The Periodic Table.

Dobereiner's Triads

The atomic mass of the middle element of a Dobereiner's triad was approximately equal to the arithmetic mean (average) of the atomic masses of the other two elements of that triad.

Example: The mean of atomic masses of chlorine and iodine is approximately same as atomic mass of bromine

$$I = \frac{35.5 + 127}{2} = \frac{162.5}{2} = 81.25$$

Reason for discarding Law of Triad

(i) He failed to arrange all the then known elements in the form of triad.

(ii) The law did not fully apply even within the same family.

Newland's Law of Octave

According to Newland's law of octave, when elements are arranged by increasing atomic mass, the properties of every eighth element starting from any element are a repetition of the properties of starting element.

Merits of Newland's Law of Octave.

1. It worked well for lighter elements
2. It relates properties of elements to their atomic masses.
3. For the first time it was shown that there is a distinct periodicity in properties of elements.

Reason for discarding Law of Octave

1. It did not worked with heavier elements.
2. Cobalt and nickel was placed with fluorine, chlorine and bromine which have very different properties than these elements.
3. Iron which ressemble cobalt and nickel was placed far away.

Mendeleev's Periodic Table

Physical and chemical properties of elements are periodic function of their atomic masses.

Merit of Mendeleev's Table.

1. He generalized the study of the elements then known to a study of mere eight groups.
2. He left gaps for undiscovered elements.

3. He predicted properties of undiscovered elements.

4. He corrected the atomic mass of elements like gold and platinum.

Drawbacks in Mendeleev's Periodic Table

1. Few pair of elements did not Mendeleev's principle
   (a) Argon (39.9) precedes K (39.1)
   (b) Cobalt (58.9) precedes Nickel (58.6)
   (c) Tellurium (127.6) precedes Iodine (126.9).
2. He could not justify the position of isotopes.
3. He grouped dissimilar elements. For example: Copper and silver were grouped with lithium and sodium.
4. He grouped chemically similar elements. For example: Gold and platinum were placed in separate groups.
5. He could not explain electron of elements.
6. He could not , the ion of hydrogen.

Atomic Number as basis for Modern Periodic Law

The wavelength of cathode rays was found to decrease in a regular manner on changing the metal of the anode in order of their position in the periodic table.

By this, he concluded that positive charge number is most fundamental property.

The number of unit positive charge present in nucleus of an atom of a particular element is called atomic number of that element.

Thus, Henrey Moseley found that atomic number is a better fundamental property of elements than atomic mass. This led to Modern Periodic Law.

Modern Periodic Law

Physical and chemical properties of elements are periodic function of their atomic number.

Explaination for anomalies in Mendeleev's classification of elements.

1 Position of isotopes was justified, as isotopes have same atomic number, so they can be placed in same position in the periodic table.

2 Position of anomalous pairs like argon, potassium and cobalt, nickel was justified when they were arranged in increasing order of atomic number.

Periodic Properties or Periodicity of elements

Periodicity: When elements are arranged in increasing order of atomic number, the occurance of similar properties of elements after a definite interval is termed as the periodicity of an element

The cause of periodicity is the same no. of electrons in the outermost orbit, i.e. recurrence of similar electronic configuration.

Salient Feature of the Modern Periodic Table.

Vertical Columns: Groups (18 Groups)

Horizontal Rows: Periods (7 Periods)

- Group 1, 2, 13, 14, 15, 16, and 17 are called representative elements or normal elements.
- Group 3 to 12 elements are called transition elements.
- Group 18 elements are called noble gases.
- First period contains 2 elements. (Shortest period).
- Second and third period contains 8 elements. (Short period)
- Forth and fifth period contains 18 elements. (Long Period)
- Sixth period contains 32 elements (Longest Period)
- Seventh period is an incomplete period
- Group 3 of 6th period contains Lanthanides (57 - 71)
- Group 3 of 7th period contains Actinides (89 - 103)

Types of Elements

1. Representative Elements
2. Transition elements
3. Inner Transition elements
4. Inert Gases or Noble Gases.

Representative elements

They include:

Group 1: Alkali Metal - form strong alkali with water.

Group 2: Alkaline Earth Metal - form weaker alkali compared to Group 1.

Group 13: Boron Family

Group 14: Carbon Family

Group 15: Nitrogen Family

Group 16: Oxygen Family

Group 17: Halogen Family: they are salt former.

