1

The Language of Chemistry

SYLLABUS

The language of Chemistry:

i. Symbol of an element; valency; formulae of radicals and formulae of compounds. Balancing of simple chemical equations.

- Symbol – definition; symbols of elements used often.
- Valency – definition; hydrogen combination and number of valence electrons of the metals and non-metals; mono, di, tri and tetravalent elements.
- Radicals – definition; formulae and valencies.
- Compounds – name and formulae.
- Chemical equation – definition and examples of chemical equations with one reactant and two or three products, two reactants and one product, two reactants and two products and two reactants and three or four products; balancing of equations (by hit and trial method).

ii. Relative Atomic Masses (atomic weights) and Relative Molecular Masses (molecular weight): either standard H atom or $\frac{1}{12}$th of carbon 12 atom.

- Definitions
- Calculation of Relative Molecular Mass and percentage composition of a compound.

Chemistry has its own language, which consists of rules and conventions to help organise the representation of substances. In class 8, we have studied about different substances—elements, compounds and mixtures. 118 elements have so far been discovered and endless numbers of compounds have been formed by the combination of such elements. To represent these elements and compounds and their reactions in short form, scientists have established certain ways and these ways are through symbols, formulae, chemical equations—the language of chemistry.

Symbols

A symbol is the short form with one or two letters that represents one atom of a specific element.

In 1814, scientist Berzelius suggested the method of representing an element with the initial letter of the element written in capital which depicted the symbol of that element. According to his method, **oxygen is represented by the symbol O, carbon as C, hydrogen as H**.

There are several elements which have the same initial letter—**C**arbon, **C**hlorine, **C**opper, **C**alcium, **C**hromium, **C**obalt, etc.

All these elements have the same initial letter 'C'.

For these elements, the second letter or subsequent letter, written in small is added to the initial letter written in capital. Only the element **Carbon** is represented by **C**. **Calcium** is denoted by **Ca, Chromium** by **Cr, Chlorine** by **Cl, Cobalt** by **Co** and **Copper** by **Cu**.

For copper, **Cu** is taken from its Latin name ***Cuprum***.

A list of some common elements and their symbols is given below.

Table 1.1 Symbols of some common elements

Element	Symbol	Element	Symbol
Aluminium	Al	Lithium	Li
Argon	Ar	Magnesium	Mg
Barium	Ba	Manganese	Mn
Boron	B	Molybdenum	Mo
Bromine	Br	Neon	Ne
Calcium	Ca	Nickel	Ni
Carbon	C	Nitrogen	N
Chlorine	Cl	Oxygen	O
Chromium	Cr	Platinum	Pt
Fluorine	F	Phosphorus	P
Helium	He	Silicon	Si
Hydrogen	H	Sulphur	S
Iodine	I	Zinc	Zn

Like copper, the symbols of some other elements are based on their Latin names. The Latin names and the symbols of these elements are given in Table 1.2.

Table 1.2 Symbols of some elements based on their Latin names

Element	Latin name	Symbol
Copper	*Cuprum*	Cu
Gold	*Aurum*	Au
Iron	*Ferrum*	Fe
Lead	*Plumbum*	Pb
Mercury	*Hydrargyrum*	Hg
Potassium	*Kalium*	K
Silver	*Argentum*	Ag
Sodium	*Natrium*	Na
Tin	*Stannum*	Sn

Significance:

A symbol has both qualitative and quantitative significance.

i. Symbol represents one atom of the element. Thus 'H' represents 1 atom of hydrogen. Similarly 2H and 3H represent 2 atoms and 3 atoms of hydrogen respectively.

ii. It also denotes the quantity of the element equal in mass to its atomic mass expressed in grams. For example, 'K' represents one atom of the element potassium and also 39 g of potassium since atomic mass of potassium is 39. Similarly 2C denotes two carbon atoms and 24 g of carbon by mass (atomic mass of carbon is 12).

iii. It denotes one gram atom of an element.

Valency

Valency of an element is the combining power of its atom when it combines with other atoms to form a compound or a molecule.

The number of hydrogen atoms that can combine with (or can displace) one atom of the element is called the valency of the element.

For example, one atom of oxygen can combine with two atoms of hydrogen to form one molecule of H_2O so, valency of oxygen is 2. One atom of nitrogen can combine with three atoms of hydrogen to form a molecule of ammonia (NH_3) as depicted in Figure 1.1. Therefore, valency of nitrogen is 3. One atom of carbon can combine with four atoms of hydrogen to form one molecule of CH_4 therefore, valency of carbon is 4.

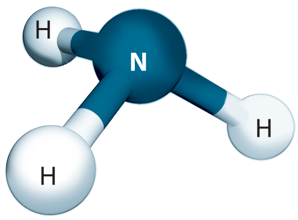

Fig. 1.1 Molecule of ammonia

An element is known as monovalent, if the valency of the element is one, divalent if the valency is two, trivalent if the valency is three and so on. Examples of monovalent, divalent, trivalent and tetravalent elements are given in Table 1.3.

Table 1.3 Valency of some common elements

Element	Type	Valency
Sodium	Monovalent	1
Potassium	Monovalent	1
Calcium	Divalent	2
Magnesium	Divalent	2
Zinc	Divalent	2
Aluminium	Trivalent	3
Hydrogen	Monovalent	1
Chlorine	Monovalent	1
Bromine	Monovalent	1
Iodine	Monovalent	1
Oxygen	Divalent	2
Nitrogen	Trivalent	3
Carbon	Tetravalent	4

Electronic Concept of Valency

Valency of an element is also defined as the number of electrons gained or lost or shared by an atom of the element.

Metals have 1, 2 or 3 electrons (valence electrons) in their last shell. Hence, they lose these electrons to have eight electrons in their last shell. **The number of electrons lost by an atom of the metal is the valency of that metal.**

For example, sodium has the electronic configuration of 2, 8, 1, i.e., it has 1 electron in its last shell, so sodium atom can lose 1 electron to have 8 electrons in the last shell. Therefore, sodium has a valency of 1. Calcium has the electronic configuration of 2, 8, 8, 2, i.e., it has 2 electrons in its last shell which it can lose to have 8 electrons in the last shell. Therefore, calcium has a valency of 2.

Non-metals usually have 4 to 7 electrons in their last shell. Hence, they gain electrons to have eight electrons in their last shell when they combine with metals or share electrons when they combine with non-metals. [Hydrogen, which is a non-metal and has only one electron in its valence shell, is an exception. It can lose as well as gain electron.] **The number of electrons gained or shared by an atom of the non-metal is the valency of the non-metal.**

For example, chlorine has the electronic configuration of 2, 8,7, i.e., 7 electrons in the last shell. So, an atom of chlorine can gain or share 1 electron to have 8 electrons in the last shell. Therefore, the valency of chlorine is 1. [Electronic concept of valency is discussed in detail in the chapter of atomic structure.]

Variable Valency

Certain elements have variable valency, i.e., the elements exhibit more than one valency. For metals having variable valency, the suffix 'ous' is used with the name to indicate lower valency and the suffix 'ic' is used to indicate higher valency. For example, iron has valency of 2 and 3. The lower valency of iron is named as ferrous and the higher valency as ferric (Latin name of iron is *ferrum*).

Therefore, $FeCl_2$, where iron exhibits valency of two is named as ferrous chloride, whereas, $FeCl_3$, where iron exhibits valency of three is named as ferric chloride. But according to the modern way of naming the compounds of metals with variable valency, instead of suffix 'ous' and 'ic' Roman numbers are used. For example, $FeCl_2$ is named as iron (II) chloride and $FeCl_3$ as iron (III) chloride.

