

Chemistry Lectures (SSC) Part – I

9th Class CHEMISTRY

CH # 3 Periodic Table & Periodicity of properties

Introduction,

Historical background of periodic table

Dobereiner's Triads, Newlands Octaves, Mendeleev's Periodic Table

Modern Periodic Law, Modern Periodic Table

&

Periodicity of Properties e.g.
Atomic radii, I. E, E. A
E. N & Shielding Effect



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(Subject Specialist M. Phil Chemistry)



Notes

Introduction

What is Periodic table?

In 19th century, chemists devoted much of their efforts in attempts to arrange elements in a systematic manner.

These efforts resulted in discovery of periodic law.

On the basis of this law, the elements known at that time, were arranged in the form of a table which is known as periodic table.

One of the significant features of the table was that it predicted the properties of those elements which were not even discovered at that time.

The vertical columns of that table were called groups and horizontal lines (rows) were called periods.

That orderly arrangement of elements generally coincided with their increasing atomic number.

The periodic table contains huge amount of information for scientists.

PERIODIC TABLE

With the discovery of the periodic table the study of individual properties of the known elements is reduced to study of few groups & periods.

We will describe various attempts which were made to classify the elements into a tabular form.

Dobereiner's Triads



Johann Wolfgang Döbereiner was a German chemist who is best known for work that foreshadowed the periodic law for the chemical elements, and for inventing the first lighter, which was known as the Döbereiner's lamp.

A German chemist Dobereiner (1829) observed relationship between atomic masses of several groups of three elements called triads.

In these groups, the central or middle element had atomic mass average of the other two elements.

Dobereiner's Triads

Elements and their Atomic Mass

Average (Mean) Atomic Mass

Group 1

Lithium (Li)	Sodium (Na)	Potassium (K)
7.0	23.0	39.0

$$\frac{7.0 + 39.0}{2} = 23.0$$

Group 2

Calcium (Ca)	Strontium (Sr)	Barium (Ba)
40.0	88.0	137.0

$$\frac{40.0 + 137.0}{2} = 88.5$$

In Group 1 triad
The atomic mass of Sodium is the average of the atomic masses of Lithium and Potassium.

In Group 2 triad
The atomic mass of Strontium is the average of the atomic masses of Calcium and Barium.

Reasons of failure

1. Only a few elements could be arranged in this way.
2. This classification did not get wide acceptance.



Newlands Octaves

After successful determination of correct atomic masses of elements by Cannizzaro in 1860, attempts were again initiated to organize elements.

In 1864 British chemist Newlands put forward his observations in the form of 'law of octaves'.

He noted that there was a repetition in chemical properties of every eighth element if they were arranged by their increasing atomic masses.

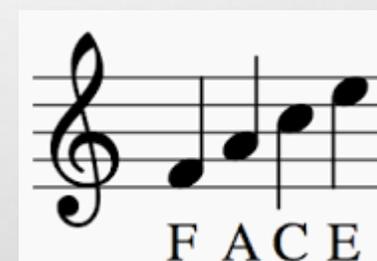
John Alexander Reina Newlands
(26 November 1837 – 29 July 1898)

was a British chemist who worked concerning the periodicity of elements.

He compared it with musical notes.

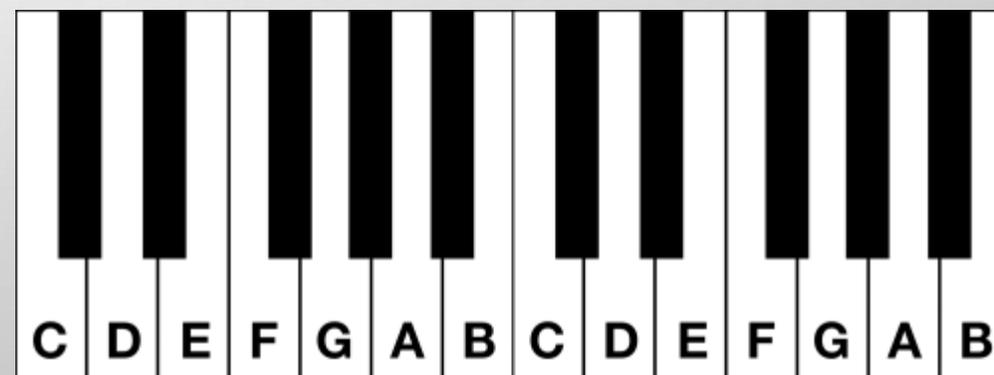
Music notes are named after the first Seven letters of the alphabet: A, B, C, D, E, F, G.

