Atoms and Molecules

Q.1 What is a "parmanu"?

Ans : Maharishi Konad first postulated that matter is divisible that is, if we keep breaking any matter, we will get smaller particles and finally, the particles may be so small that it cannot be divide further. These indivisible particles were named as "parmanu".

Q.2 Why can't we see an atom with our naked eyes?

Ans : The size of an atom is very small i.e., the radius of an atom is the order of 10^{-10} m hence we are not able to see an atom with our naked eyes.

Q.3 What is an atom?

Ans : The word 'atom' means 'indivisible' – something which cannot be divided further. So, atoms are the smallest particles of matter which may or may not be capable of free existence and takes part in a chemical reaction.

Q.4 Write down the difference between atom and molecule.

Ans : An 'atom' is the smallest particle of an element which may or may not have independent existence. For example, helium is an atom and exists as such. On the other hand, 'molecule' is the smallest particle of an element or compound, capable of independent existence. For example, hydrogen atom (H) exists as H_2, which is a molecule.

Q.5 What is atomicity?

Ans : Atomicity is the number of atoms present in any compound/molecule of any substance. For eg, in Ammonia (NH_3) there is 1 atom of N and 3 atoms of hydrogen so its atomicity is 4.

Q.6 Write down the laws of chemical combination.

Ans : In any chemical reaction, reactants react and form the products. All the chemical reactions occur according to some laws. These are known as "**laws of chemical combination".**

There are two important laws of chemical combination: -

- Law of conservation of mass
- Law of constant proportions

(A)Law of conservation of mass: - This law was given by **Antoine Lavoisier** in 1774. This law states, "**Mass can neither be created nor destroyed in a chemical reaction**" means in any chemical reaction, total mass of products is equal to the total mass of reactants. There is no change in mass during a chemical reaction.

Eg, If 100 gms of $CaCO_3$ decomposed completely then it gives 56 g of CaO and 44g of CO_2.

$$CaCO_3 \xrightarrow[\text{Heat}]{\text{Chemical reaction}} CaO + CO_2$$

Here, mass of reactant ($CaCO_3$) = 100 g

Mass of products = mass of CaO + mass of CO_2

= 56 g + 44 g = 100 g

Since total mass of products is equal to mass of reactants, there is no change of mass during the chemical reaction.

Law of definite proportions or law of constant composition :

This law was given by **Proust** in 1779. This law states, "**A chemical compound always made up of the same elements combined together in the same proportion by mass**" means that whatever be the source from which the compound is obtained, a pure compound is always made up of same elements in the same mass percentage.

Eg. CO_2 can be produced by: -

• By burning charcoal in air ($C+O_2 \rightarrow CO_2$)

• By heating limestone ($CaCO_3 \rightarrow CaO+CO_2$)

In both the cases, CO_2 is made up of same elements namely C and O.

C and O combined together in fixed ratio, i.e.

CO_2 ⇒ C : O_2

12 : 2 (16)

12 : 32 ⇒ 3 : 8

They combine in 3 : 8 by mass.

Q.7 If we burn a piece of paper its mass becomes less after burning. Is there any exception of the law of conservation of mass ?

Ans : In case of burning of a paper, it seems that the mass reduces. But the paper changes into ash, CO_2 and water vapour. The CO_2 and water vapour being gaseous

escape into the environment leaving the ash behind. If we calculate the mass of carbon dioxide and water vapour, the total mass of the reactant and the product will remain the same, thus verifying the law. Thus, there is no exception present which is against the law of conservation of mass.

Q.8 What is Dalton atomic theory? What are the postulates of his theory?

Ans : Dalton gave his atomic theory in 1808. This states, "**All matter is made up of very small particles called as atoms**".

The various postulates of Dalton's atomic theory are as follows : -

(1) All matter (element, compound or mixture) is made up of very small particles called**atoms**.

(2) Atoms cannot be divided further.

(3) Atoms can neither be created nor destroyed.

(4) Atoms of different elements have different sizes and masses and also possess different properties.

(5) Atoms of same or different elements combined to produce molecules or compounds.

(6) Atoms of a same element are identical in mass, size and chemical properties.

(7) The 'number' and 'kind' of atoms in a given compound is fixed.

(8) Atom is the smallest particle that takes place in a chemical reaction.

(9) Atoms of same element can combine in more than one ratio to form more than one compound.

(10)When atoms of different elements combine together, they do so in a simple whole number ratio.

Q.9 What are the major drawbacks of Dalton's atomic theory?

Ans : The major drawbacks of Dalton's atomic theory are as follows: -

• This theory was based on the concept of indivisibility of atom but recent studies show that **atom can be further divided into electrons, protons and neutrons.**

• This theory states that all the atoms of an element have exactly same mass. But, now it is known that atoms of the same element with different atomic mass (i.e. isotopes) also exist.

• This theory states that atoms of different elements have different masses but even atoms of different element can also have the same mass (i.e. isobars).

• This theory states that substances made up of same kind of atoms have similar properties. But, charcoal, graphite and diamond are all made up of carbon atoms but have different physical properties.

Q.10 What does symbol means?

Ans : A symbol represents an atom of an element which may consist of a single letter or a combination of letters derived either from the English name or Latin name of the element. It was **J.J. Barzelius of Sweden** who proposed that the first letter (or the first letter and another letter) of the name of an element be used as its symbol.

For e.g. :- Symbol of Carbon is C (first letter of name)

Symbol of Calcium is Ca (first and second letter of name)

Symbol of Chlorine is Cl (first and third letter of name)

Symbol of Iron is Fe (first and second letter of its latin name Ferrum)

Q.11 How do atoms exist?

Ans : The atoms of noble gases (eg He, Ne etc.) are unreactive and exist in the free state (as single atoms).But, atoms of most of the elements are very reactive and usually exist either in the form of molecules or ions.

Q.12 What is atomic mass or unified mass?

Ans : The atomic mass of an element is the relative mass of its atoms as compared with the mass of an atom of carbon-12 isotope taken as 12 units. Hence, $1/12^{th}$ of the mass of an atom of carbon-12 represents one unit of mass on the atomic scale. This is called **one atomic mass unit (amu) or unified mass** (**u**).

Q.13 What is a molecule?

Ans : A molecule can be defined as the smallest particle of an element or a compound that is capable of an independent existence and shows all properties of that substance. Molecule of an element is formed by the atoms of same type. Atoms of different elements join together in definite proportions to form molecules of compounds. For eg. H_2 , CO_2

Q.14 What are the different types of molecules?

