formula of Ammonium sulphate

Symbols	NH_4	SO_4
Valency	1+	2-
Formula	**$(NH_4)_2SO_4$**	

As we know that, if a group of atoms receives a valency number more than 1, we enclose it within brackets. Therefore, the molecular formula of ammonium sulphate is **$(NH_4)_2SO_4$.**

Significance of Molecular Formula

The molecular formula of a compound has a quantitative significance. It represents the following:

(1) The name of the substance.

(2) Both, the molecule and the molecular mass of the compound.

(3) The respective numbers of different atoms present in one molecule of a compound.

(4) The ratios of the respective masses of the elements present in the compound. Let us consider an example of carbon dioxide.

The formula CO_2 means that

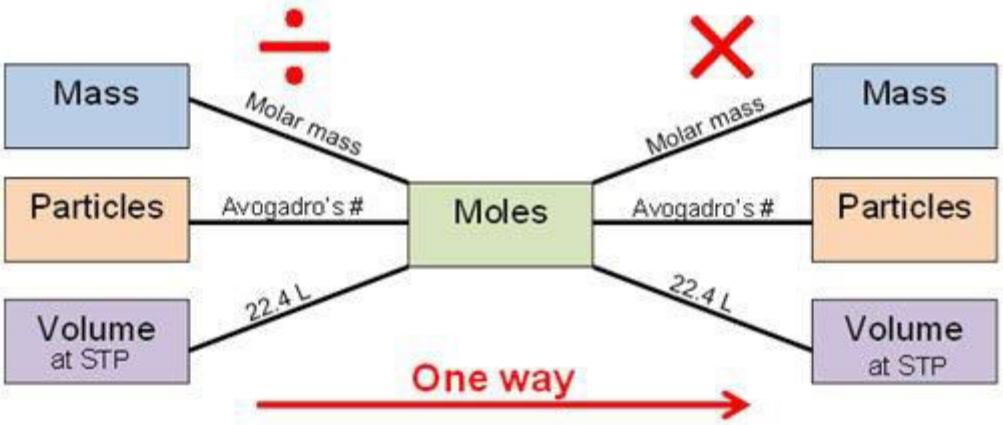
(1) It represents carbon dioxide.

(2) The molecular formula of carbon dioxide is CO_2.

(3) Each molecule contains one carbon atom joined by chemical bonds with two oxygen atoms.

The molecular mass of carbon dioxide is 44, given that the atomic mass of carbon is 12 and that of oxygen is 16.

Molecular Mass and Mole Concept



Molecular Mass

- The molecular mass of a substance is the sum of all the atoms present in one molecule of the substance. It is expressed in atomic mass unit (u).

How to determine molecular mass?

Example: Let us determine the molecular mass of water.

The molecular mass of water (H_2O) is the sum of the masses of two hydrogen atoms and one oxygen atom.

Therefore, the molecular mass of water (H_2O) = 2 × (Atomic mass of hydrogen) + 1 × (Atomic mass of oxygen).

We know that the atomic mass of hydrogen is 1 unit and that of oxygen is 16 units.

$$= 2 \times (1) + 1 \times (16)$$
$$= 2 + 16$$
$$= 18 \text{ u}$$

Therefore, the molecular mass of water is **18 u**.

Formula Unit Mass

- The formula unit mass of a substance is the sum of the atomic masses of all the atoms in a formula unit of a compound.
- We do not use term molecular mass for ionic compounds. Thus, we use term formula unit for those substances whose constituent particles are ions.

How to determine formula unit mass?

The formula unit mass is calculated in the same manner as we calculate the molecular mass. The only difference is that we use the term formula unit for those substances whose constituent particles are ions.

Mole Concept

- We know that a dozen is a collection of 12 substances, a century is a collection of 100 substances and a gross is a collection of 144 substances.
- We use the terms dozen, century, gross etc. to express a certain quantity of a substance.
- Similarly, a mole is a word used to describe a collection of particles i.e. atoms, molecules or ions.

