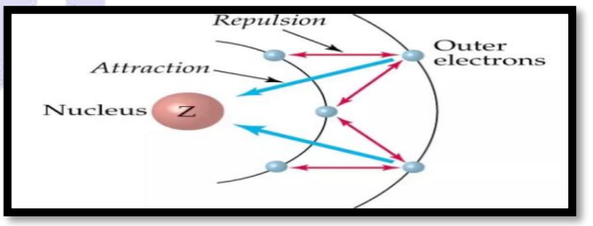
3

Periodic Table and Periodicity in Properties

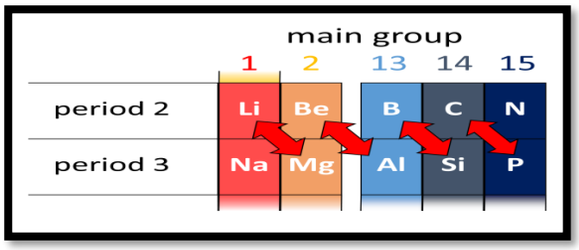
- The first classification of elements was provided by Russian chemist D.I. Mendeleev
- The physical and chemical properties of elements are periodic functions of their atomic weight.
- **Modern Periodic law:** The physical and chemical properties of elements are periodic functions of their atomic numbers. It is the long form of periodic table:

Periods→Horizontal rows
Group→Vertical columns

- The **horizontal rows** on the **periodic table** are called periods. The **periods** are numbered 1 through 7 on the left-hand side of the **table**. Elements that are in the same **period** have chemical properties that are not all that similar.
- **Period:** There are total seven periods 1st period 2 elements 2nd and 3rd period 8 elements 4th and 5th period 18 elements 6th and 7th period period 32 elements.
- The **vertical columns** on the **periodic table** are called groups or families because of their similar chemical behavior. All the members of a family of elements have the same number of valence electrons and similar chemical properties.
- **Group:** There are total eighteen Groups. Groups 1 and 2 's' block elements last electron entered in 's' subshell [s^1, s^2] 3 to 12 'd' block elements last electrons entered in 'd' subshell [d^1 to d^{10}]. 13 to 18 'p' block elements last electrons enter in 'p' subshell [p^1 to p^6]. Group 18 Noble gases.
- **(A)** In 's' and 'p' block elements the electrons enters outer most shell. In 'd' block elements the electron enter the penultimate shell (n-1). 'f' block elements last electron enter the sub penultimate shell (n-2).
- **(B)** 'f' block elements are placed in between 'd' block elements. 'f' block elements in 2 rows [4f lanthanides 5f actinides]
- **(C)** Helium is placed ns^2. But it has Noble gas configuration.
- **General electronic configuration** :
- **Screening effect** is also known as the shielding **effect**. The phenomenon which occurs when the nucleus reduces its force of attraction on the valence electrons due to the presence of electrons in the inner-shell. This is known as a **screening effect**.



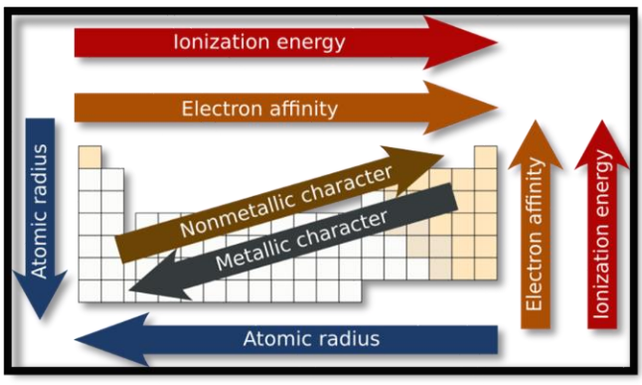
- Effective nuclear charge (Z*) = Nuclear charge Shielding effect
- Trend Left to Right Z* Increases. Top to Bottom Z* Decreases.
- Second period element Show different behavior that I group element due to **(a)** small size **(b)** High electron negativity **(c)** High polarising power **(d)** absence of 'd' orbital in I member. $Na_3[Al(OH)6]$ exists but $Na[B(OH)_4]$ not exists.
- A **diagonal relationship** is said to exist between certain pairs of **diagonally** adjacent elements in the second and third periods of the periodic table. **Diagonal relationships** occur because of the directions in the trends of various properties as you move across or down the periodic table.



