Chapter 3
Atoms and Molecules
Intext Questions

On Page 32

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.

Sodium carbonate + ethanoic acid →sodium ethanoate + carbon + dioxide + water

Solution:

Law of conservation of mass states that mass is neither created nor destroyed during a chemical reaction.
It means the mass remains the same. So, we add the mass of the reactants on LHS and add the mass of all products on RHS

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

So, the observations are in agreement with the law of conservation of mass.

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?

Solution:'Law of constant proportions' states that composition of a compound is always fixed.
Applying this
∵1 g of hydrogen gas combines with oxygen = 8 g
∴3 g of hydrogen gas will combine with oxygen = 8 x 3 = 24 g

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

Solution:Following postulate of Dalton's atomic theory is the result of the law of conservation of mass. 'Atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction.'

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

Solution:Following postulate of Dalton's atomic theory can explain the 'law of definite proportions'.
'The relative number and kinds of atoms are constant in a given compound.'

On Page 35

Question 1:Define the atomic mass unit.

Solution:One atomic mass unit (amu) is a mass unit equal to exactly one-twelfth (1/12th) the mass of one atom of carbon-12.' The relative atomic masses of all the 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?

Solution:As an atom is extremely small in size, it is not possible to see it with naked eyes.
Generally radius of an atom is of the order of nanometres. For example, atomic radius of hydrogen atom is 10-10m (or 10-1nm).

On Page 39

Question 1:Write down the formulae of

(i) sodium oxide
(ii) aluminium chloride
(iii) sodium sulphide
(iv) magnesium hydroxide

Solution:

(i)Na2O

(ii)NH4Cl

(iii)Na2SO4

(iv)Mg(OH)2

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

(i) AL2(SO4)3 (ii) CaCL2 (iii) K2SO4 (iv) KNO3(v) CaCO3

Solution:

(i) Aluminium sulphate

(ii) Calcium chloride

(iii) Potassium sulphate

(iv) Potassium nitrate

(v) Calcium carbonate.

Question 3:What is meant by the term chemical formula?

Solution:

Chemical formula of a compound (or element) is the symbolic representation of its composition. It represents
(i) The number and kind of atoms present per molecule of the compound,
(ii) One mole of the compound,
(iii) Molar mass of the compound.

Question 4:How many atoms are present in a
(i) H_2S molecule and (ii) PO_4^{3-} ion?

Solution:

(i) 2 atom of hydrogen + 1 atom of sulphur

= three (3) atoms (in a H_2S molecule).

(ii) 1 atom of phosphorus + 4 atoms of oxygen

= five (5) atoms (in a PO_4^{3-} ion).

On Page 40

Question 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:
(i) Molecular mass of H_2(hydrogen)

= Atomic mass of hydrogen × 2
= 1 × 2 = 2 u

(ii) Molecular mass of O_2 (oxygen)
=Atomic mass of oxygen × 2

= 16 × 2 = 32 u

(iii) Molecular mass of CI_2(chlorine)
= Atomic mass of chlorine × 2
= 35.5 × 2 = 71 u
(iv) Molecular mass of CO_2(carbon dioxide)
= (Atomic mass of carbon × 1)+ (Atomic mass of oxygen × 2)
= 12 + (16 × 2) = 12 + 32 = 44 u

(v) Molecular mass of CH_4(methane)
= (Atomic mass of carbon × 1) + (Atomic mass of hydrogen × 4)

= 12 + (1 × 4) = 12 + 4 = 16 u

(vi) Molecular mass of C2H6(ethane)
= (Atomic mass of carbon × 2) + (Atomic mass of hydrogen × 6)
= (12 × 2) + (1 × 6) = 24 + 6 = 30 u

(vii) Molecular mass of C2H4(ethene)
= (Atomic mass of carbon × 2) + (Atomic mass of hydrogen × 4)
= (12 × 2) + (1 × 4) = 24 + 4 = 28 u