Definition of a Mole

1 mole of a substance is equal to its atomic mass or molecular mass expressed in grams.

- The atomic mass expressed in grams is the gram atomic mass.
- The molecular mass expressed in grams is the gram molecular mass. For example
- The atomic mass of sodium is 23 grams.
  Therefore, 23 grams of sodium is equal to one mole of sodium atoms.
- Similarly, the molecular mass of oxygen (O_2) = 2 × Atomic mass of oxygen
  = 2 × 16 = 32 g

Avogadro experimentally found that one mole of any substance always contained 6.022 × 10^{23} particles. This number is called the Avogadro's number, denoted by N_0.

1 mole (of anything) = 6.022 × 10^{23} in number

For Example

How many molecules will be present in 2 grams of hydrogen gas (H_2)?

1 mole of hydrogen molecules = molecular mass of hydrogen
= 2 grams

We know that 1 mole of hydrogen molecules contains 6.022 × 10^{23} hydrogen molecules.

∴ 2 grams of hydrogen gas will also contain 6.022 × 10^{23} hydrogen molecules.

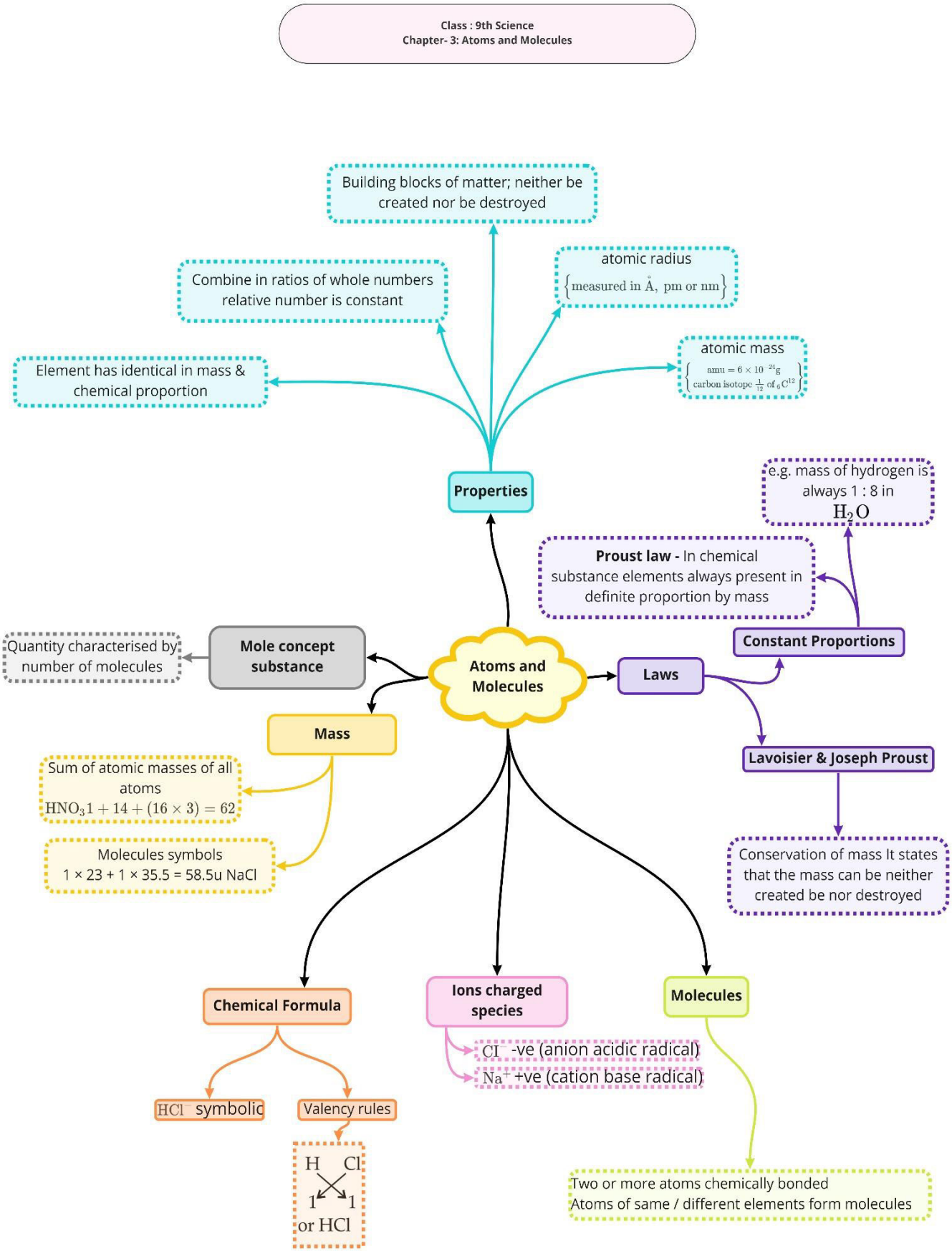
Important Formulae

Number of moles = n

Given mass = m

Molar mass = M

Given number of particles = N



Important Questions

➢ Multiple Choice Questions:

1. Which of the following correctly represents 360g of water?

(i) 2 moles of water

(ii) 20 moles of water

(iii) 6.022×10^{23} molecules of water

(iv) 1.2044×10^{25} molecules of water

(a) (i)

(b) (i) and (iv)

(c) (ii) and (iii)

(d) (ii) and (iv)

2. Which of the following statements is not true about an atom?

(a) Atoms are not able to exist independently.

(b) Atoms are the basic units from which molecules and ions are formed.

(c) Atoms are always neutral in nature.

(d) Atoms aggregate in large numbers to form the matter that we can see, feel or touch.

3. 1 u or 1 amu means

(a) 1/12th mass of C-12 atoms

(b) Mass of C-12 atom

(c) Mass of O-16 atom

(d) Mass of Hydrogen molecule