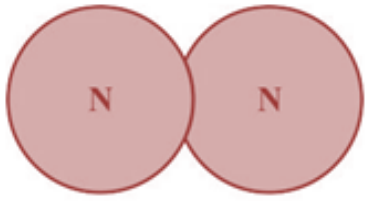
Ans : Molecules can be formed either by combination of atoms of 'same element' or of 'different elements'.

Types of molecules are as follows: -

• Molecules of elements

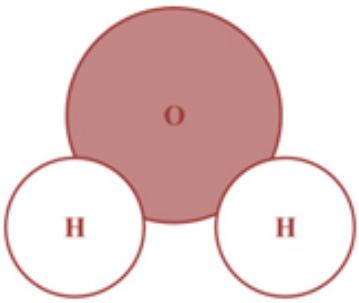
• Molecules of compounds

Molecule of elements :- The molecule of an element is made up of same atoms combined together. eg , Nitrogen gas exists as N_2



Nitrogen molecule, N_2

Molecules of compounds: - The molecule of a compound is made up of different atoms combined together. eg , Water (H_2O) is made up of hydrogen and oxygen atom.



Water molecule H_2O

Q.15 What is the meaning of the word 'atom' in Latin?

Ans : Atom means that cannot be divided (indivisible).

Q.16 Dalton's atomic theory postulated that "Atoms combine in simple whole number ratio". How has this postulate been modified?

Ans : According to the modified postulate, "Atoms combine in simple whole number ratio but this ratio may not be simple". For example,

In $C_{12}H_{22}O_{11}$(sucrose),

Ratio C : H : O = 12 : 22 : 11 which is whole number ratio but not simple.

Q.17 What is the order of size of atoms?

Ans : The atomic radius is of the order of 10^{-10} m.

Q.18 In what form are the atoms present in an aqueous solution? Give examples.

Ans : In an aqueous solution, atoms are present in the form of ions, e,g. Na^+, Cl^- etc.

Q.19 Copper is represented by the symbol 'Cu'. Why?

Ans : Symbol 'Cu' has been taken from the Latin word 'Cuprum' which represents copper.

Q.20 Define 1 amu or 1 u?

Ans : 1 amu or 1 u is equal to $1/12^{th}$ of the mass of an atom of carbon – 12 isotope.

Q.21 Give examples of bivalent cations and bivalent anions.

Ans : Bivalent cations = Mg^{2+}, Ca^{2+}

Bivalent anions = SO^2_3 , CO2−3

Q.22 What does the statement "1 mole of hydrogen" represent?

Ans : 1 mole of hydrogen does not tell whether we have 1 mole of hydrogen atoms or 1 mole of hydrogen molecules. The correct statement should be "1 mole of hydrogen atoms" or "1 mole of hydrogen molecules".

Q.23 What is the difference between homoatomic and heteroatomic molecules?

Ans : Molecules formed by similar type of atoms are known as homoatomic molecules. eg H_2, N_2 whereas, molecules made up of different types of atoms are known as heteroatomic molecules.eg. CO_2, NH_3

Q.24 What is molecular mass?

Ans : The molecular mass of substance (element or compound) is the number of times the molecule of the substance is heavier than $1/12^{th}$ the mass of an atom of Carbon -12.

OR

Molecular mass is equal to sum of the atomic masses of all the atoms present in one molecule of the substance.

For eg , molecular mass of H_2SO_4= Mass of 2 'H' atoms + Mass of 'S' atom + Mass of 4 'O'atom

= 2 × (1) + 32 + 4(16) = 2 + 32 + 64 = 98 u.

Q.25 What are ions?

Ans : An atom is made up of subatomic particles namely electrons, protons and neutrons.**Electrons carries 1 unit negative charge** and **proton carries 1 unit positive charge**.**Neutron is a neutral particle**. As every atom contains equal number of electron and proton which balance the charges and results in an electrically neutral atom. When this neutral atom loses or gains electron, it get overall electric charge. This electrically charged atom is known as '**ion**'. For e.g. Na^+, Cl^-

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Q.26 What are the differences between sodium atom and sodium ion?

Ans : When Sodium atom loses 1 electron it changes into sodium ion. Differences between atom and ion are as follows:

Sodium Atom	Sodium Ion
Na has 11 electrons in its shells. Na is neutral	Na^+ has 10 electrons in its shells. Na^+ is a positively charged particle or action.

Q.27 What are ionic compounds?

Ans : The compounds which contain ions are known as **ionic compounds**. In an ionic compound cations (positively charged ions) and anions (negatively charged ions) are held together by strong force of attraction i.e. **ionic bonds**. As ionic compounds are made up of equal number of cations and anions, their net charge is zero. For e.g. Pottasium chloride (KCl) is an ionic compound which is made up of equal number of K^+ and Cl^- ions.

Q.28 What is the significance of formula of any substance?

Ans : Significance of the formula of a substance is as follows

1. Formula represents the name of the substance. Eg H_2O represents water.

2. Name of various elements present in that substance. For e.g., water is composed of the elements hydrogen and oxygen.

3. Formula represents one molecule of the substance.

4. Formula also represents one mole or 6.022×10^{23} molecules of substance.

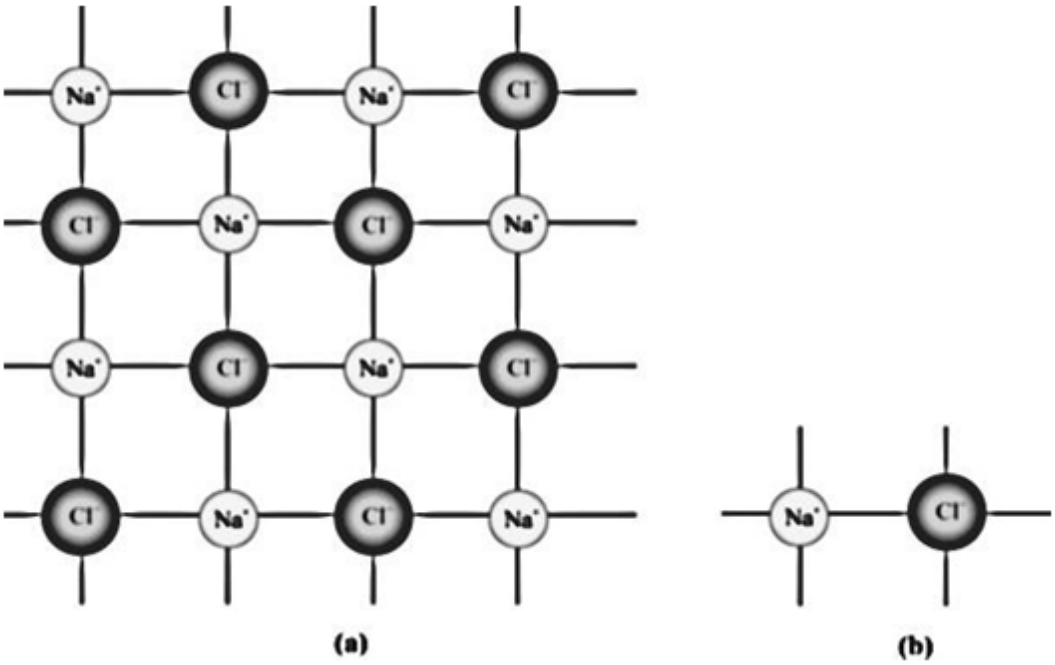
5. Formula gives the names of all the elements present in the molecule.Eg HCl (hydrogen chloride).

