

Early Models of Periodic Table

Dobereiner's Triads

Dobereiner arranged a group of three elements with similar properties in the order of increasing atomic masses and called it a triad. He showed that the atomic mass of the middle element is approximately the arithmetic mean of the other two. But, Dobereiner could identify only following three triads from the elements known at that time.

<i>Elements</i>	<i>Atomic Mass</i>	<i>Average</i>
<i>Lithium (Li)</i>	6.9	$\frac{6.9+39.0}{2} = 22.95$
<i>Sodium (Na)</i>	23.0	
<i>Potassium (K)</i>	39.0	
<i>Calcium (Ca)</i>	40.1	$\frac{40.1+137.3}{2} = 88.65$
<i>Strontium (Sr)</i>	87.6	
<i>Barium (Ba)</i>	137.3	
<i>Chlorine (Cl)</i>	35.5	$\frac{35.5+126.9}{2} = 81.2$
<i>Bromine (Br)</i>	79.9	
<i>Iodine (I)</i>	126.9	

Newlands' Law of Octaves

sa (do)	re (re)	ga (mi)	ma (fa)	pa (so)	da (la)	ni (ti)
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co and Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce and La	Zr	_____	_____

When the elements are arranged according to increasing atomic masses, the physical and chemical properties of every eighth element are similar to that of the first.

Newlands compared these octaves to the series of eight notes of a musical scale.

Assumptions and Limitations:

1. The law was applicable for elements with atomic masses up to 40.
2. Properties of new elements discovered did not fit into the law of octaves.
3. In a few cases, Newlands placed two elements in the same slot to fit elements in the table.
4. He also grouped unlike elements under the same slot.

Mendeleev's Periodic Table and Law

The physical and chemical properties of elements are periodic functions of their atomic weights.

Features of Mendeleev's Periodic Table

- Twelve horizontal rows, which were condensed to 7, known as periods.
- Eight vertical columns known as groups.
- Groups I to VII subdivided into A and B subgroups.
- Groups VIII doesn't have any subgroups and contains three elements in each row.
- Elements in the same group exhibit similar properties.

Achievements of Mendeleev's Periodic Table

1. **A systematic study of elements:** Elements with similar properties were grouped together, that made the study of their chemical and physical properties easier.
2. **Correction of atomic masses:** Placement of elements in Mendeleev's periodic table helped in correcting the atomic masses of certain elements. For example, the atomic mass of beryllium was corrected from 13.5 to 9. Similarly, atomic masses of indium, gold, platinum etc., were also corrected.
3. **Prediction of properties of yet to be discovered elements:** Eka-boron, eka-aluminium and eka-silicon were the names given to yet to be discovered elements. The properties of these elements could be predicted accurately from the elements that belonged to the same group. These elements, when discovered were named scandium, gallium, and germanium respectively.
4. **Placement of noble gases:** When discovered, they were placed easily in a new group called zero group of Mendeleev's table, without disturbing the existing order.

Limitations of Mendeleev's Periodic Table

1. **Position of hydrogen:** Hydrogen resembles both, the alkali metals (IA) and the halogens (VIIA) in properties, so, Mendeleev could not justify its position.
2. **Position of isotopes:** Atomic weight of isotopes differ, but, they were not placed in different positions in Mendeleev's periodic table.
3. **Anomalous pairs of elements:** Cobalt (Co) has higher atomic weights but was placed before Nickel (Ni) in the periodic table.
4. **Placement of like elements in different groups:** Platinum (Pt) and Gold (Au) has similar properties but were placed in different groups.
5. **Cause of periodicity:** He could not explain the cause of periodicity among the elements.

Modern Periodic Table

Modern Periodic Law

The physical and chemical properties of elements are the periodic function of their atomic numbers.

Cause of periodicity – It is due to the repetition of same outer shell electronic configuration at a certain regular interval.

Periods in Modern Periodic Table

Elements present in the same period have the same number of shells which is equal to the period number.

On moving from left to right in a given period, the number of electrons in the valence shell increases from one to eight while the number of shells remains the same.

Number of Elements in a Period

The first period contains only two elements 1H and 2He and is known as the shortest period.

The second period (3Li to 10Ne) and the third period (11Na to 18Ar) contain 8 elements each and are known as short periods.

The fourth period (19K to 36Kr) and the fifth period (37Rb to 54Xe) contain 18 elements each and are called long periods.

The sixth period contains 32 elements ($_{55}\text{Cs}$ and $_{86}\text{Rn}$) and is also known as the longest period.

