THE LANGUAGE OF CHEMISTRY

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CHAPTER

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INTRODUCTION

You would need many words to describe a chemical change in ordinary language. But you can do so with only a few letters and numbers in the language of chemistry.

J J Berzelius laid the foundation of this language in the early nineteenth century. It gradually developed into its present form. In this language, an atom is represented by a **symbol,** a molecule by a **formula,** and a chemical change (i.e., a reaction) by a **chemical equation.**

SYMBOLS

◈ **A symbol is an abbreviation of the name of an element.**

The symbols of elements have been derived in three different ways.

1. **The first letter (in capital) of the English name of an element**

Name	Symbol	Name	Symbol
Hydrogen	H	Oxygen	O
Boron	B	Fluorine	F
Carbon	C	Phosphorus	P
Nitrogen	N	Sulphur	S

2. **The first letter along with one more letter of the English name of an element (this becomes necessary when the names of two or more elements begin with the same letter)**

Name	Symbol	Name	Symbol
Helium	He	Aluminium	Al
Neon	Ne	Calcium	Ca
Nickel	Ni	Chlorine	Cl
Magnesium	Mg	Zinc	Z n
Manganese	Mn		

3. **One or two letters of the Latin name of an element**

Name		Symbol
English	Latin	
Sodium	Natrium	Na
Potassium	Kalium	K
Iron	Ferrum	Fe

Copper	Cuprum	Cu
Silver	Argentum	Ag
Tin	Stannum	Sn
Gold	Aurum	Au
Lead	Plumbum	Pb
Mercury	Hydrargyrum	Hg

◈ What does a symbol represent ?

The symbol of an element represents the following.

1. An element in particular For example, you know that the symbol of sodium is Na and that of chlorine is Cl. So, instead of saying that the compound common salt is made up of the elements sodium and chlorine, you can say that it is made up of Na and Cl. You can also say that Cu is red-brown whereas Au is yellow, and that Ca is a metal whereas Cl is a nonmetal.

2. An atom of an element In formulae and equations, a symbol represents an atom of an element. More than one atom in a molecule is shown by a numeral subscript. This is explained in the next section.

➢ FURMULAE

Atoms usually do not exist independently. They generally combine among themselves to form molecules. A molecule is the smallest part of an element or a compound that can exist independently. It is represented by a formula.

The formula of a molecule gives the numbers(s) of atoms of the same or different elements present in the molecule.

➢ FORMULAE OF ELEMENTS

When an atom of an element combines with another atom(s) of the same element, a molecule of the element is formed.

For example, two atoms of hydrogen combine to form a molecule of hydrogen. The formula of hydrogen is H_2, 2 being the subscript showing the number of H atoms in the molecule. Similarly, molecules of nitrogen, oxygen, fluorine, chlorine, bromine and iodine contain two atoms of the element. So they are represented as N_2, O_2, F_2, Cl_2, Br_2 and I_2 respectively. As these molecules have two atoms of the element, they are said to be **diatomic**, A common example of a **triatomic gas** is ozone (O_3).

There are a few highly inactive gases present in very small amounts in the air. These gases, viz., helium (He), neon (Ne), argon (Ar), krypton (Kr) and xenon (Xe), are called **noble gases.** A molecule of a noble gas contains only one atom of the element. In other words, noble gases are **monoatomic.** So the formula of a noble gas is the same as its symbol.

◈ Valency–the combining capacity of an element

When atoms of two or more elements combine, a molecule of a compound is formed. The capacities of these elements to combine with each other determine the formula of the compound formed.

◈ **The capacity of an element to combine with other elements is known as its valency.**

It will be evident from the following that the combining capacities of all elements are not the same.

1. One atom of Cl combines with one atom of H to form a molecule of hydrogen chloride.
2. One atom of O combines with two atoms of H to form a molecule of water.
3. One atom of N combines with three atoms of H to form a molecule of ammonia.

Thus, the combining capacity of O is twice that of Cl, and that of N is thrice that of Cl.

H is assigned a valency of 1. So the valencies of Cl, O and N are 1, 2 and 3 respectively. However, many atoms do not combine with H. Their valencies are calculated by the number of Cl atoms they combine with, since Cl and H have the same valency, i.e., 1.

- **The valency of an element is given by the number of H or Cl atoms that an atom o the element combines with.**

(You will learn in higher classes that the valency of an element can be expressed in many ways.)