6. Formula gives the number of atoms of various elements present in one molecule of that element or compound. Eg NH_3 has one atom of nitrogen and three atoms of hydrogen atoms.

7. Formula represents a definite mass of the substance (equal to molecular mass expressed in grams).Eg H_2O , molecular mass of H_2O is 2 + 16 = 18

Q.29 What is formula unit mass?

Ans : Ionic compounds like NaCl consist of a very large but equal number of Na ions and Cl ions arranged in a definite order in the crystal lattice. Thus, the actual formula of NaCl should be written as $(Na^+ Cl^-)_n$ where n is a very large number. The formula of NaCl , written as $Na^+ Cl^-$ represents only the simplest formula and not the actual formula. The formula $Na^+ Cl^-$ is, therefore, called **one formula unit** and its mass is called as **formula unit mass**.



(NaCl consists of equal number of Na^+ and Cl^- ions) (Formula unit of NaCl)

Q.30 Find out the formula unit mass of ZnO.

Ans : The formula unit mass of a substance is the sum of the atomic masses of all the atoms in the single unit of a compound. Hence Formula unit mass of ZnO (zinc oxide) = 65 + 16 = 81 u

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Q.31 What is the difference between cation and anion?

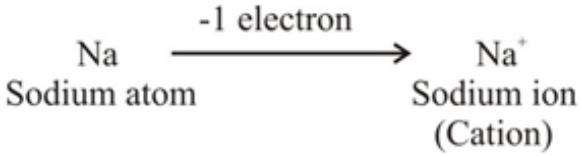
Ans : Ionic compounds are made up of positive and negative ions. When an atom loses an electron, it becomes positively charged or cation where as when atom gains electron, it becomes negatively charged or anions.

Q.32 What is cation?

Ans : A cation is formed by loss of electrons by an atom. A neutral atom contains equal number of electrons and protons. When an atom loses electron, the number of electrons becomes less than protons. So, because of more protons than electrons, a cation has a positive charge on it.

Most of the metal atoms has tendency to lose electrons, so they forms cations.

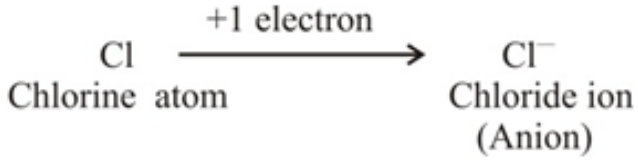
eg.Na^+



Q.33 What is anion?

Ans : An anion is formed by gain of electrons by an atom. When an atom gains electrons, the number of electrons becomes more than protons. Therefore, because of more electrons, an anion has a negative charge on it. Most of non-metals can gain electrons easily, so they form anions.

Eg . Cl^-



Q.34 What is gram atomic mass?

Ans : Gram atomic mass is the amount of a substance whose mass in grams is equal to its atomic mass.

OR

Atomic mass expressed in grams is known as gram atomic mass of that substance.

For e.g., Atomic mass of nitrogen (N) = 14 u

Gram atomic mass of nitrogen (N) = 14 g

Q.35 What is gram molecular mass?

Ans : Gram molecular mass is the amount of a substance whose mass in grams is equal to its molecular mass.

OR

Molecular mass expressed in grams is known as molecular mass of that substance.

For e.g., Molecular mass of water (H_2O) = 2(1) + 1(16) = 184 u

Gram molecular mass of H_2O = 18 g

Q.36 What is gram formula unit mass?

Ans : Formula unit mass expressed in grams is called gram formula unit mass.

For e.g., Formula unit mass of KCl = 39 + 35.5 = 74.5 u

Gram formula unit mass of KCl = 74.5 g

Q.37 What is a mole?

Ans : A group of **6.022×10^{23} particles** (atoms, molecules, ions) of any chemical substance is known as a mole. For e.g. 1 mole of C atoms = 6.022×10^{23} atoms

OR

A mole is defined as amount of substance which has mass equal to gram atomic mass.

e.g., 1 mole of N atoms = 14 g OR

A mole of any gas is the amount of the substance which has volume equal to 22.4 L at STP conditions.

E.g., 1 mole of CO_2 gas = 22.4 L of CO_2 at STP.

Q.38 What is Avogadro's number?

Ans : Mole represents a definite number of particles, atoms or molecules of a substance and this number 6.022×10^{23} is known as Avogadro number.

Q.39 What is molar mass and molar volume?

Ans : The mass of one mole of substance is known as molar mass. If the substance is atomic then its molar mass is equal to its atomic mass where as if it is in molecular form ,it is equal to its gram molecular mass.

For e.g. Molar mass of Mg = 24gram per mole

Molar mass of O_2 = 32 gram per mole

Q.40 What are differences between ionic and molecular compounds?

Ans :

Differences between Ionic and Molecular compounds		
Characteristic	**Ionic Compounds**	**Molecular Compounds**
(i) Melting points	Ionic compound are made up of ions (actions and anions) held together by strong ionic bonds. Thus, they have high melting and boiling points.	Molecular compounds are made up of molecules and no ions are present. These molecules are held together by weak covalent bonds. Hence, they have low melting and boiling points.
(ii) Solubility	Ionic compounds are soluble in water but insoluble in organic solvents.	Molecular compounds are insoluble in water but soluble in organic solvents.
(iii) Conduction of electricity	In the molten state, they conduct electricity because ions start moving towards the oppositely charged electrodes.	Molecular compounds do not conduct electricity even in the solution or molten state because no ions are present.
(iv) Rate of reaction	Reaction between ionic compounds are fast because oppositely charged ions combine quickly, e.g., $AgNO^3$ + NaCl means $Ag^+ + NO_3^- + Na^+ + Cl^-$. They form AgCl and $NaNO_3$.	Their reactions are slow because for the reaction to occur, the bonds in the molecular compounds have to be broken which require energy.