4. Which of the following contains maximum number of molecules?

(a) 19 CO_2

(b) 1g N_2

(c) 1g H_2

(d) 1g CH_4

5. A sample of NH3 molecule irrespective of source contains 82.35% Nitrogen and 17.65% of Hydrogen by mass. This data supports:

(a) Law of Conservation of Mass

(b) Las of Multiple Proportions

(c) Law of Definite Proportions

(d) Avogadro's Law

6. An element X is divalent and another element Y is tetravalent. The compound formed by these two elements will be:

(a) XY

(b) XY_2

(c) X_2Y

(d) XY_4

7. The molecular formula of potassium nitrate is _____.

(a) KNO_3

(b) KNO

(c) KNO_2

(d) KON

8. 3.42 g of sucrose are dissolved in 18 g of water in a beaker. The numbers of oxygen atoms in the solution are:

(a) 6.68 × 1023

(b) 6.09 × 1022

(c) 6.022 × 1023

(d) 6.022 × 1021

9. Molecular mass is defined as the:

(a) Mass of one molecule of any substance compared with the mass of one atom of C – 12

(b) Mass of one atom compared with the mass of one atom of hydrogen

(c) Mass of one atom compared with the mass of one molecule

(d) None of the above

10. A change in the physical state can be brought about

(a) only when energy is given to the system

(b) only when energy is taken out from the system

(c) When energy is either given to, or taken out from the system

(d) Without any energy change

11. The atomic mass of sodium is 23. The number of moles in 46g of sodium is _____.

(a) 4

(b) 2

(c) 0

(d) ½

12. Which of the following represents a correct chemical formula?

(a) CaCl

(b) $BiPO_4$

(c) $NaSO_4$

(d) NaS

13. What is the formula mass unit of ZnO?

(a) 18 u

(b) 81 u

(c) 88 u

(d) 188 u

14. How many atoms of oxygen are present in 300 grams of CaCO3?

(a) 54.207 × 1023

(b) 6.207 × 1023

(c) 12.207 × 1023

(d) 22.2 × 1023

15. Which of the following represents the correct relation between Avogadro's number (No), number of particles (N) and moles (n)?