Newlands Octaves						
H	Li	Ga	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca				



Reasons of failure

1. His work could not get much recognition as no space was left for undiscovered element.
2. The noble gases were also not known at that time.



Piano Keyboard

Mendeleev's Periodic Table

Russian chemist, Dimitri Mendeleev arranged the known elements (only 63) in order of increasing atomic masses, in horizontal rows called periods.

So that elements with similar properties were in the same vertical columns called groups.

This arrangement of elements was called Periodic Table.

He put forward the results of his work in the form of periodic law, which is stated as

"properties of the elements are periodic functions of their atomic masses"

Although, Mendeleev periodic table was the first ever attempt to arrange the elements, yet it has a few demerits in it.

His failure to explain the position of isotopes and wrong order of the atomic masses of some elements suggested that atomic mass of an element cannot serve as the basis for the arrangement of elements.

Mendeleev's Periodic Table (1869)

I	II	III	IV	V	VI	VII	VIII
H 1.01							
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0	
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5	
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9	Co 58.9
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127	Rh 103
Ce 133	Ba 137	La 139		Ta 181	W 184		Pd 106
Au 197	Hg 201	Tl 204	Pb 207	Bi 209			Os 194
			Th 232		U 238		Ir 192
							Pt 195

Mendeleev's Periodic Table

Mendeleev (1834-1907) was a Russian chemist and inventor. He was the creator of first version of periodic table of elements. With help of the table, he predicted the properties of elements yet to be discovered.



Modern Periodic Law

In 1913 Henry Moseley discovered a new property of the elements i.e. atomic number.

He observed that atomic number instead of atomic mass should determine the position of element in the periodic table and accordingly the periodic law was amended as

"properties of the elements are periodic function of their atomic numbers".

Atomic number of an element is equal to

the number of electrons in a neutral atom / number of protons in the nucleus of an atom OR simple ions

So atomic number provides the basis of electronic configurations as well.



Do you know?

Atomic number is a more fundamental property than atomic mass because atomic number of every element is fixed and it increases regularly by 1 from element to element. No two elements can have the same atomic number.

Test yourself 3.1

i. What was the contribution of Dobereiner towards classification of elements?

Ans: Dobereiner observed relationship between atomic masses of several groups of three elements called triads.

ii. How Newlands arranged the elements?

Ans: British chemist Newlands arranged elements in the form of 'law of octaves'.

He noted that there was a repetition in chemical properties of every eighth element if they were arranged by their increasing atomic masses.

iii. Who introduced the name Periodic Table ?

Ans: Dimitri Mendeleev introduced the name Periodic Table

iv. Why the improvement in Mendeleev's periodic table was made?

Ans: Because Mendeleev's Periodic table was based on the atomic masses which proved to be an unreliable basis to classify elements

v. State Mendeleev's periodic law.

Ans: Mendeleev's periodic law states

"properties of the elements are periodic functions of their atomic masses"

vi. Why and how elements are arranged in a period?

Ans: Atoms are arranged horizontally across a period by the order of increasing atomic numbers because it increases regularly.

Modern Periodic Table

Atomic number of an element is more fundamental property than atomic mass in two respects,

(a) It increases regularly from element to element, (b) It is fixed for every element.

So the discovery of atomic number of an element in 1913

led to change in Mendeleev's periodic law which was based on atomic mass.

The modern periodic table is based upon the arrangement of elements according to increasing atomic number.

When the elements are arranged according to increasing atomic number from left to right in a horizontal row,

properties of elements were found repeating after regular intervals such that

elements of similar properties and similar configuration are placed in the same group.

It was observed that after every eighth element, ninth element had similar properties to the first element.

For example, sodium ($Z=11$) had similar properties to lithium ($Z=3$).

After atomic number 18, every nineteenth element was showing similar behaviour.

So the long rows of elements were cut into rows of eight and eighteen elements

and placed one above the other so that a table of vertical and horizontal rows was obtained.

Long form of Periodic Table

The significance of atomic number

in the arrangement of elements in the modern periodic table lies in the fact that as electronic configuration is based upon atomic number,

so the arrangement of elements according to increasing atomic number shows the periodicity (repetition of properties after regular intervals)

in the electronic configuration of the elements that leads to periodicity in their properties.

Hence, the arrangement of elements based on their electronic configuration

created a long form of periodic table as shown in figure 3.1.