Characteristics

1. They include both metals and non-metals. On moving left to right there is regular gradation in metallic to non-metallic character.
2. They form electrovalent and covalent compounds.
3. On moving down, metallic character increases.
4. Group 1 and Group 2 metals are good conductor of electricity and heat.

Group 16 and Group 17 non-metals are poor conductor of heat and electricity.

6. Heavier metals like tin and lead exhibit variable valency.

Transition elements (d-block elements)

They include Group 3 to Group 12.

Characteristics

1. They have high melting and boiling point.
2. They are good conductor of heat and electricity.
3. Some of them are attracted towards magnet
4. Most of them are catalyst and exhibit variable valency.
5. Most of them form coloured ions or coloured compounds.

Inner Transition elements (f-block elements)

They include elements of sixth and seventh periods of Group 3, i.e Lanthanides and Actinides.

Characteristics

They are heavy metal with high melting and boiling point.

2. They form coloured ions and show variable valencies.

3. Actinides are all radioactive by nature.

Inert Gases or Noble Gases

They include elements of Groups 18.

- They have 8 electrons in their outermost orbit, (except He with 2 electrons)
- They donot react with other elements and are, therefore inert.

Bridge Elements

Elements of second period resemble in properties with elements of next group of third period, leading to a diagonal relationship.

Group →	1	2	13	14
Period 2	Li	Be	B	C
Period 3	Na	Mg	Al	Si

Merit of Modern Periodic Table

1. It is based on atomic number.
2. Position of element in it is related to electronic configuration
3. It shows regular change in properties on moving across period or down group.

Defect of Modern Periodic Table.

1. Position of hydrogen is not satisfactory as it resemble both Group I and Group VII.
2. It fails to accomodate inner transition elements.

General Trend of Modern Periodic Table

Group

1. Number of shells and valence electrons

- Number of shell increase arithmetically.
- Number of shell = Period Number.

Element with atomic numbers.	Number of shells	Electronic Configuration	Period to which it belong.
F (9)	2	2, 7	Second
Cl (17)	3	2, 8, 7	Third
Br (35)	4	2, 8, 18, 7	Fourth
I (53)	5	2, 8, 18, 18, 7	Fifth
At (85)	6	2, 8, 18, 32, 18, 7	Sixth

- On moving down a given group, the number of valence electrons remains the same.

2. Valency

On moving down a group, the number of valence electrons remains the same. Therefore valency in a group is also same.

Note

- Valency refers to the combining capacity of an element. It is always positive
- If the number of valence electrons are 1, 2, 3, or 4, then their valency is 1, 2, 3, 4 respectively.
- If the number of valence electron are 5, 6, 7, then their valency is 8 - no. of valence e⁻.

Properties of Element

Elements in a given group posses similar electronic configuration. Thus, they have similar physical and chemical properties, which changes uniformly down that group.

- Alkali metals are all very reactive. Their reactivity increases down the group.

$$Li < Na < K < Rb < Cs$$

Reactivity Increases.

- Halogens are also very reactive. Their reactivity decreases down the group.

$$F > Cl > Br > I$$

Reactivity Decreases.

4. Atomic Size

On moving down the group, the size of an atom increases. This is due to sucessive addition of shells.

$$Li < Na < K < Rb < Cs$$

Atomic Size Increase

5. Metallic Character:

Metallic character increases as we move down the group. It is because distance between nucleus and outermost electron increases indicating less energy is required to remove outermost electron, making them more metallic.

$$Li < Na < K < Rb < Cs$$

Metallic Character Increases

Periods

1. Number of Shell:

On moving left to right in a given period, number of shell remains the same.

2. Number of electrons in valence shell

Number of electrons in valence shell increases from left to right in a given period.

3. Valency:

On moving across the period, the number of electrons increases. Thus, the valency of the

elements also increases arithmetically from 1 to 4 and back to 1.

4. Size of Atom:

In a period, the size of atom decreases from left to right. This is because effective nuclear charge increases in same period. Thereby, bringing the outermost shell closer to the nucleus.

Li > Be > B > C > N > O > F

5. Properties of elements

Properties of elements in a period differ significantly. Reactivity first decrease upto Group 14 and then increases.

6. Metallic Character

Metallic character decreases on moving across the period. This is because effective nuclear charge increases across a period making it difficult to remove outermost electron.

Study of Specific Groups

1. Group 1 (Alkali Metals)

They include: Lithium (Li), Rubidium (Rb)
Sodium (Na), Caesium (Cs)
Potassium (K), Francium (Fr)

They have 1 electron in their valence shell, therefore show 1 valency.

