

PERIODIC TABLE & PERIODICITY OF PROPERTIES

CONCEPTUAL LINKAGE

Before reading this chapter, the student must know the,

- Symbols of Elements
- Characteristics of sub atomic particles

TIME ALLOCATION

Teaching periods = 12
Assessment periods = 03
Weightage = 11%

LEARNING OUTCOMES

After reading this chapter, the Student will be able to:

- Distinguish between a period and a group in the periodic table. (Understanding)
- State the Periodic law. (Remembering)
- Classify the Elements. (Analyzing)
- Determine the demarcation of the Periodic table into s-block and p-block. (Remembering)
- Explain the shape of the Periodic table. (Analyzing)
- Determine the location of the families in the Periodic table. (Understanding)
- Recognize the similarity in the chemical and physical properties of the Elements in the same family of elements. (Understanding)
- Identify the relationship between electronic configuration and the position of an element on the periodic table. (Analyzing)
- Explain how shielding effect influences periodic trends. (Applying)
- Describe how electronegativities change within a group and within a period in the periodic table. (Analyzing)

3.0 Introduction to classification of Elements

As already discussed that Chemistry deals with the study of matter or the elements, so far 118 elements have been discovered, if they are studied separately it would be a difficult job for any one so there is a need of classifying such a huge number of elements. As the number of discovered elements increased, the need to classify them also increased, because it became more difficult to remember the characteristics of the elements individually.

The early classifications were full of errors, but with the passage of time, the more précised classifications were presented by various scientists. Dobriener a German scientist in 1820 classified the elements into triads (a classification where each group has 3 members). Afterward an English Scientist Newland in 1865 presented the concept of classifying the elements based on law of octaves. A very important classification was presented by a Russian Chemist Mendeleev in 1869 which was based upon the atomic masses of the elements.

And after the discovery of protons, the classification based upon the number of protons built up, which finally resulted in a comprehensive periodic table called the Modern periodic table.

This classification made very easy the understanding and remembering the properties of elements, and also various predictions regarding the physical and chemical properties of these elements are now possible with very accurate results.

3.1 The Periodic Table

With the discovery of protons a new era of classification of elements started, and scientists observed that if elements are arranged in increasing



Dmitri Ivanovich
Mendeleev (Russian)
(1834-1907)

order of number of their protons (or simply their atomic numbers) all the discrepancies in classification can be removed.

Hence the modern periodic law originated stating that the properties of elements are periodic functions of their atomic numbers.

Thus all the known elements are put in the table in the increasing order of atomic number in the manner that elements with similar properties come in the same column.

In the modern periodic table the columns are called groups, and the rows are called periods. There are 18 groups and 7 periods in this periodic table (previous classification had 8 groups). Thus in the new era the periodic table has the set up shown in figure 3.1.

3.1.1 Periods in Periodic Table

A period is a horizontal row in the periodic table of the elements. In the periodic table, there are 7 periods.

In the periodic table the number of period shows actually the numbers of shell in that particular row of elements, it means the elements in the period-1 have just one shell, and the elements in 2nd period have two shells, and so on. The first period which contains only two elements (H and He) is the smallest one, 2nd and 3rd periods have 8 elements each and 4th and 5th periods have 18 elements, the 6th period contains 32 elements and is the longest one, 7th period is incomplete one and new elements discovered are being added in this period. From the 6th and 7th periods two rows are withdrawn and are written below the others, because their properties are remarkably similar with each other. These series are termed as "Lanthanides" and "Actinides" series.

3.1.2 Groups in Periodic Table

As mentioned earlier there are eighteen (18) groups in the modern periodic table (in previous classification there were 8 main groups), a group is also known as family.