See Text Book Page # 48

About Periods?

The horizontal rows of elements in the periodic table are called periods.

The elements in a period have continuously increasing atomic number

i.e. continuously changing electronic configuration along a period.

As a result properties of elements in a period are continuously changing.

The number of valence electrons decides the position of an element in a period. , For example, elements which have 1 electron in their valence shell occupies the left most position in the respective periods such as alkali metals. Similarly, the elements having 8 electrons in their valence shells

such as noble gases always occupy the right most position in the respective periods.

About Groups?

The vertical columns in the periodic table are called groups.

These groups are numbered from left to right as 1 to 18.

The elements in a group do not have continuously increasing atomic numbers.

Rather the atomic numbers of elements in a group increase with irregular gaps.

But the elements of a group have similar electronic configuration

i.e. same number of electrons are present in their valence shells.

For example, the first group elements have only 1 electron in their valence shells.

Similarly, group 2 elements have 2 electrons in their valence shells.

It is the reason due to which elements of a group have similar chemical properties.

Salient Features of Long Form of Periodic Table:

- i. This table consists of seven horizontal rows called periods.
 - ii. First period consists of only two elements.
Second and third periods consist of 8 elements each.
Fourth and fifth periods consist of 18 elements each.
Sixth period has 32 elements while seventh period has 23 elements and is incomplete.
 - iii. Elements of a period show different properties.
 - iv. There are 18 vertical columns in the periodic table numbered 1 to 18 from left to right, which are called groups.
 - v. The elements of a group show similar chemical properties.
 - vi. Elements are classified into four blocks depending upon the type of the subshell which gets the last electron.

Fig. 3.1 Modern Periodic Table or long form of the Periodic Table of Elements.

About Blocks?

[See Text Book page # 48](#)

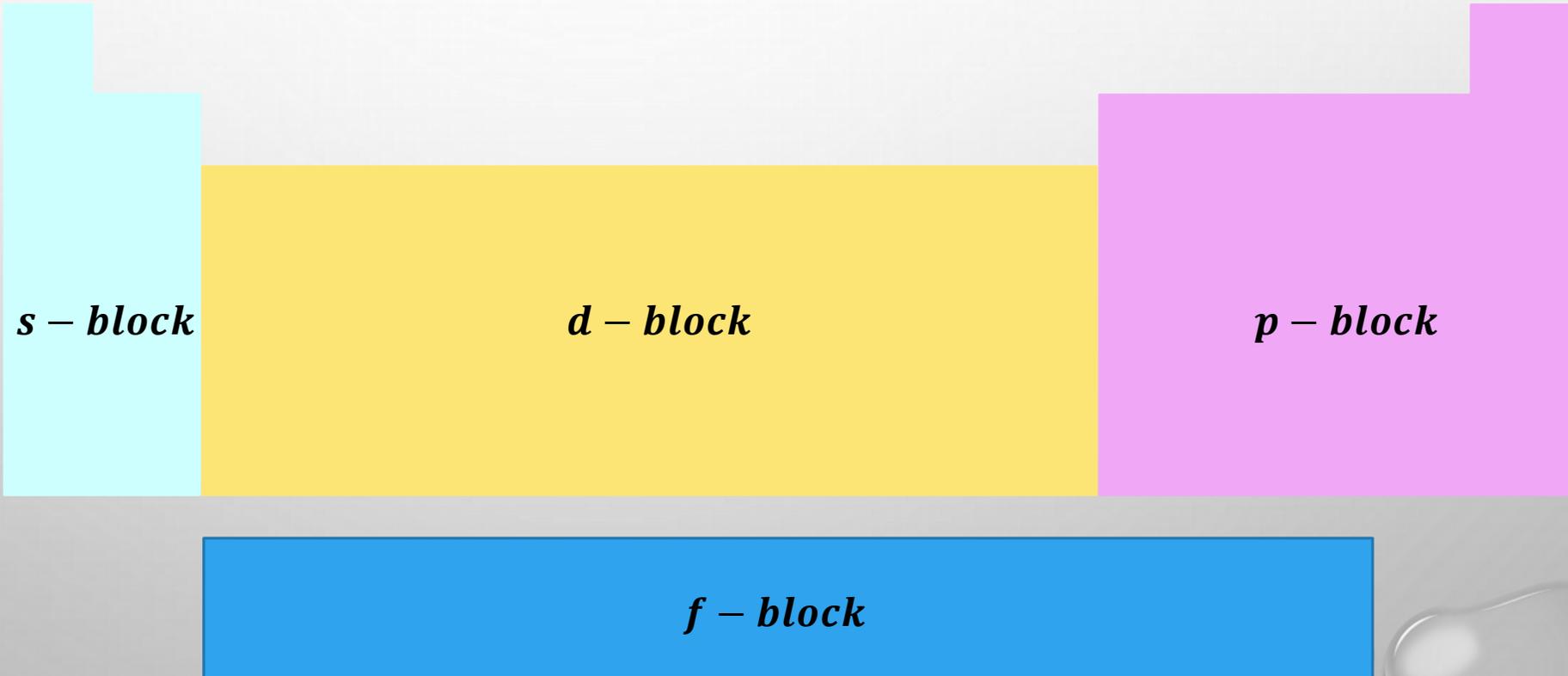
On the basis of completion of a particular subshell,