The elements having variable valencies are given in Table 1.4.

Table 1.4 Variable valencies of some elements

Element	Variable valencies	Element	Variable valencies
Copper	1, 2	Silver	1, 2
Iron	2, 3	Carbon	2, 4
Lead	2, 4	Phosphorus	3, 5
Manganese	2, 4	Sulphur	2, 4, 6
Mercury	1, 2		

Radicals

A radical is an atom or a group of atoms of different elements that participates in a reaction as a single unit and has a positive or negative charge.

Cl^-	$(SO_4)^{2-}$	$(NH_4)^+$
Chloride radical	Sulphate radical	Ammonium radical

Positive radicals go to cathode during electrolysis, and are known as **cations**. These radicals are obtained from bases. Therefore, they are also called **basic radicals**.

Negative radicals go to anode during electrolysis, and are known as **anions**. These radicals are obtained from acids. Therefore, they are called **acid radicals**.

Metals and hydrogen form positive radicals and all non-metals form negative radicals. (Hydrogen can also form negative radical—Hydride, H^-.) The name of positive radical is same as the element. For example, sodium radical, calcium radical, magnesium radical, etc.

The name of the negative radicals of the non-metals (single atom) has the suffix of 'ide'. For example, radical of oxygen is called oxide, radical of chlorine is chloride, radical of sulphur is sulphide, etc.

Radicals of group of atoms are usually negatively charged, but only ammonium radical is positively charged (NH_4^+).

The number of positive or negative charges of a radical depends upon the valency of the radical. For example, sodium radical has one positive charge, i.e., Na^+ while oxide radical has two negative charges, i.e., O^{2-}.

Na^+ Sodium radical — Sodium radical has the formula of Na^+. Sodium is a metal with valency one, therefore, the radical of sodium is positive and the number of positive charges is one.

O^{2-} Oxide radical — Oxide radical has the formula of O^{2-}. Oxygen is a non-metal with valency two, therefore, the radical of oxygen is negative and the number of negative charges is two.

In Table 1.5, the valency and the formula of some important radicals are given.

Table 1.5 List of some common positive and negative radicals and their valencies

Radical	Valency	Formula	Radical	Valency	Formula
Hydrogen	1	H^+	Bromide	1	Br^-
Potassium	1	K^+	Chloride	1	Cl^-
Sodium	1	Na^+	Iodide	1	I^-
Ammonium	1	NH_4^+			
			Bicarbonate	1	HCO_3^-
Calcium	2	Ca^{2+}	Hydroxide	1	OH^-
Magnesium	2	Mg^{2+}	Nitrate	1	NO_3^-
Zinc	2	Zn^{2+}	Nitrite	1	NO_2^-
Ferrous [Iron (II)]	2	Fe^{2+}			
Lead (II)	2	Pb^{2+}	Oxide	2	O^{2-}
Cupric [Copper (II)]	2	Cu^{2+}	Sulphide	2	S^{2-}
			Carbonate	2	CO_3^{2-}
Aluminium	3	Al^{3+}	Sulphate	2	SO_4^{2-}
Ferric [Iron (III)]	3	Fe^{3+}	Sulphite	2	SO_3^{2-}
Lead (IV)	4	Pb^{4+}			
			Nitride	3	N^{3-}
			Phosphate	3	PO_4^{3-}

Other than the radicals mentioned in Table 1.5 many more radicals are there.

Few more important radicals are—Aluminate (AlO_2^-), Zincate (ZnO_2^{2-}), Plumbite (PbO_2^{2-}), Permanganate (MnO_4^-), Dichromate ($Cr_2O_7^{2-}$), Chromate (CrO_4^{2-}), Hydrogen sulphate (HSO_4^-), Chlorate (ClO_3^-), etc.

Formula of Compounds

The short representation of one molecule of an element or compound is known as formula.

Significance:

i. A formula represents the name of the element, radical or compound.

ii. It represents one molecule of the substance (element or compound) and indicates the number of atoms of constituent elements in the molecule. For example, the formula NH_3 represents one molecule of the compound ammonia and it also indicates that one molecule of ammonia has one atom of nitrogen and three atoms of hydrogen.

iii. Quantitatively, it expresses the amount of substance having mass equal to molecular mass of the substance expressed in grams. For example, NaOH expresses 40 g of sodium hydroxide, since, relative molecular mass of NaOH is 23 + 16 + 1 = 40.

iv. It represents the relative masses of the elements present in the molecular mass of the compound. For example, the formula of nitric acid is HNO_3 which denotes that in nitric acid one part by mass of hydrogen, 14 parts by mass of nitrogen and 48 parts by mass of oxygen are present per 63 parts by mass of nitric acid.

Writing Formula of Compounds

Formula of chemical compounds are written with the knowledge of valency of the constituent atoms or radicals. **The valencies of the constituent atoms or radicals are exchanged and written along with the atoms or radicals on the right little below. This method is called criss-cross method.**

For example, **let a compound consist of two elements A and B with valencies x and y respectively. The formula of the compound will be AyBx**. Thus, the formula is written by writing the valency of B on the right of A and little below and the valency of A is written with B on the right and little below.

The same rule is applied when two radicals combine together. In this case, **the formula begins with the positive radical**. No positive or negative charge is written in the formula. For example, when sodium radical Na^+ combines with negative chloride radical Cl^-, the formula of sodium chloride will be written as NaCl.

If the valency of the combining atoms or radicals is 1, no number is written on the right. For example, in sodium chloride both sodium and chloride radicals have the valency of one. So, no number is written in the formula NaCl.

If the valencies of the combining atoms or radicals have common factors, then the valencies are divided by the highest common factor and then interchanged. For example, carbon has the valency of 4 and oxygen 2. The valencies are divided by the common factor 2 and then interchanged and written with carbon and oxygen. Thus, the formula of carbon dioxide is CO_2.

If the combining radical is a group of atom, it is enclosed in a bracket and the valency of the other radical is written on the lower right of the bracket. No bracket is required when no number is to be written on the lower right. For example, to write the formula of ammonium sulphate the following steps are followed.

i. Positive radical is written first in bracket.

ii. Negative radical is written next.

(NH_4) (SO_4)

1 ✕ 2

NH_4^+ Valency = 1

SO_4^{2-} Valency = 2

Valencies are interchanged. NH_4 is enclosed in the bracket and 2 (valency of sulphate) is written on the lower right of the bracket. **Thus, the formula of ammonium sulphate is $(NH_4)_2SO_4$.**

Writing the formula of compounds are illustrated in Table 1.6.

Table 1.6 Formulae of some compounds shown by criss-cross method

Compound	Valency of combining atoms or radicals	Formula
Calcium chloride	Ca Cl 2 1	$CaCl_2$
Aluminium oxide	Al O 3 2	Al_2O_3
Calcium sulphide	Ca S 1 $\cancel{2}$ $\cancel{2}$ 1	CaS
Magnesium nitride	Mg N 2 3	Mg_3N_2
Iron (III) hydroxide	Fe (OH) 3 1	$Fe(OH)_3$
Cupric sulphate	Cu SO_4 1 $\cancel{2}$ $\cancel{2}$ 1	$CuSO_4$
Sulphur dioxide	S O 2 $\cancel{4}$ $\cancel{2}$ 1	SO_2
Potassium nitrate	K (NO_3) 1 1	KNO_3
Lead nitrate	Pb (NO_3) 2 1	$Pb(NO_3)_2$
Aluminium sulphate	Al (SO_4) 3 2	$Al_2(SO_4)_3$

Valency of atoms or radicals from given formula:

Since the formula of a chemical compound depends upon the valency of the combining atoms or radicals, the valency of atoms or radicals can be evaluated from a given formula. For example, in SO_3, the total valency of 3 atoms of oxygen is 3 × 2 = 6, therefore, the valency of sulphur is 6.

