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Chapter – 3 Atoms and Molecules

Class 9 Science NCERT Textbook – Page No. 32 and 33

Q1. In a reaction, 5.3 g of sodium carbonate reacted with 6 g of ethanoic acid. The products were 2.2 g of carbon dioxide, 0.9 g of water and 8.2 g of sodium ethanoate. Show that these observations are in agreement with the law of conservation of mass.

Answer:

The law of conservation of mass states that a chemical compound consists of same elements combined together in the same proportion by mass.

If the two masses are equal, then the law of conservation of mass gets verified.

We will calculate the mass of reactants and products separately,

$$\boldsymbol{Sodium\ carbonate + Ethanoic\ acid = Reactants}$$

$$\boldsymbol{Sodium\ ethanoate + Carbon\ dioxide + Water = Products}$$

i) Sodium carbonate and ethanoic acid are reactants, so

$$Mass\ of\ reactants = Mass\ of\ sodium\ carbonate + Mass\ of\ ethanoic\ acid$$
$$= 5.3 + 6$$
$$= 11.3\ g$$

ii) Sodium ethanoate, carbon dioxide and water are products, so,

$$Mass\ of\ products$$
$$= Mass\ of\ sodium\ ethanoate + Mass\ of\ carbon\ dioxide + Mass\ of\ water$$
$$= 8.2 + 2.2 + 0.9$$
$$= 11.3\ g$$

- The mass of reactants = 11.3 g and the mass of products = 11.3 g. Thus, mass of reactants and of products are equal, which verifies the law of conservation of mass.

Q2. Hydrogen and oxygen combine in the ratio of 1:8 by mass to form water. What mass of oxygen gas would be required to react completely with 3 g of hydrogen gas?

Answer:

There is fixed ratio of 1:8 in which the hydrogen and oxygen combine to form water.

1 g of hydrogen gas requires = 8 g of oxygen gas

3 g of hydrogen gas requires = 8 $\times$ 3 of oxygen gas

$$= 24\ g\ of\ oxygen\ gas$$

So, 24 grams of oxygen react with 3 g of hydrogen to form water.

Q3. Which postulate of Dalton's atomic theory is result of the law of conservation of mass?

Answer:

The postulate of Dalton's atomic theory states that:

"$Atoms\ can\ neither\ be\ created\ nor\ destroyed\ in\ a\ chemical\ reaction$" which is also called law of conservation of mass.

Q4. Which postulate of Dalton's atomic theory can explain the law of definite proportions?

Answer:

The postulate of Dalton's atomic theory states that:

"$The\ number\ and\ kind\ of\ atoms\ in\ a\ given\ compound\ is\ fixed$" and explains the law of definite proportions.

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Q1. Define the atomic mass unit.

Answer:

An atomic mass unit is defined as:

$$Atomic\ mass\ unit = \frac{1}{12}\ the\ mass\ of\ a\ carbon - 12\ atom.$$

Q2. Why is it not possible to see an atom with naked eyes?

Answer:

It is not possible to see an atom with our naked eye because the size of an atom is very small that is radius of an atom is 10^{-10} meter.

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Q1. Write down the formulae of:

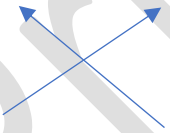
i) Sodium oxide.
ii) Aluminum chloride.
iii) Sodium sulphide.
iv) Magnesium hydroxide.

Answer:

A chemical formula shows exchange of valency**:**

i) Sodium oxide is made up of sodium $Na+$ and oxygen $O-2$.

Symbols: Na O Na O



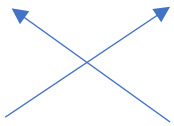
Na_2O (Formula)

Valences: $1+$ $2-$ $1+$ $2-$

So, the formula of sodium oxide is Na_2O

ii) Aluminum chloride is made up of aluminum $Al+3$ and chloride $Cl-1$.