elements with similar subshell electronic configuration are referred as a block of elements.

There are four blocks in the periodic table

named after the name of the subshell which is in the process of completion by the electrons.

These are *s*, *p*, *d* and *f* blocks as shown in figure 3.2.



s – block

d – block

p – block

f – block

For example, elements of group 1 and 2 have valence electrons in 's' subshell.

Therefore, they are called **s-block elements** as shown in figure 3.2.

Elements of group 13 to 18 have their valence electrons in subshell.

Therefore, they are referred as **p-block elements**. as shown in figure 3.2.

The **d-block** lies between the s and p blocks. d-block constitutes period 4,5 and 6.

While **f-block** lies separately at the bottom.

Each period consists of ten groups starting from group 3 to group 12.

These are called **transition metals**



Do you know?

Alchemy! For thousand years alchemy remained field of interest for the scientists. They worked with two main objectives; change common metals into gold and second find cure to diseases and give eternal life to people. They believed all kinds of matter were same combination of four basic elements. Substances are different because these elements combine differently. Changing composition or ratio of any one element, new substances can be formed. The way of making gold from silver or lead was never found and secret of eternal life was never discovered. However, many methods and techniques invented by alchemists are still used in chemistry.

Periods : First period is called short period. It consists of only two elements, hydrogen and helium.
Second and third periods are called normal periods. Each of them has eight elements in it.
Second period consists of lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine and ends at neon, a noble gas.
Fourth and fifth periods are called long periods.
Each one of them consists of eighteen elements.
Whereas, sixth and seventh periods are called very long periods.
In these periods after atomic number 57 and 89, two series of fourteen elements each, were accommodated.

Because of space problem, these two series were placed separately below the normal periodic table to keep it in a manageable and presentable form.

Since the two series start after Lanthanum ($Z=57$) and Actinium ($Z=89$), so these two series of elements are named as Lanthanides and Actinides respectively.

Table 3.1 shows the distribution of elements in periods.

All the periods except the first period start with an alkali metal and end at a noble gas.

It is to be observed that number of elements in a period is fixed because of maximum number of electrons which can be accommodated in the particular valence shell of the elements.

Table 3.1 Different Periods of the Periodic Table

Period No.	Name of the Period	Number of elements	Range of atomic numbers	
1 st	Short period	2	1 to 2	
2 nd		8	3 to 10	
3 rd	Normal period	8	11 to 18	
4 th		Long period	18	19 to 36
5 th			18	37 to 54
6 th	Very Long Period	32	55 to 86	
7 th		[32]*	87 to 118*	

*Since new elements are expected to be discovered, it is an incomplete period

Groups 1

Group 1 consists of hydrogen, lithium, sodium, potassium, rubidium, cesium and francium.

Although elements of a group do not have continuously increasing atomic numbers, yet they have similar electronic configuration in their valence shells.

That is the reason elements of a group are also called a family.

For example, all the group 1 elements have one electron in their valence shells, they are given the family name of alkali metals.

The groups 1 and 2 and 13 to 17 contain the normal elements.

In the normal elements, all the inner shells are completely filled with electrons, only the outermost shells are incomplete.

For example, group 17 elements (halogens) have 7 electrons in their valence (outermost) shell.

The groups 3 to 12 are called transition elements. In these elements 'd' sub-shell is in the process of completion. Table 3.2 shows the distribution of elements in groups.

