BASIC CONCEPT OF CHEMISTRY

• PERIODIC CLASSIFICATION

INTRODUCTION

You must visited a library. There are thousands of books in a large library. In spite of this if you ask for a particular book, the library staff can locate it easily.

HOW IS IT POSSIBLE?

In library, the books are classified into various categories and sub-categories. They are arranged on shelves accordingly. Therefore location of books becomes easy.

Let us come back to chemistry. Most of the matter that we see, touch and feel is made up of compounds. There are millions of such compounds existing presently. You will be surprised to know that compounds are formed as a result of various permutations and combination of only about 110 odd elements. To study properties of these elements and their compounds is a tough task.

How then was this task simplified?

This task was simplified by simple classification of elements into few groups. Instead of studying each and every element or compounds, we just learn the properties of groups.

The attempts were made by different scientists to classify elements based on their properties.

NECESSITY FOR CLASSIFICATION OF ELEMENTS

Following are the reasons for the classification of elements

(a) The classification may help to study them better.

(b) The classification may lead to correlate the properties of the elements with some fundamental property that is characteristic of all the elements

(c) The classification may further reveal relationship between the different elements

EARLY ATTEMPTS FOR CLASSIFICATION

i) Greeks classification :

The ancient Greeks erroneously suggested that all matter consisted of four elements only- Earth, air ,fire and water. But , their idea could not be supported by the experiments.

ii) Classification of the basis of Valency

Realising the importance of valency in chemistry, an attempt was made to classify elements on this basis.

The monovalent elements were classed together and so were the divalent ones, the trivalent ones and so on.

However, such classification suffers from the following drawbacks.

1. Several elements have variable valency , e.g. iron has a valency of 2 and 3., copper 1 and 2 , tin 2 and 4 , lead 2 and 4 . etc. This makes the positon of such elements uncertain.
2. Such classification does not explain the diverse nature of elements havig the same valency for example, both sodium and chlorine are monovalent, but they are quite different from each other in chemical behavior. Sodium is a strongly electropositive metal whereas chlorine is a strongly electronegative nonmetal.

LAW OF DOBEREINER'S TRIDS

When elements of same properties are kept in the increasing order of atomic weights, the atomic weight of middle element is equal to the mean atomic weight of remaining two elements.

Examples of Dobereiner's Triads

Element	Lithium	Sodium	Potassium	Arithmetic mean
Atomic mass	7.0	23.0	39.0	$\frac{7+39}{2}=23.0$
Element	Calcium	Strontium	Barium	Arithmetic mean
Atomic mass	40.0	87.5	137	$\frac{40+137}{2}=88.1$
Element	Chlorine	Bromine	Iodine	Arithmetic mean
Atomic mass	35.5	80	127	$\frac{35.5+127}{2}=81.25$

SIGNIFICANCE OF DOBEREINER TRIADS

This classification of elements in triads had greater significance in predicting the atomic mass and properties of the middle element. However, only a few elements could be arranged in such triads.

Defects of Triad Classification :

(i) Quite a large number of similar elements could not be grouped into triads.

Example: Iron, manganese , neckel,cobalt,zinc, and copper are similar elements but cannot be placed in the triads.

(ii) It was possible that quite dissimilar elements could be grouped into triads.
As Dobereiner failed to arranged the then known elements in the form of triads, his classification was not very successful.

Example: For example, carbon (12) , nitrogen (14) and Oxygen (16) can form a triad but their properties are entirely different from each other.

NEWLAND LAW OF OCTAVES:

The eighth element after lithium is sodium . It is similar to lithium in many of its chemical properties. Similarly, the eighth element after sodium is potassium, whose properties are similar to sodium. The eighth element from fluorine is chlorine both of which are similar in their properties. The eighth element from nitrogen is phosphorus and both these elements are similar in properties.

Based on this observation, **Newland stated his law of octaves thus "when elements are arranged in increasing order of their atomic mass, the eigths elements resembles the first in physical and chemical properties just like the eighth note on a musical scale resembles the first note.**
However, a very important conclusion was made that there is some systematic relationship between the order of atomic masses and the repetition of properties of elements. This give rise to a new term called periodicity.