(viii) Molecular mass of NH3(ammonia)
= (Atomic mass of nitrogen × 1) + (Atomic mass of hydrogen × 3)
= (14 × 1) + (1 × 3) = 14 + 3 = 17 u

(ix) Molecular mass of CH3OH (methanol or methyl alcohol)
= (Atomic mass of carbon × 1) + (Atomic mass of hydrogen × 3)+ (Atomic mass of oxygen × 1) + (Atomic mass of hydrogen × 1)

= 12 + 3 + 16 + 1 = 32 u

Question 2:Calculate the formula unit masses of Zn0, Na20, K2C03.
Given atomic masses of Zn = 65 u, Na = 23 u, K = 39 u

C = 12 u and 0 = 16 u.

Solution:

(i) Formula unit mass of ZnO (zinc oxide) =
65 + 16 = 81 u
(ii) Formula unit mass of Na2O (sodium oxide) =
(23 × 2) + (16 × 1) = 46 + 16 = 62 u
(iii) Formula unit mass of K2CO3(potassium carbonate) =
(39 × 2) + (12 × 1) + (16 × 3) = 78 + 12 + 48 = 138 u

On Page 42

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

Solution:

1 mole carbon atom = 6.022×10^{23} atoms
Molar atomic mass = 12 g
6.022×10^{23} carbon atoms weigh = 12 g

$$1 \text{ carbon atom weighs } \frac{12}{6.022 \times 10^{23}} = 1.99 \times 10^{-23} \text{g}$$

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)?

Solution:

Molar mass of sodium = 23 g
1 mole atom = 6.022×10^{23} atoms

23 g sodium contains = 6.022×10^{23} atoms

1 g sodium contains = $\frac{6.022 \times 10^{23}}{23}$ atoms

100 g sodium contains = 6.022×10^{23} atoms

= 2.618×10^{24} atoms

By the above method or by formula we find number of atoms in 100 g Fe;

Number of atoms of an element in a given mass

$$= \frac{\text{Given mass}}{\text{Gram atomic mass } 100g} \times \text{Avogadro's number}$$

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

= 1.075×10^{24} atoms

Hence, 100 g of sodium has more number of atoms as compared to 100 g of iron.

Exercises

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.

Solution:

Mass of the compound = 0.24 g
Mass of boron = 0.096 g
Mass of oxygen = 0.144 g

$$\text{Percentage of boron} = \frac{\text{Mass of boron}}{\text{Mass of compound}} \times 100 = \frac{0.096\ g}{0.240\ g} \times 100 = 40\%$$

$$\text{Percentage of oxygen} = \frac{\text{Mass of oxygen}}{\text{Mass of compound}} \times 100$$

$$= \frac{0.144g}{0.240g} \times 100$$

Alternative method

Percentage of oxygen =100 percentage of boron
=100 - 40 = 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?

Solution:

First we find the proportion of mass of carbon and oxygen in carbon dioxide.
In CO_2 , C : O = 12 : 32 or 3 : 8
In other words, we can say that
12.00 g carbon reacts with oxygen = 32.00 g
3.00 g carbon will react with oxygen = 32 x 3 = 8g

12

Therefore, 3.00 g of carbon will always react with 8.00 g of oxygen to form CO_2 (11g), even if large amount (50.00 g) of oxygen is present. This answer will be governed by 'the law of constant proportions'.

Question 3:What are polyatomic ions? Give examples.

Solution:The group of atoms which carry a fixed charge (either positive or negative) on them and behave as ions are called polyatomic ions.

Example
(i) Carbonate ion (ii) Sulphate ion
(iii) Ammonium ion (iv) Phosphate ion

Question 4:Write the chemical formulae of the following.
(i) Magnesium chloride (ii) Calcium oxide

(iii) Copper nitrate (iv) Aluminium chloride
(v) Calcium carbonate

Solution:

(i)
Formula = $MgCl_2$ (Magnesium chloride)
(ii)
Formula = CaO (Calcium oxide)
(iii)
Formula = $Cu(NO_3)_2$ (Copper nitrate)
(iv)
Formula = $AlCl_3$ (Aluminium Chloride)
(v)
Formula = $CaCO_3$ (Calcium carbonate)

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

Solution:
(a) Quick lime- Calcium oxide - CaO
Elements–Calcium, oxygen.