Table 3.2 Different Groups of the Periodic Table

Valence electrons	Group number	Family name	General Electronic configuration
1 electron	1	Alkali metals	ns^1
2 electrons	2	Alkaline earth Metals	ns^2
3 electrons	13	Boron family	$ns^2 np^1$
4 electrons	14	Carbon family	$ns^2 np^2$
5 electrons	15	Nitrogen family	$ns^2 np^3$
6 electrons	16	Oxygen family	$ns^2 np^4$
7 electrons	17	Halogen family	$ns^2 np^5$
8 electrons	18	Noble gases	$ns^2 np^6$



Do you know?

Alchemy! For thousand years alchemy remained field of interest for the scientists. They worked with two main objectives; change common metals into gold and second find cure to diseases and give eternal life to people. They believed all kinds of matter were same combination of four basic elements. Substances are different because these elements combine differently. Changing composition or ratio of any one element, new substances can be formed. The way of making gold from silver or lead was never found and secret of eternal life was never discovered. However, many methods and techniques invented by alchemists are still used in chemistry.



Test yourself?
3.2

- i. How the properties of elements repeat after regular intervals?
- ii. In which pattern modern periodic table was arranged?
- iii. How many elements are in first period and what are their names and symbols?
- iv. How many elements are placed in 4th period?
- v. From which element lanthanide series starts?
- vi. From which period actinides series starts?
- vii. How many elements are in 3rd period, write their names and symbols?
- viii. How many periods are considered normal periods ?
- ix. What do you mean by a group in a periodic table?
- x. What is the reason of arranging elements in a group?
- xi. What do you mean by periodic function?
- xii. Why the elements are called s or p block elements?
- xiii. Write down the names of elements of group 1 with their symbols?
- xiv. How many members are in group 17, is there any liquid, what is its name ?

Answers

Test yourself? 3.2

i. How the properties of elements repeat after regular intervals?

Answer: If the elements are arranged in the order of their atomic numbers from left to right in a horizontal row, their properties repeat after regular intervals. Elements having similar properties repeated at regular intervals. Elements with similar properties and similar electronic configuration are placed in a similar group.

ii. In which pattern modern periodic table was arranged?

Answer: The ascending order of atomic number is the pattern on which modern periodic table was arranged. This arrangement of elements shows the periodicity (repetition of properties after intervals) in their electronic configuration.

iii. How many elements are in first period and what are their names and symbols?

Answer: there are two elements in the first period of the modern periodic table

1. Hydrogen (**H**)

2. Helium (**He**)

iv. How many elements are placed in 4th period?

Answer: In the 4th period **18** elements are placed

v. From which element lanthanide series starts?

Answer: The Lanthanide series starts from Cerium (**Ce**)

vi. From which period actinides series starts?

Answer: The actinide series starts from 7th period

vii. From which period lanthanide series starts?

Answer: The lanthanide series starts from 6th period

viii. How many elements are in 3rd period, write their names and symbols?

Answer: There are 8 elements in the 3rd period:

1. Sodium (**Na**)
2. Magnesium (**Mg**)
3. Aluminium (**Al**)
4. Silicon (**Si**)
5. Phosphorus (**P**)
6. Sulphur (**S**)
7. Chlorine (**Cl**)
8. Argon (**Ar**)

ix. How many periods are considered normal periods ?

Answer: " 2nd and 3rd period are considered normal periods. Each having 8 elements

x. What do you mean by a group in a periodic table?

Answer: "A vertical column of elements in the periodic table is called a group"

xi. What is the reason of arranging elements in a group?

Answer: This is because they have similar electronic configuration in their valence shells

xii. What do you mean by periodic function?

Answer: A function which repeats elements having similar positions in the periodic table to have similar properties is called periodic function

xiii. Why the elements are called s or p block elements?

Answer: The elements in which last electron enters the "s" subshell are called s-block elements and the elements which have the last electrons in the "p" subshell are called p-block elements.

xiv. Write down the names of elements of group 1 with their symbols?

Answer:

- | | | | |
|--------------|------|-------------|------|
| 1. Hydrogen | (H) | 5. Rubidium | (Rb) |
| 2. Lithium | (Li) | 6. Cesium | (Cs) |
| 3. Sodium | (Na) | 7. Francium | (Fr) |
| 4. Potassium | (K) | | |

3.2.1 Atomic Size and Atomic Radius

As we know that atoms are very small and don't have defined boundaries that fix their size.

So it is difficult to measure the size of an atom.

Therefore, the common method to determine the size of an atom is to assume that atoms are spheres.

When they lie close to each other, they touch each other.

Half of the distance between the nuclei of the two bonded atoms is referred as the atomic radius of the atom.

