Exercise 3.1

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

Answer:

Given,

Mass of sodium carbonate = 5.3 g

Mass of ethanoic acid = 6 g

Mass of sodium ethanoate = 8.2 g

Mass of carbon dioxide = 2.2 g

Mass of water = 0.9 g

Now, the total mass before the reaction

= (5.3 + 6) g = 11.3 g

And, total mass after the reaction =

(8.2 + 2.2 + 0.9) g = 11.3 g

∴Total mass before the reaction = Total mass after the reaction

Hence, this is in agreement with the law of conservation of mass.

2. Hydrogen and oxygen combine in a 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:

We know hydrogen and water mix in a ratio 1: 8.

For every 1g of hydrogen, it is 8g of oxygen.

Therefore, for 3g of hydrogen, the quantity of oxygen = 3 x 8 = 24g

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

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 which is based on the law of conservation of mass is: "Atoms are indivisible particles, which can neither be created nor destroyed in a chemical reaction."

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

Answer: "The elements consist of atoms having fixed mass and the number and kind of atoms of each element in a given compound is fixed." This explains the law of definite proportion.

Exercise 3.2

1. **Define the atomic mass unit.**

   Answer: Mass unit equal to exactly one-twelfth the $(\frac{1}{12^{th}})$ mass of one atom of carbon-12 is called one atomic mass unit. It is represented as 'a.m.u.' or 'u'.

2. **Why it is not possible to see an atom with the naked eye?**

   Answer: Firstly, atoms are minuscule in nature and measured in nanometers. Secondly, except for atoms of noble gases, they do not exist independently. Hence, an atom cannot be visible to the naked eye.

Exercise 3.3 & 3.4

1. Write down the formulae of

(i) sodium oxide – Na_2O

(ii) aluminium chloride – $AlCl_3$

(iii) sodium sulphide – Na_2S

(iv) magnesium hydroxide – $Mg(OH)_2$

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

(i) $Al_2(SO_4)_3$ – Aluminium sulphate

(ii) $CaCl_2$ – Calcium chloride

(iii) K_2SO_4 – Potassium sulphate

(iv) KNO_3 – Potassium nitrate

(v) $CaCO_3$ – Calcium carbonate

3. What is meant by the term chemical formula?

Answer: The symbolic representation of the composition of a compound is known as a chemical formula. The chemical formula gives us the idea of several atoms present.

Example: from the chemical formula CO2CO2 of Carbon Dioxide, we come to know that one carbon atom and two oxygens atoms are chemically bonded together to form one molecule of the compound, carbon dioxide.

4. How many atoms are present in a

(i) H_2S molecule and

(ii) PO_4^{3-} ion?

Answer:

The number of atoms present is as follows:

(i) H_2S molecule has 2 atoms of hydrogen and 1 atom of sulphur hence 3 atoms in total.

(ii) PO_4^{3-} ion has 1 atom of phosphorus and 4 atoms of oxygen hence 5 atoms in total.

Exercise 3.5

1. 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.

Answer:

The following are the molecular masses:

The molecular mass of H_2 – 2 x atoms atomic mass of H = 2 x 1u = 2u

The molecular mass of O_2 – 2 x atoms atomic mass of O = 2 x 16u = 32u

The molecular mass of Cl_2 – 2 x atoms atomic mass of Cl = 2 x 35.5u = 71u

The molecular mass of CO_2 – atomic mass of C + 2 x atomic mass of O = 12 + (2 ×16) u = 44u

The molecular mass of CH_4 – atomic mass of C + 4 x atomic mass of H = 12 + (4 x 1) u = 16u

The molecular mass of C_2H_6– 2 x atomic mass of C + 6 x atomic mass of H = (2 x 12) +

(6 x 1) u = 24 + 6 = 30u

The molecular mass of C_2H_4– 2 x atomic mass of C + 4 x atomic mass of H = (2x 12) +

(4 x 1) u = 24 + 4 = 28u

The molecular mass of NH_3 – atomic mass of N + 3 x atomic mass of H = (14 +3 x 1) u

= 17u

The molecular mass of CH_3OH – atomic mass of C + 3x atomic mass of H + atomic mass of O + atomic mass of H = (12 + 3 × 1 + 16 + 1) u = (12+3+17)u = 32u

2. Calculate the formula unit masses of ZnO, Na_2O, K_2CO_3, given atomic masses of Zn = 65u, Na = 23 u, K=39u, C = 12u, and O=16u.

