ACTIVITY *Field*

Activity 1

Objective

To understand, that there is a change in mass when a chemical change takes place. (To understand law of conservation of mass experimentally).

Procedure

1. *Take one of the following sets,* X *and* Y *of chemicals*

|	X	Y
(i)	Copper sulphate 1.25 g	Sodium carbonate 1.43 g
(ii)	Barium chloride 1.22 g	Sodium sulphate 1.53 g
(iii)	Lead nitrate 2.07 g	Sodium chloride 1.17 g

2. Prepare separately a solution of any one pair of substances listed under X and Y each in 10 mL water.
3. Take a solution of Y in a conical flask and solution of X in a small test tube.
4. Hang the test tube in the flask carefully. Put a cork on the flask and weigh it.

   In (*i*), on weighing, its weight is $(1.25 + 1.43)$ g $= 2.68$ g

   In (*ii*), on weighing, its weight is $(1.22 + 1.53)$ g $= 2.75$ g

   In (*iii*), on weighing, its weight is $(2.07 + 1.17)$ g $= 3.24$ g

5. Now, tilt and swirl the flask, so that the solutions X and Y get mixed. We should put a cork on the mouth of the flask so that no gas can pass out, if formed.
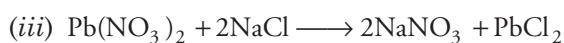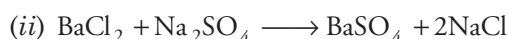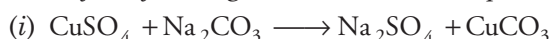6. Weigh again.

Cork
Thread
Conical flask
Small ignition tube
Solution of X
Solution of Y
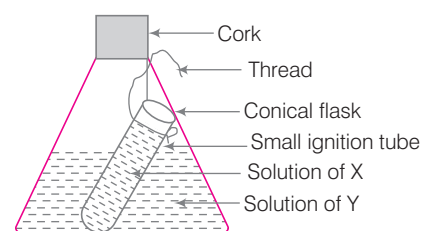
Small test tube contains solution of X, which is dipped in conical flask containing solution of Y.

Observation

The sum of weights of the products formed are the same as before the mixing of reactants.

In reaction flask, following chemical reactions take place

(*i*) $CuSO_4 + Na_2CO_3 \longrightarrow Na_2SO_4 + CuCO_3$ (*ii*) $BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$

(*iii*) $Pb(NO_3)_2 + 2NaCl \longrightarrow 2NaNO_3 + PbCl_2$

Conclusion

The mass of the flask and its contents does not change because mass is conserved in the reaction. Mass can neither be created nor destroyed in chemical reactions.

Multiple Choice *Questions*

1. Which law is verified by this activity?
   (a) Law of conservation of mass
   (b) Law of constant proportions
   (c) Law of multiple proportions
   (d) Both (b) and (c)

2. When 20 g of $BaCl_2$ is mixed with 10.6 g of H_2SO_4, it produces 8.2 g of HCl and some amount of $BaSO_4$. The mass of $BaSO_4$ is equal to
   (a) 20.4 g   (b) 22.4 g   (c) 11.2 g   (d) 18.5 g

3. The balancing of chemical equation is based on the
   (a) law of constant proportions
   (b) law of conservation of mass
   (c) law of multiple proportions
   (d) none of the above

4. The law of conservation of mass was discovered by
   (a) Dalton   (b) Democritus   (c) Proust   (d) Lavoisier

5. What is the correct formula of sodium carbonate?
   (a) $NaCO_3$ (b) $Na_2(CO_3)_2$
   (c) $Na(CO_3)_2$ (d) Na_2CO_3

6. Law of conservation of mass is applicable to
    (a) physical processes   (b) chemical reactions
    (c) nuclear reactions   (d) both (a) and (b)

7. The valency of sulphate ion is
    (a) 4   (b) 3   (c) 2   (d) 1

8. The formula of sodium chloride is
    (a) Na_2Cl (b) $NaCl_2$ (c) $NaCl_4$ (d) $NaCl$

9. Sulphate ion is
    (a) S^{2-} (b) SO_3^{2-}
    (c) SO_4^{2-} (d) SO_2

10. Matter can neither be created nor be destroyed is the
    (a) law of constant proportions
    (b) law of conservation of mass
    (c) law of multiple proportions
    (d) none of the above

Answers

1. (a)	**2.** (b)	**3.** (b)
4. (d)	**5.** (d)	**6.** (d)
7. (c)	**8.** (d)	**9.** (c)
10. (b)		

Activity 2

Objective

To understand that how atoms of different elements join together in definite proportion to form molecules of compounds.