(b)Hydrogen bromide- HBr
Elements- Hydrogen, bromine.

(c) Baking powder- Sodium hydrogen carbonate -$NaHCO_3$
Elements- Sodium, hydrogen, carbon, oxygen.

(d)Potassium sulphate- K_2SO_4
Elements- Potassium, sulphur, 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

Solution:

(a) Molar mass of C_2H_2

= (2 × Atomic mass of C) + (2 × Atomic mass of H)
= (2 × 12) + (2 × 1)
= 26 u

(b) Molar mass of S_8

= (8 × Atomic mass of S)
= 8 × 32 = 256 u

(c) Molar mass of P_4

= 4 × Atomic mass of P
= 4 × 31 = 124u

(d) Molar mass of HCl

= Atomic mass of hydrogen + Atomic mass of CI
= 1 + 35.5 = 36.5 u

(e) Molar mass of HN03

= Atomic mass of H + Atomic mass of N + (3 × Atomic mass of 0)
= 1 + 14 + (3 × 16) = 15 + 48 = 63 u

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 (Na2SO3)?

Solution:

(a) Molar mass of N atom = Atomic mass of N.
Mass of 1 mol of N atoms = 14 g

(b) Mass of 1 mole AI atoms = 27 g
Mass of 4 moles of AI atoms = 27 × 4 = 108 g

(c) Mass of 1 mole of Na2SO3 = (23 ×2) + 32 + (16 × 3)
= 46 + 32 + 48 = 126 g
Mass of 10 moles of Na2SO3 = 126 × 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.

Solution:

(a) (O2)
Molar mass of oxygen (O2) = 16 x 2 = 32 g
32 g oxygen gas = 1 mol

12 g oxygen gas = 1 x 12 g = 0.375 mol

32g

(b) (H2O)
Molar mass of water (H2O) = 2 + 16 = 18g
18 g water = 1 mol
20 g water = 1 x 20 g = 1.11 mol

18g

(c) 22g of Carbon Dioxide(CO2)
Molar mass of carbon dioxide (CO2)=12 + 32 = 44g
44 g CO2 = 1 mol
22 g CO2 =1x 22 g = 0.5 mol

44g

Question 9:What is the mass of
(a) 0.2 mole of oxygen atoms?
(b) 0.5 mole of water molecules?

Solution:

(a) Mass of 1 mole O-atoms = 16 g
Mass of 0.2 mole O-atoms = 16 × 0.2 = 3.2 g
(b) Mass of 1 mole of H2O molecules = 18 g

Mass of 0.5 mole of H_2O molecules = 18 × 0.5 = 9.0 g

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

Solution:

Molar mass of sulphur (S_8) = 32 x 8 = 256 g
Number of S_8 molecules in 256 g of solid sulphur = 6.022×10^{23}

Number of S_8 molecules in 16 g of solid sulphur $= \frac{6.022 \times 10^{23} \times 16g}{256g}$

$= 3.76 \times 10^{23}$ molecules

Question 11:Calculate the number of aluminium ions present in 0.051 g of aluminium oxide.
[HintThe mass of an ion is the same as that of an atom of the same element. Atomic mass of AI= 27 u.]

Solution:

Molar mass of $AL_2O_3 = (27 \times 2) + (16 \times 3) = 54 + 48 = 102$ g

$$\underset{(102\text{ g})}{\underset{1\text{ mol}}{AL_2O_3}} \rightleftharpoons \underset{2\text{ mol}}{2\overset{3+}{AL}} + 3\overset{2-}{O}$$

$\because$ 102 g AL_2O_3 contains AL^3 + ions $= 2 \times 6.022 \times 10^{23}$

$\therefore$ 0.051 g AL_2O_3 will contain AL^3 + ions $= \dfrac{2 \times 6.022 \times 10^{23}}{102} \times 0.05$

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