Periodic classification of elements

- Elements are classified on the basis of similarities in their properties. Classification makes the study of elements easier and systematic.

1817: Law of triads (Johann Wolfgang Dobereiner)

- Elements with similar properties were arranged in groups of three in increasing order of atomic masses and it was found that the atomic mass and properties of the middle element were approximately an average of the first and third**.**

  Example:

Triad	Atomic mass
Li	6.9
Na	23.0
K	39.0

Atomic Mass of Na = $\frac{6.9 + 39}{2}$ = 22.95

- **Limitation:**
  1. It failed to arrange all the known elements in the form of triads of elements having similar chemical properties.
  2. Only three triads could be successfully be obtained.(Li, Na, K) (Ca, Sr, Ba) (Cl, Br, I)

1866: Law of Octaves (John Newlands)

- When elements are arranged in increasing order of atomic mass, every eighth element had properties similar to the first element.
- This resembles the notes of music therefore it was called Law of octaves.

Limitation:

1. It was applicable only for lighter elements till Ca.
2. In order to fit the elements into his table, Newlands adjusted two elements in the same slot and kept some unlike elements under the same note. Co and Ni placed in the same slot as F, Cl and Br have entirely different properties. Fe which is similar to Co and Ni is placed in a separate place.
3. All 56 elements discovered at that time could not be arranged in the form of octaves.
4. Newlands assumed that only 56 elements are present in nature. But, when new elements were discovered later, they could not be fit into the table.

1872: Mendeleev's Periodic Table (Dmitri Ivanovich Mendeleev)

- **Mendeleev's Periodic Law** states that physical and chemical properties of elements are the periodic function of their **atomic masses**.
- Mendeleev studied in detail the properties of elements, the formation of their oxides and hydrides, and arranged them in order of increasing atomic masses.

- **Important features of Mendeleev's table**:
  1. He classified all the **63** elements discovered at that time.
  2. There were **8** vertical columns in his table called as **groups**.
     Groups from I to VII were subdivided into A and B.
     VIII group was not subdivided; it had three elements in each period.
  3. There were **6** horizontal rows in his table known as **periods**.

Groups	I	II	III	IV	V	VI	VII	VIII
Oxides Hydrides	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4
Periods ↓	A B	A B	A B	A B	A B	A B	A B	Transition series
1	H 1.008							
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 24.31	Al 29.98	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4 First series:	K 39.102	Ca 40.08	Sc 44.96	Ti 47.90	V 50.94	Cr 50.20	Mn 54.94	Fe 55.85 Co 58.93 Ni 58.71
Second series:	Cu 63.54	Zn 65.37	Ga 69.72	Ge 72.59	As 74.92	Se 78.96	Br 79.909	
5 First series:	Rb 85.47	Sr 87.62	Y 88.91	Zr 91.22	Nb 92.91	Mo 95.94	Tc 99	Ru 101.07 Rh 102.91 Pd 106.4
Second series:	Ag 107.87	Cd 112.40	In 114.82	Sn 118.69	Sb 121.75	Te 127.60	I 126.90	
6 First series:	Cs 132.90	Ba 137.34	La 138.91	Hf 178.49	Ta 180.95	W 183.85		Os 190.2 Ir 192.2 Pt 195.09
Second series:	Au 196.97	Hg 200.59	TI 204.37	Pb 207.19	Bi 208.98			

- **Advantages of Mendeleev's table**:
  1. He could classify all the 63 elements known at that time.
  2. He left gaps for some undiscovered elements in his table and even predicted the properties of these elements which were discovered later and found to have the mentioned properties.

eka-Aluminium	Gallium
eka-Boron	Scandium
eka- Silicon	Germanium

  3. It helped in the correction of atomic masses of some elements on the basis of their position.
  4. When noble gases were discovered later, they were kept in a separate group without disturbing the table.
- **Limitations of Mendeleev's Table:**

  1. No fixed position could be given to hydrogen in Mendeleev's periodic table.
  2. Though most elements were in order of increasing atomic masses there were some cases where the order was not maintained, but similarity in properties was maintained.(Co=58.93 and Ni=58.71)
  3. Atomic masses do not increase in a regular manner therefore number of elements to be discovered between two elements cannot be predicted.
  4. Isotopes were discovered long after and could not find a place in Mendeleev's table (because their masses are different but properties are same).