Numericals : -

Q.41 Find out the number of moles in 100 g of iron (atomic mass Fe = 56)

1 mole of iron = Gram atomic mass of Fe = 56 g

Thus, 56 g of iron = 1 mole of iron

∴ 100 g of iron
$\frac{1}{56} \times 100$ = mole = 1.786 moles.

Q.42 Find out the number of moles in 100 g of water.(Atomic masses of O =16, H = 1)

1 mole of water (H_2O) = Gram molecular mass of H_2O = 18 g

Thus, 18 g of H_2O = 1 mole of H_2O

∴ 100 g of H_2O =
$\frac{1}{18} \times 100$ moles = 5.56 moles.

Q.43 Calculate the mass of 0.5 mole of silver.(atomic mass of Ag = 108)

1 mole of silver (Ag) = Gram atomic mass of Ag = 108 g

∴ 0.5 mole of silver
$\frac{108}{1} \times 0.5 = 54$ = g.

Q.44 Calculate the mass of 0.5 mole of sugar ($C_{12}H_{22}O_{11}$) (Atomic masses of C = 12, H = 1, O = 16)

1 mole of sugar ($C_{12}H_{22}O_{11}$) = Gram molecular mass of $C_{12}H_{22}O_{11}$

= 12 × 12 + 22 × 1 + 11 × 16 g = 342 g

∴ 0.5 mole of sugar =
$\frac{342}{1} \times 0.5 = 171$ g.

Q.45 Calculate the number of atoms of gold in 1g of gold(Atomic mass of gold= 197).

Step 1. Calculation of number of moles

Number of moles =
$$\frac{Given\,mass\,in\,g}{Molar\,mass}$$

i.e.,
$$n = \frac{m}{M} = \frac{1g}{197\,g\,mol^{-1}} = \frac{1}{197} mole$$

Step 2. Calculation of number of atoms

Number of atoms = No. of moles × Avogadro's number

i.e., N = n × N_0 =
$\frac{1}{197} \times 6.022 \times 10^{23}$

= 3.06 × 10^{21} atoms.

Q.46 Calculate the mass in milligrams of 10^{21} atoms of U-238.

$$n\,(number\,of\,moles) = \frac{N}{N_0} = \frac{number\,of\,atoms}{Avogadro\,number} \text{ .. (1)}$$

m (mass) = n × M ..(2)

Placing the value of 'n' from equation (1) into equation (2)

$$m(mass) = n \times M = \frac{N}{N_0} \times M$$

$$= \frac{10^{21}}{6.022 \times 10^{23}} \times 238\ g = 0.395\ g$$

Since 1 g = 1000 mg

Hence 0.395 g = 395 mg

Q.47 Find out the mass of an atom of copper (atomic mass of Cu = 63.5).

1 mole of Cu atoms = Gram atomic mass of Cu = 63.5 g

Since 1 mole of Cu atoms = 6.022 × 10^{23} atoms of Cu

6.022 × 10^{23} atoms of Cu weigh = 63.5 g

∴ 1 atom of Cu will weigh =
$\frac{63.5}{6.022 \times 10^{23}} g$

$= 10.54 \times 10^{-23}$ g

Q.48 10^{22} atoms of an element 'X' are found to have a mass of 930 mg. Calculate the molar mass of

the element ‘X’.

Molar mass of an element is the mass of Avogadro’s number of atoms.

10^{22} atoms of the element have mass = 930 mg =
$\frac{930}{1000} g = 0.930\, g$

∴ 6.022×10^{23} atoms will have mass =
$\frac{0.930}{10^{22}} \times 6.022 \times 10^{23} g = 56.0\, g$

∴ Molar mass of the element = 56 g mol^{-1}.

Q.49 Calculate the mass of SO_2 gas which will contain the same number of molecules as present in 4.4 g of CO_2.

Molar mass of CO_2 = 12 + 2 × 16 g mol^{-1} = 44 g mol^{-1}.

No. of moles in 4.4 g CO_2 =
$\frac{Given\, mass}{Molar\, mass} = \frac{4.4 g}{44\, g\, mol^{-1}} = 0.1\, mol.$

0.1 mole of CO_2 will contain the same number of molecules as present in 0.1 mole of SO_2 (because equal number of moles contains equal number of molecules). Thus, we have to calculate mass of 0.1 mole of SO_2.

Molar mass of SO_2 = 32 + 2 × 16 g mol^{-1} = 64 g mol^{-1}

Mass (m) = n × M = 0.1 × 64 g = 6.4 g.

Q.50 Which will contain larger number of atoms, 1 g of gold or 1 g of silver ? Explain with reason. (Atomic masses of Gold = 197 u, Silver = 108 u)

No. of moles (n) in 1 g of gold =
$\frac{m}{M} = \frac{1}{197}$

No. of moles (n) in 1 g of silver =
$\frac{m}{M} = \frac{1}{108}$

As
$\frac{1}{108} > \frac{1}{197}$

Greater the number of moles, greater is the number of atoms present.

Hence silver will contain more number of atoms.

Q.51 Calculate the number of molecules present in 1 litre of water assuming that density of water is 1 g mL^{-1}.

1 Litre of water = 1000 ml

1 Litre of water = 1000 mL

Mass of 1000 mL of water = Volume × Density = 1000 mL × 1 g mL^{1} = 1000 g

No. of moles in 1000 g of H_2O =
$\frac{m}{M} = \frac{1000}{18} = 55.55\, moles$

No. of molecules (N) = n × N_0 = 55.55 × 6.022 × 10^{23}.

= 3.345 × 10^{25} molecules

Q.52 Which of the following has larger number of hydrogen atoms ?

(i) One mole of ammonia (NH_3) (ii) Two moles of hydrochloric acid (HCl)

1 mole of NH_3 contains 3 moles of H-atoms = 3 × N_0 atoms

2 moles of HCl contains 2 moles of H-atoms = 2 × N_0 atoms.

Thus, 1 mole of NH_3 contains larger number of H-atoms than 2 moles of HCl.