The groups are named by the numbers beginning from 1 to 18. These groups are shown with all member in the figure 3.1. Some of the group are

1		18																VIIA	
IA																			
1		2																2	
H		He																He	
Hydrogen		Helium																Helium	
3		4																5	
Li		Be																B	
Lithium		Beryllium																Boron	
11		12																13	
Na		Mg																Al	
Sodium		Magnesium																Aluminium	
19		20																21	
K		Ca																Sc	
Potassium		Calcium																Scandium	
37		38																39	
Rb		Sr																Y	
Rubidium		Strontium																Yttrium	
57-71		72																73	
Lanthanides		Hf																Ta	
89-103		104																105	
		Rf																Db	
		Rutherfordium																Dubnium	

also known by their specific names e.g., group '1' is called alkali metals, group '2' is alkaline earth metals, group '16' is called chalcogens, group '17' is called halogens and group '18' is called noble gases.

Some groups are also represented by the head element of their group e.g., group '13' as boron family, group '14' as carbon family, group '15' nitrogen family and group '16' as oxygen family.

In a group the members show many same properties like same last electronic configuration, same valencies and same type of chemical characters.

Group	Family Name
1	Alkali Metals
2	Alkaline Earth Metals
13	Boron Family
14	Carbon Family
15	Nitrogen Family or chalcogens
16	Oxygen Family
17	Halogens
18	Noble Gases

Table: 3.1: Some groups with their family name

Interesting Information

In the older fashion the names of the groups are written in Roman letters, and in new fashion the groups are written English numbers.

Activity: 3.1

Point out the similarities in the members of Group-17 (The halogens) of the periodic table.

3.1.3 Blocks in Periodic Table

The name of blocks depends upon the outermost electronic arrangement of the element and is very important in determining the chemical properties of the element.

The periodic table has been divided four blocks, i.e. s-block, p-block, d-block and f-block, which are shown separately in the following figure 3.2.

1 IA 1 H	2 IIA 4 Be	s - block p - block										d - block f - block										13 IIIA 5 B	14 IVA 6 C	15 VA 7 N	16 VIA 8 O	17 VIIA 9 F	18 VIIIA 2 He
3 Li	4 Be	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB			9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA 13 Al	14 IVA 14 Si	15 VA 15 P	16 VIA 16 S	17 VIIA 17 Cl	18 VIIIA 18 Ar								
11 Na	12 Mg	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	37 Rb	38 Sr								
19 K	20 Ca	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	55 Cs	56 Ba								
37 Rb	38 Sr	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	87 Fr	88 Ra								
		89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og	119 Uut	120 Uuq								

Figure 3.2 Blocks in the modern Periodic table

3.2 Periodicity of Properties

A great advantage of the periodic table is the **periodicity**, i.e. the elements show a gradual increase or decrease in physical and chemical properties, e.g. in atomic radius, ionization energy, electron affinity, and electronegativity, oxides etc.

We will discuss now some of the important of these properties individually in a little detail:

3.2.1 Atomic Size

Atomic size or more properly atomic radius is half of the distance between the nuclei of a diatomic molecule, as shown in figure 3.3.

Although in order to determine the size of an atom the distance between the last electron and nucleus should be in focus but due to fast movement of electrons the exact position of electron is difficult to identify and so for clear reference the distance between to nuclei of a homo nuclear is taken as standard and half of this distance gives the exact of atomic size e.g. for size of 'H' atom 'H₂' is taken.

