**Introduction**

Atoms and molecules are responsible for forming tiny sand particles, gargantuan black holes and everything in between. The atom is the most fundamental unit of matter, making up everything that we see around us. It is extremely small, measuring in at less than 0.1 to 0.5 nanometers.

**Laws of Chemical Combination**

**Chemical Reactions**

* In a chemical reaction, two or more molecules interact to produce new compounds; they are called reactants, whereas the newly formed compounds are called products.
* In a chemical reaction, a chemical change must occur, which is generally observed with physical changes like precipitation, heat production, colour change, etc.

**Law of Conservation of Mass**

* According to the law of conservation of mass, matter can neither be created nor destroyed in a chemical reaction. It remains conserved.
* The mass of reactants will be equal to the mass of products.

**Law of Constant Proportions**

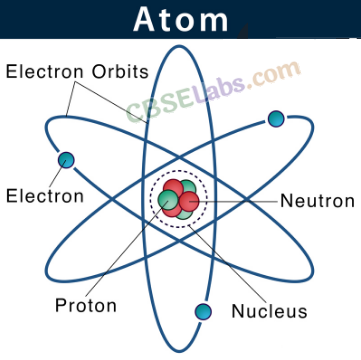
* A pure chemical compound containing the same elements combined together in a fixed proportion by mass is given by the law of definite proportions.
* For e.g., If we take water from a river or from an ocean, both have oxygen and hydrogen in the same proportion.

The elements are present in chemical compounds in a predetermined mass ratio. The “Law of Constant Proportions” is this. This “Law of Constant Proportions” is also known as “Proust’s law” or the “law of defined proportions.” For instance, the oxygen and hydrogen content in pure water is always 1:8.

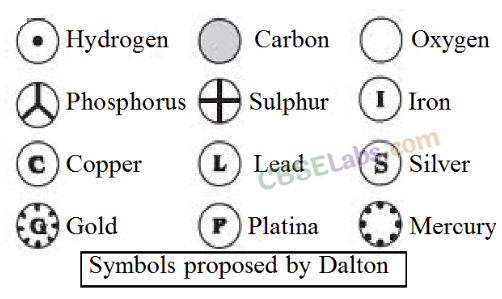
**Atoms**

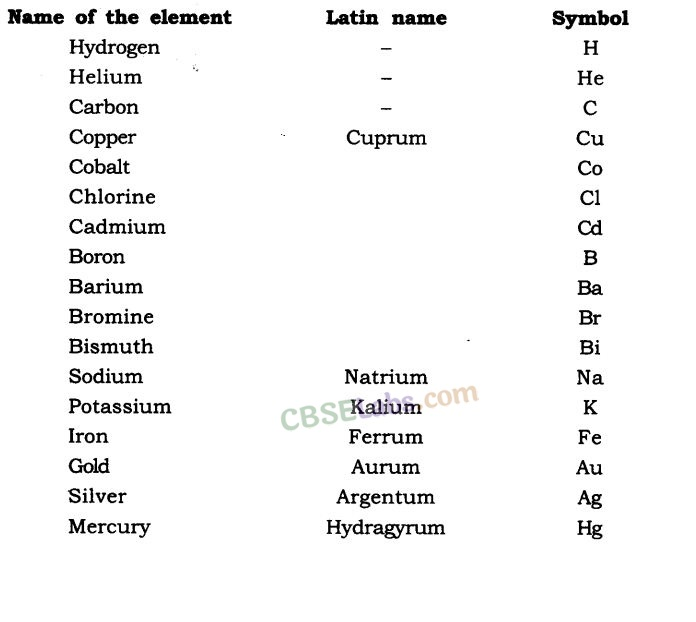
An atom is the defining structure of an element, which cannot be broken by any chemical means.

Atoms are the smallest particles of an element which can take part in a chemical reaction.  
Size of an atom: Atomic radius is measured in nanometres.

  
**Symbols of atoms:**

**(a) Symbols for some elements as proposed by Dalton:**

  
**(b) Symbols of some common elements:**

The atomic symbol has three parts:-

* The symbol X: the usual element symbol
* The atomic number A: equal to the number of protons
* The mass number Z: equal to the total number of protons and neutrons in an element.

**Atomic Number**

**The atomic number of an element is determined by the number of protons in it**, and it is used to differentiate one element from another. **The mass number of an element is determined by the number of protons and neutrons combined.**

The modern periodic table is arranged in such a way that all the elements have an **increasing atomic number, and subsequently, increasing mass number.** But do you know what mass number, or even what atomic number is?

Well, as you know, an atom consists of electrons, protons and neutrons. The number of electrons in the outermost shell gives us the valency of the atom. Similarly, the number of protons and neutrons are associated with the atomic number and mass number of the atom.

* The total number of protons in the nucleus of an atom gives us the atomic number of that atom.
* It is represented with the letter ‘Z.’
* All the atoms of a particular element have the same number of protons, and hence the same atomic number.
* Atoms of different elements have different atomic numbers.
* For example, all carbon atoms have the atomic number of 6, whereas all atoms of Oxygen have 8 protons in their nucleus.

**What is Mass Number?**

* The number of protons and neutrons combine to give us the mass number of an atom.
* It is represented using the letter ‘A.’
* As both protons and neutrons are present in the nucleus of an atom, they are together called nucleons.
* For example, an atom of carbon has 6 protons and 6 neutrons. Thus, its mass number is 12.
* While the number of protons remains the same in all atoms of an element, the number of neutrons can vary. Thus, atoms of the same element can have different mass numbers, and these are called isotopes.
* The weight of an electron is almost negligible. Thus, the atomic mass of an atom is almost the same as its mass number.

Atoms are the building blocks of matter. They combine in numerous patterns and form different substances. All atoms except the common form of hydrogen contain protons, neutrons and electrons. The atomic number of an element is equal to the number of protons in its nucleus. In a neutral atom, the number of protons equals the number of electrons in shells which is the energy level around the nucleus.

Isotopes are atoms with the same atomic number but distinct neutron numbers, and hence distinct mass numbers. The average isotopic mass of an isotopic mixture for an element in a defined environment on Earth determines the element’s standard atomic weight. A little more than three-quarters of naturally occurring elements exist as a mixture of isotopes, and the average isotopic mass of an isotopic mixture for an element in a defined environment on Earth determines the element’s standard atomic weight.

**Examples of Atomic Number**

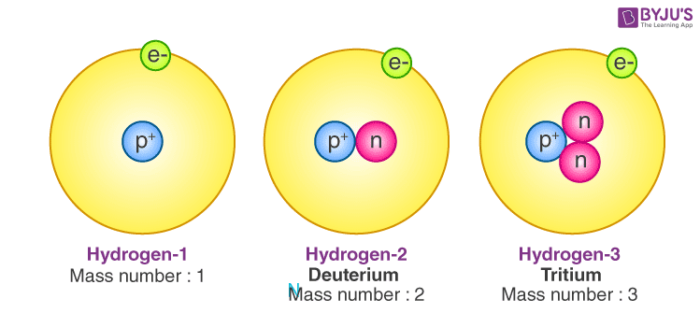
The atomic number of an atom is equal to the number of protons in the nucleus of an atom or the number of electrons in an electrically neutral atom.

**Atomic number = Number of protons**

For example, in a sodium atom, there are 11 electrons and 11 protons. Thus the atomic number of Na atom = number of electrons = number of protons = 11.  
**Atomic Number Orbital Energy Levels**

When an electron is at a specific energy level, it is more likely to be found in certain portions of that level than others. Orbitals are the name for these sections. Sublevels are made up of orbitals with the same energy. A maximum of two electrons can be found in each orbital.

The most common way of showing the arrangement of electrons in an atom is to draw diagrams like those shown in the diagram.



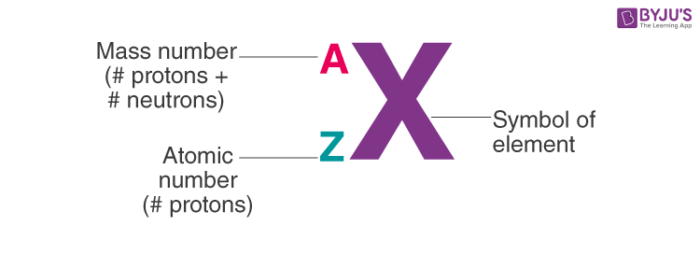
To write down the numbers of electrons in each energy level. The atomic number of an element tells us how many electrons there are in the atoms. For example, the atomic number of carbon is 6 giving us six electrons as 2,4. So an atom with the atomic number 12 has an electronic structure 2, 8, 2, with two electrons in the inner energy level, then eight in the next energy level and two in the outer highest energy level. The simplest way to understand these arrangements is to look at lots of examples of them.

**Difference between Valency, A and Z:**

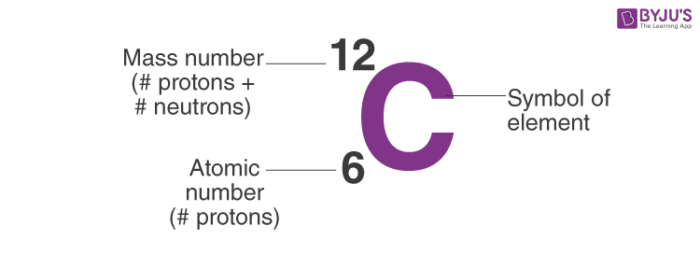
When we want to find out the valency, we look at electrons only in the outermost shell of the atom. But when we want to know the atomic number or the mass number, we look at the total number of protons and neutrons.

**1. Notation of Atom**

To write the notation of an atom, we need to know the symbol of the element, the atomic number and the mass number. The mass number of the atom goes above the symbol and the atomic number is written as a subscript.