Periodicity : It is the recurrence of characteristic properties of elements arranged in a table, at regular intervals of a period
Achievements of the Law of octaves

(i) The law of octaves was the first logical attempt to classify elements on the basis of atomic weights.
(ii) Periodicity of elements was recognized for the first time

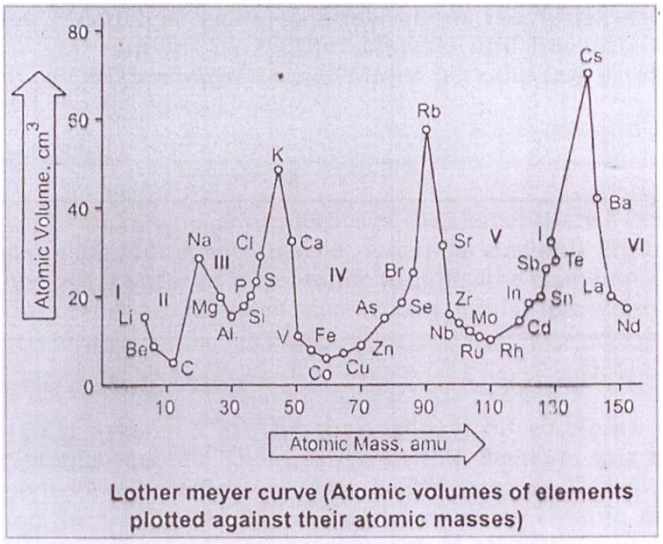
Defects of law of Octaves

(i) This law could be best applied , only up to the element calcium
(ii) Newly discovered elements could not fit into the octave structure
(iii) It failed to exhibit this feature with heavier elements

(iv) Lother Meyer classification :

In 1869, Lother Meyer, a German chemist, studied physical properties like atomic volume, melting point, boiling point etc. of various elements and plotted a graph between the atomic volumes (atomic volume of element is the atomic mass divided by the density of the element) and atomic masses (in amu) of the elements. From the atomic volume –atomic

mass curve shown in figure. Lother Meyer observed that the elements with similar properties occupy approximately similar positions on the curve.



Lother meyer curve (Atomic volumes of elements plotted against their atomic masses)

MENDELEEV'S PERIODIC TABLE

With the failures of many attempts, there was a chaotic mess in the arrangement of elements . An end of this chaotic mess of elements was put by Mendeleev.

Dmitri Ivanovich Mendeleev, a Russian chemist was the first for successful arrangement of elements . In 1869, he published a periodic table of elements

This law states that

The physical and chemical properties of the element are a periodic function of their atomic weights , i.e. when the elements are arranged in the increasing order of their atomic weights , the elements with similar properties are repeated after certain regular intervals

What is Mendeleev's periodic table?

Mendeleev (1871) arranged all the then known 63 elements in the increasing order of their atomic masses . The arrangement of elements was made in horizontal raws (called periods) and vertical columns (called groups). This arrangement showed that the elements having similar chemical properties came directly under one another in the same group. This arrangement of elements was called Mendeleev's periodic table. Thus Mendeleev's periodic table can be defined as an arrangement of elements in the increasing order of their atomic masses in different groups and periods.

Illustration – 1: (i) Who give the law of octaves?
Solution: Newland
(ii) What was the basis of mendelev's periodic law?
Solution: At wt. (Atomic weight)

CHEMICAL REACTION

Chemical reactions are the processes in which new substances with new properties are formed. Chemical reactions involve chemical changes. Chemical reactions involve breaking of old chemical bonds which exist between the atoms of reacting substances, and then making of new chemical bonds between the rearranged atoms of new substances.

(i) The substances which take part in a chemical reaction are called reactants.

(ii) The new substances produced as a result of chemical reaction are called products.

In a chemical reaction, reactants are transformed into products. The products thus formed have properties which are entirely different from those of the reactants.

Magnesium	+	Oxygen	$\xrightarrow{\text{Heat}}$	Magnesium oxide
(As ribbon)		(from air)	(White powder	

The burning of magnesium in air to form magnesium oxide is an example of a chemical reactions. In this chemical reaction there are two reactants 'magnesium and oxygen' but only one product 'magnesium oxide'. The properties of the product magnesium oxide are entirely different from those of the reactants magnesium and oxygen.

In a chemical reaction, the substances known as reactants are converted into new substances called products. The conversion of reactants into products in a chemical reaction is often accompanied by some features which can be observed easily. The easily observable features (or changes) which take place as a result of chemical reactions are known as characteristics of chemical reactions. The important characteristics of chemical reactions are:

(i) Evolution of a gas,
(ii) Formation of a precipitate,
(iii) Change in colour,
(iv) Change in temperature, and
(v) Change is state

Any one of these general characteristics can tell us whether a chemical reactions has taken place or not.