In $KMnO_4$, permanganate radical combines with one monovalent potassium, so permanganate radical has the valency of 1.

In $KMnO_4$, the valency of manganese is 7. The valency of potassium (one) is subtracted from the total valency of four oxygen atoms (eight) to get the valency of manganese.

In H_2SO_4, the valency of sulphur is: Total valency of four oxygen atoms – total valency of two hydrogen atoms, i.e., 8 – 2 = 6.

Some important formulae are given in Table 1.7.

Table 1.7 Formulae of chlorides, oxides, hydroxides, nitrates, carbonates and sulphates of some elements

Positive radical	Formula of					
	Chloride	Oxide	Hydroxide	Nitrate	Carbonate	Sulphate
Potassium	KCl	K_2O	KOH	KNO_3	K_2CO_3	K_2SO_4
Sodium	NaCl	Na_2O	NaOH	$NaNO_3$	Na_2CO_3	Na_2SO_4
Calcium	$CaCl_2$	CaO	$Ca(OH)_2$	$Ca(NO_3)_2$	$CaCO_3$	$CaSO_4$
Magnesium	$MgCl_2$	MgO	$Mg(OH)_2$	$Mg(NO_3)_2$	$MgCO_3$	$MgSO_4$
Aluminium	$AlCl_3$	Al_2O_3	$Al(OH)_3$	$Al(NO_3)_3$	$Al_2(CO_3)_3$	$Al_2(SO_4)_3$
Zinc	$ZnCl_2$	ZnO	$Zn(OH)_2$	$Zn(NO_3)_2$	$ZnCO_3$	$ZnSO_4$
Iron (II)	$FeCl_2$	FeO	$Fe(OH)_2$	$Fe(NO_3)_2$	$FeCO_3$	$FeSO_4$
Iron (III)	$FeCl_3$	Fe_2O_3	$Fe(OH)_3$	$Fe(NO_3)_3$	$Fe_2(CO_3)_3$	$Fe_2(SO_4)_3$
Lead	$PbCl_2$	PbO	$Pb(OH)_2$	$Pb(NO_3)_2$	$PbCO_3$	$PbSO_4$
Copper (II)	$CuCl_2$	CuO	$Cu(OH)_2$	$Cu(NO_3)_2$	$CuCO_3$	$CuSO_4$
Silver	AgCl	Ag_2O	AgOH	$AgNO_3$	Ag_2CO_3	Ag_2SO_4
Ammonium	NH_4Cl	—	NH_4OH	NH_4NO_3	$(NH_4)_2CO_3$	$(NH_4)_2SO_4$

More formulae are given in Table 1.8.

Table 1.8 Some more important formulae

Name of the compound	Formula
Hydrochloric acid	HCl
Sulphuric acid	H_2SO_4
Nitric acid	HNO_3
Carbonic acid	H_2CO_3
Sulphurous acid	H_2SO_3
Phosphoric acid	H_3PO_4
Manganese dioxide	MnO_2
Manganese chloride	$MnCl_2$
Trilead tetraoxide	Pb_3O_4
Sodium bicarbonate	$NaHCO_3$
Sodium bisulphate	$NaHSO_4$
Sodium sulphite	Na_2SO_3
Sodium nitrite	$NaNO_2$
Sodium aluminate	$NaAlO_2$
Sodium argentocyanide	$Na[Ag(CN)_2]$
Potassium chlorate	$KClO_3$
Potassium bicarbonate	$KHCO_3$
Potassium bisulphate	$KHSO_4$
Potassium nitrite	KNO_2
Potassium sulphite	K_2SO_3
Potassium permanganate	$KMnO_4$
Potassium dichromate	$K_2Cr_2O_7$
Ammonium dichromate	$(NH_4)_2Cr_2O_7$
Sodium thiosulphate	$Na_2S_2O_3$
Sodium plumbite	Na_2PbO_2
Sodium zincate	Na_2ZnO_2
Calcium bicarbonate	$Ca(HCO_3)_2$
Magnesium bicarbonate	$Mg(HCO_3)_2$
Barium chloride	$BaCl_2$
Barium sulphate	$BaSO_4$

Few chemical compounds are shown in Figure 1.2.

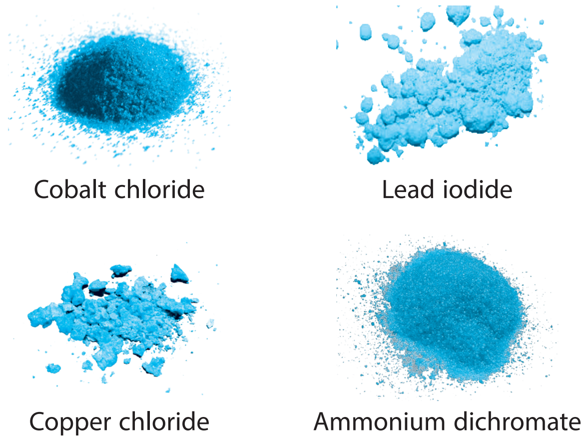

Fig. 1.2 Some chemicals used in the laboratory

Chemical Equations

A chemical reaction results either by decomposition of compounds or by union of atoms or molecules leading to new products whose properties are different from those of the reacting substances. The reacting substances undergoing chemical change are known as **reactants** and the new substances that are formed are known as **products**. A chemical equation is the representation of a chemical reaction with the aid of symbols and formulae of reactants and products.

Significance:

i. A chemical equation tells us the name of the reactants which undergo chemical change and the products which are formed during the chemical change.

ii. It gives the number of atoms and molecules of reactants and products.

iii. A chemical equation also signifies the masses of the reactants and products.

iv. If the reactants and products are gases, a chemical equation signifies the volume of the reactants and products.

For example,

$$2H_2 + O_2 \longrightarrow 2H_2O$$

This chemical equation gives the following information:

i. Hydrogen reacts with oxygen to form the product steam or water.

ii. Two molecules of hydrogen combine with one molecule of oxygen to form two molecules of steam.
iii. 2 × 2 parts by mass of hydrogen combine with 32 parts by mass of oxygen to form 2 × 18 parts by mass of steam. (Relative molecular mass of hydrogen, oxygen and steam are 2, 32 and 18 respectively.)
iv. Two volumes of hydrogen combine with one volume of oxygen to form 2 volumes of steam.

Writing of chemical equation

A chemical equation is written in the form of: **REACTANTS ⟶ PRODUCTS**, i.e., all the formulae of the reactants are written on the left hand side of the equation and the formulae of the products on the right hand side.

The number of individual atoms on the reactant side must be equal to the number of atoms on the product side, i.e., an equation must be balanced. According to 'Law of Conservation of Mass' in a chemical reaction, total mass of the reactants is equal to the total mass of the products formed. An unbalanced equation cannot represent this law correctly.

