

# CLASSIFICATION OF ELEMENTS

Matter is classified into solids, liquids and gases. However this is not the only way of classification of the matter. It is also classified into elements, compounds and mixtures based on composition.

In order to understand the elements, let us consider examples of the substances like Iron, silver etc. which we come across in our day to day life.

Iron is made of iron atoms; silver is made of silver atoms. All these are elements. How to define elements? **Elements are the pure substances containing only one kind of atoms.**

Chemists have discovered 118 elements so far. Among these elements, 92 are normal elements and remaining are synthetic elements.

## **Characteristics of the elements:**

- 1) An element is a pure substance, made up of only one kind of atoms.
- 2) An atom is smallest unit of an element and it possesses properties of that element.
- 3) Elements may occur in the free state in nature or found in the form of their compounds.
- 4) Some elements (like radioactive elements) can be prepared artificially by nuclear reactions.
- 5) The properties of different elements are different. This is because, the arrangement of electrons (electronic configuration) in atoms are different.

## **Need for classification of elements:**

During 17<sup>th</sup> Century, only few elements were known. Later on many elements were discovered in nature, the number of elements in the list of known elements went on increasing. It was thought that elements must be properly classified in order to make a systematic study of elements, otherwise it becomes impossible to understand the properties of elements.

**The following are the advantages of classification of elements.**

- i) To study the elements in a systematic manner
- ii) To correlate the properties of elements.
- iii) To know the type of different compounds that different elements can form

**Historical background of classification of element:** Earlier, an attempt was made to classify the elements into metals and non-metals.

**Metals:**

**An element is a metal if it has the following properties.**

- 1) It is lustrous i.e. it has shining of surface.
- 2) It is a good conductor of heat and electricity.
- 3) It is ductile i.e. it can be drawn into wires.
- 4) It is malleable i.e. it can be beaten into thin sheets.
- 5) It is solid at room temperature.
- 6) It has a tendency to lose one or more electrons.

**Exceptions:**

Mercury and Gallium are liquids at room temperature. Zinc is not malleable and ductile.

**Table: 1 List of common metals**

Sl No.	Name in English	Name in other Language	Symbol
1	Lithium	-	Li
2	Sodium	Natrium (Latin)	Na
3	Magnesium	-	Mg
4	Aluminium	-	Al
5	Potassium	Kalium (Latin)	K
6	Calcium	-	Ca
7	Vanadium	-	V
8	Chromium	-	Cr
9	Manganese	-	Mn
10	Iron	Ferrum (Latin)	Fe
11	Cobalt	-	Co
12	Nickel	-	Ni
13	Copper	Cuprum (Latin)	Cu

Sl No.	Name in English	Name in other Language	Symbol
14	Zinc	-	Zn
15	Gallium	-	Ga
16	Silver	Argentums (Latin)	Ag
17	Tin	Stannum (Latin)	Sn
18	Barium	-	Ba
19	Platinum	-	Pt
20	Gold	Aurum (Latin)	Au
21	Mercury	Hydrargyrum (Latin)	Hg
22	Lead	Plambun (latin)	Ph
23	Radium	-	Rq
24	Uranium	Wolfram (German)	U
25	Tungsten	-	W
26	Thorium	-	Th

Note: The first letter in the symbol is always capital and the second letter is always small alphabet.

### **Non – Metals :**

An element is a non-metal if it has the following properties.

- 1) It has no lustre.
- 2) It is a bad conductor of heat and electricity.
- 3) It is not ductile.
- 4) It is not malleable
- 5) It has a tendency to gain one or more electrons.
- 6) It is a liquid or gas or a brittle solid at room temperature.

**Table: 2 : List of common non-metals.**

Sl No.	Name	Symbol	Formula
1	Hydrogen	H	H <sub>2</sub>
2	Nitrogen	N	N <sub>2</sub>
3	Oxygen	O	O <sub>2</sub>
4	Fluorine	F	F <sub>2</sub>
5	Chlorine	Cl	Cl <sub>2</sub>
6	Bromine	Br	Br <sub>2</sub>
7	Iodine	I	I <sub>2</sub>
8	Carbon	C	C <sub>60</sub>
9	Phosphorus	P	P <sub>4</sub>
10	Sulphur	S	S <sub>8</sub>
11	Silicon	Si	Si

**Disadvantages of classifying the elements into metals and non metals.**

- i) There is no justification for more active metals or non metals.
- ii) There are some elements which have properties of metals and non-metal, such elements are known as Metalloids.