CHEMICAL EQUATIONS

The method of representing a chemical reactions with the help of symbols and formulae of the substances involved in it is known as a chemical equation. Let us take one example to understand the meaning of a chemical equation clearly. Zinc metal reacts with dilute sulphuric acid to form zinc sulphate and hydrogen gas. This reactions can be written in words as:

Zinc + Sulphuric acid → Zinc sulphate + Hydrogen

This is known as the word equation. We can change it into a chemical equation by writing the symbols and formulae of the various substances in place of their names.

Now, Symbol of zinc is Zn
Formula of sulphuric acid is H_2SO_4
Formula of zinc sulphate is $ZnSO_4$
and, Formula of hydrogen is H_2

So, putting the symbols and formulae of all the substances in the above word-equation, we get the following chemical equation:
The substances which combine or react are known as reactants.
The new substances produced in a reaction are known as products.

Illustration – 2: Translate the following statement into chemical equation.
Hydrogen gas combines with nitrogen to form ammonia.

Solution:

Hydrogen + Nitrogen $\longrightarrow$ Ammonia

$3H_2$ (g) + N_2 (g) $\longrightarrow$ $2NH_3$ (g)

Illustration – 3: Write the balanced chemical equation for the following reaction: sodium metal reacts with water to give sodium hydroxide and hydrogen.

Solution: Here, sodium reacts with water to form sodium hydroxide and hydrogen.

Sodium + Water $\longrightarrow$ Sodium hydroxide + Hydrogen

2Na (s) + $2H_2O$ (*l*) $\longrightarrow$ 2NaOH (aq) + H_2 (g)↑

TYPES OF CHEMICAL REACTIONS

Some of the important types of chemical reactions are:

1. Combination Reactions
2. Decomposition Reactions
3. Displacement Reactions
4. Double Displacement Reactions

COMBINATION REACTIONS

Those reactions in which two or more substance combine to form a single substance, are called combination reactions. In a combination reactions, two or more elements can combine to form a compound; two or more compounds can combine to form a new compound; or an element and a compound can combine to form a new compound. We will now give some examples of combination reactions.

Example 1: Magnesium and oxygen combine, when heated, to form magnesium oxide:

2Mg (g) + O_2 (g) $\xrightarrow{\text{Combination}}$ 2MgO (s)

Magnesium Oxygen Water

In this reactions, two elements, magnesium and oxygen are combining to form a single compounds magnesium oxide. So, this is a combination reactions. Thus, when we burn a magnesium ribbon (or magnesium wire) in air, then a combination reaction takes place with oxygen to form magnesium oxide.

Example 2: Hydrogen burns is oxygen to form water:

$2H_2$ (g) + O_2 (g) $\xrightarrow{\text{Combination}}$ $2H_2O$ (ℓ)

Hydrogen Oxygen Water

Example 3: Carbon (coal) burns in air to form carbon dioxide:

C (s) + O_2 (g) $\xrightarrow{\text{Combination}}$ CO_2(g)

Carbon (Coal) Oxygen (From air) Carbon dioxide

Example 4: Ammonia reacts with hydrogen chloride to form ammonium chloride. This can be written as:

NH_3 (g) + HCl (g) $\xrightarrow{\text{Combination}}$ NH_4Cl(s)

Ammonia Hydrogen chloride Ammonium chloride

DECOMPOSITION REACTIONS

Those reactions in which a compound splits up into two or more simple substances are known as decomposition reactions. The decomposition reactions are carried out by applying heat, light or electricity. Heat, light or electricity provide energy which breaks a compound into two or more simpler compounds. Please note that a decomposition reaction is just the opposite of a combination reactions. We will now give some examples of decomposition reactions.

Example 1: When calcium carbonate is heated, it decomposes to give calcium oxide and carbon dioxide:

$CaCO_3$ (s) $\xrightarrow[\text{(Decomposition)}]{\text{Heat}}$ CaO + CO_2(g)

Calcium carbonate (Limestone) Calcium oxide (Lime) Carbon dioxide

Example 2: When potassium chlorate is heated in the presence of manganese dioxide catalyst, it decomposes to give potassium chloride and oxygen:

$2KClO_3$ (s) $\xrightarrow[\text{(Decomposition)}]{\text{Heat}}$ 2KCl (s) $3O_2$ (g)

Potassium chlorate Potassium chloride Oxygen

Example 3: When lead nitrate is heated strongly, it breaks down to form simpler substances like lead monoxide, nitrogen dioxide and oxygen. This can be written as:

$2Pb(NO_3)_2$ (s) $\xrightarrow[\text{(Decomposition)}]{\text{Heat}}$ 2PbO (s) + $4NO_2$ (g) + O_2 (g)

Lead nitrate	Lead monoxide	Nitrogen dioxide Oxygen
(Colourless)	(Yellow)	(Burown fumes)

DISPLACEMENT REACTIONS

Those reactions in which one elements takes the place of another elements in a compound, are known as displacement reactions. In general, a more reactive element displaces a less reactive element from its compound. The examples of some important displacement reactions are given below.