Procedure

1. *The ratio by number of atoms for a water molecule can be found as follows*

Element	Ratio by mass	Atomic mass (u)	Mass ratio / Atomic mass	Simplest ratio
H	1	1	1/1 = 1	2
O	8	16	8/16 = 1/2	1

    Thus, the ratio by number of atoms for water is H : O = 2 : 1

2. *The ratio by number of atoms for ammonia molecule can be found as follows*

Element	Ratio by mass	Atomic mass (u)	Mass ratio / Atomic mass	Simplest ratio
N	14	14	14/14 = 1	1
H	3	1	3/1 = 3	3

    Thus, the ratio by number of atoms for ammonia is N : H = 1 : 3

3. *The ratio by number of atoms for carbon dioxide molecule can be found as follows*

Element	Ratio by mass	Atomic mass (u)	Mass ratio/ Atomic mass	Simplest ratio
C	3	12	$\frac{3}{12} = \frac{1}{4}$	$\frac{1}{4} \times 4 = 1$
O	8	16	$\frac{8}{16} = \frac{1}{2}$	$\frac{1}{2} \times 4 = 2$

    Thus, the ratio by number of atoms for carbon dioxide molecule is C : O = 1 : 2.

Multiple Choice *Questions*

1. What is the atomic mass of nitrogen?
    (a) 7   (b) 14
    (c) 21   (d) 3

2. What is the ratio of N and H by mass in ammonia molecule?
    (a) 3 : 14
    (b) 14 : 18
    (c) 14 : 3
    (d) 3 : 7

3. Find the ratio of C and O by mass in CO_2.
    (a) 3 : 8   (b) 8 : 3
    (c) 4 : 3   (d) 3 : 4

4. The simplest ratio by number of atoms of C and O for carbon dioxide is
    (a) 1 : 1   (b) 1 : 2
    (c) 2 : 1   (d) 3 : 2

5. The formula of ammonia is
    (a) NH_3 (b) NH_4^+
    (c) NH_2 (d) N_2

6. How many moles are present in 34 g of NH_3?
    (a) 1   (b) 2
    (c) 3   (d) 4

Answers

1. (b)	**2.** (c)	**3.** (a)
4. (b)	**5.** (a)	**6.** (b)

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Intext Questions

Q 1. In a reaction, 5.3 g of sodium carbonate reacted with 6 g of ethanoic acid. The products were 2.2 g of CO_2, 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.

Sodium carbonate + Ethanoic acid → Sodium ethanoate + Carbon dioxide + Water   (Pg 32)

Sol. Mass of reactants = mass of sodium carbonate + mass of ethanoic acid

$$= 5.3 + 6.0 = 11.3 \text{ g}$$

Mass of products = mass of sodium ethanoate + mass of carbon dioxide + mass of water

$$= 8.2 + 2.2 + 0.9$$

$$= 11.3 \text{ g}$$

Since, the mass of reactants is equal to the mass of products, therefore, the observation made is in agreement with the law of conservation of mass.

Q 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?   (Pg 33)

Sol. Since, H and O combine in the ratio of 1:8 by mass. Therefore,

$$\frac{\text{Mass of H}}{\text{Mass of O}} = \frac{1}{8}$$

Let the mass of oxygen required be x.

$$\therefore \quad \frac{3}{x} = \frac{1}{8} \quad \text{or} \quad x = 24 \text{ g}$$

Therefore, oxygen required to react with 3 g of hydrogen to form water = 24 g

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

     (Pg 33)

Sol. The postulate which is the result of law of conservation of mass is 'atoms are indivisible particles, which cannot be created or destroyed in a chemical reaction'.

Q 4. Which postulate of Dalton's atomic theory can explain the law of definite proportions ?   (Pg 33)

Sol. The relative number as well as kinds of atoms are constant in a given compound. This is the postulate that explains law of definite proportions.

