Chapter 3 Atoms and Molecules

Question 1. 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 water and 8.2 g of sodium ethanoate. Show that these observations are in agreement with the law of conservation of mass carbonate.
Answer.

Sodium carbonate	+	Ethanoic acid	→	Sodium ethanoate	+	Carbon dioxide	+	Water
5.3 g	+	6 g	→	8.2 g	+	2.2 g	+	0.9 g
		LHS RHS						
∴		11.3 g = 11.3 g						

(Mass of reactant) (Mass of product)

This shows that during a chemical reaction mass of reactant = mass of product.

(*b*) Aluminium oxide

Symbol → Al O

Valency → +3 −2

Formula → Al_2O_3

- **Molecular Mass**

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).

e.g., $2H^+ + O_2 \quad H_2O$ [H = 1, O = 16]

$1 \times 2 + 16 = 18$ u

- **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.

e.g., $Na^+ + Cl^- \rightarrow NaCl$

$1 \times 23 + 1 \times 35.5 = 58.5$ u

- **Mole Concept**

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 = 6.022×10^{23} in number

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

1u of hydrogen has → 1 atom of hydrogen

1g of hydrogen has → 1 mole of hydrogen

= 6.022×10^{23} atoms of hydrogen

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Question 1. 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 water and 8.2 g of sodium etkanoate. Show that these observations are in agreement with the law of conservation of mass carbonate.
Answer:

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5.3 g	+	6 g	→	8.2 g	+	2.2 g	+	0.9 g
		LHS RHS						
∴		11.3 g = 11.3 g						

(Mass of reactant) (Mass of product)

This shows that during a chemical reaction mass of reactant = mass of product.

Question 2. 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: Ratio of H : O by mass in water is:

Hydrogen : Oxygen —> H_2O

∴ 1 : 8 = 3 : x

x = 8 x 3

x = 24 g

∴ 24 g of oxygen gas would be required to react completely with 3 g of hydrogen gas.

Question 3. Which postulate of Dalton's atomic theory is the result of the law of conservation of mass?

Answer: The postulate of Dalton's atomic theory that is the result of the law of conservation of mass is—the relative number and kinds of atoms are constant in a given compound. Atoms cannot be created nor destroyed in a chemical reaction.

Question 4. Which postulate of Dalton's atomic theory can explain the law of definite proportions?

Answer: The relative number and kinds of atoms are constant in a given compound.

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Question 1. Define the atomic mass unit.

Answer: One atomic mass unit is equal to exactly one-twelfth (1/12th) the mass of one atom of carbon-12. The relative atomic masses of all elements have been found with respect to an atom of carbon-12.

Question 2. Why is it not possible to see an atom with naked eyes?

Answer: Atom is too small to be seen with naked eyes. It is measured in nanometres.

1 m = 109 nm

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Question 1. Write down the formulae of

(i) Sodium oxide

(ii) Aluminium chloride

(iii) Sodium sulphide

(iv) Magnesium hydroxide

Answer: The formulae are

(i) Formula of Sodium Oxide

Symbol → Na O

Charge → +1 −2

Formula → Na_2O

(ii) Formula of aluminium chloride

Symbol → Al Cl

Charge → +3 − 1

Formula → $AlCl_3$

(iii) Formula of Sodium Oxide

Symbol → Na S

Charge → +1 −2

Formula → Na_2S

(iv) Formula of magnesium hydroxide

Symbol → Mg OH

Charge → +2 1

Formula → $Mg(OH)_2$

Question 2. What is meant by the term chemical formula?
Answer: The chemical formula of the compound is a symbolic representation of its composition, e.g., chemical formula of sodium chloride is NaCl.

Question 3. How many atoms are present in a
(i) H_2S molecule and
(ii) $P0_4^{3-}$ ion?
Answer: (i) H_2S —> 3 atoms are present
(ii) $P0_4^{3-}$ —> 5 atoms are present

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Question 1. Calculate the molecular masses of H_2, O_2, Cl_2, $C0_2$, CH_4, C_2H_2,NH_3, CH_3OH.
Answer: The molecular masses are:

$$H_2 \Rightarrow 1 \times 2 \rightarrow 2 \text{ u}$$
$$O_2 \Rightarrow 16 \times 2 \rightarrow 32 \text{ u}$$
$$Cl_2 \Rightarrow 35.5 \times 2 \rightarrow 71 \text{ u}$$
$$CO_2 \Rightarrow 1 \times 12 + 2 \times 16 = 12 + 32 = 44 \text{ u}$$
$$CH_4 \Rightarrow 1 \times 12 + 4 \times 1 = 16 \text{ u}$$
$$C_2H_6 \Rightarrow 2 \times 12 + 6 \times 1 = 30 \text{ u}$$
$$C_2H_4 \Rightarrow (2 \times 12) + (4 \times 1) = 28 \text{ u}$$
$$NH_3 \Rightarrow (1 \times 14) + (3 \times 1) = 17 \text{ u}$$
$$CH_3OH \Rightarrow 12 + (3 \times 1) + 16 + 1 = 32 \text{ u}$$