So, the notation of Carbon is:



**2. Calculating Number of Neutrons:**

If we know the number of protons and the mass number of an element, we can also calculate the number of neutrons simply by subtracting its atomic number from its mass number.



**Atomic Radius**

The distance between an atom’s nucleus and outer electron shell. The atomic radius is calculated by measuring the distance between the nuclei of two identical atoms bonded together. Half this distance is the atomic radius.

**What are Shells**?

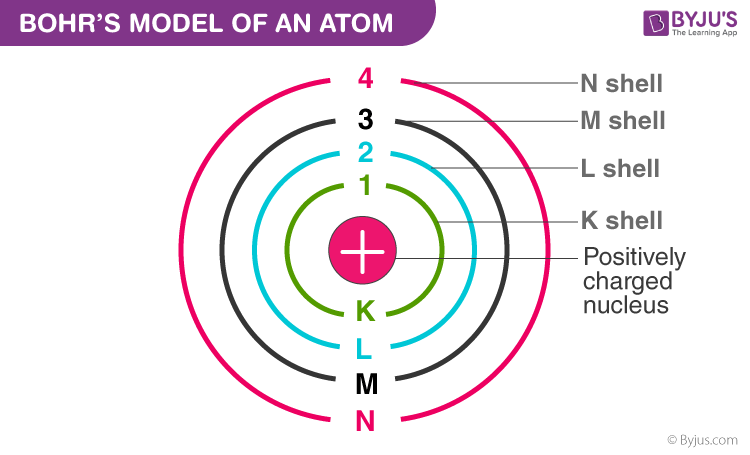
According to Bohr’s Atomic model electrons revolve around the nucleus in a specific circular path known as orbit or called a shell. Shells have stationary energy levels, the energy of each shell is constant.

Each stationary orbit or shell is associated with a definite amount of energy. The greater the distance of the orbit from the nucleus, the more shall be the energy associated with it. These shells are called energy levels. It is numbered as 1, 2, 3, 4, ……. or K, L, M, N, ….. from the nucleus outwards.

An electron shell may contain only a fixed number of electrons, each shell is associated with a particular range of electron energy, and thus each shell must fill completely before electrons can be added to an outer shell.

**Characteristic of Shells**

* The principal quantum number is denoted by ‘n’. It represents the name, size and energy of the shell to which the electron belongs. The value of n lies between 1 to ∞.



| **The value of ‘n’** | **Designation of shell** |
| --- | --- |
| 1 | K |
| 2 | L |
| 3 | M |
| 4 | N |
| 5 | O |
| 6 | P |
| 7 | Q |

* Higher the value of ‘n’ the greater the distance of the shell from the nucleus.

r1 < r2 < r3 < r4 <…….

r = (n2/Z) x 0.529 Å

* Greater the value of ‘n’ higher the magnitude of energy.

E1 < E2 < E3 < E4 < E5 ……

* Energy separation between two shells decreases on moving away from the nucleus.

(E2 – E1) > (E3 – E2) > (E4 – E3) > ……..

* The maximum number of electrons present in the shell on the 2n2 rule.

| **Name of Shell** | **The value of ‘n’** | **Maximum electrons present (2n2)** |
| --- | --- | --- |
| K | 1 | 2 |
| L | 2 | 8 |
| M | 3 | 18 |
| N | 4 | 32 |

* The angular momentum of each shell can be calculated by the formula.

mvr = (nh/2π)

**Definition of Subshell**

All the electrons having the same shall do not have the same energy. Based on the energy of the electrons, the shells are divided into sublevels or subshells. Each shell is composed of one or more subshells, which are themselves composed of atomic orbitals.

* The subshells are described with the help of [Azimuthal quantum numbers](https://byjus.com/chemistry/quantum-numbers/) (l).
* The value of ‘l’ depends upon the value of the shell (n) with which it is associated.
* These subshells have been designated as s (l = 0), p (l =1), d (l = 2) and f (l =3) .
* The energies of the various subshells in the same shell are in the order s < p < d <f.
* The subshell having equal ‘l’ value but with different n values have similar shape but their size increases as the value of n increases. 2s- subshell is greater in size than 1s- subshell.
* The maximum electrons present in a subshell = 2(2l +1).

| **Subshell** | **Maximum electrons** | **The historical name of subshell** |
| --- | --- | --- |
| s | 2 | sharp |
| p | 6 | principal |
| d | 10 | diffuse |
| f | 14 | fundamental |

**Number of electrons present in the shell**

* Each shell contains one or more subshells.
* K shell contains only one subshell – 1s
* L shell contains two subshells – 2s, 2p
* M shell contains three subshells – 3s, 3p, 3d
* N shell contains four subshells – 4s, 4p, 4d, 4f

The electrons are arranged in the shell in the following manner:

| **Name of the shell** | **Name of the subshell** | **Maximum no. of electrons present in the shell** | **Distribute the electron in the subshell** |
| --- | --- | --- | --- |
| K | 1s | 2 | 1s2 |
| L | 2s, 2p | 8 | 2s2 2p6 |
| M | 3s, 3p, 3d | 18 | 3s2, 3p6, 3d10 |
| N | 4s, 4p, 4d, 4f | 32 | 4s2, 4p6, 4d10, 4f14 |

**The order of energy of the subshell**

The filling of the shells and subshells with electrons proceeds from subshells of lower energy to subshells of higher energy. This follows the Aufbau principle.

According to this subshells with a lower n + ℓ value are filled before those with higher n + ℓ values. In the case of equal n + ℓ values, the subshell with a lower n value is filled first.

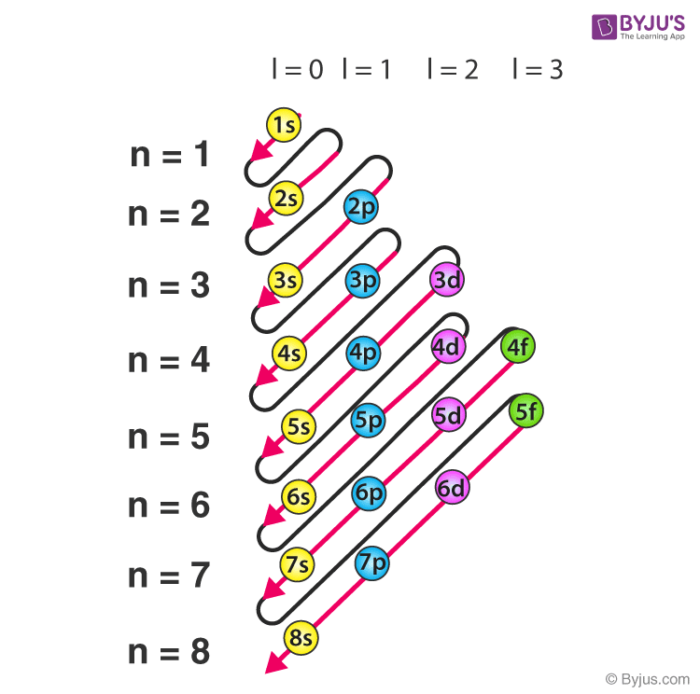
A subshell that has a lower n + ℓ means lower energy. Among 4s and 3d;

4s ; (n + l) = (4 + 0) = 4

3d ; (n + l) = (3 + 2) = 5

4s < 3d (energy)

The energy order of the subshells is given below



Arrangement of electrons in the shell and subshell

The first 20 element electrons are arranged in shell and subshell according to their energy level in the below table.

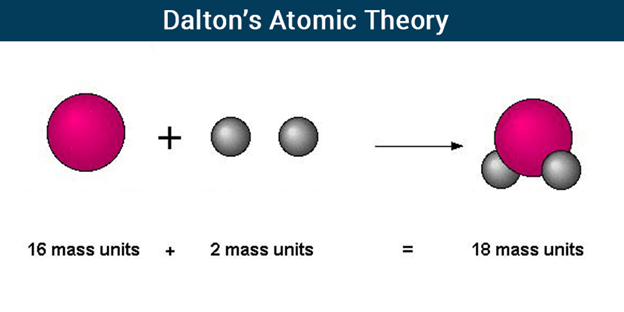
| **Atomic Number** | **Element Name** | **K** | **L** | | **M** | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | Hydrogen (H) | 1s1 |  |  |  |  |  |
| 2 | Helium (He) | 1s2 |  |  |  |  |  |
| 3 | Lithium (Li) | 1s2 | 2s1 |  |  |  |  |
| 4 | Beryllium (Be) | 1s2 | 2s2 |  |  |  |  |
| 5 | Boron (B) | 1s2 | 2s2 | 2p1 |  |  |  |
| 6 | Carbon (C) | 1s2 | 2s2 | 2p2 |  |  |  |
| 7 | Nitrogen (N) | 1s2 | 2s2 | 2p3 |  |  |  |
| 8 | Oxygen (O) | 1s2 | 2s2 | 2p4 |  |  |  |
| 9 | Fluorine (F) | 1s2 | 2s2 | 2p5 |  |  |  |
| 10 | Neon (Ne) | 1s2 | 2s2 | 2p6 |  |  |  |
| 11 | Sodium (Na) | 1s2 | 2s2 | 2p6 | 3s1 |  |  |
| 12 | Magnesium (Mg) | 1s2 | 2s2 | 2p6 | 3s2 |  |  |
| 13 | Aluminium (Al) | 1s2 | 2s2 | 2p6 | 3s2 | 3p1 |  |
| 14 | Silicon (Si) | 1s2 | 2s2 | 2p6 | 3s2 | 3p2 |  |
| 15 | Phosphorous (P) | 1s2 | 2s2 | 2p6 | 3s2 | 3p3 |  |
| 16 | Sulfur (S) | 1s2 | 2s2 | 2p6 | 3s2 | 3p4 |  |
| 17 | Chlorine (Cl) | 1s2 | 2s2 | 2p6 | 3s2 | 3p5 |  |
| 18 | Argon (Ar) | 1s2 | 2s2 | 2p6 | 3s2 | 3p6 |  |
| 19 | Potassium (K) | 1s2 | 2s2 | 2p6 | 3s2 | 3p6 | 4s1 |
| 20 | Calcium (Ca) | 1s2 | 2s2 | 2p6 | 3s2 | 3p6 | 4s2 |

**Dalton’s Atomic Theory**

According to Dalton’s Atomic Theory, atoms, which are indestructible and indivisible building blocks, make up all substances. Unlike other elements, which have atoms of different sizes and weights, an element’s atoms have all the same size and mass.