Q.53 Calculate the number of atoms in each of the following :

(i) 16 moles of He (ii) 16 u of He

(i) As 1 mole of He contains = 6.022× 10^{23} atoms

N = n × N_0 = 16 × 6.022 × 10^{23} atoms = 96.352 × 10^{23} atoms

(ii) 4 u of He = 1 atom of He

∴ 16 u of He =
$\frac{1}{4} \times 16 = 4$ = atoms of He

Q.54 Calculate the molar mass of the following substances.

(a) Ammonia

(b) Phosphorus molecule

(a) Molar mass of ammonia (NH_3) = 1 ×14 + 3 × 1 = 17 u

(b) Molar mass of phosphorus molecule (P_4) = 4 × 31 = 124 u

Q.55 How many litres does 2 moles of H_2 gas at STP contain?

Avogadro's law confirms that one mole of any gas (ideal) occupies 22.4 litre at STP. Therefore, 2 moles of H_2 gas will occupy 22.4 × 2 = 44.8 litre of volume.

Q.56 In formation of CO_2 , Carbon and oxygen react. They do so in the same ratio 3: 8.What mass of oxygen would be required to react completely with 6.0 g of carbon ? Calculate the mass of carbon dioxide gas so formed ?

Carbon and oxygen combine as per law of constant proportions, i.e. 3 g of carbon will always combine with 8 g of oxygen or

3 g carbon(C) combines with oxygen(O) = 8 g

∴ 6 g carbon(C) will combine with oxygen (O)=

$$\frac{8}{3}\times 6 = 16\,g$$

Total amount of carbon dioxide(CO_2) = 6 + 16 = 22 g

Q.57 Write the chemical formula of following compounds using criss – cross method.

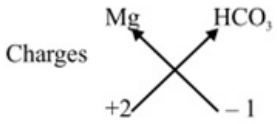
(a) Magnesium bicarbonate

(b) Barium nitrate

(a) Using criss – cross method of finding chemical formula

Valency of Mg = +2

Valency of HCO_3= -1

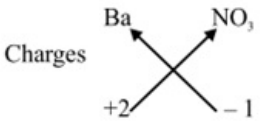


By Cross over valencies , formula will be $Mg(HCO_3)_2$.

(b) Using criss – cross method of finding chemical formula

Valency of Ba = +2

Valency of NO_3= -1



By Cross over valencies , Formula will be $Ba(NO_3)_2$.

Q.58 If one mole of carbon atoms weighs 12 g. What is the mass (in grams) of 1 atom of carbon ?

1 mole of C atoms = 6.022×10^{23} atoms = 12 g

6.022×10^{23} atoms of C weighs 12 g

∴ 1 atom of C will weigh = $\frac{12 \times 1}{6.022 \times 10^{23}} = 1.99 \times 10^{-23} g$

Q.59 Calculate the molar mass of the following substances.

(a) Ammonia

(b) Phosphorus molecule

(a) Molar mass of ammonia (NH_3) = 1 ×14 + 3 × 1 = 17 u

(b) Molar mass of phosphorus molecule (P_4) = 4 ×31 =1 24 u

Q.60 Find the mass of

(a) 1 mole of nitrogen atoms

(b) 8 moles of aluminium atoms

(a) Mass of 1 mole of nitrogen atoms = molar mass in gram = 14 g

(b) Mass of 1 mole of Al atoms = 27 g

Therefore, Mass of 8 moles of Al atoms = 8 × 27 = 216 g

Q.61 Give the names of the elements present in the following compounds.

(a) Quicklime

(b) Hydrogen bromide

(c) Baking powder

(d) Potassium sulphate

(e) Marble

(a) Quicklime - CaO (Calcium oxide)

Elements – Calcium, oxygen

(b) Hydrogen bromide —— HBr

Elements - Hydrogen, bromine

(c) Baking powder — $NaHCO_3$ (Sodium hydrogen carbonate)

Elements – Sodium , hydrogen , carbon , oxygen

(d) Potassium sulphate - K_2SO_4

Elements- Potassium , sulphur , oxygen

(e) Marble - $CaCO_3$ (Calcium carbonate)

Elements- Calcium, carbon, oxygen

Q.62 Calculate the number of moles in 71g of chlorine. [Atomic mass of Cl = 35.5]

Molecular mass of Cl_2 = 2 × 35.5 = 71 u

$$\frac{Given\,mass}{Molar\,mass}$$

Q.63 How many molecules are present in 34 gm of ammonia ?

Molecular mass of ammonia (NH_3) = 1 (N) + 3(H) = 1(14) + 3(1) = 14 + 3 = 17

Since 17 gm of ammonia contains 6.022×10^{23} molecules

Therefore 34 gm of ammonia (NH_3)contains = $2\times 6.022 \times 10^{23}=12.044 \times 10^{23}$ molecules.

Q.64 Find the number of moles of

(a) 48 g of oxygen gas

(b) 22 g of CO_2 gas

(a) Molecular weight of Oxygen(O_2) = 2 × 16 = 32 u

i.e. mass of 1 mole of O_2 = 32 g

32 g of O_2 = 1 mol

∴ 48 g of O_2 =
$\frac{1\times 48}{32}=\frac{3}{2}=1.5\,mol$

number of moles =
$\frac{Given\,mass}{Molar\,mass}=\frac{48}{32}=1.5\,mol$

(b) Molecular weight of CO_2 = 12 + 2 × 16 = 44 g

44 g of CO_2 = 1 mol

∴ 22 g of CO_2 =
$\frac{1}{44}\times 22=0.5\,mol$

Number of moles =
$\frac{Given\,mass}{Molar\,mass}=\frac{22}{44}=0.5\,mol$

Value Based Questions :-

Q.1 Two students of class IX, Kaveri and Nalini, were asked to take 5.3 g of sodium carbonate and 6 g of ethanoic acid to make 2.2 g of carbon dioxide, 0.9 g of water and 8.2 g of sodium ethanoate. Kaveri followed the instructions but Nalini took the chemicals without measuring their amounts.
Read the above passage and answer the following questions

Ans : (a) whose activity do you think will be in agreement with the law of conservation of mass?
(b) State the law of conservation of mass.
(c) Whose method do you like and why?

(a) Kaveri took the chemicals after measuring them so she is following the law of conservation of mass.

(b) Accoring to law of conservation of mass , *"Mass can neither be created nor be destroyed in a chemical reaction."*

(c) I liked the method of Kaveri, as she performed the experiment following all the instructions.

Q.2 Some people take lot of junk food like pizza, burger, chowmein which contains lot of common salt. Pickles and sauces also contain a lot of salt. As a result, nowadays high blood pressure and heart disease are on the rise.