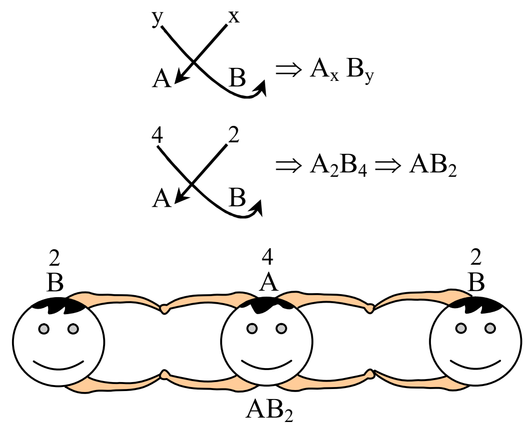
Elements with valencies 1, 2, 3, etc., are said to be **monovalent, divalent (or bivalent), trivalent,** and so on. The valencies of some common elements are indicated in Table

Table: The valencies of some common elements

Monovalent	Divalent	Trivalent	Tetravalent
Hydrogen	Oxygen	Nitrogen	Carbon
Chlorine	Sulphur	Aluminium	**Silicon**
Iodine	Magnesium		
Sodium	Calcium		
Potassium	Zinc		

- **Obtaining the formulae of compounds**

The formula of a **binary compound,** i.e., a compound formed by two elements only, is obtained by transposing their valencies. Suppose an element A has a valency y and element B has a valency x. Then the compound formed between A and B usually has the formula A_xB_y. The subscripts should be divided by a common factor, if any.



There are some exceptions like H_2O_2 (hydrogen peroxide) in which the numeral subscripts are not divided by the common factor.

The formulae of some common compounds are given in table

Table: Formulae of some common compounds

Elements with valencies		Formula	Name of the compound
$\overset{1}{H}$	$\overset{2}{O}$	H_2O	Water
$\overset{1}{H}$	$\overset{1}{Cl}$	HCl	Hydrogen chloride
$\overset{1}{Na}$	$\overset{1}{Cl}$	NaCl	Sodium chloride
$\overset{2}{Mg}$	$\overset{1}{Cl}$	$MgCl_2$	Magnesium chloride
$\overset{2}{Ca}$	$\overset{1}{Cl}$	$CaCl_2$	Calcium chloride
$\overset{3}{N}$	$\overset{1}{H}$	NH_3	Ammonia
$\overset{2}{Mg}$	$\overset{2}{O}$	MgO	Magnesium oxide
$\overset{2}{Ca}$	$\overset{2}{O}$	CaO	Calcium oxide
$\overset{4}{C}$	$\overset{2}{O}$	CO_2	Carbon dioxide

VARIABLE VALENCY

Some elements have variable valency. For example, iron has valencies of 2 (e.g., in $FeCl_2$) and 3 (e.g., in $FeCl_3$). $FeCl_2$ is named iron(II) chloride, and $FeCl_3$ is named iron(III) chloride. This method of naming a compound is adopted if it contains an element with variable valency.

Table: Some elements with variable valencies

Metal	Nonmetal
Copper —1, 2	Phosphorus—3, 5
Iron —2, 3	Sulphur —2, 4, 6
Tin—2, 4	
Lead—2, 4	

Let us look at a few examples of compounds containing elements of variable valency.

Copper (I) chloride $\overset{1}{Cu}\ \ \overset{1}{Cl} \Rightarrow CuCl$

Copper (II) chloride $\overset{2}{Cu}\ \ \overset{1}{Cl} \Rightarrow CuCl_2$

Iron (II) oxide $\overset{2}{Fe}\ \ \overset{2}{O} \Rightarrow FeO$

Iron (III) oxide $\overset{3}{Fe}\ \ \overset{2}{O} \Rightarrow Fe_2O_3$

Can you guess the valencies of phosphorus in PCl_3, and of sulphur in H_2S, SO_2 and SO_3 ?

WHAT ARE COMPOUND RADICALS

Certain groups of atoms of different elements remain intact in many chemical reactions. In fact, they behave like single atoms and have a valency. They are called **compound radicals.** They do not exist independently, but only as parts of compounds. Common examples of monovalent radicals are hydroxide (OH) and nitrate (NO_3). Carbonate (CO_3) and sulphate (SO_4) are examples of divalent radicals. The phosphate (PO_4) radical is trivalent.

The formulae of compounds containing compound radicals are also obtained by transposing valencies (Table)

Table: Formulae of some compounds containing compound radicals

Elements or radicals with valencies		Compound formed	
		Formula	**Name**
$\overset{1}{Na}$	$\overset{1}{OH}$	NaOH	Sodium hydroxide
$\overset{1}{K}$	$\overset{1}{NO_3}$	KNO_3	Potassium nitrate
$\overset{1}{NH_4}$	$\overset{2}{SO_4}$	$(NH_4)_2SO_4$	Ammonium sulphate
$\overset{1}{Na}$	$\overset{2}{CO_3}$	Na_2CO_3	Sodium carbonate
$\overset{1}{H}$	$\overset{1}{NO_3}$	HNO_3	Nitric acid
$\overset{1}{H}$	$\overset{2}{SO_4}$	H_2SO_4	Sulphuric acid

CHEMICAL EQUATIONS

You know that an element is represented by a symbol and a compound, by a formula. A chemical change is represented by an equation called a **chemical equation.** For example, the burning of carbon in a sufficient supply of oxygen to form carbon dioxide is represented by the following equation.

$$\underbrace{C + O_2}_{reactants} \rightarrow \underbrace{CO_2}_{product}$$

If the supply of oxygen is insufficient, carbon monoxide (CO) is formed. Let us express the reaction thus:

$$C + O_2 \rightarrow CO$$

The substances that react among themselves are called **reactants** and those that are formed are called **products.** Remember that no atoms are lost or gained in a chemical reaction. So **the number of atoms of each element on the reactant side must be the same as that on the product side.**

