Atoms and Molecules

Exercise-3.1 Page: 32

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.

Sodium carbonate + acetic acid → Sodium acetate + carbon dioxide + water

Solution:

Sodium carbonate + acetic acid → Sodium acetate + carbon dioxide + water

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5.3g 6g 8.2g 2.2g 0.9g

As per the law of conservation of mass, the total mass of reactants must be equal to the total mass of

products.

As per the above reaction, L.H.S. = R.H.S. i.e., 5.3g + 6g = 2.2g + 0.9 g + 8.2 g = 11.3 g

Hence, the observations are 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?

Solution:

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?

Solution:

The relative number and types of atoms are constant in a given composition, says Dalton's atomic theory, which is based on the rule of conservation of mass.

"Atoms cannot be created nor be destroyed in a chemical reaction."

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

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Solution:

The postulate of Dalton's atomic theory that can explain the law of definite proportions is that the

relative number and kinds of atoms are equal in given compounds.

Exercise-3.2 Page: 35

1. Define the atomic mass unit.

Solution:

An atomic mass unit is a unit of mass used to express the weights of atoms and molecules where one

atomic mass is equal to 1/12th the mass of one carbon-12 atom.

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

Solution:

Firstly, atoms are minuscule in nature, measured in nanometers. Secondly, except for atoms of noble

gases, they do not exist independently. Hence, an atom cannot be visible to the naked eyes.

Exercise-3.3-3.4 Page: 39

1. Write down the formulae of

(i) sodium oxide

(ii) aluminium chloride

(iii) sodium sulphide

(iv) magnesium hydroxide

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Solution:

The following are the formulae:

(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) $Al_2(SO_4)_3$

(ii) $CaCl_2$

(iii) K_2SO_4

(iv) KNO_3

(v) $CaCO_3$.

Solution:

Listed below are the names of the compounds for each of 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?

Solution:

Chemical formulas are used to describe the different types of atoms and their numbers in a compound or element. Each element's atoms are symbolised by one or two letters. A collection of chemical symbols that depicts the elements that make up a compound and their quantities.

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For example, the chemical formula of hydrochloric acid is HCl.

4. How many atoms are present in a

(i) H_2S molecule and

(ii) PO_4^{3-} ion?

Solution:

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-3.5.1-3.5.2 Page: 40

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.

Solution:

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

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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.

Solution:

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

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Exercise-3.5.3 Page: 42

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

Solution:

Given: 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, mass of 1 carbon atom = $12 / 6.022 \times 10^{23} = 1.99 \times 10^{-23}$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)?

Solution:

(a) In 100 grams of Na:

m = 100g, Molar mass of Na atom = 23g, $N_0 = 6.022 \times 10^{23}$, N = ?

N = (Given mass x N_0)/Molar mass

$N = (100 \times 6.022 \times 10^{23})/ 23$

$N = 26.18 \times 10^{23}$ atoms

(b) In 100 grams of Fe:

m = 100 g, Molar mass of Fe atom = 56 g, $N_0 = 6.022 \times 10^{23}$, N = ?

N = (Given mass x N_0)/ Molar mass

$N = (100 \times 6.022 \times 10^{23})/ 56$

$N = 10.75 \times 10^{23}$ atoms

Therefore, the number of atoms is more in 100 g of Na than in 100 g of Fe.

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Exercise Page: 43

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.

Solution:

Given: Mass of the sample compound = 0.24g, mass of boron = 0.096g, mass of oxygen = 0.144g

To calculate the percentage composition of the compound,

Percentage of boron = mass of boron / mass of the compound x 100

= 0.096g / 0.24g x 100 = 40%

Percentage of oxygen = 100 – percentage of boron

= 100 – 40 = 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?

Solution:

When 3.0 g of carbon is burnt in 8.00 g of oxygen, 11.00 g of carbon dioxide is produced.

Given that

3.0 g of carbon combines with 8.0 g of oxygen to give 11.0 of carbon dioxide.

Find out

We need to find out the mass of carbon dioxide that will be formed when 3.00 g of carbon is burnt in 50.00 g of oxygen.

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Solution

First, let us write the reaction taking place here.

$C + O2 \rightarrow CO2$

As per the given condition, when 3.0 g of carbon is burnt in 8.00 g of oxygen, 11.00 g of carbon dioxide is produced.

$3g + 8g \rightarrow 11\ g$ (from the above reaction)

The total mass of reactants = mass of carbon + mass of oxygen

$=3g+8g$

$=11g$

The total mass of reactants = Total mass of products

Therefore, the law of conservation of mass is proved.

Then, it also depicts that carbon dioxide contains carbon and oxygen in a fixed ratio by mass, which is 3:8.

Thus, it further proves the law of constant proportions.

3 g of carbon must also combine with 8 g of oxygen only.

This means that (50−8)=42g of oxygen will remain unreacted.

The remaining 42 g of oxygen will be left un-reactive. In this case, too, only 11 g of carbon dioxide will be formed

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

3. What are polyatomic ions? Give examples.

Solution:

Polyatomic ions are ions that contain more than one atom, but they behave as a single unit.

Example: CO_3^{2-}, $H_2PO_4^-$

4. Write the chemical formula of the following.

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(a) Magnesium chloride

(b) Calcium oxide

(c) Copper nitrate

(d) Aluminium chloride

(e) Calcium carbonate

Solution:

The following are the chemical formula of the above-mentioned list:

(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

Solution:

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

(a) Quick lime – Calcium and oxygen (CaO)

(b) Hydrogen bromide – Hydrogen and bromine (HBr)

(c) Baking powder – Sodium, Carbon, Hydrogen, Oxygen ($NaHCO_3$)

(d) Potassium sulphate – Sulphur, Oxygen, Potassium (K_2SO_4)

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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

Solution:

Listed below is the molar mass of the following substances:

(a) Molar mass of Ethyne C_2H_2= 2 x Mass of C+2 x Mass of H = (2×12)+(2×1)=24+2=26g

(b) Molar mass of Sulphur molecule S_8 = 8 x Mass of S = 8 x 32 = 256g

(c) Molar mass of Phosphorus molecule, P_4 = 4 x Mass of P = 4 x 31 = 124g

(d) Molar mass of Hydrochloric acid, HCl = Mass of H+ Mass of Cl = 1+35.5 = 36.5g

(e) Molar mass of Nitric acid, HNO_3 =Mass of H+ Mass of Nitrogen + 3 x Mass of O = 1 + 14+

3×16 = 63g

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)?

Solution:

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

(a) Atomic mass of nitrogen atoms = 14u

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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

Solution:

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 = Mass given / molar mass of oxygen gas = 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 = Mass given / molar mass of water

= 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 + 2x 16 = 12+32=44g

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Number of moles = Mass given/ molar mass of carbon dioxide = 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?

Solution:

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.

Solution:

To calculate the molecular mass of sulphur,

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

Mass given = 16g

Number of moles = mass given/ molar mass of sulphur

= 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

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11. Calculate the number of aluminium ions present in 0.051g 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 = 27u)

Solution:

To calculate the number of aluminium ions in 0.051g of aluminium 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

= (2x 27) + (3 x16) = 54 +48 = 102g

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

Therefore, 0.051g of aluminium oxide has = 6.022 x 10^{23} / 102 x 0.051

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

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

= 6.022 x 10^{20}

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