(a) Write the formula of common salt?

(b) Why should we take less common salt?

(c) Why are people prone to heart diseases these days?

Ans : (a) NaCl

(b) Salt increases blood pressure if taken in excess. So we should take less amount of salt.

(c) High intake of carbohydrate and lack of exercise is the reason behind heart diseases.

Q.3 Anurag could not understand the mole concept taught by his school teacher. Next day he went to the market with his friend to buy fruits. He bought one dozen apples and one dozen oranges. The fruit seller gave them fruits according to their weight in kg. On noticing their relevant masses, Anurag understood the mole concept clearly.

Read the above passage and answer the following question:

(a) Define mole concept?

(b) How many pieces come in one dozen?

(c) How did Anurag understand the mole concept ?

Ans : (a) Mass of 1 mole of a substance (atoms, molecules, ions or particles) is equal to its relative atomic or molecular mass in gram. The molecular mass in grams of a substance contains one mole of particle

N_a = Avogadro's Number = 6.02×10^{23}

(b) 12 pieces

(c) Weight of one dozen each of apples and oranges are different in kg. Similarly, the weight of 1 mole of atoms of different elements has 6.022×10^{23} atoms/ ions / molecules with different masses in gram. This made Anurag understand mole concept.

As 1 dozen = 12 pieces

Similarly, 1 mole = 6.02×10^{23} atoms

Previous Year's Questions

1 Mark Questions

Q.1 10 gm of silver nitrate solution is added to 10 gm of sodium chloride solution. What change in mass do you expect after the reaction and why?

[Board, 2013]

Ans : No change in mass will take place because mass can neither be created nor destroyed in a chemical reaction as law of conservation of mass states.

Q.2 Write the atomicity of the following molecules:

(i) H_2SO_4 (ii) CCl_4

[Board, 2012]

Ans : Atomicity is the number of atoms present in a molecule.

(i) H_2SO_4 = 7 atoms are present

(ii) CCl_4 = 5 atoms are present.

Q.3 Define the term mole.

[CBSE 2011]

Ans : The mole is the amount of the substance which contains same number of particles (atoms/molecules/ formula units, etc) as there are C-12 isotope atoms in 12 gram.

Q.4 What is the law of constant proportions?

[CBSE 2011]

Ans : The law of constant proportions states "*a pure chemical compound always consists of the same elements that are combined together in a fixed proportion by mass.*

For example, H_2O obtained from any source contains hydrogen and oxygen in the ratio of 1 : 8 by mass."

Q.5 What is molar mass? What are its units?

[CBSE 2011]

Ans : The mass of one mole of substance (i.e. Avogadro's number of particles = 6.023×10^{23}) is called its molar mass. Its unit is gram per mole (g / mol) or kilogram per mole (kg / mol).

Q.6 Define atomicity.

[CBSE 2010]

Ans : Atomicity is defined as number of atoms present in a molecule.

e.g. Atomicity of NH_3 is 4 because there is one atom of N and three atoms of H.

Q.7 Calculate the formula unit mass of Na_2CO_3. [Atomic mass of Na = 23 u, C = 12 u, O = 16 u]

[CBSE (CCE), 2010]

Ans : The formula unit mass of a substance is the sum of the atomic masses of all the atoms in the formula unit of an ionic compound.

Therefore, formula unit mass of Na_2CO_3

= 2Na + 1C + 3O = (2 × 23) + (1 × 12) +(3 × 16) = 46 + 12 + 48 = 106 u.

Q.8 Give the definition of a cation and an anion.

[CBSE, 2010]

Ans : Cation- It is the positively charged ion, e.g., Na^+ which is attracted towards cathode (negative electrode) in an electric field.

Anion – It is the negatively charged ion, e.g., Cl^-which is attracted towards anode (positive electrode) in an electric field.

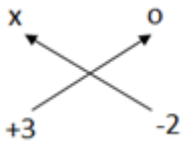
Q.9 An element X has a valency 3. Write the formula of its oxide.

[CBSE (CCE), 2012, KVS 2008]

Ans : Using criss – cross method of finding chemical formula

Valency of X = +3

Valency of O = -2



After cross over valencies, formula will be X_2O_3.

2 Marks Questions

Q.10 Calculate the number of moles is 52 g of He (Helium)

[At mass : O = 16 u, He = 4 u]

[CBSE (CCE) 2011]

$$\text{Number of moles} = \frac{Given\ mass}{Molar\ mass} = \frac{52}{4} = 13 \text{ moles.}$$

Q.11 If 12 gm of carbon is burnt in the presence of 32 gm of oxygen, how much carbon dioxide will be formed ?

[Board, 2011]

The law of conservation of mass states that mass can neither be created nor destroyed or mass of reactants is always equal to that of products.

$$C + O_2 \rightarrow CO_2$$

Carbon + Oxygen → Carbon dioxide

Mass of reactants = 12 + 32 = 44 g

Mass of Product (CO_2) = 44 g

(One mole of C reacts with 1 mole of oxygen to form 1 mole of CO_2)

Q.12 Calculate the number of moles in 17 gm of H_2O_2. (Atomic weight of H = 1 u, O = 16 u).

[Board, 2011]

Atomic mass of H = 1

Atomic mass of O = 16

Molecular mass of H_2O_2 = (2 × 1) + (2 × 16) = 34 gm

Since 34 gm of hydrogen peroxide (H_2O_2) = 1 mole

Hence 17 gm of $H_2O_2 = \frac{1}{34} \times 17 = \frac{1}{2} = 0.5\ moles$

Q.13 Define and explain atomic mass of an element.

[MSE, 2008, CBSE, 2011]

Atomic mass of an element is the relative mass of its atoms compared with the mass of an single atom of C-12 isotope taken as 12 units.For example, the atomic mass of oxygen is 16 which indicates that an atom of oxygen is 16 times heavier than 1/12th of a ^{12}C atom.

Atomic Mass Unit (amu) = $\frac{1^{th}}{12}$ the mass of ^{12}C atom.

Q.14 If one mole of carbon atoms weighs 12 g. What is the mass of 1 atom of carbon ?

[CBSE (CCE), 2010]

1 mole of C = 12 g

Number of atoms in1 mole of C = 6.022×10^{23} atoms

Mass of 6.022×10^{23} atoms of C = 12 g

Mass of 1 atom of $C = \frac{12}{6.022 \times 10^{23}} = 1.99 \times 10^{-23} g$

Q.15 Calculate the mass of 1 molecule of oxygen gas.