Q 5. Define the atomic mass unit.   (Pg 35)

Sol. One atomic mass unit is the mass unit (u), equal to 1/12th of the mass of an atom of C-12.
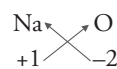
Q 6. Why is it not possible to see an atom with naked eyes?   (Pg 35)

Sol. The size of an atom is very small (the radius of an atom is of the order of 10^{-10} m). Also, the atoms of the most elements do not exist independently.
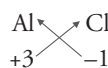
Q 7. Write down the formulae of   (Pg 39)
(a) sodium oxide
(b) aluminium chloride
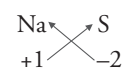(c) sodium sulphide
(d) magnesium hydroxide

Sol. (a) **Sodium oxide**

$$\underset{+1}{\text{Na}} \diagdown \underset{-2}{\text{O}}$$

Formula = Na_2O

(b) **Aluminium chloride**

$$\underset{+3}{\text{Al}} \diagdown \underset{-1}{\text{Cl}}$$

Formula = $AlCl_3$

(c) **Sodium sulphide**

$$\underset{+1}{\text{Na}} \diagdown \underset{-2}{\text{S}}$$

Formula = Na_2S

(d) **Magnesium hydroxide**

$$\underset{+2}{\text{Mg}} \diagdown \underset{-1}{\text{(OH)}}$$
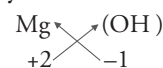
Formula = $Mg(OH)_2$

Q 8. *Write down the names of compounds represented by the following formulae* (Pg 39)

(a) $Al_2(SO_4)_3$　　　(b) $CaCl_2$

(c) K_2SO_4　　　(d) KNO_3

(e) $CaCO_3$

Sol. (a) Aluminium sulphate　(b) Calcium chloride

(c) Potassium sulphate　(d) Potassium nitrate

(e) Calcium carbonate

Q 9. *What is meant by the term chemical formula?* (Pg 39)

Sol. It is the short way to represent a compound with the help of symbols and valency of elements.

For example,

Elements　　　　Ca　　Cl

Valency　　　　+2 ✕ −1

Formula　　　　$CaCl_2$

Q 10. *How many atoms are present in a* (Pg 39)

(a) H_2S molecule and

(b) PO_4^{3-} ion ?

Sol. (a) In H_2S molecule, 3 atoms are present.

(b) In PO_4^{3-} ion, five atoms are present.

Q 11. *Calculate the molecular masses of* (Pg 40)

H_2, O_2, Cl_2, CO_2, CH_4, C_2H_6, C_2H_4, NH_3, CH_3OH

Sol. (a) Molecular mass of H_2 (hydrogen)

= Atomic mass of hydrogen × 2

= 1 × 2 = 2 u

(b) Molecular mass of O_2 (oxygen)

= Atomic mass of oxygen × 2

= 16 × 2 = 32 u

(c) Molecular mass of Cl_2 (chlorine)

= Atomic mass of chlorine × 2

= 35.5 × 2 = 71 u

(d) Molecular mass of CO_2 (carbon dioxide)

= (Atomic mass of carbon × 1)

+ (Atomic mass of oxygen × 2)

= 12 + (16 × 2)

= 12 + 32 = 44 u

(e) Molecular mass of CH_4 (methane)

= (Atomic mass of carbon × 1)

+ (Atomic mass of hydrogen × 4)

= 12 + (1 × 4) = 12 + 4 = 16 u

(f) Molecular mass of C_2H_6 (ethane)

= (Atomic mass of carbon × 2)

+ (Atomic mass of hydrogen × 6)

= (12 × 2) + (1 × 6) = 24 + 6 = 30 u

(g) Molecular mass of C_2H_4 (ethene)

= (Atomic mass of carbon × 2)

+ (Atomic mass of hydrogen × 4)

= (12 × 2) + (1 × 4) = 24 + 4 = 28 u

(h) Molecular mass of NH_3 (ammonia)

= (Atomic mass of nitrogen × 1)

+ (Atomic mass of hydrogen × 3)

= (14 × 1) + (1 × 3) = 14 + 3 = 17 u

(i) Molecular mass of CH_3OH (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