Examples of Metalloids

- 1) Boron (B)                      2) Silicon (Si)                      3) Germanium (Ge)
- 4) Arsenic (As)                      5) Antimony (Sb)                      6) Tellurium (Te)
- 7) Polonium (Po) and 8) Astatine (At)

**Dobernier's triads:**

After the development of atomic theory and determination of the atomic masses of a large number of elements, attempts were made to classify the elements on the basis of atomic mass. Dobernier was the first to correlate the properties of elements with their atomic masses.

In 1863, Dobernier classified the elements into group of three elements such that the three elements had similar properties and the atomic mass of the middle element was the arithmetic mean of the atomic masses of the first and the third elements. The group of such three elements was called Triads.

Dobernier's Triads

Element	Atomic Mass	Element	Atomic Mass	Element	Atomic Mass
Li	7	Ca	40	Cl	35.45
Na	23	Sr	88	Br	80
K	39	Ba	137	I	127

$$\text{At. mass of Na} = \frac{\text{At.mass of Li} + \text{At. Mass of K}}{2} = \frac{7+39}{2} = \frac{46}{2} = 23$$

$$\text{At. mass of Sr} = \frac{\text{At.mass of Ca} + \text{At. Mass of Ba}}{2} = \frac{40+137}{2} = \frac{177}{2} = 88$$

**Disadvantages of Dobernier's triads.**

- i) It was not possible to group all elements into triads.
- ii) The elements with dissimilar properties were grouped as triads.

Element	Carbon	Nitrogen	Oxygen
At mass	12	14	16

$$\text{At. mass of N} = \frac{\text{At.mass of C} + \text{At. Mass of O}}{2} = \frac{12+16}{2} = \frac{28}{2} = 14$$

**Newland's Classification:** In 1863, J.A. Newland observed that when elements are arranged in the increasing order of their atomic masses, **the properties of elements repeated at every eighth element, similar to repetition of musical notes in an Octave.** Newland called this as Law of Octaves.

Element	Li	Be	B	C	N	O	F
At. Mass	7	9	11	12	14	16	19
Element	Na	Mg	Al	Si	P	S	Cl
At. Mass	23	24	27	28	31	32	35.45
Element	K	Ca					
At. Mass	39	40					

- i) The eighth element from lithium is sodium, eighth element from sodium is potassium, therefore Lithium, sodium and potassium have similar properties.
- ii) Similarly eighth element from beryllium is magnesium, eighth element from magnesium is calcium, therefore, beryllium, magnesium and calcium have similar properties.

However this did not hold good beyond Ca.

**Advantages of Newland's classification.**

- i) Atomic mass of the element was considered as basis of classification.
- ii) It explains periodicity in the properties of elements.

**Disadvantages of Newland's classification.**

- i) There was no proper place for hydrogen.
- ii) Transition elements were not considered for Octaves.
- iii) The observation made by Newland does not hold good beyond Ca.

**Lothar Meyer's Graph:** Lothar Meyer (1869) tried to classify by plotting a graph of atomic volume versus atomic masses of different elements. Similar elements occupied similar positions in the graph.

**Mendeleev's Classification:** The classification of elements made by Newland on the basis of atomic mass was continued by Mendeleev. He observed that when elements are arranged in the increasing order of their atomic masses, the properties of the elements repeated at certain intervals. He gave his observation in the form of a law, known as **Mendeleev's periodic law.** It states that the **properties of the elements are periodic functions of their atomic masses.**

When Mendeleev arranged the elements in the increasing order of their atomic masses, the elements with similar properties were placed in the same column, and a table was prepared. It is known as Mendeleev's periodic table.

**A periodic table is a chart representing the systematic arrangement of elements into vertical columns and horizontal rows such that elements with similar properties fall in the same column.**

#### **Characteristics of Mendeleev's periodic table**

- i) The vertical columns in the periodic table are called groups.
- ii) There are 8 groups. These are numbered as I, II, III, IV, V, VI, VII & VIII.
- iii) Each of group from I & VII were divided into subgroups a & b. Thus, there were 15 vertical columns that constituted 8 groups.
- iv) The horizontal rows in the periodic table are called periods.
- v) There is gradual change in the property of elements from metallic to non-metallic along the period from left to right.