Dalton proposed that the concept of atoms could be used to explain the laws of conservation of mass and definite proportions. He proposed that atoms, which he described as “solid, massy, hard, impenetrable, moving particle(s)”, are the smallest, indivisible units of matter.

1. The matter is made up of indivisible particles known as atoms.
2. The properties of all the atoms of a given element are the same, including mass. This can also be stated as – all the atoms of an element have identical mass and chemical properties; atoms of different elements have different masses and chemical properties.
3. Atoms of different elements combine in fixed ratios to form compounds.
4. Atoms are neither created nor destroyed. The formation of new products (compounds) results from the rearrangement of existing atoms (reactants) in a chemical reaction.
5. The relative number and kinds of atoms are constant in a given compound.



* Every matter is made up of very small or tiny particles called atoms.
* Atoms are not divisible and cannot be created or destroyed in a chemical reaction.
* All atoms of a given element are same in size, mass and chemical properties.
* Atoms of different elements are different in size, mass and chemical properties.
* Atoms combine in the ratio of a small whole number to form compounds.
* The relative number and kinds of atoms are constant in a given compound.

**Atomic Mass**

**Atomic Mass and Atomic Mass Unit**

* Atomic mass is the total of the masses of the electrons, neutrons, and protons in an atom, or in a group of atoms, the average mass.
* The mass of an atomic particle is called the atomic mass.
* This is commonly expressed as per the international agreement in terms of a unified atomic mass unit (AMU).
* It can be best defined as 1/12 of the mass of a carbon-12 atom in its ground state.

## What is Atomic Mass?

Atomic mass can be defined as the total mass of one atom of any given element. The unit of atomic mass is called the unified atomic mass unit (denoted by ‘u’). Most of the atomic mass of a substance is made up of protons and neutrons. Therefore, it is almost equal to its mass number.

Relative isotopic mass refers to the mass of an isotope of an element when compared to one-twelfth of the mass of the carbon 12 isotope (which is equal to 12). It is also called atomic weight.

## ****How to Find Atomic Mass?****

### Find Atomic Mass for a Single Atom

Since the combined masses of protons and neutrons account for almost all the mass of the given atom, the atomic mass of a single atom can be calculated by adding the total number of protons and the total number of neutrons of that particular isotope.

The number of protons in a given atom is always equal to its atomic number. For example, the atomic number of oxygen is 8, therefore the total number of protons in an oxygen atom is 8. The total number of neutrons is generally specified when describing which isotope the atom belongs to.

**Example**: Calculation of the atomic mass of an oxygen molecule with 9 neutrons.

Total number of protons in oxygen = Atomic number of oxygen = 8

Total number of neutrons in the isotope (given) = 9

Atomic mass of the given oxygen atom = 8+9 = 17

### Find the Atomic Mass of a Natural Sample

The atomic mass of the given natural sample can be easily looked up on the periodic table. To find the element on the periodic table, the element symbol or its atomic number must be known. Once the required data is attained, it can be compared with the periodic table where the atomic mass of the natural sample in atomic mass units will be provided in decimal figures.

### Find the Atomic Mass of a Given Ratio of Isotopes

When the sample is a mixture of isotopes of the given element in varying percentages, the following method can be used:

**Step 1:** Multiply the atomic mass of the isotope with its abundance percentage and divide the result by 100.

**Step 2:** Add the values gained from step 1 for each given isotope in the sample.

**Example:** Calculating the atomic mass of a given chlorine sample where two isotopes are mixed. The first isotope has an atomic mass of 34.96885 and has an abundance of 75.78%. The second isotope has an atomic mass of 36.96590 and has an abundance of 24.22%.

**Step 1:** (Atomic mass of each isotope) x (%Abundance /100)

34.96885\*0.7578 = 26.50 (i)

36.96590\*0.2422 = 8.95 (ii)

**Step 2:** Adding (i) and (ii), the atomic mass of the given sample is determined.

26.50 + 8.95 = 35.45

Thus, the atomic mass of the given sample of chlorine was found to be 35.45

**Molecule**

The smallest identifiable unit into which a pure substance may be divided while retaining its composition and chemical properties is a molecule, which is a collection of two or more atoms.

It is the smallest particle of an element or a compound which can exist independently.

* Molecules of an element constitute the same type of atoms.
* Molecules may be monoatomic, diatomic or polyatomic.
* Molecules of compounds join together in definite proportions and constitute a different type of atoms

**Molecules of Elements**

A molecule is a collection of two or more chemically bound atoms, whether they are from the same element or another.

For example, when two hydrogen (H2) atoms and one oxygen (O2) atom interact, one water molecule is created.

**Molecules of Compounds**

Salts and molecular compounds are the two categories into which compounds can be divided. Covalent bonds hold the atoms together in molecular molecules. Ionic bonds hold it together in salts. Every compound is composed of one of these two types of bonds.

Actually, a compound is a kind of molecule. The atoms that join together must be distinct from one another for the substance to qualify as a compound. O2, for instance, is a molecule, not a compound, due to its atomic connection with another oxygen atom. NaCl, however, is a compound since it is made up of two distinct atoms that are chemically bound together.

**Molecular mass**

Molecular mass of an element is defined as the sum of the masses of the elements present in the molecule.

* Molecular mass is obtained by multiplying the atomic mass of an element by the number of atoms in the molecule and then adding the masses of all the elements in the molecule.

It is the sum of the atomic masses of all the atoms in a molecule of the substance. It is expressed in atomic mass unit (u).

**1.png**

**Formula Unit Mass**

It is the sum of the atomic masses of all atoms in a formula unit of a compound. The constituent particles are ions.

**1.png**

**Mole Concept & Avogadro Number**

* In a substance, the amount of entities present. For e.g. atoms, molecules, and ions are defined as a mole. A mole of any substance is 6.022×1023 molecules.
* The Mole concept is one of the most convenient ways of expressing the amount of reactants and products in the reaction.

The value of Avogadro’s number is approximately 6.022×1023. The definition of Avogadro’s number is that it tells us the number of particles in 1 mole (or mol) of a substance. These particles could be electrons or molecules, or atoms.

**Definition of mole**: It is defined as one mole of any species (atoms, molecules, ions or particles) is that quantity in number having a mass equal to its atomic or molecular mass in grams.

1 mole = 6.022 x 1023 in number

**Molar Mass**

A substance is something which has mass and occupies space. The molar mass/molecular weight is actually the sum of the total mass in grams of the atoms present to make up a molecule per mole. The unit of molar mass is grams/mole.

Molar mass = mass of 1 mole → is always expressed in grams and is also known as gram atomic mass.

1 u of hydrogen has → 1 atom of hydrogen 1g of hydrogen has → 1 mole of hydrogen

= 6.022 x 1023atoms of hydrogen

**Atomic Valency**

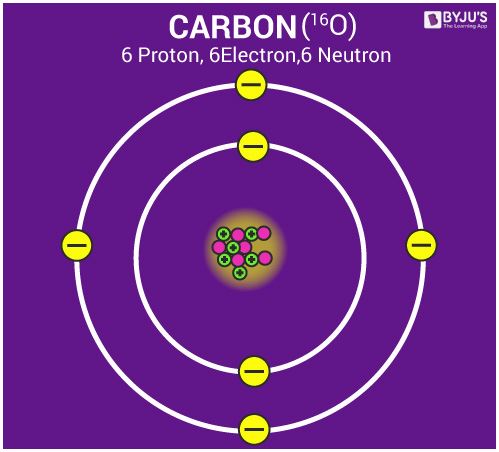
**Molecules and Atomicity**

A molecule is defined as the smallest unit of a compound that contains the chemical properties of the compound.

* The atomicity of an element is the number of atoms in one molecule of the element.
* For e.g., Hydrogen, nitrogen, oxygen, chlorine, iodine, and bromine all have two atoms in each of their molecules. So, the atomicity of hydrogen, nitrogen, oxygen, chlorine, iodine, and bromine is two each.

**Structure of an Atom**

* Atom is made of three particles; electron, proton and neutron.
* The centre of the atom is called the nucleus. The nucleus of an atom contains the whole mass of an atom.
* Electrons in an atom are arranged in shells/orbitals.



**Valency**

Valence electrons are those electrons which are present in the outermost orbit of the atom.

* The capacity of an atom to lose, gain or share valence electrons in order to complete its octet determines the valency of the atom.