Example 1: When a strip of zinc metal is placed in copper sulphate solution, then zinc sulphate solution and copper are obtained:

$CuSO_4$ (aq)	+	Zn (s)	→	$ZnSO_4$	+	Cu (s)
Copper sulphate (Blue solution)		Zinc		Zinc sulphate (colourless solution)		Copper

Example 2: When a piece of magnesium metal is placed in copper sulphate solution then magnesium sulphate solution and copper metal are formed:

$CuSO_4$ (aq)	+	Mg (s)	→	$MgSO_4$ (aq)	+	Cu (s)
Copper sulphate (Blue solution)		Magnesium		Magnesium sulphate (colourless solution)		Copper

Example 3: When a piece of iron metal (say, an iron nail) is placed in copper sulphate solution, then iron sulphate solution and copper metal are formed:

$CuSO_4$ (aq)	+	Fe (s)	→	$FeSO_4$ (aq)	+	Cu (s)
Copper sulphate (Blue solution)		Iron		Iron sulphate (Greenish solution)		Copper

DOUBLE DISPLACEMENT REACTIONS

Those reactions in which two compounds react by an exchange of ions to form two new compounds are called double displacement reactions. A double displacement reaction usually occurs in solution and one of the products, being insoluble, precipitates out (separates as a solid). Some of the examples of double displacement reactions are given below:

Example 1: When silver nitrate solution is added to sodium chloride solution, then a white precipitate of silver chloride is formed along with sodium nitrate solution:

$AgNO_3$ (aq)	+	NaCl (aq)	→	AgCl (s)	+	$NaNO_3$ (aq)
Silver nitrate		Sodium chloride		Silver chloride (white ppt.)		Sodium nitrate

Example 2: When potassium iodide solution is added to lead nitrate solution, then a yellow precipitate of lead iodide is produced along with potassium nitrate solution:

$Pb(NO_3)_2$ (aq)	+	2KI (aq)	→	PbI_2 (s)	+	$2KNO_3$ (aq)

Lead nitrate	Potassium iodide	Lead iodide (Yellow ppt.)	Potassium nitrate

Illustration – 4: Identify the type of reaction

(a) Barium chloride (aq) + Potassium sulphate (aq) ⟶ Barium sulphate (s) + Potassium chloride (aq)

(b) Zinc carbonate (s) ⟶ Zinc oxide (s) + Carbon dioxide (g)

Solution:

(a) $BaCl_2$ (aq) + K_2 SO_4 (aq) ⟶ $BaSO_4$ (s) + 2KCl (aq) this is a double displacement reaction.

(b) This is a decomposition reaction.

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KEY POINTS

- Elements are classified on the basis of similarities in their properties.
- Dobereiver grouped the elements into triads newlands gave the law of octaves.
- Mandeleev's periodic law states that the physical and chemical properties of elements are the periodic function of their atomic number.
- A complete chemical equations represents the reactions, products and their physical state symbolically.
- In a combination reaction two or more substances combine to from a new single substance.
- Ina decomposition reaction, a single substance decomposes to give two or more substances.
- When an element displaces another element from its compound a displacement reaction occurs.
- Two different atoms or groups of atoms are exchanged in double displacement reactions.

ASSIGNMENT – I

1. The law of triads was proposed by:
   (A) Dobereiner (B) Newlands
   (C) Lother Meyer (D) Chancourts

2. Which of the following is not a Dobereiner triad?
   (A) Cl, Br, I (B) Ca, Sr, Ba
   (C) Li, Na, K (D) Fe, Co, Ni

3. The law of triads is applicable to :
   (A) Lithium, beryllium, boron (B) Fluorine, chlorine, bromine
   (C) Chlorine, bromine, iodine (D) Sodium, potassium, rubidium

4. Select the following pair of elements in which their arithemetic mean of atomic weights in equal to the atomic weight of strontium.
   (A) Lithium, Barium (B) Sodium, Calcium
   (C) Calcium, Barium (D) Sodium , Barium