Question 2.Calculate the formula unit masses of ZnO, Na_2O, K_2C0_3, given atomic masses of Zn = 65 u, Na = 23 u, K = 39 u, C = 12 u, and O = 16 u.
Answer: The formula unit mass of
(i) ZnO = 65 u + 16 u = 81 u
(ii) Na_2O = (23 u x 2) + 16 u = 46 u + 16 u = 62 u
(iii) K_2C0_3 = (39 u x 2) + 12 u + 16 u x 3
= 78 u + 12 u + 48 u = 138 u

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Question 1. If one mole of carbon atoms weigh 12 grams, what is the mass (in grams) of 1 atom of carbon?
Answer:

:

$$1 \text{ mole of carbon atoms } 6.022 \times 10^{23} \text{ atoms} = 12 \text{ g}$$

$$\text{Mass of 1 atom} = ?$$

$$\therefore \quad \text{Mass of 1 atom of carbon} = \frac{12}{6.022 \times 10^{23}}$$

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

Question 2. Which has more number of atoms, 100 grams of sodium or 100 grams of iron (given atomic mass of Na = 23 u, Fe = 56 u)?
Answer:

:

$$23 \text{ g of Na} = 6.022 \times 10^{23} \text{ atoms (1 mole).}$$

$$\therefore \quad 100 \text{ g of Na} = ?$$

$$= \frac{100 \times 6.022 \times 10^{23}}{23} = \frac{602.2}{23} \times 10^{23}$$

$$= 26.182 \times 10^{23} = 2.6182 \times 10^{24} \text{ atoms}$$

$$56 \text{ g of Fe} = 6.022 \times 10^{23} \text{ atoms}$$

$$100 \text{ g of Fe} = ?$$

$$= \frac{100 \times 6.022 \times 10^{23}}{56} = \frac{602.2 \times 10^{23}}{56}$$

$$= 10.753 \times 10^{23} = 1.075 \times 10^{24}$$

$$100 \text{ g of Na contain} \rightarrow 2.618 \times 10^{24} \text{ atoms}$$

$$100 \text{ g of Fe contain} \rightarrow 1.075 \times 10^{24} \text{ atoms}$$

$$\therefore \text{ 100 g of Na contains more atoms.}$$

Questions From NCERT Textbook for Class 9 Science

Question 1. 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: Boron and oxygen compound —> Boron + Oxygen
0.24 g —> 0.096 g + 0.144 g

Percentage composition of the compound

For boron:

$$0.24\ g \rightarrow 0.096\ g$$
$$100\ g \rightarrow ?$$
$$\frac{100 \times 0.096}{0.24} = 40\%$$

For oxygen:

$$0.24\ g \rightarrow 0.144\ g \text{ of oxygen}$$
$$100\ g \rightarrow ?$$
$$\frac{100 \times 0.144}{0.24} = 60\%$$

Question 2. 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: The reaction of burning of carbon in oxygen may be written as

$$\underset{\text{1 mole carbon}\ 12\ g}{C} + \underset{\text{Oxygen 1 mole}\ 32\ g}{O_2} \longrightarrow \underset{\text{carbon dioxide}\ 44\ g}{CO_2}$$

It shows that 12 g of carbon bums in 32 g oxygen to form 44 g of carbon dioxide. Therefore 3 g of carbon reacts with 8 g of oxygen to form 11 g of carbon dioxide. It is given that 3.0 g of carbon is burnt with 8 g of oxygen to produce 11.0 g of CO_2. Consequently 11.0 g of carbon dioxide will be formed when 3.0 g of C is burnt in 50 g of oxygen consuming 8 g of oxygen, leaving behind 50 – 8 = 42 g of O_2. The answer governs the law of constant proportion.

Question 3. What are poly atomic ions? Give examples.

Answer: The ions which contain more than one atoms (same kind or may be of different kind) and behave as a single unit are called polyatomic ions e.g., OH^-, SO_4^{2-}, CO_3^{2-}.

Question 4. Write the chemical formulae of the following:

(a) Magnesium chloride

(b) Calcium oxide

(c) Copper nitrate

(d) Aluminium chloride

(e) Calcium carbonate.