**Writing Chemical Formulae**

**Compounds**

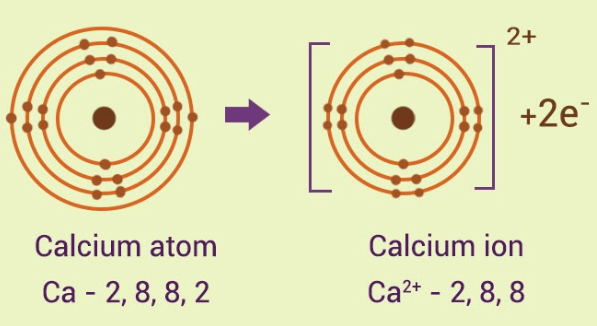
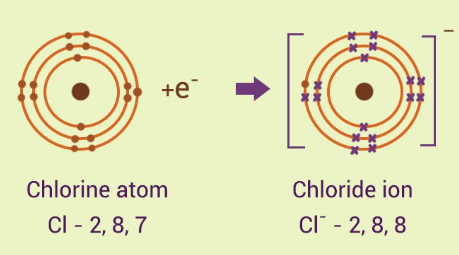
* When two or more elements chemically combine in a fixed ratio by mass, the obtained product is known as a compound.
* Compounds are substances consisting of two or more different types of elements in a fixed ratio of its atoms.

**Ions**

* An ion is defined as an atom or molecule which has gained or lost one or more of its valence electrons, giving it a net positive or negative charge.
* A negatively charged particle is called an anion, and a positively charged particle is called a cation.

**Ionic Compounds: Chemical Formula**

Each constituent element in a chemical formula is identified by its chemical symbol, along with the relative number of atoms that make up each element. These ratios are used in empirical equations to start with a key element and then assign atom counts for the remaining elements in the compound in relation to the key element.

* Ionic compounds are chemical compounds in which ions are held together by specialised bonds called ionic bonds.
* An Ionic compound always contains an equal amount of positive and negative charge.
* For example: In calcium chloride, the ionic bond is formed by oppositely charged calcium and chloride ions.
* The calcium atom loses 2 electrons and attains the electronic configuration of the nearest noble gas (Ar). By doing so, it gains a net charge of +2.  
  The two chlorine atoms take one electron each, thus gaining a charge of -1 (each) and attain the electronic configuration of the nearest noble gas (Ar).  
  

**Chemical Formulae** **Rules:**

* 1. The valencies or charges on the ion must balance.
  2. Metal and non-metal compound should show the name or symbol of the  
     metal first.

e.g., Na+ Cl– → NaCl

If a compound consists of polyatomic ions. The ion is enclosed in a bracket before writing the number to indicate the ratio.

e.g., [SO4]2- → polyatomic radical

H1+ SO42-→  H2SO4

**Question** Name two scientists who established the laws of chemical combination?  
**Answer:** Antoine L. Lavoiser and Joseph L. Proust.

**Question** Give an example of a triatomic molecule of an element.  
**Answer** Ozone (O3)

**Question** Define atomicity.  
**Answer** It is the number of atoms present in one molecule of a substance.

**Question** Write the atomicity of the following molecules:  
(i) Sulphur  
(ii) Phosphorus  
**Answer**  
(i) 8  
(ii) 4

**Question** What is an ion? Give one example.  
**Answer** The negatively and positively charged particles are called ions.  
For example: Cl– , Br– , SO2−4,PO3−4,H+, Pb+ , etc.

**Question** Give one word for the following:  
(i) A group of atoms carrying a charge  
(ii) Positively charged ion  
Answer:  
(i) Ion  
(ii) Cation

Question 7.  
The atomic number of three elements A, B and C are 9, 10 and 13 respectively. Which of them will form a cation?  
**Answer** Electronic configuration of A : 2, 7  
Electronic configuration of B : 2, 8  
Electronic configuration of C : 2, 8, 3  
‘C’ will form a cation because a cation is formed by the loss of one or more electrons by an atom.

**Question** What is wrong in saying ‘one mole of nitrogen’?  
**Answer** The statement does not clarify whether we are talking about atoms or molecules of nitrogen. We should say ‘one mole of nitrogen atoms’ or ‘one mole of nitrogen molecule’.

**Question** ‘Dalton’s atomic theory is contradicted by the formula of sucrose (C12H22O11).’ Justify the statement.  
**Answer** Dalton’s atomic theory states that atoms of different elements combine together in simple whole number ratio. In the formula of C12H22O11 the carbon, hydrogen and oxygen combine in whole number ratio but the ratio is not simple.

**Question** How many times heavier is one atom of carbon than one atom of oxygen?  
**Answer** Atomic mass of carbon = 12 u  
Atomic mass of oxygen = 16 u  
Therefore, one atom of carbon is 12*u*16*u*=34 times heavier than one atom of oxygen.

**Question** Give an example to show law of conservation of mass applies to physical changes also.  
**Answer** Law of conservation of mass states that mass can neither be created nor destroyed in a chemical reaction. However, this law applies to physical changes also. For example, when ice melts into water, the mass of ice equals to the mass of water, i.e., the mass is conserved. This verifies the law of conservation of mass.

**Question** Which of the following symbols of elements are incorrect? Give their correct symbols.  
(a) Cobalt CO  
(b) Carbon c  
(c) Aluminium AL  
(d) Helium He  
(e) Sodium So   
**Answer**  
(a) Incorrect, the correct symbol of cobalt is Co.  
(b) Incorrect, the correct symbol of carbon is C.  
(c) Incorrect, the correct symbol of aluminium is Al.  
(d) Correct (He)  
(e) Incorrect, the correct symbol of sodium is Na.

**Question** Which of the following are tri-atomic and tetra-atomic molecules?  
CH3Cl, CaCl2, NH3, PCl3, P2O5, H2O, C2H5OH  
**Answer**  
(i) Tri-atomic molecules are CaCl2, H2O.  
(ii) Tetra-atomic molecules are NH3, PCl3.

**Question** Differentiate between the actual mass of a molecule and gram molecular mass.  
**Answer** Actual mass of a molecule is obtained by dividing the molar mass by Avogadro’s number whereas gram molecular mass represents the molecular mass expressed in grams, i.e., it is the mass of 1 mole of molecules, i.e., Avogadro’s number of molecules.

**Question** Calculate the formula mass of sodium carbonate (Na2CO3.10H2O).  
**Answer** Formula mass of sodium carbonate  
= (2 × atomic mass of Na) + (1 × atomic mass of C) + (3 × atomic mass of O) + 10 [(2 × atomic mass of H) + (1 × atomic mass of O)]  
= 2 × 23 + 1 × 12 + 3 × 16 + 10 [(2 × 1) + (1 × 16)]  
= 46 + 12 + 48 + 180 = 286 u

**Question** Calculate the mass of one atom of hydrogen atom.  
**Answer**  
1 mole of hydrogen atom = 1 g  
or 6.022 × 1023 atoms of hydrogen weigh = 1 g  
Mass of one atom = 16.022×1023g  
= 1.66058 × 10-24g

**Question** How many moles are present in 4 g of sodium hydroxide?  
**Answer** Gram molar mass of NaOH = 23 + 16 + 1 = 40 g  
40 g of NaOH = 1 mol  
∴ lg of NaOH = 140mol  
∴ 4 g of NaOH = 140 × 4 mol = 0.1 mol

**Question** A sample of ammonia weighs 3.00 g. What mass of sulphur trioxide contains the same number of molecules as are in 3.00 g ammonia?  
**Answer** Number of moles of ammonia in 3.00 g = 3.00 17 mol  
= 0.1764 mol  
Molecular mass of S03 = 1 × 32u + 3 × 16u = 80u  
1 mole of SO3 weighs 80 g  
∴ 0.1764 moles weigh = 80 × 0.1764 g  
= 14.11 g

**Question** Carbon dioxide produced by action of dilute hydrochloric acid on potassium hydrogen carbonate is moist whereas that produced by heating potassium hydrogen carbonate is dry. What would be the difference in the composition of carbon dioxide in the two cases? State the associated law.  
**Answer** The composition of CO2 in both the cases would be same, i.e., the carbon and oxygen will combine in the same ratio 1 : 2.  
The law associated is law of constant proportion.

**Question** How many atoms would be present in a black dot marked on the paper with graphite pencil as a full stop at the end of a sentence. [Given mass of a dot = 10-18 g]  
**Answer**  
1 mole of carbon atoms weigh = 12 g  
Also, 1 mole of carbon atoms = 6.0 2 2 × 1023 atoms  
Thus, 12 g of carbon atoms has 6.022 × 1023 atoms.  
∴ 10-18 g of carbon will have 6.022×102312×10−18 × 10-18 carbon atoms  
= 5.02 × 104 carbon atoms.

**Question** Does the solubility of a substance change with temperature? Explain with the help of an example.   
**Answer** Yes, it is a temperature dependent property. The solubility generally, increases with increase in temperature. For example, you can dissolve more sugar in hot water than in cold water.

**Question** Write the cations and anions present (if any) in the following compounds:  
(a) CH3COONa  
(b) NaCl  
(c) H2  
(d) NH4NO3  
**Answer** Anions Cations  
(a) CH3COO– Na+  
(b) Cl– Na+  
(c) H2—It is a covalent compound  
(d) NO−3 NH+4

**Question** Calculate the mass percentage of oxygen present in the following compounds and state the law of chemical combination associated. Given, H = 1, O = 16.  
(i) Water (H2O) and  
(ii) Hydrogen peroxide (H2O2)  
**Answer** According to Law of multiple proportions  
(i) H2O % of O = 1618 × 100 = 88.89%  
(ii) H2O2, % of O = 3234 × 100 = 94.12%

**Question** Classify each of the following on the basis of their atomicity.  
(a) F2  
(b) NO2  
(c) CO2−3  
(d) C2H6  
(e) CO  
(f) H2O2  
(g) P4O10  
(h) O3  
(i) HCl  
(j) CH4  
(k) He  
(l) Ag   
**Answer**:  
(a) 2  
(b) 3  
(c) 4  
(d) 8  
(e) 2  
(f) 4  
(g) 14  
(h)3  
(i) 2  
(j)5  
(k) 1 (Noble gases do not combine and exist as monoatomic gases)  
(l) Polyatomic: It is difficult to talk about the atomicity of metals as any measurable quantity will contain millions of atoms bound by metallic bond.