Answer:

Given:

The atomic mass of Zn = 65u

The atomic mass of Na = 23u

The atomic mass of K = 39u

The atomic mass of C = 12u

The atomic mass of O = 16u

The formula unit mass of ZnO= Atomic mass of Zn + Atomic mass of O = 65u + 16u = 81u

The formula unit mass of Na_2O = 2 x Atomic mass of Na + Atomic mass of O = (2 x 23)u + 16u = 46u + 16u = 62u

The formula unit mass of K_2CO_3 = 2 x Atomic mass of K + Atomic mass of C + 3 x Atomic mass of O = (2 x 39) u + 12u + (3 x 16) u = 78u + 12u + 48u = 138u

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

   Answer:

   1 mole of carbon weighs 12g

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

   The molecular mass of carbon atoms = 12g = an atom of carbon mass

   Hence, a mass of 1 carbon atom = $\frac{12}{6.022\ x\ 10^{23}}$ = 1.99×10^{-23}g

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

Answer:

Ans: Atomic mass of Na = 23 u (Given)

Then, the gram atomic mass of Na = 23 g

Now, 23 g of Na contains = 6.022×10^{23} number of Na atoms

Thus, 100 g of Na contains = $\frac{6.022 \times 10^{23}}{23}$ x 100 number of Na atoms

= 2.6182×10^{24} number of Na atoms

The atomic mass of Fe = 56 u (Given)

Then, the gram atomic mass of Fe = 56 g

Now, 56 g of Fe contains = 6.022×10^{23} number of Fe atoms

Thus, 100 g of Fe contains = $\frac{6.022 \times 10^{23}}{56}$ x 100 number of Fe atoms

=1.0753×10^{24} number of Fe atoms

$2.6182 \times 10^{24} > 1.0753 \times 10^{24}$

Therefore, 100 grams of sodium contain a more number of atoms than 100 grams of iron.

Exercise Questions

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

Answer:

Mass of boron = 0.096 g

Mass of oxygen = 0.144 g

Mass of sample = 0.24 g

The percentage of boron by weight in the compound = $\frac{0.096}{0.24}$ x 100 % = 40 %

And, the percentage of oxygen by weight in the compound = $\frac{0.144}{0.24}$ x 100 % = 60 %

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

Answer: Carbon + Oxygen ⟶ Carbon dioxide

3 g of carbon reacts with 8 g of oxygen to produce 11 g of carbon dioxide.

If 3 g of carbon is burnt in 50 g of oxygen, then 3 g of carbon will react with 8 g of oxygen to form 11 g of carbon dioxide.

The remaining (50 –8) = 42 g of oxygen will be left unreacted.

The above answer is governed by the law of constant proportions.

3. What are polyatomic ions? Give examples.

Answer: Polyatomic ions are ions that contain more than one atom, but they behave as a single unit. (*The ions that contain more than one atom (same kind or may be of a different kind) and behave as a single unit are called polyatomic ions* or *A polyatomic ion is a group of atoms carrying a charge either positive or negative*.)

Example: ammonium ion (NH_4^+), hydroxide ion (OH^-), carbonate ion (CO_3^{2-}),

sulphate ion(SO_4^{2-})

4. Write the chemical formula 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 - $CU(N0_3)_2$

(d) Aluminium chloride
Symbol —> Al Cl
Change —> +3 -1
Formula —> $AlCl_3$

(d) Calcium carbonate
Symbol —> Ca CO_3
Change —> +2 -2
Formula —> $CaC0_3$

(a) Magnesium chloride – $MgCl_2$

(b) Calcium oxide – CaO

(c) Copper nitrate – $Cu(NO_3)_2$

(d) Aluminium chloride – $AlCl_3$

(e) Calcium carbonate – $CaCO_3$

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:

The following are the names of the elements present in the following compounds:

Compound	Chemical Formula	Elements Present
Quick Lime	CaO	Calcium, Oxygen
Hydrogen Bromide	HBr	Hydrogen, Bromine

Baking Powder	$NaHCO_3$	Sodium, Hydrogen, Carbon, Oxygen
Potassium Sulphate	K_2SO_4	Potassium, Sulphur, Oxygen

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:

Listed below is the molar mass of the following substances:

a) Ethyne C_2H_2

Ans: Molar mass of

$C_2H_2 = 2 \times 12 + 2 \times 1 = 28g/mol$

b) Sulphur molecule, S_8

Ans: Molar mass of

$S_8 = 8 \times 32 = 256$ g/mol

c) Phosphorus molecule

P_4

(atomic mass of phosphorus = 31)

Ans: Molar mass of

$P_4 = 4 \times 31 = 124g/mol$

c) Hydrochloric acid, HCl

Ans: Molar mass of

HCl = 1 + 35.5 = 36.5 g/mol

d) Nitric acid,

HNO_3

Ans: Molar mass of

$HNO_3 = 1 + 14 + 3 \times 16 = 63$ g/mol

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_2SO_3)?