#### **Advantages of Mendeleev's periodic table.**

- i) It is based on atomic mass of the element which is considered as fundamental property of element.
- ii) The elements with similar properties fall in the same group.
- iii) There is repetition in the properties of elements at certain intervals. This is known as periodicity in the properties of elements. Thus it explains periodicity in the properties of elements.
- iv) Some gaps were left for undiscovered elements. The properties of undiscovered elements were predicted by Mendeleev on the basis of other elements in the same group.
- v) Mendeleev corrected the atomic massus of some elements.

#### **Disadvantages of Mendeleev's periodic table.**

- i) **Position of Hydrogen:** There was no proper position for hydrogen atom. It is placed in Ib and VIIb in original Mendeleev's periodic table.
- ii) **Anomalous pairs:** In Mendeleev's periodic table, the elements are arranged in the increasing order of their atomic masses but some pairs of elements were placed such that elements with higher atomic masses were placed prior to those with lower atomic masses.

Eg.	Cobalt	58.9	Nickel 58.6
	Tellurium	128	Iodine 127

- iii) **Position of rare earth elements & actinides**  
The position of rare earth elements & actinides cannot be justified on the basis of atomic masses.
- iv) **Position of isotopes:** Isotopes are the atoms of the same elements with different atomic mass & same atomic number. They have similar properties but the position of isotopes cannot be justified.
- v) **Position of transition elements:** According to Mendeleev, elements of only VIII group are the transition elements. This is not justified.
- vi) **Superfluous relationships :** Elements with different properties are placed in same group.
- Alkali metals with copper, silver and gold in group I b
  - Fluorine and manganese in group VII a

### Mendeleev's period table of elements (1869)

Groups	I		II		III		IV		V		VI		VII		VIII		
Sub Groups	a	b	A	b	a	b	a	b	a	b	a	b	a	B			
1		H 1												H 1			
2	Li 7		Be 9		B 11		C 12		N 14		O 16			F 19			
3	Na 23			Mg 24		Al 27		Si 28		P 31		S 32		Cl 35.5			
4	K 39		Ca 40				Ti 48		V 51		Cr 52		Mn 55		Fe 56	Co 58.9	Ni 58.6
5		Cu 63		Zn 65						Ar 75		Se 79		Br 80			
6	Rb 86		Sr 88		Yt 89		Zr 91		Nb 93		Mo 96				Ra 101	Rh 103	Pd 106
7		Ag 108		Cd 112		In 113		Sn 122		Sb 122		Te 128		I 127			
8	Cs 133		Ba 137					Ce 140									
9																	
10					Fr 167		La 181		Ta 181		W 184				OS 190	Ir 192	Pt 195
11		As 197		Hg 201		Tl 204		Pb 207		Bi 209							
12	-						Tb 232				U 238						

## **Modern Periodic Table:**

In 1918, H.G.I. Moseley showed by X-ray analysis that the atomic number is a better fundamental property of an element than its atomic mass, therefore he classified the elements based on atomic number. He proposed his observation in the form of a law known as Modern periodic law. **It states that the physical and chemical properties of all elements are periodic functions of their atomic number.**

Based on this, elements were classified and a periodic table was prepared. It consists of 7 periods and 18 groups. The significance of the modern periodic table is that the properties of the elements depend on the arrangement of the electrons (electronic configuration) of their atoms. It is observed in the periodic table that the elements with similar electronic configuration fall in the same group. The similar properties of the elements repeat in some intervals. This is known as periodicity in the properties of the elements. This is due to repetition of similar electronic configuration of elements in the same interval. The following are the periodic properties of the elements

1. Atomic radius.
2. Ionisation energy.
3. Electronegativity.
4. Electron affinity.

The details of modern periodic table are discussed in XI Std.

### **Exercise:**

1. What are elements?
2. Why are the properties of elements different?
3. What is the need for classification of elements?
4. What are metalloids?
5. What do you mean by Dobernier's triad?
6. State Newland's law of octaves.
7. Give examples of liquid metals.
8. State Mendeleev's periodic law.
9. What is a periodic table?
10. Write any two characteristics of Mendeleev's periodic table.
11. Mention the disadvantages of classification of the elements by Mendeleev.

### **Fill in the blanks**

1. A metal has a tendency to ..... one or more electrons.
2. A non metal has a tendency to ..... one or more electrons.
3. Mendeleev's classification of elements is based on .....