**Question** Calculate the molecular mass of the following:  
(a) H2CO3  
(b) C2H5OH  
(C) MgSO4  
**Answer**  
(a) Molecular mass of H2CO3 = 2 × 1 + 1 × 12 + 3 × 16  
= 2 + 12 + 48  
= 62 u  
(b) Molecular mass of C2H5OH = 2 × 12 + 5 × 1 + 1 × 16 + 1  
= 24 + 5 + 16 + 1  
= 46 u  
(c) Molecular mass of MgSO4 =1 × 24 + 1 × 32 + 4 × 16  
= 24 + 32 + 64  
= 120 u

**Question** What are ionic and molecular compounds? Give examples.   
**Answer** Atoms of different elements join together in definite proportions to form molecules of compounds. For example, water, ammonia, carbon dioxide. Compounds composed of metals and non-metals contain charged species. The charged species are known as ions. An ion is a charged particle and can be negatively or positively charged. A negatively charged ion is called an anion and the positively charged ion is called cation. For example, sodium chloride, calcium oxide.

**Question** Give three significance of mole.  
**Answer**

* One mole represents 6.022 × 1023 entities of a substance.
* One mole of an element contains 6.022 × 1023 atoms of the element.
* One mole of a substance represents one gram formula mass of the substance.

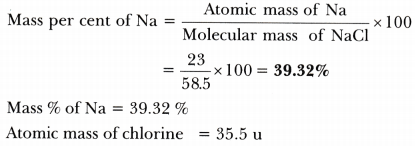
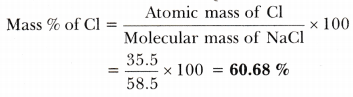
**Question** How many (a) molecules (b) hydrogen atoms (c) oxygen atoms are there in 0.5 mol of water?  
**Answer**   
(a) 1 mol of water contains 6.022 × 1023 molecules  
∴ 0.5 mol of water contains 6.022×10232 molecules  
= 3.011 × 1023 molecules

(b) 1 molecule of water contains 2 atoms of hydrogen  
1 mol of water contains 2 × 6.022 × 1023 atoms of hydrogen  
∴ 0.5 mol of water contains 2×6.022×10232 atoms of hydrogen  
= 6.022 × 1023 atoms of hydrogen

(c) 1 molecule of water contains 1 atom of oxygen  
1 mol of water contains 6.022 × 1023 atoms of oxygen  
∴ 0.5 mol of water contains 6.022×10232 atoms of oxygen  
= 3.011 × 1023 atoms of oxygen

**Question** Calculate the number of moles present in:  
(i) 3.011 × 1023 number of oxygen atoms.  
(it) 60 g of calcium  
[Given that atomic mass of Ca = 40 u, Avogadro No. = 6.022 × 1023]  
**Answer**  
(i) 1 mole of oxygen contains 6.022 × 1023 atoms  
∴ 6.022 × 1023 atoms of oxygen = 1 mol  
1 atom of oxygen = 16.022×1023 mol  
∴ 3.011 × 1023 atoms of oxygen = 1×3.011×1023/ 6.022×1023 mol  
= 0.5 mol

(ii) Atomic mass of Ca = 40 u  
40g of calcium = 1 mol  
60g of calcium = 6040 mol =1.5 mol

**Question** Calculate the mass per cent of each element of sodium chloride in one mole of it.  
**Answer** Molecular mass of NaCl = (1 × 23 + 1 × 35.5) u = 58.5 u  
Atomic mass of sodium = 23 u  
  


**Question** Calculate the number of particles in each of the following:  
(a) 46 g of Na atom  
(b) 8 g of O2 molecules  
(c) 0.1 moles of carbon atom  
**Answer**  
(a) No. of moles of sodium = 4623 = 2 moles  
We know that one mole of sodium contains 6.022 × 1023 atoms.  
∴ 2 moles of sodium contain = 2 × 6.022 × 1023 atoms  
= 1.204 × 1024 atoms

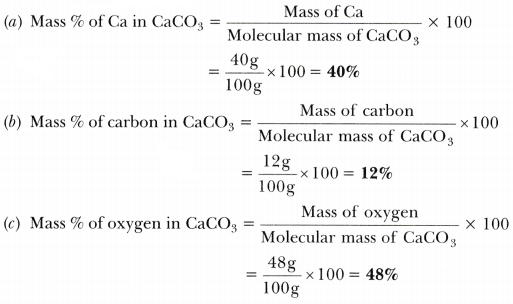
(b) 1 mole of oxygen = 32 g  
32 g of 02 contains 6.02 2 × 1023 molecules  
∴ 8 g of O2 contains = 6.022×102332 × 8 molecules  
= 1.51 × 1023 molecules

(c) 1 mole of carbon atoms contains 6.022 × 1023 atoms  
∴ 0.1 mole of carbon atoms contains = 6.022 × 1023 × 0.1 atoms  
= 6.022 × 1022 atoms

**Question** Raunak took 5 moles of carbon atoms in a container and Krish also took 5 moles of sodium atoms in another container of same weight.   
(a) Whose container is heavier?  
(b) Whose container has more number of atoms?  
**Answer**  
(a) Mass of sodium atoms carried by Krish = (5 × 23) g = 115 g  
Mass of carbon atoms carried by Raunak = (5 × 12) g = 60 g  
Thus, Krish’s container is heavier.  
(b) Both the bags have same number of atoms as they have same number of moles of atoms.

**Question** Arrange the following in order of decreasing masses:  
(i) 1023 molecules of CO2 gas  
(ii) 0.1 g atom of silver  
(iii) 1 gram of carbon  
(iv) 0.1 mole of H2SO4  
(v) 1023 atoms of calcium.  
(Given Atomic masses: Ag = 108 u, S = 32 u, N = 14 u, Ca = 40 u)  
**Answer**  
(i) 1 mole of CO2= 44 g = 6.02 × 1023 molecules  
i.e., 6.02 × 1023 molecules of CO2 = 44 g of CO2  
1023 molecules of CO2 = 446.02×1023 × 1023 = 7.31 g  
(ii) 1 g atom of Ag = Gram atomic mass of Ag = 108 g  
∴ 0.1 g atom of Ag = 0.1 × 108 g = 10.8 g  
(iii) 1 g of carbon = 1 g  
(iv) 1 mole of H2SO4 = Gram molecular mass  
= 2 × 1 + 32 + 4 × 16 = 98 g  
∴ 0.1 mole of H2SO4 = 0.1 × 98 g = 9.8 g  
(v) 1 mole of Ca = 40 g = 6.02 × 1023 atoms of Ca  
i.e., 6.02 × 1023 atoms of Ca have mass = 40 g  
∴ 1023 atoms of Ca have mass = 406.02×1023 × 1023 = 6.64 g  
Thus, masses in the decreasing order are: 0.1 g atom of Ag > 0.1 mole of H2SO4 > 1023 molecules of CO2 > 1023 atoms of Ca > 1 g of carbon

**Question** Calculate the number of aluminium ions (Al3+) in 0.056 g of alumina (Al2O3).  
**Answer** Molecular mass of alumina (Al2O3) = 2 × Al3+ + 3 × O2-  
= 2 × 27 u + 3 × 16 u  
= 102 u  
Gram molecular mass = 102 g  
1 mol of alumina (Al2O3) = 102 g  
102 g of Al2O3 = 1 mol  
∴ 0.056 g of Al2O3 = 1×0.056102 mol  
= 5.49 × 10-4 mol  
We know that one mol of alumina contains 2 mol of Al3+ ions.  
∴ 5.49 × 10-4 mol of Al2O3 contains 2 × 5.49 × 10-4 mol of Al3+ ions  
∴Number of Al3+ ions in 0.056 g = 2 × 5.49 × 10-4 × 6.022 × 1023  
= 6.613 × 1020 ions of Al3+

**Question** Calculate the mass per cent of each element present in the molecule of calcium carbonate.  
**Answer** Molecular formula of calcium carbonate = CaCO3  
Molecular mass of CaCO3 = 1 × Ca + 1 × C + 3 × O  
= 1 × 40u + 1 × 12u + 3 × 16u = 100u  
Gram molecular mass =100 g/mol  
1 mol of CaC03 = 100 g  


**Question** Verify by calculating that  
(a) 5 moles of CO2 and 5 moles of H20 do not have the same mass.  
(b) 240 g of calcium and 240 g of magnesium elements have a mole ratio of 3 : 5.   
**Answer**  
(a) CO2 has molar mass = 44 g mol-1  
5 moles of CO2 have molar mass = 44 × 5 = 220 g  
H2O has molar mass = 18 g mol-1  
5 moles of H2O have mass = 18 × 5g = 90g

(b) Number of moles in 240 g Ca metal = 24040 = 6  
Number of moles in 240 g of Mg metal = 24040 = 10  
Ratio is 6 : 10  
or, 3 : 5

**Question** Find the ratio of mass of the combining elements in the following compounds:  
(a) CaCO3  
(b) MgCl2  
(c) H2SO4  
(d) C2H5OH  
(e) NH3  
(f) Ca(OH)2  
**Answer**  
(a) CaCO3  
Ca : C : O × 3  
40 : 12 : 16 × 3  
40 : 12 : 48  
10 : 3 : 12

(b) MgCl2  
Mg : Cl × 2  
24 : 35.5 × 2  
24 : 71

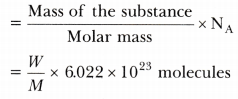
(c) H2SO4  
H × 2 : S : O × 4  
1 × 2 : 32 : 16 × 4  
2 : 32 : 64  
1 : 16 : 32

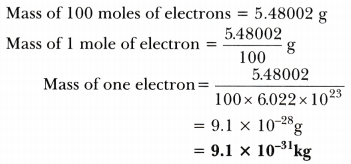
(d) C2H5OH  
C × 2 : H × 6 : O  
12 × 2 : 1 × 6 : 16  
24 : 6 : 16  
12 : 3 : 8

(e) NH3  
N : H × 3  
14 : 1 × 3  
14 : 3

(f) Ca(OH)2  
Ca : O × 2 : H × 2  
40 : 16 × 2 : 1 × 2  
40 : 32 : 2  
20 : 16 : 1

**Question** Calcium chloride when dissolved in water dissociates into its ions according to the following equation.  
CaCl2 (aq) → Ca2+ (aq) + 2Cl– (aq)  
Calculate the number of ions obtained from CaCl2 when 222 g of it is dissolved in water.   
**Answer**  
1 mole of calcium chloride = 111 g  
∴ 222 g of CaCl2 is equivalent to 2 moles of CaCl2  
Since 1 formula unit CaCl2 gives 3 ions, therefore, 1 mole of CaCl2 will give 3 moles of ions.  
2 moles of CaCl2 would give 3 × 2 = 6 moles of ions.  
Number of ions = Number of moles of ions × Avogadro number  
= 6 × 6.022 × 1023  
= 36.132 × 1023  
= 3.6132 × 1024 ions.