Chemical reactions may involve:

i. **One reactant and two or more products, i.e., the reactant can decompose to form two or more products.**

For example,

$$2KClO_3 \longrightarrow 2KCl + 3O_2$$
$$2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$$

ii. **Two reactants and one product, i.e., the reactants can combine to form one product.**

For example,

$$2Mg + O_2 \longrightarrow 2MgO$$
$$NH_3 + HCl \longrightarrow NH_4Cl$$

iii. **Two reactants and two products**

For example,

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$
$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2NaCl$$

iv. **Two reactants and three or more products**

For example,

$$MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$$
$$K_2Cr_2O_7 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2$$

Balancing of Chemical Equations

All chemical equations should be balanced. Two methods are discussed here for balancing of equations.

1. Hit and Trial Method

This method involves counting of the total number of atoms of individual elements on both sides of the equation and then balancing the atoms on both sides. This is done by increasing the number of molecules of the reactants and products so that the number of atoms of each element on both sides of the equation becomes same. For example,

i. $$\underset{\substack{\text{Hydrogen atom: 1}\\ \text{Chlorine atom: 1}}}{Al + HCl} \longrightarrow \underset{\substack{\text{Chlorine}\\ \text{atom: 3}}}{AlCl_3} + \underset{\substack{\text{Hydrogen}\\ \text{atom: 2}}}{H_2}$$

This is an unbalanced equation.

1 hydrogen atom and 1 chlorine atom is in the molecule of HCl on the L.H.S. whereas, 2 hydrogen atoms and 3 chlorine atoms are on the R.H.S. Hence, the number of HCl molecules can be increased to 6 and the number of hydrogen and chlorine atoms can also be made 6 on the R.H.S. to balance the equation.

$$Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$$

Finally the number of Al can be made equal on both sides.

$$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$$

This is the balanced equation for the reaction of aluminium with hydrochloric acid.

ii. $$\underset{\substack{\text{Sulphur atom: 2}\\ \text{Oxygen atom: 2}}}{H_2S + SO_2} \longrightarrow \underset{\substack{\text{Sulphur atom: 1}\\ \text{Oxygen atom: 1}}}{S + H_2O}$$

This is an unbalanced equation.

There are 2 atoms of hydrogen on the L.H.S. and 2 on the R.H.S., i.e., hydrogen atoms are balanced. But 2 atoms of oxygen are present in SO_2 and 1 in H_2O. Hence, the number of H_2O molecules should be increased to 2 to make the number of oxygen atoms equal on both sides.

$$H_2S + SO_2 \longrightarrow S + 2H_2O$$

This makes the number of hydrogen atoms 4 on the R.H.S. Hence, the number of H_2S is increased to make the number of hydrogen atoms 4 on the L.H.S.

$$2H_2S + SO_2 \longrightarrow S + 2H_2O$$

Finally the number of S atoms is made equal on both sides.

$$2H_2S + SO_2 \longrightarrow 3S + 2H_2O$$

This is the balanced equation for the reaction of hydrogen sulphide with sulphur dioxide.

iii. $Pb(NO_3)_2 \longrightarrow PbO + NO_2 + O_2$

Oxygen atom: 6 Oxygen atom: 5
Nitrogen atom: 2 Nitrogen atom: 1

This is an unbalanced equation.

In this equation, the number of oxygen atoms on the L.H.S. is an even number whereas, the total number of oxygen atoms on the R.H.S. is 1 + 2 + 2 = 5, which is an odd number. Hence, the number of PbO molecules is made two to make the number of oxygen atoms even.

$$Pb(NO_3)_2 \longrightarrow 2PbO + NO_2 + O_2$$

With the increase in the number of PbO molecules, the number of lead atoms on the R.H.S. becomes 2. Therefore, the number of lead nitrate is made 2 to make the number of lead atoms 2 on the L.H.S.

$$2Pb(NO_3)_2 \longrightarrow 2PbO + NO_2 + O_2$$

The number of nitrogen atoms is made equal on both sides by increasing the number of molecules of NO_2 to 4.

$$2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$$

This is the balanced equation for the decomposition of lead nitrate.

2. Partial Equation Method

Partial equation method is used to balance equations for the reactions which are assumed to take place in different steps. Balanced equations are written for every step which are said to be partial equations. The final balanced equation is obtained by adding the partial equations.

For example,

i. Reaction of carbon and concentrated sulphuric acid to form carbon dioxide, sulphur dioxide and water:

$$C + H_2SO_4 \longrightarrow CO_2 + SO_2 + H_2O$$

Step 1: Concentrated sulphuric acid decomposes to produce nascent oxygen [O].

$$H_2SO_4 \longrightarrow H_2O + SO_2 + [O] \quad \ldots(i)$$

Step 2: $C + O \longrightarrow CO_2$ Nascent oxygen oxidises carbon to produce carbon dioxide. By the hit and trial method the equation is balanced.

$$C + 2[O] \longrightarrow CO_2 \quad \ldots(ii)$$

Since two nascent oxygen atoms are required to form carbon dioxide, equations (i) is multiplied by 2 and added to equation (ii) to get the final balanced equation.

$$\begin{array}{l} 2H_2SO_4 \longrightarrow 2H_2O + 2SO_2 + 2[O] \\ C + 2[O] \longrightarrow CO_2 \\ \hline C + 2H_2SO_4 \longrightarrow CO_2 + 2H_2O + 2SO_2 \end{array}$$

This is the balanced chemical equation for the reaction of carbon with concentrated sulphuric acid.

ii. Reaction of sulphur and concentrated nitric acid:

$$S + HNO_3 \longrightarrow H_2SO_4 + NO_2 + H_2O$$

Step 1: $HNO_3 \longrightarrow H_2O + NO_2 + [O]$

Concentrated nitric acid decomposes to produce nascent oxygen. The equation is balanced by hit and trial method.

$$2HNO_3 \longrightarrow H_2O + 2NO_2 + [O] \quad \ldots(i)$$

Step 2: Nascent oxygen oxidises sulphur to sulphur trioxide.

$$S + 3[O] \longrightarrow SO_3 \quad \ldots(ii)$$

Step 3: Finally sulphur trioxide combines with water to produce sulphuric acid.

$$SO_3 + H_2O \longrightarrow H_2SO_4 \quad \ldots(iii)$$

Equation (i) is multiplied by 3 to get 3 nascent oxygen which are required by sulphur and then all three equations are added to get the final balanced equation.

$$\begin{array}{l} 6HNO_3 \longrightarrow 3H_2O + 6NO_2 + 3[O] \\ S + 3[O] \longrightarrow SO_3 \\ SO_3 + H_2O \longrightarrow H_2SO_4 \\ \hline S + 6HNO_3 \longrightarrow H_2SO_4 + 6NO_2 + 2H_2O \end{array}$$

This is the balanced equation for the oxidation of sulphur with concentrated nitric acid.

iii. Oxidation of hydrogen chloride by acidified potassium dichromate:

$K_2Cr_2O_7 + HCl \longrightarrow KCl + CrCl_3 + Cl_2 + H_2O$

Step 1: Acidified potassium dichromate produces nascent oxygen.

$$K_2Cr_2O_7 \longrightarrow K_2O + Cr_2O_3 + [O]$$

The equation is balanced by hit and trial method.

$$K_2Cr_2O_7 \longrightarrow K_2O + Cr_2O_3 + 3[O] \qquad \ldots(i)$$

Step 2: Nascent oxygen oxidises hydrogen chloride to chlorine.