Q 12. *Calculate the formula unit masses of ZnO, Na_2O, K_2CO_3. [Given, atomic mass of Zn = 65 u, Na = 23 u, K = 39 u, C = 12 u and O = 16 u.]* (Pg 40)

Sol. (i) Formula unit mass of ZnO (zinc oxide)

= 65 + 16 = 81 u

(ii) Formula unit mass of Na_2O (sodium oxide)

= (23 × 2) + (16 × 1) = 46 + 16 = 62 u

(iii) Formula unit mass of K_2CO_3 (potassium carbonate)

= (39 × 2) + (12 × 1) + (16 × 3)

= 78 + 12 + 48 = 138 u

Q 13. *If one mole of carbon atoms weighs 12 g, what is the mass (in grams) of 1 atom of carbon?* (Pg 42)

Sol. 1 mole of C atoms = 6.023×10^{23} atoms = 12 g

∵ 6.023×10^{23} atoms of C weigh 12 g

∴ 1 atom of C weighs $\dfrac{12 \times 1}{6.023 \times 10^{23}} = 1.99 \times 10^{-23}$ g

Q 14. *Which has more number of atoms, 100 g of sodium or 100 g of iron? [Given, atomic mass of Na = 23 u, Fe = 56 u]* (Pg 42)

Sol. 23 g-atomic unit or 23 g (1 mol) Na = 6.023×10^{23} atoms

∴ 100 g sodium contains $\dfrac{6.023 \times 10^{23}}{23} \times 100$

= 2.617×10^{24} atoms

Again, 56 g-atomic unit or 56 g (1 mol) iron

= 6.023×10^{23} atoms

∴ 100 g iron contains $\dfrac{6.023 \times 10^{23}}{56} \times 100$

= 1.075×10^{24} atoms

Therefore, 100 g of Na has more atoms than 100 g of iron.

Exercises

Q 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.

Sol. Mass of the compound = 0.24 g

Mass of boron = 0.096 g

Mass of oxygen = 0.144 g

Percentage of boron $= \dfrac{\text{Mass of boron}}{\text{Mass of compound}} \times 100$

$= \dfrac{0.096 \text{ g}}{0.240 \text{ g}} \times 100 = 40\%$

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

$= \dfrac{0.144 \text{ g}}{0.240 \text{ g}} \times 100 = 60\%$

Alternative method

Percentage of oxygen = 100 − percentage of boron

= 100 − 40 = 60%

Q 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?

Sol. 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 = 32.00g

∴ 3.00 g carbon will react with oxygen $= \dfrac{32}{12} \times 3 = 8$ g

$$\begin{array}{cccc} C & + & O_2 & \longrightarrow & CO_2 \\ 12\text{ g} & & 32\text{ g} & & 12 + 16 \times 2 = 44\text{ g} \\ 3\text{ g} & & 8\text{ g} & & 3 + 8 = 11\text{g} \end{array}$$

Therefore, 3.00 g of carbon will always react with 8.00 g of oxygen to form 11 g of CO_2, even if large amount (50.00 g) of oxygen is present.

This answer will be governed by the law of constant proportions.

Q 3. What is poly-atomic ion? Give examples.

Sol. A group of atoms carrying a charge and behaving like one entity is known as poly-atomic ion.

For example, oxygen atom and hydrogen atom combine to form hydroxide ion (OH^-) and one C atom and three O atoms combine to form carbonate ion (CO_3^{2-}).

Q 4. *Write the chemical formulae of the following*
  (a) Magnesium chloride
  (b) Calcium oxide
  (c) Copper nitrate
  (d) Aluminium chloride
  (e) Calcium carbonate

Sol.