**Question** What is a mole? What is the unit of mole? How many molecules are there in a certain mass of a substance?  
**Answer** A mole is the amount of a substance which contains the same number of chemical units (atoms, molecules or ions) as there are atoms in exactly 12 g of carbon-12. The unit of mole is given by the symbol ‘mol’.  
We know that Avogadro number is 6.022 × 1023  
Number of molecules in a certain mass  
  
where ‘W is the mass of the substance in which number of molecules is to be calculated and ‘M’ is the molecular mass of the substance.

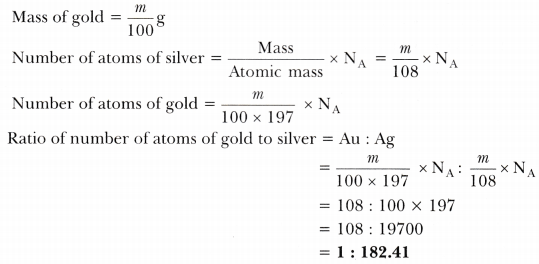
**Question** The difference in the mass of 100 moles each of sodium atoms and sodium ions is 5.48002 g. Compute the mass of an electron.   
**Answer** A sodium atom and ion differ by one electron. For 100 moles each of sodium atoms and ions there would be a difference of 100 moles of electrons.  


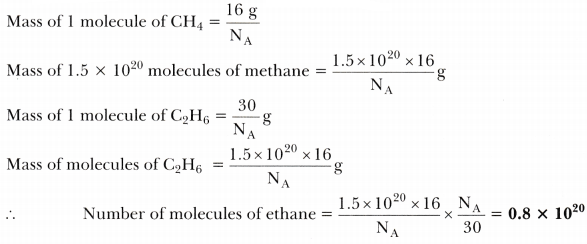
**Question** The mass of one steel screw is 4.1 lg. Find the mass of one mole of these steel screws. Compare this value with the mass of the Earth (5.98 × 1024 kg). Which one of the two is heavier and by how many times?   
**Answer**  
1 mole of steel screws = 6.022 × 1023 screws  
Mass of 1 screw = 4.11 g  
∴ Mass of 1 mole of screws = 4.11 × 6.022 × 1023 g  
= 24.75 × 1023 g = 2.475 × 1024 g  
One mole of screw weighs = 2.475 × 1024 g = 2.475 × 1021 kg  
 Mass of the Earth  Mass of 1 mole of screws =5.98×1024kg2.475×1021kg = 2.4 × 1021kg  
Mass of Earth is 2.4 ×103 times the mass of screws.  
The Earth is 2400 times heavier than one mole of screws.

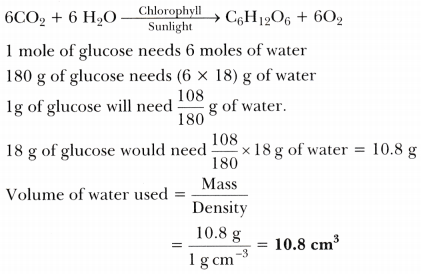
**Question** Compute the number of ions present in 5.85 g of sodium chloride.   
**Answer**  
5.85 g of NaCl = 5.8558.5 = 0.1 moles  
or 0.1 moles of NaCl particle.  
Each NaCl particle is equivalent to 2 ions, i.e., one Na2 and one Cl–  
⇒ Total moles of ions = 0.1 × 2 = 0.2 moles  
Number of ions = 0.2 × 6.022 × 1023  
= 1.2042 × 1023 ions

**Question** A gold sample contains 90% of gold and the rest copper. How many atoms of gold are present in one gram of this sample of gold? .  
**Answer** One gram of gold sample will contain 90100 = 0.9 g of gold  
Number of moles of gold =  Mass of gold  Atomic mass of gold   
= 0.9197 = 0.0046  
One mole of gold contains NA atoms = 6.022 × 1023  
∴ 0.0046 mole of gold will contain = 0.0046 × 6.022 × 1023  
= 2.77 × 1021 atoms

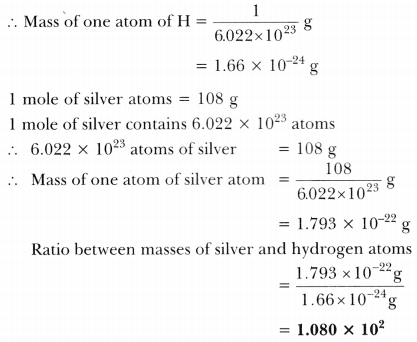
**Question** Compute the difference in masses of one mole each of aluminium atoms and one mole of its ions. (Mass of an electron is 9.1 × 10-28 g). Which one is heavier? **Answer**  
Mass of 1 mole of aluminium atom = Molar mass of aluminium = 27 g mol-1.  
An aluminium atom needs to lose three electrons to become an ion. Al3+.  
For one mole of Al3+ ion, three moles of electrons are to be lost.  
The mass of three moles of electrons = 3 × (9.1 × 10-28) × 6.0 2 2 × 1023 g  
= 27.3 × 6.022 × 10-5g  
= 164.400 × 10-5g = 0.00164 g  
Molar mass of Al3+ = (27 – 0.00164) g mol-1  
= 26.9984 g mol-1  
Difference = 27 – 26.9984  
= 0.0016 g

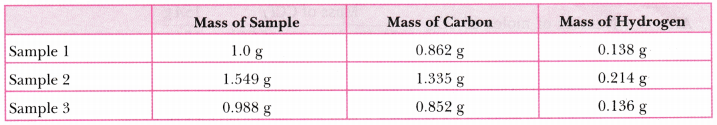
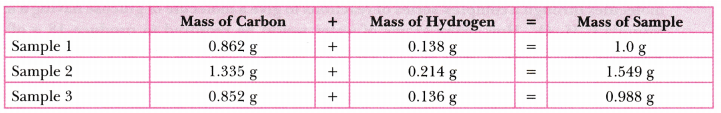
**Question** A silver ornament of mass ‘m’ gram is polished with gold equivalent to 1% of the mass of silver. Compute the ratio of the number of atoms of gold and silver in the ornament.   
**Answer** Mass of silver = m g  


**Question** A sample of ethane (C2H6) gas has the same mass as 1.5 × 1020 molecules of methane (CH4). How many C2H6 molecules does the sample of gas contain? **Answer**

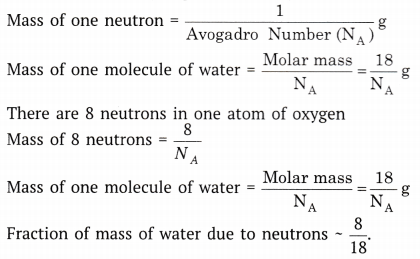
**Question** In photosynthesis, 6 molecules of carbon dioxide combine with an equal number of water molecules through a complex series of reactions to give a molecule of glucose having a molecular formula C6H12O6. How many grams of water would be required to produce 18 g of glucose? Compute the volume of water so consumed assuming the density of water to be lg cm-3.  
**Answer**  


**Question** Calculate the ratio between the mass of one atom of hydrogen and mass of one atom of silver.  
**Answer**

1 mole of H atoms = 1 g  
1 mole of H atoms = 6.022 × 1023 atoms.  
Mass of 6.022 × 1023 atoms of H = 1 g  


**Question** A colourless liquid is thought to be a pure compound. Analysis of three samples of the material yield the following results.  
  
Could the material be a pure compound?  
**Answer** Analysis  
  
Yes, the material is a pure compound as all the three samples have the same composition.

**Question** A big drop of water has volume 1.0 mL. How many molecules of water are there in this drop, If the density of water is lg/mL?  
**Answer** Volume of drop of water = 1.0 mL  
Density of water = 1.0 g/mL  
∴ Mass of drop of water = Volume × Density = 1.0 g  
Molecular mass of H2O = 2 × lu + 1 × 16u = 18u  
Gram molecular mass of water =18 g/mol  
18 g of water contains = 6.02 2 × 1023 molecules  
∴ 1 g of water contains = 6.022×102318 molecules  
= 3.34 × 1022 molecules

**Question** What is the fraction of the mass of water due to neutrons?   
**Answer** Mass of one mole (Avogadro Number) of neutrons ~ 1 g  


**Question** You are provided with a fine white coloured powder which is either sugar or salt. How would you identify it without tasting?   
**Answer** On heating the powder, it will char if it is a sugar.  
Alternatively, the powder may be dissolved in water and checked for its conduction of electricity. If it conductsm it is salt.