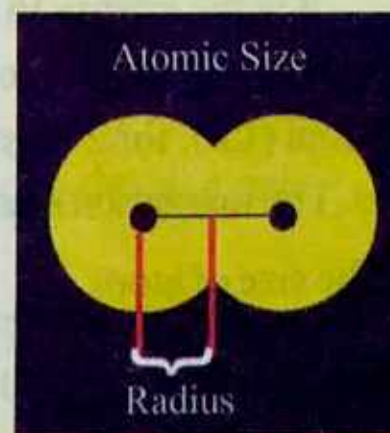
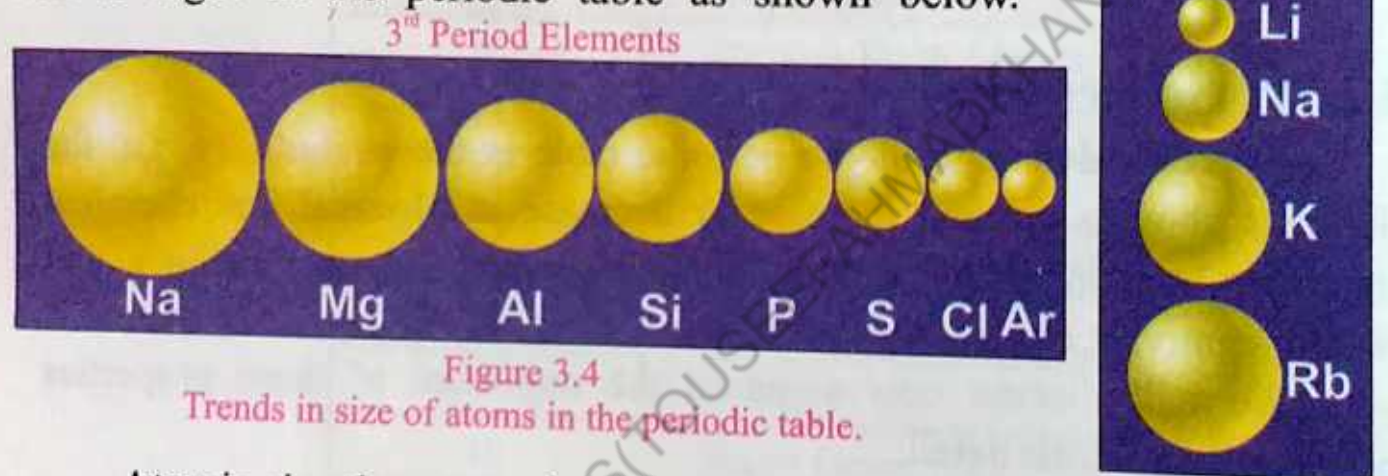


Figure: 3.3:
The Atomic size

The Atomic radius is influenced by 3 main factors:

- Energy level → Higher the energy level greater will be the size.
- Nuclear charge → more is the nuclear charge in a periods lesser will be the size.
- Shielding effect → greater is the shielding effect of electrons i.e. the repulsion between the electrons, higher will be the size.

The Atomic radius increases down a group due to increase in energy level, and decrease along a period from left to right in the periodic table as shown below.



Atomic size decreases along a period, which is due to increase in the nuclear charge, while in a period all atoms have same energy level.

3.2.2 Ionization Potential / Energy

It is the energy to remove the least bonded last electron from an atom. The energy required to remove the last electron is called 1st ionization potential (I.P), for 2nd last electron it is called 2nd ionization potential (I.P) and so on. The ionization energy depends upon:

- The size of atom ⇒ Greater the size less will be the ionization potential.
- The nuclear charge ⇒ higher is the nuclear greater; more will be the ionization potential.
- The Shielding effect ⇒ the electrons in the outermost energy level experience more inter electron

repulsion (shielding), so greater shielding less will be the ionization potential.

- The filled and half filled $\Rightarrow$ filled and half filled orbitals have higher ionization energy, so achieving them is easier.

In the periodic table, the ionization potential decreases down the group because the electron is farther from nucleus and also there is more shielding. Along a period the ionization energy increases because, although all the atoms in a period have same energy level and same shielding but the nuclear charge increases so I.P increases. (Exceptions for filled and half filled sub shells occur). Full energy levels require lot of energy to remove their electrons, so noble gases have very high ionization potentials. The arrows show (Figure 3.5) the total trend changes among elements in the periodic table.