Answer:

The mass of the above-mentioned list is as follows:

(a) Atomic mass of nitrogen atoms = 14u

Mass of 1 mole of nitrogen atoms = Atomic mass of nitrogen atoms

Therefore, the mass of 1 mole of nitrogen atom is 14g.

(b) Atomic mass of aluminium = 27u

Mass of 1 mole of aluminium atoms = 27g

1 mole of aluminium atoms = 27g, 4 moles of aluminium atoms = 4 x 27 = 108g

(c) Mass of 1 mole of sodium sulphite Na_2SO_3 = Molecular mass of sodium sulphite = 2 x Mass of Na + Mass of S + 3 x Mass of O = (2 x 23) + 32 +(3x 16) = 46+32+48 = 126g

Therefore, mass of 10 moles of Na_2SO_3 = 10 x 126 = 1260g

8. Convert into a mole.

(a) 12g of oxygen gas

(b) 20g of water

(c) 22g of carbon dioxide

Answer:

Conversion of the above-mentioned molecules into moles is as follows:

(a) Given: Mass of oxygen gas = 12g

Molar mass of oxygen gas = 2 Mass of Oxygen = 2 x 16 = 32g

Number of moles = $\frac{\text{Mass given}}{\text{mass of oxygen gas}} = \frac{12}{32}$ = 0.375 moles

(b) Given: Mass of water = 20g

Molar mass of water = 2 x Mass of Hydrogen + Mass of Oxygen = 2 x 1 + 16 = 18g

Number of moles = $\frac{\text{Mass given}}{\text{mass of oxygen gas}} = \frac{20}{18}$ = 1.11 moles

(c) Given: Mass of carbon dioxide = 22g

Molar mass of carbon dioxide = Mass of C + 2 x Mass of Oxygen = 12 + 2 x 16 = 12+32=44g

Number of moles = $\frac{\text{Mass given}}{\text{mass of oxygen gas}} = \frac{22}{44}$ = 0.5 moles

9. What is the mass of:

(a) 0.2 mole of oxygen atoms?

(b) 0.5 mole of water molecules?

Answer:

The mass is as follows:

(a) Mass of 1 mole of oxygen atoms = 16u; hence, it weighs 16g.

Mass of 0.2 moles of oxygen atoms = 0.2 x 16 = 3.2g

(b) Mass of 1 mole of water molecules = 18u; hence, it weighs 18g.

Mass of 0.5 moles of water molecules = 0.5 x 18 = 9g

10. Calculate the number of molecules of sulphur (S_8) present in 16g of solid sulphur.

Answer:

To calculate the molecular mass of sulphur,

Molecular mass of Sulphur (S_8) = 8 x Mass of Sulphur = 8 × 32 = 256g

Mass given = 16g

Number of moles = mass given/ molar mass of sulphur

Number of moles = $\frac{\text{Mass given}}{\text{mass of sulphur}} = \frac{16}{256}$ = 0.0625 moles

To calculate the number of molecules of sulphur in 16g of solid sulphur,

Number of molecules = Number of moles x Avogadro number

= 0.0625 x 6.022 x 10^{23} molecules

= 3.763 x 10^{22} molecules

11. Calculate the number of aluminum ions present in 0.051g of aluminum oxide.

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

Answer:

To calculate the number of aluminum ions in 0.051g of aluminum oxide,

1 mole of aluminium oxide = 6.022 x 10^{23} molecules of aluminium oxide

1 mole of aluminium oxide (Al_2O_3) = 2 x Mass of aluminium + 3 x Mass of oxygen

= (2 x 27) + (3 x 16) = 54 + 48 = 102g

1 mole of aluminium oxide = 102g = 6.022 x 10^{23} molecules of aluminium oxide

Therefore, 0.051g of aluminum oxide has = $\frac{6.022 \text{ x } 10^{23}}{102 \text{ x } 0.051}$

= 3.011 x 10^{20} molecules of aluminium oxide

One molecule of aluminum oxide has 2 aluminum ions; hence, the number of aluminum ions present in 0.051g of aluminum oxide = 2 x 3.011 x 10^{20} molecules of aluminum oxide.

= 6.022 x 10^{20}