**Question** Calculate the number of electrons present in 15.4 g of carbon tetrachloride (CCl4).  
**Answer** Number of moles of CCl4 =  Mass of CCl4 Molecular mass of CCl4=15.4g154g  
∵ = 0.1 mole  
1 mole of CCl4 = 6.02 2 × 1023 molecules of CCl4  
∴ 0.1 mole of CCl4 = 0.1 × 6.022 × 1023 molecules of CCl4  
= 6.022 × 1022 molecules of CCl4  
We know that one atom of carbon has 6 electrons and one atom of chlorine has 17 electrons. Therefore, one molecule of CCl4 will contain 6 + (4 × 17) = 74 electrons.  
∴ Number of electrons in 6.022 × 1022 molecules of CCl4  
= 74 × 6.022 × 1022 electrons  
= 445.6 × 1022 electrons  
= 4.456 × 1o24 electrons

**Question** What is radioactivity? What are radioisotopes used for?

**Answer** Radioactivity is the process in which spontaneous emission of radiation in the form of particles or high-energy photons results from a nucleus decay. Radioactivity causes the release of energy from the decay of the nucleus atoms or isotopes. Radioisotopes are used in the following applications:

* Co 60 is an isotope that emits radiation that can be used to treat cancer.
* I 131 – used for the diagnosis and treatment of thyroid gland diseases.
* P 32 – used for the diagnosis and treatment of leukaemia.
* C 14 – This is used for studying biochemical processes

**Question** Create an experiment to prove that cathode rays travel in a straight line.

**Answer** A fluorescent-coated discharge tube, a source of cathode radiation, an opaque object and a high voltage source can all be used to demonstrate that cathode beams travel in a straight line. The experiment’s setup:

* A fluorescent substance-coated discharge tube can initiate the production of cathode radiations by using a high voltage source.
* Place an opaque object in the cathode radiation path to observe fluorescence phenomena.
* Fluorescence is produced when cathode radiation strikes the screen. Because of the position of the opaque object on the screen, we will see a sharp shadow that is shaped by the object.
* The shadow of an object can be created if the cathode radiations travel in a straight line and not around its edges.
* This experiment shows that cathode radiation travels in a straight line.

**Question** What were the limitations of Dalton’s Atomic Theory?

**Answer** (i) It doesn’t account for subatomic particles. It said that atoms were a unit of matter. This postulate was disproved by discovering subatomic particles, namely protons, electrons and neutrons.

(ii) It doesn’t account for isotopes. For example, hydrogen 1H1, deuterium 2H1 and tritium h3H1 all have the same atomic numbers but different mass numbers.

(iii). It doesn’t account for isobars. Example: (40 Ar18) vs (40 Ca 20) – they have different atomic numbers but the same mass.

(iv) Elements do not have to combine in simple whole-number combinations to make compounds. Complex organic compounds are composed of many constituent atoms and cannot be combined in simple proportions. Example: sugar/sucrose ( C H O 11 22 11 ).

(v) It doesn’t account for allotropes. Dalton’s atomic theory can’t explain the differences in properties of graphite and diamond, even though they contain carbon.

**Question** What do you mean by atomicity? What is the atomicity of ozone?

**Answer** The atomicity of a molecule is defined as the number of atoms constituting that molecule.

**Question** What does the term chemical formula mean?

**Answer** The chemical formula is the symbol for a compound’s composition. It can also be a notation that indicates the type and number of atoms within a compound’s molecule using atomic symbols or numbers. These numbers provide information about the elements that make up the molecules of a compound, as well as the ratio of the elements to create the molecules.

Example: A molecule containing water, a chemical compound, has two molecules of hydrogen and one molecule of oxygen. Its chemical formula is H O2.

**Question** Write the chemical formulae of the following.

(a) Magnesium chloride

**Answer** Magnesium chloride – MgCl2

(b) Calcium oxide

**Answer** Calcium oxide – CaO

(c) Copper Nitrate

**Answer** Copper Nitrate – CuNO3

(d) Aluminium chloride

**Answer** Aluminium Chloride – AlCl3

(e) Calcium carbonate

**Answer** Calcium carbonate – CaCO3

**Question** What is Avogadro Constant? Write its value.

**Answer** Avogadro’s numbers tell us the number of particles that make up one mole (or mole) of an element. They could be molecules, electrons, or atoms. The Avogadro number is around 6.022140857×1023 mol−1. With the help of this formula, we measure the total volume of a substance, the mass or temperature of a substance and general things along those lines. The substances are measured at the atomic level per atomic mass unit.

Besides, the mass unit is defined as the 1/12th weight of the mass of one carbon atom. For example, the atomic mass unit of hydrogen is 1.00794 amu. Now to calculate the ability of a single particle to say, carry out a reaction isn’t possible. Therefore, experts came up with the atomic mass unit and the gram.

1 amu = 1.66 x 10 grams

**Question** Write a short note on the following:

(a) Law of conservation of mass

**Answer** A law on conservation of mass says that the mass in closed systems remains constant throughout time.

Mass cannot be created, nor can it get destroyed; however, it can be transformed from one form to another. Based on the conservation laws of mass, reactants must be the same as their mass in the product to have a low-energy thermal process.

It is believed that few theories of classical mechanics determine mass conservation. Later, the conservation of mass law was modified with quantum mechanics and special relativity, which states that mass and energy are a single conserved quantity. Wood burning is a way to conserve mass since burning wood requires oxygen, carbon dioxide, water vapour and ashes.

(b) Law of constant proportion:

**Answer** A constant proportion law says that in all chemical compounds, the elements will always be present in a constant and specific proportion in mass. This means that the same chemical composition will contain the same elements in the exact proportion, regardless of the source, the compound, the method of making the compound, or the quantity of the substance.

A law called constant composition says that chemical compounds comprise elements found in a particular proportion to their mass. This means that a pure substance will always have the same elements and proportion in the mass regardless of origin.

**Question** State the postulates of Dalton’s Theory.

**Answer** Dalton’s atomic theory states every particle, be it an element, compound, or a mix, is made up of atoms, which are tiny particles. The tenets of the theory include:

* Everything is composed of tiny particles known as atoms. They are involved in chemical reactions.
* Atoms are unbreakable particles that cannot be made or destroyed by the course of a chemical reaction.
* The elements that make up an element have the same mass and chemical characteristics.
* Atoms from different elements are different in mass and physical properties.
* Atoms mix in the form of small whole numbers to make compounds.
* The proportions and types of atoms remain constant within the same compound.

**Question** What exactly is the chemical formula?

**Answer**  The chemical formulas used in the process explain the various types of atoms and their number within a compound or an element. The atoms of an element are represented as a combination of two letters or sometimes as just one letter. A set of chemical symbols that represent the elements that comprise compounds and their proportions. For instance, the chemical formula of the acid hydrochloric is HCl.

**Question** What are polyatomic ions? Give examples.

**Answer** A polyatomic ion develops when a neutral molecule acquires or loses electrons in the same manner as ions form when neutral atoms lose or gain electrons. In the end, a polyatomic ion is a collection of covalently bonded atoms with net charges because the number of electrons within the molecule doesn’t equal the number of protons.

The total of all the charges of every atom in the Lewis dot structure of a polyatomic ion should be equal to the net charge of the Ion. Polyatomic ions have more than one atom but function in a singular unit. Example CO32- H2PO4

**Question** How to calculate the molecular masses of:

H2, O2, Cl2, CO2, CH4, C2H6, NH3, CH3OH

**Answer** Molecular mass of H2: 2 x Atomic mass of H = 2 x 1u = 2u

Molecular mass of O2: 2 x Atomic mass of O = 2 x 16u = 32u

Molecular mass of Cl2: 2 x Atomic mass of CL = 2 x 35.5 u = 71u

Molecular mass of CO2: Atomic mass of C + 2 x Atomic mass of O = 12 + 2 x 16 = 44 u

Molecular mass of CH4: Atomic mass of C + 4 x Atomic mass of H = 12 + 4 x 1 = 16 u

Molecular mass of C2H6: 2 x Atomic mass of C + 6 x Atomic mass of H = 2 x 12 + 6 x 1 = 30 u

Molecular mass of NH3: Atomic mass of N + 3 x Atomic mass of H = 14 + 3 x 1 u = 17 u

Molecular mass of CH3OH = Atomic mass of C + 4 x Atomic mass of H + Atomic mass of O = 12 + 4 x 1 + 16 = 32 u

**Question** The oxygen and hydrogen mix in a ratio of 1:18 in mass to create water. What is the volume of oxygen gas needed to react with 3 grams of hydrogen gas completely?

**Answer** We know that water and hydrogen are mixed in the proportion of 1:8. For each 1 gram of hydrogen, it’s 8 grams of oxygen.

Thus, for 3 grams of hydrogen, the amount of oxygen is 3 x 8 = 24 grams.

Hence, 24 grams of oxygen would be needed for the complete reaction with 3 grams of hydrogen gas.

**Question** In a reaction, 5.3 grams of sodium carbonate was reacted with 6.0 grams of ethanoic acid. The products included 2.2 grams of carbon dioxide, 0.9 grams of water, and 8.2 grams of sodium ethanoate. The results show that these measurements are in line with the conservation law.

**Answer** The chemical reaction that produces results is sodium carbonate + the acid ethanoic. The reaction is sodium ethanoate plus carbon dioxide plus water.

The mass of the reactants is (5.3 + 6.0) = 1.3 grams

Mass of the product is (8.2 + 2.2 + 0.9) = 11.3 g.

The products and reactants are of identical mass. This implies that it was impossible to lose mass in the reaction. Thus, the results are in line with the conservation law.