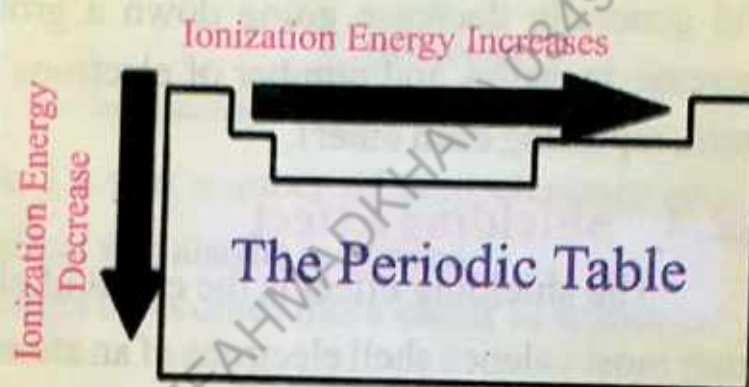


Figure 3.5: Trends in ionization energy of atoms in periodic table.

3.2.3 Electron Affinity (E_{ea})

The electron affinity is the energy change when an electron is added to a gaseous atom. Generally, the element liberates energy when electron is added to them:



The value of energy released greatly depends upon the size and nuclear charge of that element.

Thus the atoms whose anions are relatively more stable than neutral atoms have a smaller E_{ea} . e.g. Chlorine most strongly attracts extra electrons, and its anion is more stable as compared to mercury, which most weakly attracts an extra electron.

E_{ea} of noble gases are close to 0.

E_{ea} generally increases across a period (row) since the radius slightly decreases, because of the increased attraction from the nucleus, and the number of electrons in the top shell increases (helping the atom reach maximum stability) in the periodic table and generally decrease going down a group (family) (because of a large increase in radius and number of electrons that decrease the stability of the atom, repulsing each other).

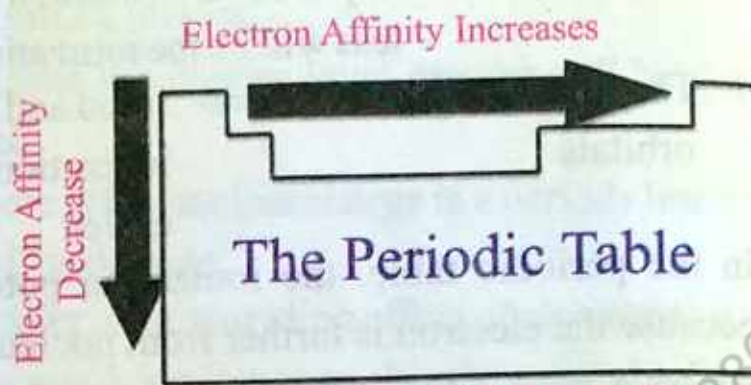


Figure 3.6: Trend of electron affinity in periodic table

3.2.4 Shielding Effect

The shielding effect is the effect of electrons between the nucleus and outer most valence shell electrons of an atom.

This shielding effect causes the inner electrons to block the outer electrons from the nuclear charge of the nucleus so it becomes easier for the valence electrons to be removed. The shielding effect increases down the group in the periodic table, but across a period it remains unchanged. This is further elaborated in the following figure 3.7 and figure 3.8.