They react with water to form their hydroxide which are strong alkalies (base soluble in water)

$$2M + 2H_2O \longrightarrow 2MOH + H_2$$

Characterstics

1. They are very reactive and do not occur in free state.
2. They are soft and have low melting and boiling point
3. They form ionic salt except lithium.
4. They react rapidly with oxygen and water vapour.

$$4Na + O_2 \longrightarrow 2Na_2O$$
$$Na_2O + H_2O \longrightarrow 2NaOH$$
$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

Their reactivity increases down the group.

5. They react violently with water and form hydrogen gas.

$$2M + 2H_2O \longrightarrow 2MOH + H_2$$

6. They react violently with dil. HCl and dil H_2SO_4 to form hydrogen gas.

$$2M + 2HCl \longrightarrow 2MCl + H_2$$

7. They form unipositive ions easily

$$M(g) - e^- \longrightarrow M^+(g)$$

They are strong reducing agent

8. They show silvery white metallic lustre when cut.

9. These salt impart colour to the flame.
   Lithium (Crimson Red)
   Sodium (Golden Yellow)
   Potassium (Pale Violet)

10. They are obtained by the electrolysis of their molten salt.

Group 2: Alkaline Earth Metal

They include:
Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba), and Radium (Ra).

Characteristics:

1. They are reactive (less than alkali metals). Hence, do not occur in free state in nature.
2. They are greyish white in colour and harder than the alkali metals.

3. They form ionic compounds except beryllium

4. They are less reactive than alkali metals There reactivity increases on moving down the group.

5. They react with water to produce hydrogen gas.

$$M + 2H_2O \longrightarrow M(OH)_2 + H_2$$

6. They react with dilute acid (HCl, H_2SO_4) to produce hydrogen gas.

$$M + 2HCl \longrightarrow MCl_2 + H_2$$
$$M + H_2SO_4 \longrightarrow MSO_4 + H_2$$

7. They form dipositive ion.

$$M - 2e^- \longrightarrow M^{2+}$$

They are also strong reducing agent.

8. Their melting and boiling point are comparatively low but these are higher than alkali metals.

9. They impart colour to the flame except beryllium and magnesium.

Calcium : Brick Red.

Strontium : Radium : Crimson

Barium : Apple Green.

10. They are obtained by electrolysis of their molten salt.

Group 17 : Halogens

They include :
Fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I), Astatine (As).

Characteristics

1. They have 7 electrons in their valence shell.
2. They are most reactive non-metals. Their reactivity decreases down the group.
3. There is steady increase in MP and BP as we go down the group.
4. Fluorine - Gas
   Bromine - Liquid
   Iodine - Solid
   Astatine - Highly radioactive - (rare)
5. Intensity of colour increases from pale to dark
   Fluorine - Pale yellow gas
   Chlorine - Greenish yellow gas
   Bromine - Reddish Brown Liquid
   Iodine - Violet solid
6. They are all poisonous and have a similar strong odour (pungent and unpleasent)

7. They all form diatomic molecule. (F_2, Cl_2, I_2)
8. Their valency is 1 and they form HX type compounds.
9. They form halides like chloride, bromide, and iodide.
10. They react with metals to form metal halides (salt)
11. They form anion with 1 negative charge.

Group Zero or 18 Group (Noble Gases)

They include: Helium, Neon, Argon, Krypton, Xenon, and Radon.

Characteristics

1. All are colourless, tasteless, odourless gases.
2. They are neither inflammable nor supporter of combustion.
3. They are monoatomic because their electronic configuration is stable.
4. They donot liquify easily.
5. They are slightly soluble in water and on moving from He to Rn solubility increases.
6. They emit coloured light when an electrical discharge is passed through them.

6. Their MP and BP is extremely low. Helium has the lowest melting point and can't be solidify by cooling alone.

7. Their unreactive nature is of great use.
Helium: Airship, and Balloons: Light and unreactive.
Argon: Fill light bulbs: Unreactive at high temperatures.

Uses of Periodic Table

1. Useful in predicting the existance of new elements.
2. Useful in correcting properties of elements.
3. Made study of elements and their compounds systematic and easy to remember.
4. Position of elements revealed:
   a) Atomic Number
   b) Electronic Configuration
   c) Number of valence e^-.
   d) Properties.
5. Predicted nature of chemical bond, formula of compound formed and properties of that compound.
6. Predicted valency of element and its metallic or non-metallic nature.
   Metals: Extreme left and Bottom
   Non-Metals: Extreme Right.