Answer: (a) Magnesium chloride

Symbol —> Mg Cl

Change —> +2 -1

Formula —> $MgCl_2$

(b) Calcium oxide

Symbol —> Ca O

Charge —> +2 -2

Formula —> CaO
(c) Copper nitrate
Symbol —> Cu NO
Change +2 -1
Formula -4 $CU(N0_3)_2$
(d) Aluminium chloride
Symbol —> Al Cl
Change —> +3 -1
Formula —> $AlCl_3$
(d) Calcium carbonate
Symbol —> Ca CO_3
Change —> +2 -2
Formula —> $CaC0_3$

Question 5. Give the names of the elements present in the following compounds:
(a) Quick lime
(b) Hydrogen bromide
(c) Baking powder
(d) Potassium sulphate.
Answer: (a) Quick lime —> Calcium oxide
Elements —> Calcium and oxygen
(b) Hydrogen bromide
Elements —> Hydrogen and bromine
(c) Baking powder —> Sodium hydrogen carbonate
Elements —> Sodium, hydrogen, carbon and oxygen
(d) Potassium sulphate
Elements —> Potassium, sulphur and oxygen

Question 6. Calculate the molar mass of the following substances.
(a) Ethyne, C_2H_2
(b) Sulphur molecule, S_8
(c) Phosphorus molecule, P_4 (Atomic mass of phosphorus = 31)
(d) Hydrochloric acid, HCl
(e) Nitric acid, HNO_3
Answer: The molar mass of the following: [Unit is 'g']
(a) Ethyne, C_2H_2 = 2 x 12 + 2 x 1 = 24 + 2 = 26 g
(b) Sulphur molecule, S_8 = 8 x 32 = 256 g
(c) Phosphorus molecule, P_4=4 x 31 = i24g
(d) Hydrochloric acid, HCl = 1 x 1 + 1 x 35.5 = 1 + 35.5 = 36.5 g
(e) Nitric acid, $HN0_3$ = 1 x 1 + 1 x 14 + 3 x 16 = 1 + 14 + 48 = 63 g

Question 7. 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_2S0_3)?
Answer: (a) Mass of 1 mole of nitrogen atoms = 14 g
(b) 4 moles of aluminium atoms
Mass of 1 mole of aluminium atoms = 27 g
∴ Mass of 4 moles of aluminium atoms = 27 x 4 = 108 g
(c) 10 moles of sodium sulphite (Na_2SO_3)

Mass of 1 mole of Na_2SO_3 = 2 x 23 + 32 + 3 x 16 = 46 + 32 + 48 = 126 g
∴ Mass of 10 moles of Na_2SO_3 = 126 x 10 = 1260 g

Question 8. Convert into mole.
(a) 12 g of oxygen gas
(b) 20 g of water
(c) 22 g of Carbon dioxide.
Answer: (a) Given mass of oxygen gas = 12 g
Molar mass of oxygen gas (O_2) = 32 g
Mole of oxygen gas 12/32 = 0.375 mole
(b) Given mass of water = 20 g
Molar mass of water (H_2O) = (2 x 1) + 16 = 18 g
Mole of water = 20/18 = 1.12 mole
(c) Given mass of Carbon dioxide = 22 g
Molar mass of carbon dioxide (CO_2) = (1 x 12) + (2 x 16)
= 12 + 32 = 44 g
∴ Mole of carbon dioxide = 22/44 = 0.5 mole

Question 9. What is the mass of:
(a) 0.2 mole of oxygen atoms?
(b) 0.5 mole of water molecules?
Answer: (a) Mole of Oxygen atoms = 0.2 mole
Molar mass of oxygen atoms = 16 g
Mass of oxygen atoms = 16 x 0.2 = 3.2 g
(b) Mole of water molecule = 0.5 mole
Molar mass of water molecules = 2 x 1 + 16= 18 g .
Mass of H_2O = 18 x 0.5 = 9 g

Question 10. Calculate the number of molecules of sulphur (S_8) present in 16 g of solid sulphur.
Answer: Molar mass of S_8 sulphur = 256 g = 6.022×10^{23} molecule
Given mass of sulphur = 16 g

$$\text{Molecules of sulphur} = \frac{16 \times 6.022 \times 10^{23}}{256} = \frac{96.35 \times 10^{23}}{256}$$
$$= 0.376 \times 10^{23}$$
$$= 3.76 \times 10^{22} \text{ molecules}$$

Question 11. 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: Molar mass of aluminium oxide Al_2O_3
= (2 x 27) + (3 x 16)
= 54 + 48 = 102 g.

$\therefore$ 102 g of Al_2O_3 contains $= 2 \times 6.022 \times 10^{23}$ aluminium ions

$\therefore$ 0.051 g of Al_2O_3 contains $= \frac{2 \times 6.022 \times 10^{23}}{102} \times 0.051$

$= \frac{12.044 \times 10^{23} \times 0.051}{102} = \frac{0.614 \times 10^{23}}{102}$

$= 0.006022 \times 10^{23}$

$= 6.022 \times 10^{20}$ Al^{3+} ions