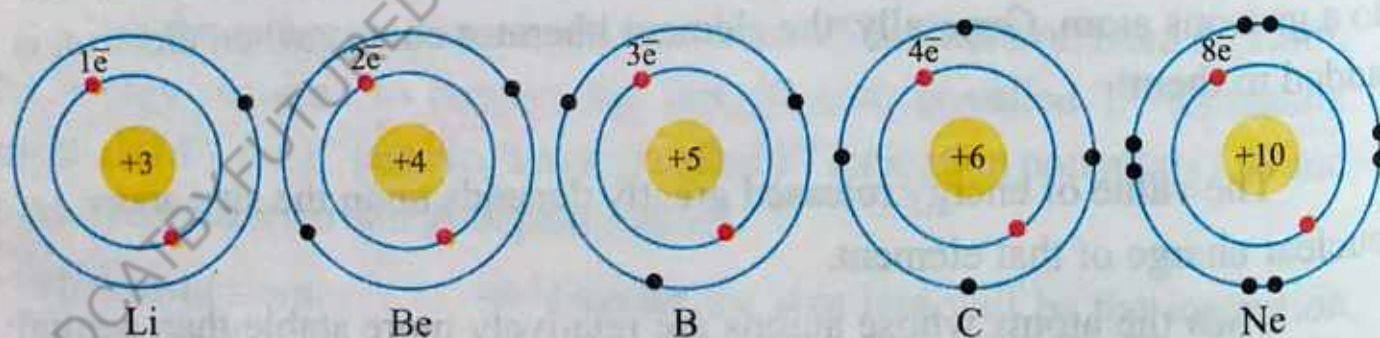


Figure 3.7: Shielding across period 2

• = Core Electron • = Valence Shell Electron

It can be seen that in the above figure all atoms have same number of core electron (2), so their effect will also be same.

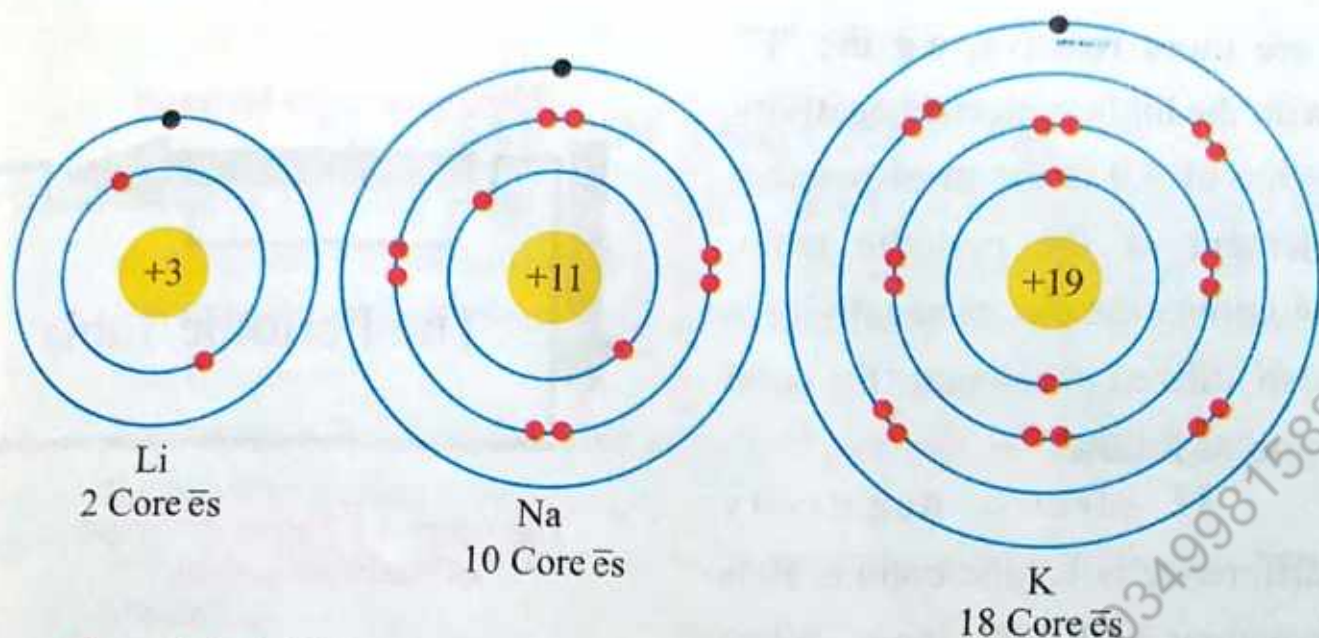


Figure 3.8: Shielding in group 1 ● = Core Electron • = Valence Shell Electron

It can be seen here in figure 3.8 that number of core electrons are increasing down the group, so their effect will also be increased.