Symbol: Al Cl Al Cl



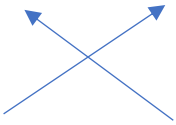
$AlCl_3$ (Formula)

Valences: $3+$ $1-$ $3+$ $1-$

So, the formula of aluminum chloride is $AlCl_3$.

iii) Sodium sulphide is made up of sodium $Na+$ and Sulphur S-2

Symbols: Na S Na S



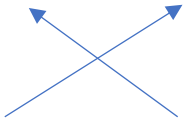
Na_2S (Formula)

Valences: $1+$ $2-$ $1+$ $2-$

So, the formula of sodium sulphide is Na_2S.

iv) Magnesium hydroxide is made up of magnesium $Mg + 2$ and hydroxide $OH - 1$

Symbols: Mg OH Mg OH



$Mg(OH)_2$ (Formula)

Valences: $2+$ $1-$ $2+$ $1-$

So, the formula of magnesium hydroxide is $Mg(OH)_2$.

Q2. Write down the names of compounds represented by the following formulae:

i) $\boldsymbol{Al_2(SO_4)_3}$
ii) $\boldsymbol{CaCl_2}$
iii) $\boldsymbol{K_2SO_4}$
iv) $\boldsymbol{KNO_3}$
v) $\boldsymbol{CaCO_3}$

Answer:

i) Aluminum sulphate.
ii) Calcium chloride.
iii) Potassium sulphate.
iv) Potassium nitrate.
v) Calcium carbonate.

Q3. What is meant by the term chemical formula?

Answer:

The chemical formula represents composition of a molecule of the compound in terms of the symbols of the elements present in it.

Example: the chemical formula of water H_2O tells us that one molecule of water is made up of 2 atoms of hydrogen and 1 atom of oxygen chemically combined together.

Q4. How many atoms are present in:

i) H_2S molecule.

ii) PO_4^{3-} ion?

Answer:

i) Three atoms are present in H_2S molecule, 2 hydrogen atoms and 1 atom of Sulphur.

ii) Five atoms are present in PO_4^{3-} ion, 4 atoms of oxygen and 1 atom of Phosphorus.

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Q1. Calculate the molecular masses of H_2, O_2, Cl_2, CO_2, CH_4, C_2H_6, C_2H_4, NH_3, CH_3OH.

(Atomic masses: H=1, O=16, Cl=35.5, C=12, N=14)

Answer:

i) Molecular mass of H_2 = Mass of 2H atoms
= 2 × 1
= 2 u.

ii) Molecular mass of O_2 = Mass of 2 'O' atoms
= 2 × 16
= 32 u.

iii) Molecular mass of Cl_2 = Mass of 2 Cl atoms
= 2 × 35.5
= 71 u.

iv) Molecular mass of CO_2 = Mass of C atom + Mass of 2 'O' atoms
= 12 + 2 × 16
= 44 u.

v) Molecular mass of CH_4 = Mass of C atom + Mass of 4 H atoms
= 12 + 4 × 1
= 12 + 4
= 16 u.

vi) Molecular mass of C_2H_6 = Mass of 2 C + Mass of 6 H atoms
= 2 × 12 + 6 × 1
= 24 + 6
= 30 u.

vii) Molecular mass of C_2H_4 = Mass of 2 C + Mass of 4 H atoms
= 2 × 12 + 4 × 1
= 24 + 4
= 28 u.

viii) Molecular mass of NH_3 = Mass of N atoms + Mass of 3 H atoms
= 14 + 3 × 1
= 14 + 3
= 17 u.

ix) Molecular mass of CH_3OH = Mass of C + Mass of 4 H + Mass of O
= 12 + 4 × 1 + 16
= 12 + 4 + 16
= 32 u.

Q2. Calculate the formula unit masses of ZnO, Na_20, K_2CO_3.

Answer:

Given: Atomic masses of Zn = 65 u, Na = 23 u, K = 39 u, C = 12 and O = 16 u.

i) Formula mass of ZnO = Mass of Zn atom + Mass of O atom
= 65 + 16
= 81 u.

ii) Formula mass of Na_20 = Mass of 2 Na atoms + Mass of O
= 2 × 23 + 16
= 46 + 16
62 u.

iii) Formula mass of K_2CO_3 = Mass of 2K atoms + Mass of C atom + Mass of 3 'O' atoms
= 2 × 39 + 12 + 3 × 16
= 78 + 12 + 48
= 138 u.