(a)   Mg   Cl
    +2   −1
  Formula = $MgCl_2$ (Magnesium chloride)

(b)   Ca   O
    +2   −2
  Formula = Ca_2O_2 or CaO (Calcium oxide)

(c)   Cu NO_3
    +2   −1
  Formula = $Cu(NO_3)_2$ (Copper nitrate)

(d)   Al   Cl
    +3   −1
  Formula = $AlCl_3$ (Aluminium chloride)

(e)   Ca CO_3
    +2   −2
  Formula = $CaCO_3$ (Calcium carbonate)

Q 5. *Give the names of the elements present in the following compounds*
  (a) Quicklime
  (b) Hydrogen bromide
  (c) Baking powder
  (d) Potassium sulphate
  (e) Marble

Sol. (a) **Quicklime** 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
  (e) **Marble** Calcium carbonate — $CaCO_3$
    Elements Calcium, carbon, oxygen

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Q 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

Sol. (a) Molar mass of $C_2H_2 = (2 \times$ Atomic mass of C)
$+ (2 \times$ Atomic mass of H)
$= (2 \times 12) + (2 \times 1) = 26$ u

(b) Molar mass of S_8
$= 8 \times$ Atomic mass of $S = 8 \times 32 = 256$ u

(c) Molar mass of P_4
$= 4 \times$ Atomic mass of $P = 4 \times 31 = 124$ u

(d) Molar mass of HCl
$=$ (Atomic mass of H) + (Atomic mass of Cl)
$= 1 + 35.5 = 36.5$ u

(e) Molar mass of HNO_3
$=$ (Atomic mass of H) + (Atomic mass of N)
$+ (3 \times$ Atomic mass of O)
$= 1 + 14 + (3 \times 16) = 15 + 48 = 63$ u

Q 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)?

Sol. (a) Molar mass of N atoms = Atomic mass of N
$\therefore$ Mass of 1 mole of N atoms = 14 g

(b) Mass of 1 mole of Al atoms = 27 g
$\therefore$ Mass of 4 moles of Al atoms = $27 \times 4 = 108$ g

(c) Mass of 1 mole of Na_2SO_3
$= (23 \times 2) + 32 + (16 \times 3) = 46 + 32 + 48 = 126$ g
Mass of 10 moles of $Na_2SO_3 = 126 \times 10 = 1260$ g

Q 8. Convert into mol

(a) 12 g of oxygen gas

(b) 20 g of water

(c) 22 g of carbon dioxide

Sol. (a) **12 g of oxygen gas** (O_2)

Molar mass of oxygen (O_2) = $16 \times 2 = 32$ g

$\because$ 32 g oxygen gas = 1 mol

$\therefore$ 12 g oxygen gas = $\dfrac{1}{32g} \times 12$ g = 0.375 mol

(b) **20 g of water** (H_2O)

Molar mass of water (H_2O) = $2 + 16 = 18$ g

$\because$ 18 g water = 1 mol

$\therefore$ 20 g water = $\dfrac{1}{18\ g} \times 20$ g = 1.11 mol

(c) **22 g of carbon dioxide** (CO_2)

Molar mass of carbon dioxide (CO_2) = $12 + 32 = 44$ g

$\because$ 44 g CO_2 = 1 mol

$\therefore$ 22 g CO_2 = $\dfrac{1}{44\ g} \times 22$ g = 0.5 mol

Q 9. *What is the mass of*

(a) 0.2 mole of oxygen atoms?

(b) 0.5 mole of water molecules?

Sol. (a) Mass of 1 mole O atoms = 16 g

Mass of 0.2 mole O atoms = $16 \times 0.2 = 3.2$ g

(b) Mass of 1 mole of H_2O molecules = 18 g

Mass of 0.5 mole of H_2O molecules
$= 18 \times 0.5 = 9.0$ g

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

Sol. Molar mass of sulphur (S_8) = $32 \times 8 = 256$ g

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

Number of S_8 molecules in 16 g of solid sulphur
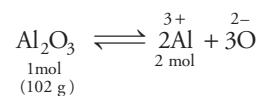$= \dfrac{6.022 \times 10^{23}}{256\ g} \times 16$ g $= 3.76 \times 10^{22}$ molecules

Q 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]

Sol. Molar mass of $Al_2O_3 = (27 \times 2) + (16 \times 3)$
$= 54 + 48 = 102$ g

$$Al_2O_3 \rightleftharpoons 2Al^{3+} + 3O^{2-}$$
$$\underset{(102\ g)}{1\text{mol}} \qquad \underset{2\ mol}{}$$

$\because$ 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

$= \dfrac{2 \times 6.022 \times 10^{23}}{102} \times 0.051$

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