Due to increase in shielding effect it becomes more easier to withdraw the valence shell electrons.

3.2.5 Electronegativity

The term electronegativity is defined as the ability of an atom to attract shared electron pair of bond in a compound. The electronegativity of an element is the net effect of electron affinity and first ionization potential.

Electronegativity is the property of non metals because non metals have lower size and more nuclear charge, so they attract the shared electron pair, this ability of attracting electron pair decreases as the size increases down the groups.

In the periodic table, electronegativity values decreases down the group and increases along the period.

Thus 'F' has the greatest electro negativity value of 4.0 and 'Cs' has lower value of '0.7'.

The electronegative values are very often used in prediction of reactivity and the bond type. The elements with high electronegativity value

called the **electron affinity**.

- ❖ The electron affinity increases along a period from left to right and decreases down a group.
- ❖ The inner electron produce a shield around nucleus, and make it easy for the valence shell electron to be removed, this effect is called the **Shielding effect**.
- ❖ The shielding effect increases down a group and decreases along a period.
- ❖ The tendency of an atom to attract shared electron pair is termed as the **Electronegativity** of that atom.
- ❖ The electronegativity increases along a period and decreases down a group.

EXERCISE

Q1. Fill in the blanks with suitable words.

- i) Triads were proposed by
- ii) Mendeleev in classified the all known Elements into groups, and is regarded as of modern periodic table.
- iii) Modern Periodic table has groups and periods.
- iv) A period is a of elements in the periodic table.
- v) Halogen constitutes the group of periodic table.
- vi) The concept of electronegativity was given by
- vii) Smaller atoms have ionization energy.
- viii) d-block elements are also known as
- ix) The size of atoms in the periods from left to right.
- x) Noble gases constitute the group of periodic table.

Q2. Choose the correct answer.

- i) In a group the elements have almost same
 - (a) Physical characters
 - (b) Chemical characters
 - (c) Both physical and chemical characters

- (d) Neither physical nor chemical
- ii) Group 1 members are generally known as:
(a) Alkali metals (b) Alkaline earth metals
(c) transition metals (d) noble gases
- iii) At ordinary temperature and pressure, Hydrogen exists as:
(a) liquid (b) gas (c) solid (d) plasma
- iv) Periodicity is seen in the periodic table in:
(a) groups (b) periods
(c) both in groups and periods
(d) Neither in group nor in period
- v) The atomic size increases in:
(a) group (b) period (c) in both of above (d) none of above

Q3. Answer the following questions in short.

- i) How Dobriener classified elements? Why his classification did not received popularity?
- ii) What is the resemblance between Newland's classification elements and Music?
- iii) Why in the history of periodic table the name of Mandeleev is so important?
- iv) Describe the importance of groups in periodic table.
- v) How many periods are there in Modern periodic table?
- vi) What are Alkali metals?
- vii) Discuss importance of Noble gases.
- viii) What do you understand by the term "blocks of periodic table"?
What types of blocks are there in modern periodic table?
- ix) What is ionization energy? How it varies across modern periodic table?
- x) Define periodicity of elements in modern periodic table.

Q4. Answer the following questions with reasoning.

- i) What is the relation between electronic configuration and the positioning of element in period table?

- ii) How atomic size is related with the nuclear charge?
- iii) How electron affinity varies in periodic table?
- iv) How electronegativity is important for chemists?
- v) Discuss inertness of noble gases.

- Q5. Why it is necessary to classify the elements? Explain with reasoning.
- Q6. Discuss the importance of groups and periods in the modern periodic table?
- Q7. What do you understand by periodicity of properties? Explain with examples.
- Q8. Write a brief note on evolution of periodic table?
- Q9. What is modern periodic law? Explain with examples.
- Q10. What do you know about the blocks of the modern periodic table?