**Question** Is it impossible to see an atom with your naked eyes?

**Answer** It is impossible to observe an atom through the naked eye due to its size. For instance, it is estimated that the radius composed of hydrogen is on the order of 10-10 millimetres. In reality, an atom can be described as a microscopic part. They are microscopic and cannot be seen by the naked eye.

**Question** If 3.0 grams of carbon are burned in 8.0 grams of oxygen, 11.0 grams of carbon dioxide are produced. What mass of carbon dioxide will be created when 3.0 grams of carbon are burned in 50.0 grams of oxygen? What law of chemical mixture will be the determining factor?

**Answer** Oxygen and carbon react to create carbon dioxide in accordance with this equation: CO2 = Carbon (C) + oxygen (O 2) > Carbon dioxide (CO 2)

In the first case, the 3.0 gram of carbon is burnt in 8.0 grams of oxygen to form 11.0 grams of CO2.

In the second case: 3.0 grams of carbon must also combine such that 8.0 grams of oxygen blend with each other. This means that (50-8) = 42 grams of oxygen will remain unreacted. Here, the mass of CO2, in this case, will become 11 grams. This answer is based on the law of constant proportions. In another case, only 8.0 grams of oxygen react, although 50.0 grams are available. It shows that the mass of carbon dioxide formed depends upon the mass of carbon.

The substance present in smaller amounts in a reaction limits the participation of the other reactants. It is known as the limiting reactant. Carbon is the limiting reactant in this case.

**Question** Give the names of the respective elements present in the following compounds:

(a) Quick lime

(b) Hydrogen bromide

(c) Baking powder

(d) Potassium sulphate

**Answer** The names of the elements present are only available when the compound’s chemical formula is already known. For example,

(a) Quick lime: It is the trade name for the chemical. The chemical name of the compound is calcium oxide.

Chemical formula: CaO.

Elements present: calcium (Ca) : oxygen (O).

(b) Hydrogen bromide, the chemical formula for the compound, is HBr.

There are elements in the form of hydrogen (H) and bromine (Br).

(c) Baking powder: It is used to commercialise the chemical. The chemical name of the compound is sodium carbonate, and its chemical formula is NaHCO3.

Elements present sodium (Na), hydrogen (H), carbon (C), and oxygen (O).

(d) Potassium sulphate: The chemical formula of this substance is 2SO4

Elements present: potassium (K), sulphur (S), and oxygen (O).

**Question** Calculate the molar mass of the respective substances:

a) Ethyne

b) Sulphur molecular

c) Phosphorus molecule

d) Hydrochloric acid

e) Nitric acid

**Answer**

a) Molar mass of ethyne = 2 x 12 + 2 x 1 = 28 gram

b) Molar mass of sulphur molecules = 8 x 32 = 256 gram

c) Molar mass of phosphorus molecules = 4 x 31 = 124 gram

d) Molar mass of hydrochloric acid = 1 + 35.5 = 36.5 gram

e) Molar mass of nitric acid = 1 + 14 + 3 x 16 = 63 gram

**Question** Calculate the formula unit masses of ZnO, Na2O, and K2CO3, given the atomic masses of Zn = 65 u, Na = 23 u, K = 39 u, C= 12 u, and O = 16 u.

**Answer** Given that the atomic mass of Zn = 65 u,

The atomic mass of Na = 23 u

The atomic mass of K = 39 u

The atomic mass of C = 12 u

The atomic mass of O = 16 u

Now, formula unit mass of ZnO = Atomic mass of Zinc + Atomic mass of O = 65 u + 16 u = 81 u

Formulas unit mass of Na20 = 2 x Atomic mass of Na + Atomic mass of O = 2 x 23 u + 16 u = 62 u

Formula unit mass of K2CO3 = 2 x Atomic mass of K + Atomic mass of C + 3 x atomic mass of O = 2 x 39 u + 12 u + 3 x 16 u = 138 u.

**Question** Which is the mass of:

(a) 0.2 mole oxygen molecules?

(b) 0.5 mole of water molecules?

**Answer** The mass is as follows:

(a) Mass of 1 mole of oxygen atoms = 16u so it weighs 16g. From 0.2 moles oxygen molecules = 0.2  x 16 = 3.2g

(b) A mole of water molecules mass is 18u, weighing 18g. 0.5 moles of water molecules equals 0.5 + 18 = 9g

Multiple Choice Questions

**Question** Do the following observations apply to an atom?

(a)Atoms cannot exist on their own.

(b)Atoms are the primary unit that is the basis of molecules and ions.

(c)Atoms are neutral.

(d) Atoms are gathered in huge numbers to create the material we can feel, touch, or see.

**Answer**

(d) This observation is not valid.

Explanation:

The correct statement is that the molecules and ions assemble in large numbers to create the substance. It is impossible to see individual molecules/ions through our eyes. However, we can see the many substances which form an extensive collection of molecules and ions. This means that alternative (d) is not correct.

The atoms of most elements are very reactive and are not present in the state of freedom. The atoms in noble gases are chemically non-reactive and are present in the free state. Atoms are usually found in two types.

(i) molecular and (ii) Ions

So atoms are the primary element from which molecules and ions form.

When atoms create the form of molecules or even ions, they are stable due to their stable arrangement for electrons in the noble gas. Thus, they are naturally neutral.

**Question** A change in the system’s physical state can come about

(a) only if energy is supplied to the system.

(b) only the moment that energy is removed from the system.

(c) the energy source is given to or withdrawn from the system.

(d) without energy changes

**Answer**

(c) the energy source is given to or withdrawn from the system.

Explanation:

Changes in physical properties can be triggered by the transfer of energy to or removed from the system. It’s because energy changes can alter the force of attraction between particles, which assists change the physical state (i.e. gas, liquid, solid).

**Question** Is the following symbol for elements wrong? Provide the correct symbols.

(a) Cobalt CO

(b) Carbon c

(c) Aluminium AL

(d) Helium He

(e) Sodium So

**Answer**

(a) Cobalt CO is an incorrect symbol. The correct symbol should be Co.

(b) Carbon c is not the correct symbol. Its sound symbolism is C.

(c) Aluminium AL is an incorrect symbol. The correct symbol should be Al.

(e) So is an incorrect symbol. The appropriate symbolism is Na. (It comes from the Latin name “Natrium”).

(d)  ‘He’ is the correct symbol of Helium.

**Question** Which of the following correctly represents 360 grams of water?

i) 2 moles of H2O

ii) 20 moles of water

iii) 6.022 x 10 (23) molecules of water

iv) 1.2044 x 10 (25) molecules of water

Options.

a) (i)

b) (i) and (iv)

c) (ii) and (iii)

d) (ii) and (iv)

**Answer** Option d

Explanation: The two moles of water molecule H2O is 36 grams. Thus, the 20 moles of water molecules (H20) will be 360 grams.

If the mass of 6.022 x 10 molecules of water molecules is 18 grams, then the mass of 1.2044 x 10 is 20 x 18 grams = 360 grams. Therefore, the options representing 360 grams of water are option (ii) and option (iv).

Therefore, the options representing 360 grams of water are option (ii) and option (iv). So, the answer is an option (d).

**Question** It is possible to change the physical state of your body:

(a) Only when energy has been given to the system.

(b) When energy is removed from the system.

(c) Energy is given or taken from the system.

(d) Without any energy changes

**Answer** The correct option is  (c) energy is given or taken from the system.

Explanation:

Energy can be given or taken out of a system to change its physical state. A solid becomes a liquid and absorbs energy. A liquid becomes a solid and releases energy. The correct answer is option c.

**Question** Classify each of the following based on their atomicity:

a) F2

**Answer** The atomicity of F2 is two atoms.

b) NO2

**Answer** The atomicity of NO2 is three atoms.

c) N2O

**Answer** The atomicity of N2O is three atoms.

d) C2H6

**Answer** The atomicity of C2H6 is eight atoms.

e) P4

**Answer** The atomicity of P4 is four atoms.

**Question** A fine white powder is provided, which can be either sugar or salt. It is difficult to identify without tasting it. Which two experiments can be conducted to determine if the finely coloured powder is sugar or salt?

**Answer**

Heating:

Sugar melts into liquid when heated. This is because sucrose has a melting point and a decomposition temperature between 190 and 192 degrees Celsius. This will make sugar light brown. Further heat will cause sugar to turn black. Salt has a melting temperature of 841 degrees Celsius and 1545.8 degrees Fahrenheit. It will not change if it isn’t heated to that temperature.

Electric conductivity:

We can test for electric conductivity by soaking the substance in water. This will allow us to determine if it is sugar or salt. It conducts electricity if it is salt. Salt (NaCl), which has both positive sodium ions and harmful chloride, conducts electricity. However, sugar doesn’t conduct electricity because it only has positive ions.

**Question**

(a) Name an element used to determine the atomic mass scale?

(b) What atom of this element is used to accomplish this purpose?

(c) What is the value of this reference atom’s mass unit?

**Answer**

(a) Carbon is used in the atomic mass scale as a standard.

(b) The atomic mass scale is handy for the carbon-12 atom.

(c) Carbon-12 has been given precisely 12 units of mass

**Question** Answer the following questions:

(a) Two symbols that have been derived using the English names of the elements.

(b) Two symbols that have been derived using the Latin names of the elements.

**Answer**

(a) Two example symbols that have been derived using the “English names of their respective elements”: Sulphur – S and Aluminium – Al.

(b) The symbols derived from Latin names of the elements are Iron-Ferrum (Fe)-Cuprum.

**Question** Answer the following questions:

(a) What form of oxygen gas can be found in nature?

(b) What form of noble gases can you find in nature?

**Answer**

(a) Oxygen naturally as diatomic molecules. To create a molecule of O2, two oxygen atoms are chemically mixed.

(b) Noble gases are found in the earth’s atmosphere. They are monatomic gaseou