[Atomic mas of O = 16 u, $N_A = 6.022 \times 10^{23}$ mol^{-1}]

[CBSE, 2010]

Weight of 1 mole of oxygen molecules = 32g of oxygen

Number of atoms in 1 mole of oxygen = 6.022×10^{23} molecules

Because 6.022×10^{23} molecules of O_2 weigh 32 g

Therefore, 1 molecule of O_2 will weigh = $\frac{32}{6.022 \times 10^{23}}$

= 5.313×10^{-23} g

Q.16 The mass of single atom of an element is 2.65×10^{-23} g. Calculate its atomic mass. [$N_A = 6.022 \times 10^{23}$ mol^{-1}]

[CBSE, 2010]

Mass of 1 atom = 2.65×10^{-23} g

Therefore, mass of 6.022×10^{25} atoms

$= 2.65 \times 10^{-23} \times 6.022 \times 10^{23} = 15.96$ 16 g mol^{-1}

Therefore, the atomic mass of the element is 16 u.

Q.17 Calculate percentage composition of glucose ($C_6H_{12}O_6$).

(C = 12, H = 1, O = 16)

[KVS, 2009]

Molecular mass of glucose ($C_6H_{12}O_6$) = $6 \times 12 + 1 \times 12 + 6 \times 16$

$= 72+12+ 96 = 180$ g

$$\%\text{of carbon(C) in glucose} = \frac{72}{180} \times 100 = 40$$

$$\%\text{ of hydrogen (H) in glucose} = \frac{12}{180} \times 100 = 6.66$$

$$\%\text{ of oxygen(O) in glucose} = \frac{96}{180} \times 100 = 53.33.$$

3 Marks Questions

Q.18 John placed 10 moles of sulphur molecules (S_8) and 5 moles of glucose ($C_6H_{12}O_6$) in the two different pans of a physical balance. Find which pan of the balance would be heavier, support your answer with calculations.

(atomic mass : O = 16 u, C = 12 u, H = 1 u, S = 32 u)

[Board, 2014]

Molecular mass of sulphur molecules (S_8)

= 32 × 8 = 256 gm

Molecular mass of glucose ($C_6H_{12}O_6$)

=(6 × 12) +(1 × 12) +(6 × 16)

= 72 + 12 + 96=180

Weight of 10 moles of S_8 =10 × 256 = 2560

Weight of 5 moles of glucose = 5 × 180 = 900

Therefore, 10 moles of sulphur would weigh more.

Q.19 (a) What is Avogadro constant ?

(b) Calculate the number of particles present in 56 gm of N_2 molecule.

[Board, 2012]

(a) The number of atoms or molecules in 12 gm of carbon-12 (in a mole of a substance) is called as Avogadro constant (6.022×10^{23})

$$\text{(b) Number of molecules(N)} = \frac{Given\ mass \times Avogadro's\ number}{Molar\ mass}$$

Molar mass of 1 mole of N_2=14 × 2 =28

$$N = \frac{56}{28} \times 6.022 \times 10^{23}$$

$N = 12.044 \times 10^{23}$

Hence there are 12.044×10^{23} particles present in 56 gm of N_2

Q.20 Calculate the number of moles present in

(a) 60 g of calcium.

(b) 3.011×10^{23} number of oxygen atoms.

[Given that Ca = 40u; Avogadro number, $N_A = 6.022 \times 10^{23}$ per mole]

[CBSE (CCE), 2012]

(a) Number of moles of Ca = $\frac{Given\ mass\ of\ Calcium}{Molar\ mass\ of\ Calcium}$

$= \frac{60}{40} = 1.5\ moles$

(b) Number of moles = $\frac{Given\ No.\ of\ molecules}{6.022 \times 10^{23}}$

$= \frac{3.011 \times 10^{23}}{6.022 \times 10^{23}} = 0.5\ mol$

Q.21 (a) The average atomic mass of a sample of an element X is 35.5u. What are the percentages of isotopes $_{17}X^{37}$ and $_{17}X^{35}$ in the sample ?

(b) Write any two applications of isotopes.

[CBSE (CCE), 2012]

(a) Let the percentage of $^{37}_{17}X$ is p

Percentage of $^{35}_{17}X$ = (100 – p)

Average atomic weight = 35.5

Therefore

$35.5 = \frac{37p + 35(100 - p)}{100}$

$3550 = 37p + 3500 - 35p$

3550-3500=37p-35p

$2p = 50 \Rightarrow p = 25\%$

Therefore, sample of ${}^{37}_{17}X$ is 25% and ${}^{35}_{17}X$ will be 100 – 25 = 75%

(b) Cesium 137 – Used to treat cancerous tumors.

Calcium 47 – It is an important aid for biomedical researchers studying the cellular functions.

Q.22 Nitu presented a silver lamp to her mother on her birthday. The lamp contained 3.011×10^{23} atoms of silver in it. What is the mass of silver lamp and the cost of it if 1 gm silver costs Rs 60.

Atomic mass of Ag = 108 u, $N_0 = 6.022 \times 10^{23}$ per mole.

[Board, 2012]

Atomic mass of silver(Ag) = 108 u

since mass of 6.022×10^{23} atoms of silver(Ag) = 108 u

Hence mass of 3.011×10^{23} atoms of silver (Ag) = $\frac{108 \times 3.011 \times 10^{23}}{6.022 \times 10^{23}} = 54\ gm$

Cost of 1 gm silver = 60

Therefore, cost of silver lamp = 60 × 54 = Rs. 3240

Q.23 Give an account of the 'mole concept'.

[CBSE, 2011]

Mole is a unit to express amount of any chemical compound that contains atoms/molecules/ions equal to atoms present in 12 gram of carbon-12 isotope. This number of atoms is fixed and is equal to 6.023×10^{23} (Avagadro's number). Thus a mole expresses a collection of 6.023×10^{23} atoms, molecules, ions, etc. For e.g., 1 mole of oxygen atom refers to 6.023×10^{23} atoms of oxygen.

Q.24 Calculate the ratio by number of atoms for Magnesium sulphide.

[Atomic mass of Mg => 24, S => 32]

[CBSE, 2011]

Atomic mass of Mg = 24

Atomic mass of S = 32

Ratio of Mg and S in Magnesium sulphide = 24:32 = 3:4

Mass ratio / Atomic mass of Magnesium (Mg) = $\frac{3}{24} = \frac{1}{8}$

Mass ratio / Atomic mass of Sulphur (S) = $\frac{4}{32} = \frac{1}{8}$

Hence, ratio of atoms in Magnesium sulphide (MgS) = $\frac{1}{8} : \frac{1}{8}$ or 1 : 1.