(a) $n = N / N_o$

(b) n = No / N

(c) $n = N N_o$

(d) all are correct

➢ Very Short Question:

1. Define law of conservation of mass.
2. Explain law of constant proportion.
3. Who coined the term atom?
4. Define atom.

5. Define molecule.

6. Define atomicity.

7. What is atomic mass unit?

8. How do atoms exist?

9. Give the atomicity of phosphorous and nitrogen.

10. What is an ion?

➢ Short Questions:

1. Give the unit to measure size of atom and give size of hydrogen atom.

2. What is IUPAC, give its one function?

3. Give the Latin name for sodium, potassium, gold and mercury.

4. What is the ratio by mass of combining elements in H_2O, CO_2 and NH_3?

5. Define valency and give the valency for the following elements:

6. What is polyatomic ton? Give one example.

7. Write down the formula for:

Copper nitrate, calcium sulphate and aluminium hydroxide.

8. What is formula unit mass? How is it different from molecular mass?

➢ Long Questions:

1. (a) How do atoms exist?

(b) What is atomicity?

(c) What are polyatomic ions?

2. Calculate

(a) the mass of one atom of oxygen

(b) the mass of one molecule of oxygen

(c) the mass of one mole of oxygen gas

(d) the mass of one ion of oxygen

(e) the number of atoms in 1 mole of oxygen molecule

3. What is meant by atomic mass, gram atomic mass of an element? Why is the mass have different expressions i.e., ‘u’ and ‘g’?

➢ Assertion Reason Questions:

1. For two statements are given- one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

   a. Both Assertion and Reason are correct, and reason is the correct explanation for assertion.

   b. Both Assertion and Reason are correct, and Reason is not the correct explanation for Assertion.

   c. Assertion is true but Reason is false.

   d. Both Assertion and Reason are false.

   Assertion: Atom is the smallest unit of molecule

   Reason: Atom is not seen by our naked eyes.

2. For two statements are given- one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

   a. Both Assertion and Reason are correct, and reason is the correct explanation for assertion.

   b. Both Assertion and Reason are correct, and Reason is not the correct explanation for Assertion.

   c. Assertion is true but Reason is false.

   d. Both Assertion and Reason are false.

   Assertion: Atom is the smallest unit of molecule

   Reason: Atoms are combined with each other forming molecule.

   Case Study Question:

   1. Read the passage and answer any four questions:

      The simplest compounds, which are made up of two different elements are called binary compounds. While writing the chemical formulae for compounds, the constituent elements and their valencies are written. Then crossover the valencies of the combining atoms. For the ionic compound, the symbol of cation written first followed by the symbol of the anion. Then their charges are criss-crossed to get the formula. The positive and negative charges must balance each other and the overall structure must be neutral. The molecular mass of a substance is the sum of the atomic masses of all the atoms in a molecule of the substance.

      i. Which of the following statement correctly justifies that crystallisation technique considered better than simple evaporation to purify solid?

         a. Solid decompose or get charred on heating to dryness.

b. Impurities may remain dissolved in the solution even after filtration.

c. Both (a) and (b)

d. Impurities are easily removed in solution.

ii. In magnesium chloride, chloride ions for each magnesium ion.

a. one

b. two

c. three

d. four

iii. The molecular mass of HNO_3 is

a. 63u

b. 7u

c. 54u

d. 45u

iv. The formula unit mass of $CaCl_2$ is

a. 111u

b. 342u

c. 213u

d. 122u

v. The formula unit mass of a substance is:

a. the sum of the atomic masses of all atoms.