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Q1. If one mole of carbon atoms weights 12 grams, what is the mass (in grams) of 1 atom of carbon?

Answer:

As, 1 mole of carbon atom is 6.022×10^{23} carbon atoms. and 1 mole of carbon atoms weights 12 grams. It means that the mass of 6.022×10^{23} atoms of carbon is 12 grams.

6.022×10^{23} atoms of carbon have mass = 12 g

1 atom of carbon has mass $= \frac{12}{6.022 \times 10^{23}}$ g

$$= 1.99 \times 10^{-23}\ g$$

So, the absolute mass of 1 atom of carbon is $1.99 \times 10^{-23}\ g$.

Q2. Which has more number of atoms, 100 grams of sodium or 100 grams of iron?

(Given: atomic masses of Na = 23 u, Fe = 56 u)

Answer:

Convert 100 grams of sodium into moles of sodium and 100 grams of iron into moles of iron.

So, the element which have more moles will have more atoms.

i) Moles of sodium = $\frac{Mass\ of\ sodium}{Molar\ mass\ of\ sodium}$

$$= \frac{100}{23}$$

$$= 4.34$$

ii) Moles of iron = $\frac{Mass\ of\ iron}{Molar\ mass\ of\ iron}$

$$= \frac{100}{56}$$

$$= 1.78$$

Thus 100 grams of sodium contain 4.34 moles of atoms whereas 100 grams of iron contain 1.78 moles of atoms. So, 100 grams of sodium has more moles, it contains more atoms than 100 grams of iron.

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Q1. A $0.24\ g$ sample of compound of oxygen and boron was found by analysis to contain $0.096\ g$ of boron and $0.144\ g$ of oxygen. Calculate the percentage composition of the compound by weight.

Answer:

Given: Total mass of compound $= 0.24\ g$

Mass of boron in it $= 0.096\ g$

Mass of oxygen in it $= 0.144\ g$

Solution:

i. To calculate the % composition of boron –

Total mass of compound $= 0.24\ g$

Mass of boron $= 0.096\ g$

$$\boldsymbol{Percentage\ composition\ of\ boron = \frac{Mass\ of\ oxygen}{Total\ mass\ of\ compound} \times 100}$$

$$\%\ composition\ of\ boron = \frac{(0.096)}{(0.24)} \times 100$$

$$\%\ composition\ of\ boron = 0.4 \times 100$$

$$\boldsymbol{Percentage\ composition\ of\ boron = 40\%}$$

ii. To calculate the % composition of oxygen –

Total mass of compound $= 0.24\ g$

Mass of oxygen $= 0.144\ g$

$$\boldsymbol{Percentage\ composition\ of\ oxygen = \frac{Mass\ of\ oxygen}{Total\ mass\ of\ compound} \times 100}$$

$$\%\ composition\ of\ oxygen = \frac{(0.144)}{(0.24)} \times 100$$

$$\%\ composition\ of\ oxygen = 0.6 \times 100$$

$$\boldsymbol{Percentage\ composition\ of\ oxygen = 60\%}$$

- The compound is made up of boron and oxygen, so, the percentage composition of the compound sum to 100%.
- The percentage composition by weight of **Boron** $= \mathbf{40\%}$**.**
- The percentage composition by weight of **Oxygen** $= \mathbf{60\%}$**.**

Q2. When $3.0\ g$ of carbon is burnt in $8.00\ g$ oxygen, $11.00\ g$ of carbon dioxide is produced. What mass of carbon dioxide will be formed when $3.00\ g$ of carbon is burnt in $50.00\ g$ of oxygen? Which law of chemical combination will govern your answer?

Answer:

Given: When $3.0\ g$ of carbon is burnt in $8.00\ g$ of oxygen, the $11.00\ g$ of carbon dioxide is produced.