$$HCl + [O] \longrightarrow H_2O + Cl_2$$

The balanced equation is:

$$2HCl + [O] \longrightarrow H_2O + Cl_2 \qquad \ldots(ii)$$

Equation (ii) is multiplied by 3, since 3 nascent oxygen atoms are given out in equation (i).

$$6HCl + 3[O] \longrightarrow 3H_2O + 3Cl_2 \qquad \ldots(iii)$$

K_2O and Cr_2O_3 being basic oxides combines with hydrogen chloride to form salts.

$$K_2O + 2HCl \longrightarrow 2KCl + H_2O \qquad \ldots(iv)$$

$$Cr_2O_3 + 6HCl \longrightarrow 2CrCl_3 + 3H_2O \qquad \ldots(v)$$

Equations (i), (iii), (iv) and (v) are added to get the final equation.

$$\begin{array}{r} K_2Cr_2O_7 \longrightarrow K_2O + Cr_2O_3 + 3[O] \\ 6HCl + 3[O] \longrightarrow 3H_2O + 3Cl_2 \\ K_2O + 2HCl \longrightarrow 2KCl + H_2O \\ Cr_2O_3 + 6HCl \longrightarrow 2CrCl_3 + 3H_2O \\ \hline K_2Cr_2O_7 + 14HCl \longrightarrow 2KCl + 2CrCl_3 + 7H_2O + 3Cl_2 \end{array}$$

This is the balanced equation for the oxidation of hydrogen chloride with acidified potassium dichromate solution.

KNOW MORE

To denote physical states of reactants and products in a chemical equation we put symbols like (s) for solid, (l) for liquid, (g) for gas and (aq) for chemicals which react in solution form.

Relative Atomic Masses (Atomic Weights) and Relative Molecular Masses (Molecular Weights)

Atoms and molecules are minute particles and their masses are so negligible that it is not possible to find out their actual mass with the help of a chemical balance. To overcome this difficulty, comparative values for the masses of atoms and molecules are used instead of their actual masses. Therefore, **the masses of atoms and molecules are expressed as their relative masses with reference to a standard atom—hydrogen or carbon 12 isotope**. Relative atomic masses or relative molecular masses are just numbers and have no unit.

Thus, **the relative atomic mass (weight) of an element is the number which indicates how many times an atom of the element is heavier than one hydrogen atom or $\frac{1}{12}$th of a carbon atom (^{12}C isotope)**.

$$\text{RAM} = \frac{\text{Mass of one atom of an element}}{\frac{1}{12}\text{th the mass of one atom of C-12}}$$

The relative atomic mass of sodium is 23, which means that 1 sodium atom is 23 times heavier than 1 hydrogen atom or 23 times heavier than $\frac{1}{12}$th of a carbon atom.

[Atomic mass is expressed in atomic mass units (amu). 1 amu $=1.661 \times 10^{-24}$ g.]

The relative molecular mass (weight) of an element or compound is the number which indicates how many times one molecule of the element or compound is heavier than one hydrogen atom or one carbon atom (^{12}C isotope).

$$\text{RMM} = \frac{\text{Mass of one molecule of a substance}}{\frac{1}{12}\text{th the mass of one atom of C-12}}$$

The relative molecular mass of carbon dioxide is 44, which means that 1 carbon dioxide molecule is 44 times heavier than 1 hydrogen atom or 44 times heavier than $\frac{1}{12}$th of a carbon atom.

Calculation of Relative Molecular Mass and Percentage Composition of a Compound

The relative molecular mass of a compound is calculated by adding the relative atomic masses of all the atoms present in the compound.

Example:

1. Relative molecular mass (RMM) of ammonia: [N = 14; H = 1]

   RMM of ammonia (NH_3)
   $= \text{mass of 1 N atom} + \text{mass of 3 H atoms}$
   $= 14 + 3 \times 1 = 17$

2. Relative molecular mass (RMM) of ammonium nitrate: [N = 14; H = 1; O = 16]

   RMM of ammonium nitrate (NH_4NO_3)
   = mass of 2 N atoms + mass of 4 H atoms + mass of 3 O atoms
   $= 2 \times 14 + 4 \times 1 + 3 \times 16 = 80$

   Therefore, relative molecular mass of ammonium nitrate is 80.

3. Relative molecular mass (RMM) of calcium nitrate [$Ca(NO_3)_2$]: [Ca = 40; N = 14; O = 16]

   RMM of calcium nitrate [$Ca(NO_3)_2$]
   = mass of 1 Ca atom + mass of 2 N atoms + mass of 6 O atoms
   $= 40 + 2 \times 14 + 6 \times 16 = 164$

   Therefore, relative molecular mass of calcium nitrate [$Ca(NO_3)_2$] is 164.

Percentage composition of a compound is the percentage by mass of each element present in the compound.

Percentage composition of an element in a compound

$$= \frac{\text{Total mass of the element in one molecule of the compound}}{\text{Relative molecular mass of the compound}} \times 100$$

Numericals:

1. Find the percentage composition of ammonium nitrate (NH_4NO_3).

RMM of ammonium nitrate (NH_4NO_3) = 80

$$\text{Percentage of nitrogen} = \frac{2 \times 14 \times 100}{80} = 35\%$$

$$\text{Percentage of hydrogen} = \frac{4 \times 1 \times 100}{80} = 5\%$$

$$\text{Percentage of oxygen} = \frac{3 \times 16 \times 100}{80} = 60\%$$

Therefore, the percentage composition of ammonium nitrate is 35% of nitrogen, 5% of hydrogen and 60% of oxygen.

2. Calculate the percentage composition of calcium nitrate.

RMM of calcium nitrate [$Ca(NO_3)_2$]
$= 40 + 2 \times 14 + 6 \times 16 = 164$

$$\text{Percentage of calcium} = \frac{40 \times 100}{164} = 24.39\%$$

$$\text{Percentage of nitrogen} = \frac{2 \times 14 \times 100}{164} = 17.07\%$$

$$\text{Percentage of oxygen} = \frac{6 \times 16 \times 100}{164} = 58.54\%$$

Therefore, the percentage composition of calcium nitrate is 24.39% of calcium, 17.07% of nitrogen and 58.54% of oxygen.

3. Calculate the percentage of water of crystallisation in blue vitriol [$CuSO_4.5H_2O$].
[Cu = 64, S = 32, O = 16, H = 1]

RMM of blue vitriol [$CuSO_4.5H_2O$]
$= 64 + 32 + 4 \times 16 + 5 \times 18 = 250;$
($\because H_2O = 18$)

Percentage of water of crystallisation

$$= \frac{\text{Total mass of water of crystallisation}}{\text{Gram molecular mass of } CuSO_4.5H_2O} \times 100$$

$$= \frac{5 \times 18}{250} \times 100 = 36\%$$

Therefore, the percentage of water of crystallisation in blue vitriol is 36%.

4. Calculate the percentage of oxygen in $Na_2CO_3 \cdot 10H_2O$.
[at. mass of Na = 23, C = 12]

RMM of $Na_2CO_3 \cdot 10H_2O$
$= 2 \times 23 + 12 + 3 \times 16 + 10 \times 18 = 286$
[$\because$ RMM of $H_2O = 18$]

Percentage of oxygen

$$= \frac{\text{Total mass of oxygen}}{\text{Gram molecular mass } Na_2CO_3 \cdot 10H_2O} \times 100$$

$$= \frac{3 \times 16 + 10 \times 16}{286} \times 100 = 72.72\%$$

Therefore, the percentage of oxygen in washing soda crystals is 72.72%.