An equation satisfying this rule is called a **balanced chemical equation.** For example, the equation showing the formation of carbon dioxide is a balanced chemical equation. But the one showing the formation of carbon monoxide is not. Because there are two O atoms on the reactant side, the only one on the product side. To balance this equation, we place the numeral 2 before C on the reactant side and CO on the product side.

$$2C + O_2 \rightarrow 2CO$$

Only balanced chemical equations are acceptable. Here are a few examples of such equations.

$$H_2 + Cl_2 \rightarrow 2HCl$$

$$2H_2 + O_2 \rightarrow 2H_2O$$

$$2Mg + O_2 \rightarrow 2MgO$$

Sometimes, an equation is made more informative by mentioning the conditions o the reaction above the arrow.

$$C + O_2 \xrightarrow{\text{heat}} CO_2$$

POINTS TO REMEMBER

- A symbol is an abbreviation of the name of an element.
- A symbol represents an element and an atom of the element.
- The formula of an element or a compound represents a molecule of the element or compound. It gives the number(s) of atoms of the same or different elements present in the molecule.
- Noble gases (helium, neon, argon, krypton and xenon) are monoatomic, whereas hydrogen, nitrogen, oxygen, fluorine, chlorine, bromine and iodine are diatomic. Ozone(O_3) is a triatomic gas.
- The capacity of an element to combine with other elements is known as its valency.
- The formula of a compound containing two elements is obtained by transposing their valencies.
- Some elements like iron (Fe), copper (Cu), lead (Pb), phosphorus (P) and sulphur(S) have variable valency.
- A group of atoms of two or more elements, which behaves like a single atom and has a valency, is known as a compound radical.
- Chemical changes are represented by chemical equations.
- The number of atoms of each elements on the reactant side must be the same as that on the product side. An equation that satisfies this rule is called a balanced chemical equation.

EXERCISE # 1

(A). Answer the following in not more than 20 words.

Q.1 What does the formula of a substance tell you ?

Q.2 What do you mean by the valency of an element ?

Q.3 What is the following called ?

A group of atoms of two or more elements behaving like an atom and having a valancey

Q.4 Name two elements that have variable valency. Give the formulae and names of two compounds formed by each of these elements

Q.5 What is a balanced chemical equation ? Why should a chemical equation be balanced ?

(B). Find the valencies of the underlined elements or radicals in the following compounds.

$\underline{Ba}Cl_2$, $\underline{P}Cl_3$, $\underline{P}Cl_5$, $\underline{N}H_3$, $Mg\underline{SO_4}$, $Ca\underline{CO_3}$, $\underline{Na_2}O$, $\underline{Ca}O$, $\underline{Ca}(OH)_2$, $\underline{Fe}SO_4$, $\underline{Fe}Cl_3$, $\underline{Fe_2}O_3$, $Na\underline{OH}$, $\underline{Al}(OH)_3$, $\underline{Na_2}CO_3$

(C). Answer the following in not more than 100 words.

Q.1 What are compound radicals ? Give examples of a few radicals, along with their valencies. Also mention some compounds containing compound radicals. Give the valencies of the parts that make up the compound.

D. Complete the following.

1. A…… is an abbreviation of the name of **an element.**

2. A molecule of an element or a compound is represented by its…….

3. The valencies of the two elements of a binary compound are…… to obtain its formula.

4. Atoms are neither lost nor……in a chemical reaction.

EXERCISE # 2

(A). Choose the correct option.

Q.1 Which of the following is the symbol of gold ?

(a) Gd (b) Ag

(c) Au (d) Pb

Q.2 Which of the following is a divalent radical ?

(a) Hydroxide (b) Nitrate

(c) Sulphate (d) Phosphate

Q.3 The valency of sulphur in sulphur dioxide is

(a) 1 (b) 2

(c) 3 (d) 4

Q.4 How many times greater is the valency of N in NH_3 than that of Cl in HCl ?

(a) 2 (b) 3

(c) 4 (d) 5

(B). Match columns A and B.

A	B
(a) Helium	(i) Hg
(b) Mercury	(ii) He
(c) Copper	(iii) Pb
(d) Calcium	(iv) P
(e) Phosphorus	(v) Cu
(f) Lead	(vi) Ca

(C). True or False ?

1. The valency of hydrogen is 1.

2. The valency of oxygen is 2.

3. The symbol of iron is I.

4. The symbol of silver is Ag.

5. The valency of calcium is 2 and that of chlorine is 1. So, calcium chloride is Ca_2Cl.

6. The valency of both zinc and oxygen is 2. So, zinc oxide is ZnO.

(D). Write the formula of each of the following compounds.

Water	**Calcium oxide**	**Carbon dioxide**	**Carbon monoxide**	**Magnesium oxide**
Hydrogen chloride	Sodium chloride	Potassium chloride	Magnesium chloride	Zinc chloride
Nitric acid	Sodium nitrate	Sodium carbonate	Potassium carbonate	Calcium carbonate