b. the sum of the atomic mass of only one atom

c. both (a) and (b)

d. none of these

2. Atoms are too small, or they are smaller than anything that we can imagine or compare with. Our entire world is made up of atom. Dalton was the first scientist to use the symbols for elements in a very specific sense. When he used a symbol for an element he also meant a definite quantity of that element, that is, one atom of that element. In the beginning, the names of elements were derived from the name of the place where they were found for the first time. For example, the name copper was taken from Cyprus. Many of the symbols are the first one or two letters of the element's name in English. The first letter of a symbol is always written as a capital letter (uppercase) and the second letter as a small letter (lowercase)

i. 1m is equal to nm

a. 1010

b. 109

c. 108

d. 106

ii. is the symbol of

a. sulphur

b. iron

c. silver

d. mercury

iii. Who suggested the symbol of elements are made from one or two-letter of the atom?

a. Proust

b. Berzelius

c. Boyle

d. Robert

iv. Law of constant proportion is given by

a. Proust

b. Lavoisier

c. Dalton

d. Berzelius

v. Full form of IUPAC

a. International Union of Pure and Applied Chemistry

b. International Unity of Pure and Applied Chemistry

c. Indian Union of Pure and Applied Chemistry

d. none of these

✓ Answer Key-

➢ Multiple Choice Answers:

1. (d) (ii) and (iv)
2. (d) Atoms aggregate in large numbers to form the matter that we can see, feel or touch.

3. (a) 1/12th mass of C-12 atoms
4. (c) 1g H_2
5. (c) Law of Definite Proportions
6. (b) XY_2
7. (a) KNO_3
8. (a) 6.68×10^{23}
9. (a) Mass of one molecule of any substance compared with the mass of one atom of C – 12
10. (c) When energy is either given to, or taken out from the system
11. (b) 2
12. (b) $BiPO_4$
13. (b) 81 u
14. (a) 54.207×10^{23}
15. (a) $n = N / N_o$

➢ Very Short Answers:

1. Answer: In a chemical reaction mass can neither be created nor destroyed.

   E.g., $2Na + Cl_2 \rightarrow 2NaCl$

   $2 \times 23 + 2 \times 35.5 \rightarrow 2(23 + 35.5)$
2. Answer: In a chemical substance the elements are always present in definite proportions by mass.

   E.g., In water, the ratio of the mass of hydrogen to the mass of oxygen H : O is always 1:8
3. Answer: John Dalton coined the term atom.
4. Answer: The smallest particle of matter, which can take part in a chemical reaction is called atom.
5. Answer: The smallest particle of an element or compound which can exist independently is called molecule.
6. Answer: The number of atoms constituting a molecule is known as its atomicity.
7. Answer: The sum of the atomic masses of all the atoms in a molecule of the substance is expressed.in atomic mass unit. E.g., $H_2O = 1 \times 2 + 16 = 18$ amu
8. Answer: Atoms exist in the form of atom, molecule or ions.
9. Answer. The atomicity of phosphorus is P_4 i.e., 4.

The atomicity of nitrogen is N_2 i.e., 2.

10. Answer: Charged atom is called as an ion. The ion can be positively charged called cation or negatively charged called anion.

➢ Short Answer:

1. Answer: The unit to measure size of atom, is nanometer, size of hydrogen atom is 10^{-10}m.
2. Answer: IUPAC is International Union for Pure and Applied Chemistry. It approves the names of elements.
3. Answer:
   - Sodium → Natrium, Gold → Aurum
   - Potassium → Kalium, Mercury → Hydrargyrum
4. Answer:
   - H_2O ratio by mass of combining elements 2 : 16 → 1 : 8 (H : O)
   - CO_2 ratio by mass of combining elements 12 : 32 → 3 : 08 (C : O)
   - NH_3 ratio by mass of combining elements 14 : 3 → 14 : 3 (N : H)
5. Answer: Valency: The combining capacity of an element is called its valency. Valency of the following elements:

   Magnesium – 2

   Aluminium – 3

   Chlorine – 1

   Copper – 2
6. Answer: A group of atoms carrying a charge is known as a polyatomic ion.