To find: Mass of carbon dioxide when $3.00\ g$ of carbon is burnt in $50.00\ g$ of oxygen.

Solution:

The chemical reaction between carbon dioxide and oxygen:

$$C + O_2 \rightarrow CO_2$$

According to above chemical equation, when $3.0\ g$ of carbon is burnt in $8.00\ g$ oxygen, $11.00\ g$ of carbon dioxide is produced.

$$3\ g + 8\ g \rightarrow 11\ g$$

$$Total\ mass\ of\ reactants = mass\ of\ carbon + mass\ of\ oxygen$$

$$Total\ mass\ of\ reactants = 3\ g + 8\ g$$

$$Total\ mass\ of\ reactants = 11\ g$$

$$Total\ mass\ of\ reactants = Total\ mass\ of\ products$$

The law of chemical combination follows the "***Law of conservation of mass***".

- It shows that the carbon dioxide contains carbon and oxygen in a fixed ratio by mass, that is $3:8$.

- The same mass of carbon dioxide $(11\ g)$ is obtained if we burn $3\ g$ of carbon in $50\ g$ of oxygen.
- The extra oxygen $(50 - 8 = 42\ oxygen)$ will remain unreacted.

Q3. What are polyatomic ions? Give examples.

Answers:

Polyatomic Ions:

- The prefix poly means many, so a polyatomic ion is an ion that contains more than one atom.
- Ions which are formed from groups of atoms are called compound ions or polyatomic ions.

Examples of Polyatomic ion are: -

S/No.	Name of the ion	Symbol (or Formula)
1.	Ammonium ion.	NH_4^+
2.	Magnesium ion.	Mg^{2+}
3.	Carbonate ion.	CO_3^{2-}
4.	Sulphate ion.	SO_4^{2-}
5.	Phosphate ion.	PO_4^{3-}

Q4. Write the chemical formulae of the following.

a) Magnesium chloride.
b) Calcium oxide.
c) Copper nitrate.
d) Aluminium chloride.
e) Calcium carbonate.

Answer:

Chemical Formulae of some chemicals:

S/No.	Name of the Chemical	Chemical Formulae
1.	Magnesium chloride	$MgCl_2$
2.	Calcium oxide	CaO
3.	Copper nitrate	$Cu(NO_3)_2$
4.	Aluminium chloride	$AlCl_3$
5.	Calcium carbonate	$CaCO_3$

Q5. Give the names of the elements present in the following compounds.

a) **Quick lime.**
b) **Hydrogen bromide.**
c) **Baking powder.**
d) **Potassium sulphate.**

Answer:

S/No.	Name of the Compound	Formula of the Compound	Elements present in the Compound
1.	Quick lime	CaO	Calcium and Oxygen.
2.	Hydrogen bromide	HBr	Hydrogen and Bromine
3.	Baking powder	$NaHCO_3$	Sodium, Hydrogen, Carbon and Oxygen
4.	Potassium sulphate	K_2SO_4	Potassium, Sulphur and Oxygen

Q6. Calculate the molar mass of the following substances.

a) **Ethyne, C_2H_2**
b) **Sulphur molecule, S_8**
c) **Phosphorous molecule, P_4 (Atomic mass of phosphorous = 31)**
d) **Hydrochloric acid, HCl**
e) **Nitric acid, HNO_3**

Answer:

The atomic masses of all the elements present in the above-mentioned substances.