5 Marks Questions

Q.25 Verify by calculating that 5 mole of CO_2 and 5 mole of H_2S do not have the same mass.

(Atomic mass of C = 12 u, O = 16 u, H = 1 u, S = 32 u)

[Board, 2013]

Molecular mass of CO_2 = 1(C) + 2(O)

= 1(12) + 2(16)

= (1 × 12) +(2 × 16)

= 44 u

5 mole of CO_2 = 5 × 44

= 220 gm

Molecular mass of H_2S = 2(H) + 1(S)

= (2 × 1) + (1 × 32)

= 34 u

Hence, both (CO_2 and H_2S) do not have same mass.

Q.26 A solution is made by dissolving sodium chloride in water and its concentration is expressed as 0.9% by mass.

Calculate :

(i) the number of moles, and

(ii) number of molecules present in NaCl for this solution.

[Given : mass % = $\frac{Mass\ of\ solute}{Mass\ of\ solution} \times 100$]

(Atomic mass of Na = 23.0 u, Cl = 35.5 u)

[Board, 2012]

0.9% mass by mass means 0.9 gm NaCl in 100 gm of solution

Therefore, Given mass of solute (NaCl) = 0.9 gm

Molar mass of NaCl = 23 + 35.5 = 58.5 mol^{-1}

$$\text{Number of moles} = \frac{Given\ mass(m)}{Molar\ mass(M)} = \frac{0.9}{58.5} = 0.015\ u$$

Number of molecules = number of moles(n) × Avogadro constant (N_0)

= $0.015 \times 6.022 \times 10^{23}$

= 0.09×10^{23} or 9.033×10^{21}

Q.27 (i) What do the following symbols / formulae stand for :

(a) 2O (b) O_2 (c) O_3 (d) H_2O

(ii) Give the chemical formula of the following compounds :

(a) Potassium carbonate (b) Calcium chloride

(iii) Calculate the formula unit mass of $Al_2(SO_4)_3$.

(Given : Atomic mass of Al = 27 u, S = 32 u, O = 16 u)

[Board, 2012]

(i) (a) 2O = 2 atoms of oxygen

(b) O_2 = Diatomic oxygen

(c) O_3= Triatomic oxygen / ozone

(d) H_2O=Two atoms of hydrogen and one atom of oxygen construct one molecule of water (H_2O)

(ii) Potassium carbonate - K_2CO_3

Calcium chloride - $CaCl_2$

(iii) Formula unit mass of any compound is the sum of atomic masses of all atoms in the formula of that compound.

Formula unit mass of $Al_2(SO_4)_3$

Atomic mass of Al = 27 × 2 = 54 u

Atomic mass of S = 32 × 3 = 96 u

Atomic mass of O = 16 × 12 = 192 u

Formula unit mass = 54 + 96 + 192 = 342 u.

Hence Formula unit mass of $Al_2(SO_4)_3$ is 342.

Q.28 An element $_7A^{14}$ exists as diatomic gas in nature which is relatively inert and forms 78% of earth's atmosphere.

(a) Identify the gas and write its molecular formula. Write the formulae of its nitrite and nitrate ions.

(b) How many moles of this gas would contain 12.044×10^{23} atoms of this element ? (Avogadro's no. = 6.022×10^{23})

(c) Calculate the molecular mass of

(a) NH_4NO_3 and (b) HNO_3

(Given atomic masses N = 14 u, O = 16 u, H = 1u)

[CBSE 2012]

(a) Element A has atomic number 7 so it is Nitrogen gas (N_2)

Formulae : Nitrite ion (NO_2^-)

Nitrate ion (NO_3^-)

(b) 1 mole of N_2 gas = 6.022×10^{23} molecules of N_2

= 12.044×10^{23} atoms of N

(c) (i) Molecular mass of $NH_4NO_3 = 14 + 1 \times 4 + 14 + 3 \times 16 = 80$ u

(ii) Molecular mass of $HNO_3 = 1 + 14 + 3 \times 16 = 63$ u

Q.29 (a) In ammonia, nitrogen and hydrogen are always present in the ratio 14 : 3 by mass. State the law which explains the above statement.

(b) During the formation of ammonia, what mass of hydrogen gas would be required to react completely with 42 g of nitrogen gas ?

[CBSE, 2011]

(a) In ammonia (NH_3) , N and H present in fixed ratio which supports the law of definite or constant proportions. This law states, *"a pure chemical compound always consists of the same elements that are combined together in a fixed proportion by mass".*

(b) Molecular mass of ammonia (NH_3) = mass of N + mass of H

= 14+(3×1)

=17

To react with 14 g N , mass of H required = 3 g

Therefore to react with 42 g N, mass of H required = $\frac{3}{14} \times 42 = 9\ g.$

Q.30 (a) Calculate the number of moles in 112 g of iron.

(b) Calculate the mass of 0.5 moles of sugar ($C_{12}H_{22}O_{11}$).

(c) Define the term molecular mass.

(d) Determine the molecular mass of $ZnSO_4$.

[Atomic mass of Zn = 65 u, S = 32 u, O = 16 u]

(e) Calculate the number of molecules of carbon dioxide, present in 4.4 g of CO_2.

[Atomic mass of C = 12 u, O = 16 u, $N_A = 6.022 \times 10^{23}\ mol^{-1}$]

[CBSE, 2010]

(a) 1 mole of iron (Fe) = 56 g (molar mass)

Since 56 g of iron = 1 mol

Therefore, 112 g of *iron* = $\frac{1}{56} \times 112$ mol = 2 mol

(b) Molar mass of $C_{12}H_{22}O_{11}$ = (12 × 12) +(22 × 1) + (11 × 16) = 342 g

Since mass of 1 mole of sugar = 342 g of sugar

Therefore mass of 0.5 mole of sugar = 342 × 0.5 = 171 g

(c) Molecular mass: Molecular mass is the sum of the atomic masses of all theatoms in a molecule of that substance.

(d) Molecular mass of $ZnSO_4$ = (1 × 65) + (1 × 32) +(4 ×16) = 161 g

(e) Molecular mass of CO_2 = 12 + 2 × 16 = 44 g

Since 44 g of CO_2 contains 6.022×10^{23} molecules

Therefore, 4.4 g of CO_2 contains = $\frac{6.022 \times 10^{23}}{44} \times 4.4$

= 6.022×10^{22} molecules