   E.g., Ammonium – NH_4^+

   Nitrate – $N0_3^-$

   Copper nitrate, calcium sulphate and aluminium hydroxide.
7. Answer: Chemical formula:

   Copper nitrate → $Cu(N0_3)$

   Calcium sulphate → $CaS0_4$ Aluminium hydroxide $Al(OH)_3$
8. Answer: The formula unit mass of a substance is a sum of the atomic masses of all atoms in a formula unit of a compound. The constituent particles of formula unit mass are ions and the constituent particles of molecular mass are atoms.

➢ Long Answer:

1. Answer: (a) Atoms of some elements are not able to exist independently. For such elements atoms form molecules and ions. In case of metals and inert gases atoms can exist independently.

   Atoms of metals and inert gases: *E.g.*, Na, Mg, Al, (Metals) He, Ne, Ar (Inert gases)

   Non-metals: *E.g.*, H_2, Cl_2, P_4, S_8

   Exceptional non-metal C

   (b) The number of atoms constituting a molecule is known as its atomicity.

   E.g., O_3 → atomicity is 3

   O_2 → atomicity is 2

   (c) Polyatomic ions: When more than two atoms combine together and act like an atom with a charge on it is called polyatomic ion.

   E.g., OH^-, NO_3^-, NH_4^+

2. Answer:

(*a*) Mass of one atom of oxygen

1 mole of oxygen atom = 16 gm = 6.022×10^{23} atoms.

$$\therefore \text{Mass of one atom of oxygen} = \frac{16}{6.022 \times 10^{23}} = 2.65 \times 10^{-23}$$

(*b*) Mass of one molecule of oxygen

1 molecule of oxygen = O_2

$= 2 \times 16$

$= 32$ u

(*c*) Mass of one mole of oxygen gas

1 mole of oxygen gas is O_2 = 32 u

(*d*) Mass of one ion of oxygen

One mole of oxygen = 6.022×10^{23} atoms = 16g.

$$\text{Mass of one ion of oxygen} = \frac{16}{6.022 \times 10^{23}}$$

$= 2.65 \times 10^{-23}$

(*e*) Number of atoms in one mole of oxygen molecule

1 mole of oxygen molecule *i.e.*,

$O_2 = 6.022 \times 10^{23}$ molecules.

1 molecule of O_2 = 2 atoms.

3. Answer: The atoms are very tiny and their individual mass cannot be calculated as it is negligible. Hence the mass of atoms is expressed in units with respect to a fixed standard. Initially hydrogen atom with mass 1 was taken as standard unit by Dalton. Later, it was replaced by oxygen atom (0=16). But due to the isotopes the masses were found in fractions instead of whole number. Hence, carbon (C=12) isotope was taken as standard unit and was universally accepted.

   The atomic mass unit is equal to one twelfth (1/12) the mass of an atom of carbon-12, its unit is u.

   Gramatomic mass: When the atomic mass of an element is expressed in grams, it is called the gramatomic mass of the element.

   The mass of atoms, molecules is expressed in 'u' and the mass of moles i.e., molar mass is expressed in g.

➢ Assertion Reason Answer:

1. (b) Both Assertion and Reason are correct, and Reason is not the correct explanation for

Assertion.

2. (b) Both Assertion and Reason are correct, and Reason is not the correct explanation for Assertion.

➢ Case Study Answer:

1. Answer:

i) c) Both (a) and (b)

ii) b) two

iii) a) 63u

iv) a) 111u

v) a) sum of atomic masses of all element

2. Answer:

i) b) 10^9

ii) a) sulphur

iii) b) Berzelius

iv) a) proust

v) a) International Union of Pure and