RECAPITULATION

- A symbol is the short form with one or two letters that represents one atom of a specific element.
- Valency of an element is the number of hydrogen atoms that combine with one atom of the element. It is the number of electrons lost by an atom of a metal or the number of electrons gained or shared by an atom of a non-metal.
- Certain elements, like iron, copper, lead, etc., have variable valency.
- A radical is an atom or a group of atoms of different elements that behaves as a single unit and have a positive or negative charge. The number of charges of the radical depends upon the valency of the radical.
- Positive radicals are known as cations or basic radicals. Metals and hydrogen form positive radicals.
- Negative radicals are known as anions or acid radicals. Non-metals form negative radicals.
- The short representation of one molecule of an element or compound is known as formula.
- For writing the formula of a compound, the symbol of the constituent atoms or formula of the constituent radicals are written and their valencies are interchanged and written on their right little below.
- A chemical equation is the representation of a chemical reaction with the aid of symbols and formulae of reactants and products.
- A chemical equation should always be a balanced equation, i.e., the number of atoms of individual elements on both sides of the equation must be the same.
- Equations can be balanced by hit and trial method, i.e., counting the total number of atoms of individual elements on both sides and making them equal by increasing the number of molecules of the reactants and products.
- Equations can also be balanced by partial equation method where reactions are assumed to take place in different steps. Balanced equations are written for every step which are said to be partial equations. The final balanced equation is obtained by adding the partial equations.
- The relative atomic mass (weight) of an element is the number which indicates how many times an atom of the element is heavier than one hydrogen atom or one carbon atom (^{12}C isotope).
- The relative molecular mass (weight) of an element or compound is the number which indicates how many times one molecule of the element or compound is heavier than one hydrogen atom or one carbon atom (^{12}C isotope).
- The relative molecular mass of a compound is calculated by adding the relative atomic masses of all the atoms present in the compound.
- Percentage composition of a compound is the percentage by mass of each element present in the compound.
- Percentage composition of an element in a compound

$$= \frac{\text{Total mass of the element in one molecule of the compound}}{\text{Relative molecular mass of the compound}} \times 100$$

OBJECTIVE QUESTIONS

1 **Choose the correct answer from the options given below.**

a. The symbol of potassium is 'K' from its Latin name

i. *kalium* ii. *kottash* iii. *korolium* iv. *karium*

b. Valency of an element is

i. the number of electrons in the last shell of an atom of the element

ii. the number of electrons gained, lost or shared by an atom of the element

iii. the combining capacity of its atom with other atoms of elements

iv. both (ii) and (iii)

c. The correct formula of ammonium sulphate is

i. NH_4SO_4 ii. $(NH_4)_2SO_4$ iii. $NH_4(SO_4)_2$ iv. $(NH_4)_2(SO_4)_3$

d. In a balanced chemical equation

i. number of atoms on reactant and product side should be same

ii. number of molecules on reactant and product side should be same

iii. number of coefficients on reactant and product side should be same

iv. valency of elements on reactant and product side should be same

e. The percentage of water of crystallisation in blue vitriol is

i. 36% ii. 72% iii. 18% iv. 9%

f. Positive radicals are also known as

i. basic radicals ii. acidic radicals iii. amphoteric radicals iv. neutral radicals

g. Atomic masses are measured in comparison to the mass of

i. isotope of oxygen ii. isotope of carbon iii. isotope of chlorine iv. isotope of nitrogen

h. Which of the following does not have a variable valency?

i. Iron ii. Copper iii. Lead iv. Zinc

i. Element X has valency 2 and element Y has valency 3. What will be the formula of the compound formed by combination of X and Y?

i. X_2Y_3 ii. X_3Y_2 iii. X_2Y_2 iv. X_3Y_3

j. The valency of chromium in ammonium dichromate $[(NH_4)_2Cr_2O_7]$ is

i. 3 ii. 4 iii. 5 iv. 6

2 **Fill in the blanks.**

i. NH_3 represents one ______________ of ammonia.

ii. A molecule of alum, $K_2SO_4.Al_2(SO_4)_3 \cdot 24H_2O$, contains ______________ atoms of oxygen.

iii. In ferric chloride, iron exhibits a valency of ______________ .

iv. A chemical equation needs to be balanced to satisfy the Law of ______________ .

v. Latin name of silver is ______________ .

3 **Match the following.**

Column I	Column II
i. Symbol	a. the substances formed during a chemical reaction
ii. Radical	b. symbolic representation of a chemical compound
iii. Valence electrons	c. a group of charged atoms
iv. Chemical formula	d. are present in the last shell of an atom
v. Products	e. short hand representation of an atom of an element

ASSERTION—REASON QUESTIONS

In the following questions a statement of Assertion is followed by a statement of Reason. Mark the correct choice as:

i. If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
ii. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
iii. If Assertion is true but Reason is false.
iv. If Reason is true but Assertion is false.
v. If both Assertion and Reason are false.

1. **Assertion:** Valence electrons are also called valency of an atom.
   Reason: Valence electrons represent the number of electrons in the last shell of an atom.
2. **Assertion:** Number of atoms on both sides in a balanced chemical equation are equal.
   Reason: The total number of molecules also remain same in a balanced chemical equation.
3. **Assertion:** Relative atomic mass of an atom is just a number and has no units.
   Reason: It indicates how many times the atom is heavier than 1/12th of a carbon atom.
4. **Assertion:** Symbol represents one atom of the element.
   Reason: Symbols are derived from their Latin names also.
5. **Assertion:** Metals and hydrogen form positive radicals.
   Reason: These radicals are obtained from bases.

PASSAGE-BASED QUESTIONS

Read the following passages carefully and answer the questions.

1. A balanced chemical equation tells us about the substances in the form of symbols and formulae that take part in a reaction. The quantity and mass of the reactants and products involved can be easily calculated. It gives an idea about the physical state of the reactants and products also. However, it does not tell us whether the reaction has come to completion or not. A balanced chemical equation also does not give any idea about the speed of the reaction or any information about the external support in the form of temperature, pressure, etc., required to initiate or complete the reaction.

   Now answer the following:

   i. What information do we get from a balanced chemical reaction?
   ii. Write the balanced chemical reaction between nitrogen and hydrogen to produce ammonia.
   iii. Balanced chemical reactions cannot be written for reversible reactions. (True/False)

2. Atomic mass unit is a very small unit developed for measuring mass of the substances. It is defined as the number of times an atom is heavier as compared to the mass of $\frac{1}{12}$th of one atom of carbon C-12 isotope. It is used to calculate the atomic as well as molecular masses. However, it differs from gram atomic or gram molecular mass which corresponds to one mole quantity of the substance. For example, relative atomic mass of oxygen is 16 amu, whereas its gram atomic mass is 16 g.

   Now answer the following:

   i. What was the need to develop atomic mass unit?
   ii. Which isotope of carbon is used to calculate the relative atomic mass?
   iii. What is the difference between amu and gram atomic mass?

3 Valency of an atom is its combining capacity with another atom to form compounds. Some elements show variable valencies and hence are named accordingly. The valency of hydrogen and all other metals is considered as positive and similarly valency of all non-metals except hydrogen is considered as negative. For a molecule, total positive and negative valencies are same so, it is electrically neutral.