- **Elements with outer shell:**

a. **1, 2, 3, e - metals**
b. **4e - metalloids**
c. **5, 6, 7, e - non-metals**
d. **8e - noble gas**

- **Atomic radius:** It is one-half the distance between the nuclei of two atoms
- Atomic radius decreases from left to right within a period. This is caused by the increase in the number of protons and electrons across a period.
- Atomic radius increases from top to bottom within a group. This is caused by electron shielding.
- Noble gases large radius than group 17 due to complete filling of electron in outer shell electron-electron repulsion mildly increases.
- **Ionization energy** is the energy required to remove an electron from a neutral atom in its gaseous phase.
- The ionization energy of the elements within a period generally increases from left to right. This is due to valence shell stability.
- The ionization energy of the elements within a group generally decreases from top to bottom. This is due to electron shielding.
- The noble gases possess very high ionization energies because of their full valence shells as indicated in the graph. Note that helium has the highest ionization energy of all the elements.
- **Metallic behavior**: Decrease from left to right due to increase in ionization enthalpy.
- **Non metallic behavior:** Increase from left to right due to more number of electrons in outershell and added electron goes towards nucleus.
- **Ionic radius**: Cation radius < Atomic radius due to more no. of protons than number of electron columbic force increases size decreases. [Mg^{2+} < Mg^{+1} < Mg]
- Anion radius > Atomic radius due to more number of electron than number of protons. [N^{3-} > O^{2-} > F^{-}] Electron-Electron repulsion increases, coloumbic force of attraction decreases.
- For Isoelectronic species more is the charge of cation lesser in the size.
- **Electronegativity**: It can be understood as a chemical property describing an atom's ability to attract and bind with electrons.
- From left to right across a period of elements, electro negativity increases.
- From top to bottom down a group, electro negativity decreases.
- Important exceptions of the above rules include the noble gases, lanthanides, and actinides.
- **Electron Affinity**: As the name suggests, electron affinity is the ability of an atom to accept an electron.
- Electron affinity increases from left to right within a period. This is caused by the decrease in atomic radius.
- Electron affinity decreases from top to bottom within a group. This is caused by the increase in atomic radius.



Check Yourself

1. Both elements of 1st period contain valence electrons in

(A) M shell **(B)** N shell

(C) K shell **(D)** S shell

2. In the periodic table, helium is placed at

(A) Top left corner

(B) Bottom right corner

(C) Bottom left corner

(D) Top right corner

3. Across the period the atomic size decreases due to

(A) Shielding effect

(B) Photoelectric effect

(C) Increase in nuclear force of attraction

(D) Decrease in nuclear force of attraction

4. The first three periods are

(A) Long periods **(B)** Short periods

(C) Moderate periods **(D)** all of above

5. On basis of electronic configuration the group and period of $_5B^9$ is

(A) 2 and IIIA **(B)** 3 and IIA

(C) 4 and VIA **(D)** 5 and VIIA

Stretch Yourself

1. What physical and chemical properties of elements were used by Mendeleev in creating his periodic table? List two observations which posed a challenge to Mendeleev's Periodic Law.

2. Lithium, sodium and potassium form a Dobereiner's triad. The atomic masses of lithium and potassium are 7 and 39 respectively. Predict the atomic mass of sodium.

3. Give reason, why was the system of classification of elements into triads not found suitable?

4. (a) What is meant by periodicity in properties of elements with reference to the periodic table?

(b) Why do all the elements of the same group have similar properties?

(c) How will the tendency to gain electrons change as we go from left to right across a period? Why?

5. What are 'groups' and 'periods' in the 'periodic table'?

Test Yourself

Q. Draw all the atomic models given in your textbook and compare which one is the correct explanation for the atomic structure.

Also discuss the Drawbacks of some atomic models.

Answers

Check Yourself

Answer: 1(C); 2(D); 3(C); 4(B); 5(A)

Stretch Yourself

1. The physical property used was the atomic mass of an element. The chemical property used was the nature of oxide and hydride formed (i.e. similarity in chemical properties were used by Mendeleev). The two observations that posed challenge in Mendeleev Periodic Law were:

(i) Arranging elements according to the increasing order of atomic mass could not be maintained. Chemical properties do not depend on atomic mass.

(ii) Isotopes were not given any place in the table as they have different atomic mass but same chemical properties.

2. Hint: Li=7, K=39 Atomic mass of Na = 7+39/2= 46/2=23

3. It is because all the elements discovered at that time could not be classified into triads.

4. (a) The repetition of same properties after definite interval is called periodicity in properties.

(b) All elements in group have same number of valence electrons.

(c) Tendency to gain electrons increases from left to right in the period because the atomic size goes on decreasing and nuclear charge increases, which can attract the nearby electron.

5. The columns of the periodic table are called groups. Members of the same group in the table have the same number of electrons in the outermost shells of their atoms and form bonds of the same type. The horizontal rows are called periods.