The seventh period is an incomplete period.

(After the recent discoveries of the new elements and their addition to the periodic table, the seventh period is officially complete)

Groups in Modern Periodic Table

The modern periodic table contains 18 vertical columns known as groups.

Group 1 elements are known as alkali metals.

Group 2 elements are known as alkaline earth metals.

Group 15 elements are known as pnictogens.

Group 16 elements are known as chalcogens.

Group 17 elements are known as halogens.

Group 18 elements are known as noble gases.

Alkali Metals

The elements in the first group, lithium (Li), sodium (Na), potassium (K), rubidium (Rb), caesium (Cs), and francium (Fr) are called alkali metals.

They were given the name because they all react with water to form alkalis.

The alkali metals are all shiny, soft, highly reactive solids at standard temperature and pressure and readily lose their outermost electron to form cations with charge +1.

Number of valence electrons = 1

Alkali Earth Metals

The elements in the second group, beryllium(Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra) are called alkaline earth metals.

They were given the name because their oxides are alkaline in nature.

They are all shiny, silvery-white, somewhat reactive hard solids at standard temperature and pressure. They lose two electrons from their outermost shell to form cations with charge +2.

Number of valence electrons = 2

Halogens

The elements in the seventeenth group (F, Cl, Br, I and As) are called halogens and exist as diatomic molecules. The symbol 'X' is often used generically to refer to any halogen. They were given the name halogen, from the Greek words, Hal- ("salt") and -gen ("to produce"), because they all produce a wide range of salts on reacting with metals. The halogens exist at room temperature in all three states of matter: Solid- Iodine, Astatine. Liquid- Bromine. Gas- Fluorine, Chlorine. Number of valence electrons = 7

Noble Gases

The elements in the eighteenth group, helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and the radioactive radon (Rn) are called noble gases. They are all odourless, colourless and monatomic gases with very low chemical reactivity. Since their valence shell is considered to be "full", they have little tendency to participate in chemical reactions. When discovered and identified, scientists thought they are exceedingly rare, as well as chemically inert, and therefore these gases were also given the names 'rare' or 'inert' gases. Number of valence electrons = 8

Classification of Modern Periodic Table

The modern periodic table is also classified into metals, nonmetals and metalloids.

Metals

Metals are electropositive as they form bonds by losing electrons. In general cases, oxides of metals are basic in nature.

Nonmetals

Nonmetals are electronegative as they form bonds by gaining electrons. In general cases, oxides of non-metals are acidic in nature.

Metalloids

The elements which show the properties of both metals and nonmetals are called metalloids or semimetals. For example – Boron, silicon, germanium, arsenic, antimony, tellurium, and polonium.

Trends in the Modern Periodic Table

Trends in Modern Periodic Table

In a group – Elements have the same number of valence electrons.
Down the group – number of shells increases.
In a period – Elements have the same number of shells.

Along the period – valence shell electrons increase by one unit.

Variation of Valency

Valency of an element can be calculated from the electronic configuration in two ways –

Valency = number of valence electrons (if they are 1, 2, 3 or 4).

Valency = 8 – number of valence electrons (if they are 5, 6, 7 or 8).

All the elements of a group have the same number of valence electrons. Therefore, they all have the same valency.

Variation of Atomic Size

Atomic size or radii: It is defined as the distance from the centre of the nucleus to the valence shell of the atom.

Along the period – Atomic radius decreases because effective nuclear charge increases by one unit and it pulls valence electrons or the electron cloud closer to the nucleus.

Down the group – Atomic radius increases because new shells are added, hence, the distance between the nucleus and valence electrons or the electron cloud increases.

Variation of Metallic Properties

Along the period – Metallic character decreases because the tendency to lose valence electrons decreases due to increasing nuclear charge.

Down the group- As the distance between the nucleus and outermost electron increases, nuclear pull decreases. This increases the tendency of an atom to lose valence electron/s, hence metallic character increases.

Variation of Nonmetallic Properties

Along the period – Non-metallic character increases as the tendency to gain electrons in the valence shell increases due to increasing nuclear charge.

Down the group – As the distance between the nucleus and valence shell increases, nuclear pull decreases. This decreases the tendency of an atom to gain an electron in its valence shell, hence non-metallic character decreases.

Variation of Electronegativity

Along the period – Electronegativity increases as the tendency to gain electrons in the valence shell increases due to increasing nuclear charge.

Down the group – As the distance between the nucleus and valence shell increases, nuclear pull decreases. This decreases the tendency of an atom to gain an electron, hence electronegativity decreases.