Now answer the following:

i. What is the difference between valency and valence electrons?

ii. Give two examples of metals with variable valencies and write their names.

iii. Write valencies of all the atoms in a molecule of sodium carbonate.

REVIEW QUESTIONS

1 Name the elements represented by the following symbols.

i. Au ii. Hg iii. K iv. Pt v. Na

vi. I vii. P viii. Si ix. Ar x. F

xi. Li xii. B xiii. Br xiv. Ag

2 What do the following symbols or formulae represent?

i. N, 2N, N_2 ii. 2H, H_2, $2H^+$, $2H^-$ iii. $2O_2$, 2O, $2O^{2-}$

3 The elements oxygen, nitrogen, chlorine have atomic masses 16, 14 and 35.5 respectively. What information is conveyed by the following symbols or formulae?

i. 2O and O_2 ii. Cl and Cl_2 iii. N and N_2

4 Define:

i. Valency ii. Product iii. Radical

iv. Cation v. Chemical equation

5 Give an example of:

i. A monovalent metal

ii. A monovalent gas

iii. A divalent gas

iv. A monovalent solid non-metal

v. A divalent metal

vi. A monovalent radical with positive charge

vii. A divalent anion

viii. A tetravalent element

ix. A trivalent non-metal

x. A monovalent acid radical

6 Certain elements have variable valency. State the variable valency of the following elements.

i. Iron ii. Carbon iii. Sulphur

iv. Phosphorus v. Copper vi. Lead

7 What is represented by the following formula?

i. Br_2 ii. $2Br^-$ iii. SO_3 iv. SO_3^{2-} v. NO_2

vi. NO_2^- vii. NH_3 viii. NH_4^+ ix. CO_3^- x. HCO_3^-

xi. $2Br_2$ xii. N^{3-} xiii. S^{2-} xiv. Fe_2O_3 xv. FeS

8 Write the formula of the following.

i. Sulphate radical ii. Nitrate radical iii. Ammonia

iv. Sodium aluminate v. Potassium permanganate vi. Hydrogen sulphide

vii. Sodium zincate viii. Potassium chlorate ix. Manganese dioxide

x. Calcium bicarbonate xi. Sodium bicarbonate xii. Lead nitrate

xiii. Ammonium dichromate xiv. Aluminium sulphate xv. Magnesium nitride

9 Name the following compounds.

i. Na_2PbO_2 ii. $NaHSO_4$ iii. AlN iv. ZnS v. $K_2Cr_2O_7$

vi. Cr_2O_3 vii. $Mg(HCO_3)_2$ viii. Fe_3O_4 ix. N_2O x. KNO_2

xi. CaC_2 xii. $KHSO_3$ xiii. $BaCl_2$ xiv. $BaSO_4$ xv. PbO

10 Find the valency of the element, the atom of which is underlined in the following formulae.

i. $H\underline{N}O_3$ ii. $\underline{C}O_2$ iii. $H_2\underline{S}_2O_3$ iv. $K_2\underline{Cr}_2O_7$ v. $K_2\underline{Mn}O_4$

vi. $\underline{Mn}O_2$ vii. $\underline{N}_2O$ viii. $\underline{N}O$ ix. $H_2\underline{S}O_3$ x. $Na_2\underline{Cr}O_4$

xi. $\underline{P}_2O_3$ xii. $\underline{P}_2O_5$ xiii. $K\underline{N}O_2$ xiv. $Na_2\underline{Pb}O_2$ xv. $\underline{Pb}O_2$

11 Write the formula of compounds where sulphur shows the valency of 2, 4 and 6.

12 Fill in the blanks with the correct word/formula from the bracket.

i. SO_3 is the formula of a __________. (radical/compound)

ii. Aluminate radical has the valency of __________. (one/two)

iii. Valency of a metal is the number of electrons __________ by the atom of the metal. (lost/gained)

iv. Positive radicals are known as __________. (anions/cations)

v. Valency of an element is the number of atoms of __________ (hydrogen/the element) that combines with one atom of __________. (hydrogen/the element)

vi. Formula of ammonia is __________. (NH_3/NH_4)

vii. Copper has the variable valency of __________. (two and three/one and two)

viii. The symbol for metal cobalt is __________. (CO/Co)

ix. Calcium is a __________ metal. (monovalent/divalent)

x. Radical is a __________. (compound/part of a compound)

13 Balance the following equations.

i. $KNO_3 \longrightarrow KNO_2 + O_2$

ii. $(NH_4)_2Cr_2O_7 \longrightarrow Cr_2O_3 + N_2 + H_2O$

iii. $KClO_3 \longrightarrow KCl + O_2$

iv. $Cu(NO_3)_2 \longrightarrow CuO + NO_2 + O_2$

v. $NaHCO_3 \longrightarrow Na_2CO_3 + CO_2 + H_2O$

vi. $Na + H_2O \longrightarrow NaOH + H_2$

vii. $Al + NaOH + H_2O \longrightarrow NaAlO_2 + H_2$

viii. $Mg_3N_2 + H_2O \longrightarrow Mg(OH)_2 + NH_3$

ix. $NH_3 + Cl_2 \longrightarrow NH_4Cl + N_2$

x. $NH_3 + O_2 \xrightarrow{\text{Pt, 800°C}} NO + H_2O$

xi. $NH_3 + O_2 \longrightarrow N_2 + H_2O$

xii. $N_2 + H_2 \longrightarrow NH_3$

xiii. $Cu + HNO_3(\text{conc.}) \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$

xiv. $Cu + HNO_3\ (\text{dilute}) \longrightarrow Cu(NO_3)_2 + NO + H_2O$

xv. $MnO_2 + HCl \longrightarrow MnCl_2 + Cl_2 + H_2$

xvi. $NH_3 + CuO \longrightarrow Cu + N_2 + H_2O$

xvii. $Fe + Cl_2 \longrightarrow FeCl_3$

xviii. $C + HNO_3 \longrightarrow CO_2 + NO_2 + H_2O$

xix. $FeCl_3 + NH_4OH \longrightarrow Fe(OH)_3 + NH_4Cl$

xx. $Al + O_2 \longrightarrow Al_2O_3$

14 Write balanced chemical equations for the following word equations.

i. Sodium carbonate + Hydrochloric acid ⟶ Sodium chloride + Carbon dioxide + Water

ii. Ammonium sulphate + Sodium hydroxide ⟶ Sodium sulphate + Ammonia + Water

iii. Aluminium nitride + Water ⟶ Aluminium hydroxide + Ammonia

iv. Zinc + Sodium hydroxide ⟶ Sodium zincate + Hydrogen

v. Calcium hydroxide + Carbon dioxide ⟶ Calcium carbonate + Water

vi. Chlorine + Potassium iodide ⟶ Potassium chloride + Iodine

vii. Barium chloride + Sulphuric acid $\longrightarrow$ Barium sulphate + Hydrochloric acid

viii. Ammonium chloride + Slaked lime $\longrightarrow$ Calcium chloride + Ammonia + Water

ix. Ammonia + Chlorine $\longrightarrow$ Nitrogen + Hydrogen chloride

x. Lead monoxide + Nitric acid $\longrightarrow$ Lead nitrate + Water

15 a. Calculate the relative molecular mass of each the following compounds and also calculate the percentage composition of the compounds.
[H = 1, C = 12, O = 16, Na = 23, Mg = 24, S = 32, Cl = 35.5, Ca = 40]

i. Calcium carbonate   ii. Magnesium chloride   iii. Sodium sulphate

iv. Ethanol (C_2H_5OH)   v. Ethane (C_2H_6)

b. Calcium phosphate has the formula $Ca_3(PO_4)_2$. Find: [Ca = 40, P = 31, O = 16]

i. The relative molecular mass of calcium phosphate.