- **1913: The Modern Periodic Table** (Long Form of the Periodic Table)

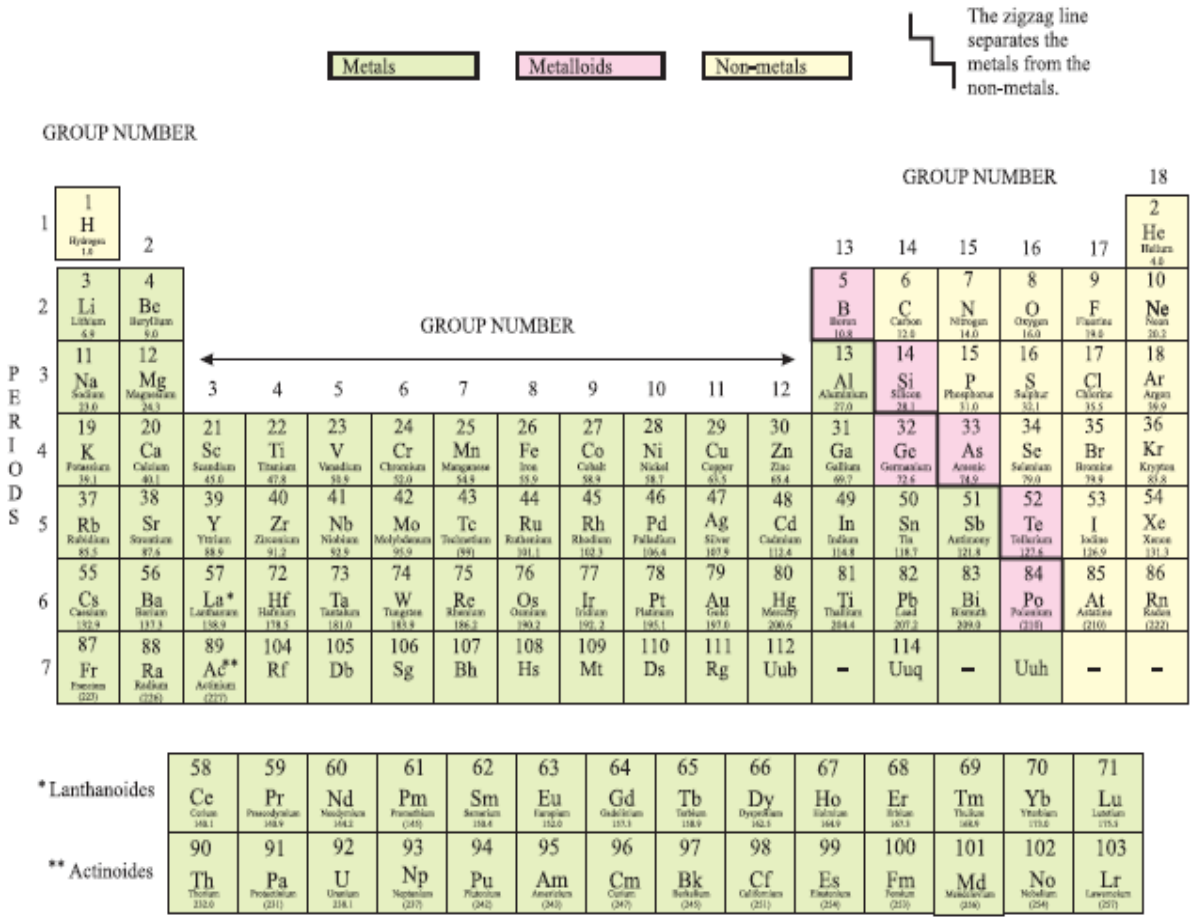
Modern Periodic Law: (Henry Moseley – 1913)

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

Periodicity:

- The periodical repetition of elements with similar properties after certain intervals when the elements are arranged in the order of increasing atomic number (recurrence of elements with similar properties).
- Similar properties of elements are due to their similar outer shell electronic configuration.

The modern periodic table



- Has **18** vertical columns called groups and **7** horizontal rows called periods.

Characteristics of periods

- There are 7 periods.

Period 1	Starting element	Ending element	No: of elements	Remarks
1	H	He	2	Shortest period
2	Li	Ne	8	Short period
3	Na	Ar	8	Short period
4	K	Kr	18	Long period
5	Rb	Xe	18	Long period
6	Cs	Rn	32	Longest (Monster)
7	Fr	….	…	Incomplete period

Eg: Period 3

At. No:	11	12	13	14	15	16	17	18
Element	Na	Mg	Al	Si	P	S	Cl	Ar
Electronic configuration	2, 8, 1	2, 8, 2	2, 8, 3	2, 8, 4	2, 8, 5	2, 8, 6	2, 8, 7	2, 8, 8
No: of shells	3	3	3	3	3	3	3	3
Valence electrons	1	2	3	4	5	6	7	8

Elements belonging to a particular period have different properties. Why?