5. Which of the following is wrong triad ?
   (A) Chlorine, bromine, iodine (B) Lithium, sodium, potassium
   (C) Carbon, nitrogen, oxygen (D) Calcium, strontium, barium

6. Which of the following is an achievement of the triads classification ?
   (A) Relation between all properties of an element
   (B) Relation between only atomic weights of an element
   (C) Relation between the properties of same elements
   (D) Relation between the atomic mass of all elements

7. According to Dobereiner's law of triads_____ elements arranged in the order of their _____ in the groups of three elements
   (A) Physically similar, atomic weights
   (B) Chemically different, atomic mass
   (C) Physically different, atomic weights
   (D) Chemically similar, atomic weights

8. The most significant contribution towards the development of periodic table was made by
   (A) Mendeleev (B) Avogadrao
   (C) Dalton (D) Cavendish

9. Lother Meyer plotted a Graph showing variation of
   (A) Atomic volume with increase in atomic number
   (B) Atomic volume with increase in atomic weight
   (C) Atomic radii with increase in atomic weight
   (D) Atomic weight with increase in atomic number.

10. Which of the following statement is wrong about Lother-Meyer's plot between atomic volume against atomic weight ?
   (A) The most strongly electropositive alkali metals occupy peaks on the curve.
   (B) The strongly electronegative halogen atoms occupy ascending positions on the curve.
   (C) The less strongly electropositive alkaline earth metals occupy descending positions in the curve
   (D) None of these

ASSIGNMENT – II

1. What happens when dilute hydrochloric acid is added to iron filings? Tick the correct answer:
   (A) Hydrogen gas and iron chloride are produced.
   (B) Chlorine gas and iron hydroxide are produced.
   (C) No reaction takes place.
   (D) Iron salt and water are produced.

2. $Fe_2O_3 + 2Al \longrightarrow Al_2O_3 + 2Fe$, The above reaction is an example of:
   (A) Combination reaction
   (B) Double displacement reaction
   (C) Decomposition reaction
   (D) Displacement reaction
   Choose the correct answer .

3. Translate the following statements into chemical equations.
   (A) Hydrogen sulphide gas burns in air to give water and sulphur dioxide.
   (B) Phosphorus burns in oxygen to give phosphorus pentoxide.

4. What type of reactions are represented by the following equations?
   (i) $CaCO_3 \longrightarrow CaO + CO_2$
   (ii) $CaO + H_2O \longrightarrow Ca(OH)_2$
   (iii) $2FeSO_4 \longrightarrow Fe_2O_3 + SO_2 + SO_3$
   (iv) $NH_4Cl \longrightarrow NH_3 + HCl$
   (v) $2Ca + O_2 \longrightarrow 2CaO$

5. A colourless lead salt, when heated, produces a yellow residue and brown fumes.
   (A) Name the lead salt.
   (B) Name the brown fumes.

6. State an important use of decomposition reactions.

7. Give one example of a decomposition reaction which is carried out with electricity.

8. Give one example of a decomposition reaction which is carried out by applying heat.

9. What type of chemical reaction is used to extract several metals from their naturally occurring compounds like oxides or chlorides?

10. Why are decomposition reactions called the opposite of combination reactions? Explain with equations of these reactions.

KEY & HINTS

Basic Concept of Chemistry

ASSIGNMENT – I

1. (A)
2. (D)
3. (C)
4. (C)
5. (C)
6. (B)
7. (D)
8. (A)
9. (B)
10. (B)

ASSIGNMENT – II

1. (a) Hydrogen gas and iron chloride are produced.
2. The Correct answer is: (d) displacement reaction.
3. (a) $2H_2S + 3O_2 \longrightarrow 2H_2O + 2SO_2$

   (b) $P_4 + 5O_2 \longrightarrow 2P_2O_5$
4. (i) decomposition (ii) combination (iii) decomposition (iv) decomposition (v) combination
5. (a) Lead nitrate (b) Nitrogen.
6. Digestion of food
7. $2NaCl(\ell) \xrightarrow[\text{(Decomposition)}]{\text{Electricity}} c$ $2Na$ (s) $+ Cl_2$ (g)
8. $2FeSO_4$ (s) $\xrightarrow[\text{(Decomposition)}]{\text{Heat}}$ Fe_2O_3 (s) + SO_2 (g) + SO_3 (g)

   Ferrous sulphate — Ferric oxide Sulphur — Sulphur
9. Electrolysis
10. Conceptual

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