Atomic masses:

1. $C = 12\ u.$
2. $H = 1\ u.$
3. $S = 32\ u.$
4. $P = 31\ u.$
5. $Cl = 35.5\ u.$

6. $N = 14\,u.$
7. $O = 16\,u.$

- The molar masses of all these substances is equal to the molecular masses expressed in g/mol :

a) Molar mass of ethyne, $C_2H_2 = Mass\ of\ C\ \times 2 + Mass\ of\ H\ \times 2$
$= 12\ \times 2 + 1\ \times 2$
$= 24 + 2$
=26

b) Molar mass of sulphur molecule, $S_8 = Mass\ of\ S\ \times 8$
$= 32\ \times 8$
=256

c) Molar mass of phosphorous molecule, $P_4 = Mass\ of\ P\ \times 4$
$= 31\ \times 4$
=124

d) Molar mass of hydrochloric acid, $HCl = Mass\ of\ H + Mass\ of\ Cl$
$= 1 + 35.$
=36.5

e) Molar mass of nitric acid, $HNO_3 = Mass\ of\ H + Mass\ of\ N + Mass\ of\ O\ \times 3$
$= 1 + 14 + 16\ \times 3$
$= 15 + 48$
= 63

Q7. What is the mass of –

a) 1 mole of nitrogen atoms?
b) 4 moles of aluminium atoms (Atomic mass of aluminium = 27)?
c) 10 moles of sodium sulphite (Na_2SO_3)?

Answer:

- The atomic masses of various elements are:

1. $N = 14\ u$
2. $Al = 27\ u$
3. $Na = 23\ u$
4. $S = 32\ u$
5. $O = 16\ u$

a) $\boxed{Mass\ of\ 1\ mole\ of\ nitrogen\ atoms\ (N)} = \boxed{Atomic\ mass\ of\ nitrogen\ expressed\ in\ grams}$

- The atomic mass of nitrogen $= 14\ u$.
- So, the mass of 1 mole of nitrogen atoms $\boxed{= 14\ grams}$

b) The atomic mass of aluminium $= 27\ u$. It means, that 1 mole of aluminium atoms has a mass of 27 $grams$.

Now, 1 mole of aluminium atoms $= 27\ g$
So, 4 moles of aluminium atoms $= 27$ $\boxed{= 108\ g}$

c) $\boxed{Mass\ of\ 1\ mole\ of\ sodium\ sulphite} = \boxed{Molecular\ mass\ of\ sodium\ sulphite\ in\ grams}$

$$= Mass\ of\ 2Na + Mass\ of\ S + Mass\ of\ 3\ 'O'$$
$$= 2\ \times 23 + 32 + 3\ \times 16$$
$$= 46 + 32 + 48$$
$$= 126\ g$$
$$Mass\ of\ 10\ moles\ of\ = 126\ \times 10\ g$$

$$\boxed{Sodium\ sulphite = 1260\ g}$$

Q8. Convert into moles:

a) 12 g of oxygen gas.
b) 20 g of water.
c) 22 g of carbon dioxide.

Answer:

- Atomic masses of Oxygen, Water and Carbon dioxide are as follows –

1. $O = 16\,u$
2. $H = 1\,u$
3. $C = 12\,u$

a) Oxygen gas consists of O_2 molecules. So, the mass of oxygen gas (O_2) = $16 \times 2 = 32\,u$.

$$1\ mole\ of\ oxygen\ gas = mass\ of\ oxygen\ in\ grams$$
$$= 32\ g$$

If $32\ g$ of oxygen gas $= 1\ mole$

Then $12\ g$ of oxygen gas $= \frac{1}{32} \times 12\ mole$

$$12\text{ g of oxygen gas} = 0.375\ mole$$

b) Water consists of H_2O molecules. So, mass of water (H_2O) $= 1 \times 2 + 16 = 18\,u$.

$$1\ mole\ of\ water = mass\ of\ water\ in\ grams$$
$$= 18\ g$$

If $18\ g$ of water $= 1\ mole$

Then, $12\ g$ of water $= \frac{1}{18} \times 20\ mole$

$$20\text{ g of water} = 1.11\ moles$$

c) Carbon dioxide consists of CO_2 molecules.