The elements belonging to a particular period have

1. different electronic configuration
2. different valence electrons.

- The number of shells remains same for the elements of a period.
- The number of shells gives the number of the period to which the element belongs.

Period number = No: of shells

Characteristics of groups

There are 18 groups numbered from 1 to 18.

Eg: group 1

Atomic Number	Element	Electronic configuration	No: of valence electrons
3	Li	2,1	1
11	Na	2,8,1	1
19	K	2,8,8,1	1
37	Rb	2,8,18,8,1	1
55	Cs	2,8,18,18,8,1	1
87	Fr	2,8,18,32,18,8,1	1

- The number of shells increases as we go down the group.
- The outermost shell of each element in a group has the same number of valence electrons i.e. same outer shell electronic configuration.

Group number = Number of valence electrons

Advantages of Modern Periodic table:

1. When elements are arranged in increasing order of atomic numbers, most anomalies of Mendeleev's table were corrected. Position of hydrogen however, still could not be fixed.
2. Isotopes of an element have same number of protons, i.e. same atomic number; hence they can be placed at one position in the periodic table.
3. The anomaly of elements with higher atomic mass before that of lower atomic mass was removed as the modern table was based on increasing atomic numbers.
4. Knowing the atomic number of an element, its position in the periodic table can be determined and its properties can be predicted.
5. The modern periodic table can explain why all the elements in a group have similar properties while the elements in a period have different properties.
6. The modern periodic table can explain the cause of periodicity (due to recurrence of elements with similar outer shell configuration)

Mendeleev's Periodic table	Modern periodic table
Based on Mendeleev's periodic law	Based on Modern periodic law
Elements are arranged in the increasing order of their atomic masses.	Elements are arranged in the increasing order of their atomic numbers.
Has 7 groups and 6 periods	Has 18 groups and 7 periods
Elements having similar properties were placed directly under one another.	Elements having the same valence shell are placed in the same period while elements having the same number of valence electrons are placed in the same group.
No distinguishing position for metals and non-metals.	Metals and non- metals are separated by a zigzag line. Metals are paced to its left and non-metals to its right.

Trends in the modern periodic table

1. Valency:

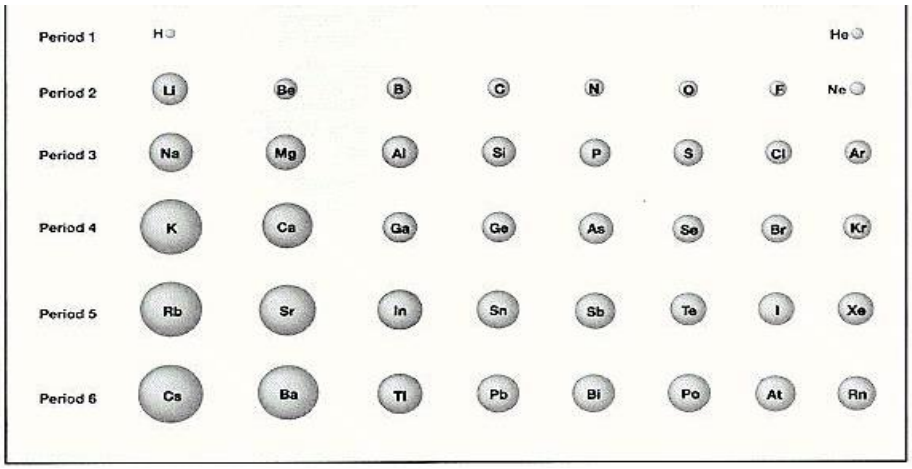
- It is the combining capacity of an element, i.e. the number of electrons an atom can lose, gain or share to form a bond.
- Valency can be determined by the number of electrons in the outermost shell of the atom.

At. No:	11	12	13	14	15	16	17	18
Element	Na	Mg	Al	Si	P	S	Cl	Ar
Electronic configuration	2, 8, 1	2, 8, 2	2, 8, 3	2, 8, 4	2, 8, 5	2, 8, 6	2, 8, 7	2, 8, 8
Valence electrons	1	2	3	4	5	6	7	8
Valency	1	2	3	4	3	2	1	0

- **Variation in a group:**
  Valency of all elements in a group remains the same.
- **Variation in a period**:
  On moving from left to right in a period, valency increases from 1 to 4 and then decreases to 0. Valency is zero for noble gases.