ii. Percentage of phosphorus in it.

c. Calculate the relative molecular mass of ammonium dichromate, $(NH_4)_2Cr_2O_7$·[N = 14, Cr = 52, H = 1, O =16]

QUESTION BANK

1 XCl_2 is the chloride of a metal X. State the formula of the sulphate and the hydroxide of the metal X.

Ans. XSO_4, $X(OH)_2$

2 An element X is trivalent. Write the balanced equation for the combustion of X with oxygen.

Ans. $4X + 3O_2 \longrightarrow 2X_2O_3$

3 The formula of the nitride of a metal X is XN, state the formula of:

i. its sulphate   ii. its hydroxide

Ans. i. $X_2(SO_4)_3$ ii. $X(OH)_3$

4 What is the valency of nitrogen in:

i. NO   ii. N_2O iii. NO_2

Ans. i. 2   ii. 1   iii. 4

5 Find the total percentage of oxygen in magnesium nitrate crystals $Mg(NO_3)_2 \cdot 6H_2O$
[O = 16, N = 14, H = 1, Mg = 24]

Ans. RMM of $Mg(NO_3)_2.6H_2O = 24 + 2 \times 14 + 6 \times 16 + 6 \times 18 = 256$

$$\text{Percentage of oxygen} = \frac{\text{Total mass of oxygen}}{\text{RMM of } Mg(NO_3)_2} \times 100 = \frac{192}{256} \times 100 = 75\%$$

6 What is the mass of nitrogen in 1000 kg of urea $CO(NH_2)_2$? (Answer to nearest kg)

Ans. Molecular mass of urea = 60

Now, 60 g of urea contains nitrogen = 28 g

$$\text{Therefore, 1000000 g will contain nitrogen} = \frac{28}{60} \times 1000000 \text{ g} = 466666.6 \text{ g} = 467 \text{ kg}$$

7 Calculate the percentage of boron in borax, $Na_2B_4O_7.10H_2O$. Answer correct to 1 decimal place.
[H = 1, B = 11, O = 16, Na = 23]

Ans. $$\text{Percentage of boron} = \frac{\text{Mass of boron}}{\text{Molecular mass of borax}} \times 100 = \frac{44}{382} \times 100 = 11.5\%$$

8 If a crop of wheat removes 20 kg of nitrogen per hectare of soil, what mass in kg of the fertiliser calcium nitrate would be required to replace nitrogen in a 10 hectare field? [N = 14, O = 16, Ca = 40]

Ans. Molecular mass of calcium nitrate, $Ca(NO_3)_2 = 164$

Nitrogen replaced in one hectare of soil = 20 kg

Nitrogen replaced in 10 hectare of soil = 200 kg = 200000 g

Now, 28 g of nitrogen is present in 164 g of calcium nitrate

Therefore, 200000 g of nitrogen will be present in $\frac{164}{28} \times 200000 = 1171428.5$ g = 1171 kg

9 Calculate the percentage of phosphorus in the fertiliser superphosphate, $Ca(H_2PO_4)_2$. (Answer correct to 1 decimal place.) [H = 1 , O = 16 , P = 31 , Ca = 40]

Ans. Percentage of phosphorus in superphosphate $= \frac{\text{Mass of phosphorus}}{\text{Molecular mass of superphosphate}} \times 100$

$$= \frac{62}{234} \times 100 = 26.5\%$$

10 Calculate the percentage of platinum in ammonium chloroplatinate, $(NH_4)_2PtCl_6$. (Answer correct to the nearest whole number.) [N = 14, H = 1, Cl = 35.5, Pt = 195]

Ans. Percentage of platinum in ammonium chloroplatinate $= \frac{\text{Mass of platinum}}{\text{Molecular mass of ammonium chloroplatinate}} \times 100$

$$= \frac{195}{444} \times 100 = 44\%$$

11 Calculate the percentage of nitrogen in aluminium nitride. [Al = 27, N = 14]

Ans. Percentage of nitrogen in aluminium nitride $= \frac{\text{Mass of nitrogen}}{\text{Molecular mass of aluminium nitride}} \times 100 = \frac{14}{41} \times 100 = 34.15\%$

12 Calculate the percentage of sodium in sodium aluminium fluoride (Na_3AlF_6). (Answer correct to the nearest whole number.) [F = 19, Na = 23, Al = 27]

Ans. Percentage of sodium in sodium aluminium flouride

$$= \frac{\text{Mass of sodium}}{\text{Molecular mass of sodium aluminium flouride}} \times 100 = \frac{69}{210} \times 100 = 32.86\%$$

13 Determine the percentage of oxygen in ammonium nitrate.

Ans. Percentage of oxygen in ammonium nitrate, NH_4NO_3

$$= \frac{\text{Mass of nitrogen}}{\text{Molecular mass of ammonium nitrate}} \times 100 = \frac{48}{80} \times 100 = 60\%$$

14 Calculate the percentage of nitrogen and oxygen in ammonium nitrate. [Relative molecular mass of ammonium nitrate is 80, H = 1, N = 14, O = 16]

Ans. Percentage of nitrogen in ammonium nitrate, $NH_4(NO_3)$

$$= \frac{\text{Mass of nitrogen}}{\text{Molecular mass of ammonium nitrate}} \times 100 = \frac{28}{80} \times 100 = 35\%$$

Percentage of oxygen in ammonium nitrate, $NH_4(NO_3)$

$$= \frac{\text{Mass of oxygen}}{\text{Molecular mass of ammonium nitrate}} \times 100 = \frac{48}{80} \times 100 = 60\%$$

15 Find the total percentage of magnesium in magnesium nitrate crystals, $Mg(NO_3)_2.6H_2O$.

[Mg = 24; N = 14; O = 16 and H = 1]

Ans. Percentage of magnesium in magnesium nitrate, $Mg(NO_3)_2.6H_2O$

$$= \frac{\text{Mass of Mg}}{\text{Molecular mass of magnesium nitrate}} \times 100 = \frac{24}{256} \times 100 = 9.37\%$$

16 Element X is a metal with valency of 2, Y is a non-metal with valency 3.

i. Write an equation to show how Y forms an ion.

ii. If Y is a diatomic gas, write an equation for the direct combination of X and Y to form a compound.

Ans. **i.** $Y + 3e^- \longrightarrow Y^{3-}$ **ii.** $3X + Y_2 \longrightarrow X_3Y_2$

17 Write one word answer for the following.

i. Reactions proceeding with the absorption of light.

ii. The process of losing oxygen and gaining hydrogen.

iii. Substance that increases the rate of a reaction.

iv. The electron combining capacity of an element.

Ans. i. Photochemical reaction ii. Reduction iii. Catalyst iv. Valency

18 The lower valency is named as suffix ______(ous/ic) and the higher valency as ______ (ous/ic).

Ans. ous, ic

19 A chemical reaction does not tell about ______(rate/kind) of a chemical reaction.

Ans. rate

20 What information is conveyed about the symbol Mg (atomic mass = 24)?

Ans. The symbol Mg represents 1 atom of magnesium.

It tells that mass of 1 g atom of magnesium is 24 g or its atomic mass is 24 g.