So, mass of carbon dioxide $(CO_2) = 12 + 16 \times 2 = 12 + 32 = 44\ u$.

$$1\ mole\ of\ carbon\ dioxide = mass\ of\ carbon\ dioxide\ grams$$
$$= 44\ g$$

If $44\ g$ of carbon dioxide $= 1\ mole$

$22\ g$ of water $= \frac{1}{44} \times 22\ mole$

$$22\ g\ of\ water = \frac{1}{2}\ mole$$

$$22\ g\ of\ water = 0.5\ mole$$

Q9. What is the mass of?

a) $0.2\ mole$ of oxygen atoms?
b) $0.5\ mole$ of water molecules?

Answer:

a) The atomic mass of oxygen (O) is $16\ u$.

So, the mass of $1\ mole$ of oxygen atoms will be $16\ grams$.

$1\ mole$ of oxygen atoms $= 16\ g$

$0.2\ mole$ of oxygen atoms $= 16 \times 0.2\ g$

The mass of $0.2\ mole$ of oxygen atoms $= 3.2\ g$

b) The molecular mass of water (H_2O) is $18\ u$.

So, the mass of $1\ mole$ of water molecules will be $18\ grams$.

$1\ mole$ of water molecules $= 18\ g$

$0.5\ mole$ of water molecules $= 18 \times 0.5\ g$

The mass of 0.5 $mole$ of water molecules $= 9\ g$

Q10. Calculate the number of molecules of sulphur (S_8) present in $16\ g$ of solid sulphur.

Answer:

- The atomic mass of sulphur, $S = 32$.
- The molecule formula of sulphur is S_8, it contains 8 atoms of sulphur.
- As, the molecular mass of sulphur molecule is $32 \times 8 = 256\ u$.
- So, 1 mole of sulphur molecules $= 256\ g$.

$256\ g$ of sulphur $= 1\ mole$ of sulphur molecules

$16\ g$ of sulphur $= \frac{1}{256} \times 16\ mole$ of sulphur molecules

$16\ g$ of sulphur$= 0.0625\ mole$ of sulphur molecules

$1\ mole$ of sulphur molecules $= 6.023 \times 10^{23}\ molecules$

$0.0625\ mole$ of sulphur molecules $= 6.023 \times 10^{23} \times 0.0625\ molecules$

$0.0625\ mole$ of sulphur molecules $= 3.76 \times 10^{22}\ molecules$

Q11. Calculate the number of aluminium ions present in $0.051\ g$ of aluminium oxide.

(Hint: The mass of an ion is the same as that of an atom of the same element. Atomic mass of $Al = 27\ u$).

Answer:

- The mass of the aluminium ion is the same as that of an aluminium atom.
- So, we will calculate the mass of aluminium atom in $0.051\ g$ of aluminium oxide, which gives the mass of aluminium ions.

$$1\ mole\ of\ Al_2O_3 = Formula\ mass\ of\ Al_2O_3\ in\ grams$$

$$= Mass\ of\ Al \times 2 + Mass\ of\ O \times 3$$

$$= 27 \times +16 \times 3$$

$$= 54 + 48$$

$$= 102\ grams$$

1 $mole\ of\ Al_2O_3$ contains 2 $moles$ of Al.

$Mass\ of\ Al\ in\ 1\ mole\ of\ Al_2O_3 = Mass\ of\ Al\ \times 2$

$$= 27\ \times 2$$

$$= 54\ grams$$

As, $102\ g$ aluminium oxide contains $= 54\ g\ Al$

So, $0.051\ g$ aluminium oxide contains $= \frac{54}{102} \times 0.051\ g\ Al$

$$= 0.027\ g\ Al$$

- The atomic mass of aluminium is $27\ u$. That is $1\ mole$ of aluminium atoms, or aluminium ions, has a mass of $27\ grams$, and it contains $6.022\ \times 10^{23}\ aluminium\ ions$.

$27\ g$ aluminium has ions $= 6.022\ \times 10^{23}$

$0.027\ g$ of aluminium has ions $= \frac{6.022 \times 10^{23}}{27} \times 0.027$

$0.027\ g$ of aluminium has ions $= 6.022\ \times 10^{20}$

Thus, the number of aluminium ions (Al^{3+}) in $0.051\ gram$ of aluminium oxide is $= 6.022\ \times 10^{20}$.