2. Atomic Size:

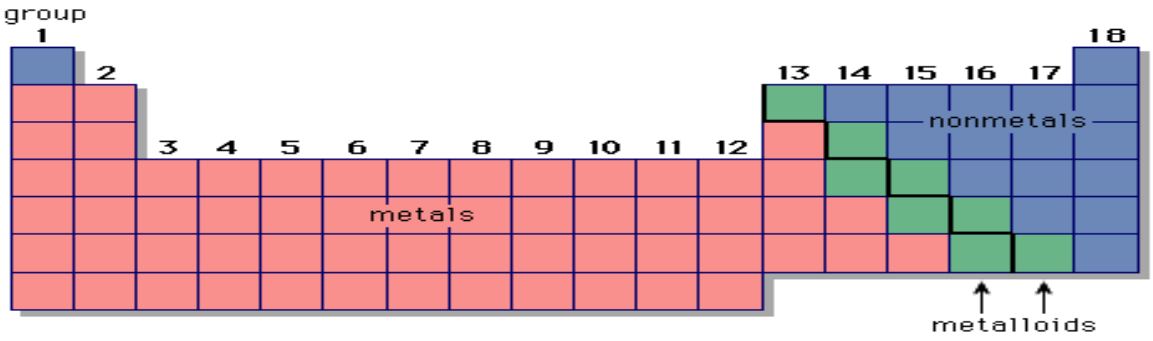
- The term atomic size refers to the radius of an atom.
- **Atomic radius** is the distance between the centre of the nucleus and the outermost shell of an isolated gaseous atom.
- The unit is pm (picometre 1pm = 10^{-12}m).
- The atomic radius of hydrogen atom is 37 pm.



- **Variation of atomic size in a group:**
  Atomic radius increases from top to bottom in a group
  Reason: A new shell is added for each subsequent element down the group. With increase in the number of shells, atomic size of elements will increase down the group.

- **Variation in a period:**
  Atomic radius decreases from left to right along a period
  Reason: The net nuclear charge increases for every next element in a period.
  With an increase in the nuclear charge, the electrons will be pulled closer to the nucleus and the size of the atom gets reduced.

3. Metallic and Non-metallic Properties



- Metals are placed on the left and in the center while nonmetals are on the right side of the periodic table.
- More than 80% of the elements are metals.
- Metals and non-metals are separated by metalloids or semi metals, from Boron to Astatine. The zig-zag line separates metals from non-metals.
- **Metalloids** are borderline elements that have properties intermediate between metals and non-metals.
  eg. B, Si, Ge, As, Sb etc.

Metallic character.

Metals have 1, 2 or 3 valence electrons. They lose the valence electrons to give positive ions. Hence, metals are electropositive in nature.

- Metallic character refers to the tendency to lose electrons.
- **Metallic character decreases along a period**.
  Reason: As the effective nuclear charge increases along a period, the tendency to lose electrons will decrease.
- **Metallic character increases down the group.**
  Reason: Down the group, the effective nuclear charge experienced by the valence electrons decreases due to addition of new shells. Hence, the valence electrons are farther away from the nucleus and can be lost easily.

  - Caesium is the most electropositive element.

Non-metallic character:

Non-metals have 4, 5, 6, 7 or 8 electrons in their outermost shells. So, they share or gain electrons and form negative ions. Hence, non-metals are electronegative in nature.

- Non-metallic character refers to the tendency to gain electrons.

- **Nonmetallic character increases along a period**
  Reason: As the size of the atom decreases along a period, an electron can be gained with greater ease.
- **Nonmetallic character decreases down the group**
  Reason: As the size of the atom increases down the group, the attraction of nucleus on the gained electron is reduced. This decreases the tendency to gain electrons.

  - Flourine is the most electronegative element.

4. Reactivity

- Reactivity refers to how likely or vigorously an atom is to react with other substances. This is usually determined by how easily electrons can be removed and how badly they want to take other atom's electrons (electronegativity). (because it is the transfer/interaction of electrons that is the basis of chemical reactions).
  - Metals and nonmetals each have their own trends.

Metals

Along a period - reactivity decreases as you go from left to right across a period.
Down a group - reactivity increases as you go from top to bottom down a group.
Reason: The farther to the left and down the periodic table, the easier it is for electrons to be given or taken away, resulting in higher reactivity.

Non-metals

Along a period - reactivity increases as you go from left to right across a period.
Down a group - reactivity decreases as you go from top to bottom down a group
Reason: The farther right and up you go on the periodic table, the higher the electronegativity, resulting in a more vigorous exchange of electrons.

Property	Variation along a period	Variation down a group
Valency	Increases from 1 to 4 and then decreases to 0	Remains the same.
Atomic size	Decreases from left to right	Increases from top to bottom
Metallic character (electro positivity)	Decreases	Increases
Non-metallic character (electronegativity)	Increases	Decreases
Reactivity of metals	Decreases	Increases
Reactivity of non-metals	Increases	Decreases

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