For example, the distance between the nuclei of two carbon atoms in its elemental form is 154 pm,

its means its half 77 pm is radius of carbon atom as shown in Figure 3.3:

When we move from left to right in a period although atomic number increases, yet the size of atoms decreases gradually. It is because with the increase of atomic number, the effective nuclear charge increases gradually because of addition of more and more protons in the nucleus.

But on the other hand addition of electrons takes place in the same valence shell i.e. shells do not increase.

There is gradual increase of effective nuclear charge which increases due to addition of protons.

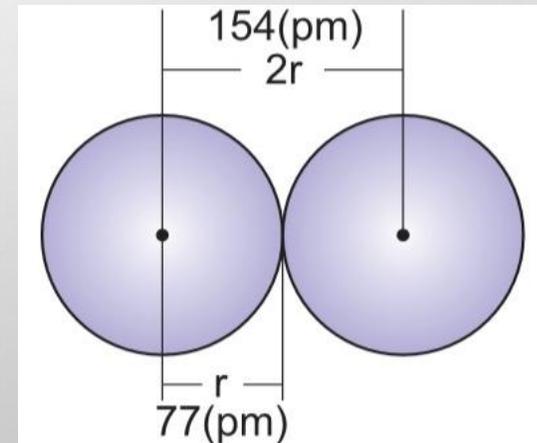


Fig. 3.3 The radius of carbon atom.

This force pulls down or contracts the outermost shell towards the nucleus.

For example, atomic size in period 2 decreases from Li (152 pm) to Ne (69 pm).

2 nd period elements	³ Li	⁴ Be	⁵ B	⁶ C	⁷ N	⁸ O	⁹ F	¹⁰ Ne
Atomic radii (pm)	152	113	88	77	75	73	71	69

1 st group elements	Atomic radii (pm)
--------------------------------	-------------------

³ Li	152
-----------------	-----

¹¹ Na	186
------------------	-----

¹⁹ K	227
-----------------	-----

³⁷ Rb	248
------------------	-----

⁵⁵ Cs	265
------------------	-----

The size of atoms or their radii increases from top to bottom in a group. It is because a new shell of electrons is added up in the successive period, which decreases the effective nuclear charge.

The trend of atomic size of transition elements has slight variation when we consider this series in a period.

atomic size of the elements first reduces or atom contracts and then there is increase in it when we move from left to right in 4th period.

Shielding Effect

The electrons present between the nucleus and the outer most shell of an atom, reduce the nuclear charge felt by the electrons present in the outer most shell.

The attractions of outer electrons towards nucleus is partially reduced because of presence of inner electrons.

As a result valance electron experiences less nuclear charge than that of the actual charge, which is called effective nuclear charge (Z). It means that the eff electrons present in the inner shells screen or shield the force of attraction of nucleus felt by the valance shell electrons. This is called shielding effect.

With increase of atomic number, the number of electrons in an atom also increases, that results in increase of shielding effect.

The shielding effect increases down the group in the periodic table as shown in the figure 3.4. Because of this it is easy to take away electron from Potassium ($Z=19$) than from Sodium ($Z=11$) atoms.

Similarly the shielding effect decreases in a period if we move from left to right.

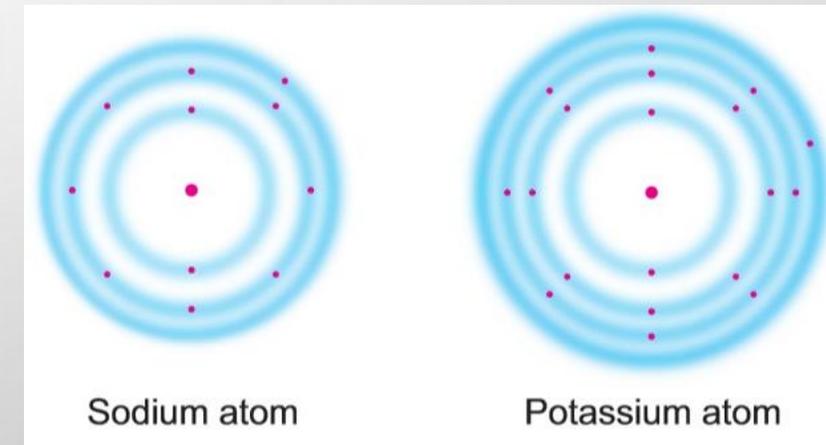


Fig. 3.4: Shielding effect is more in potassium atom than that of sodium atom.

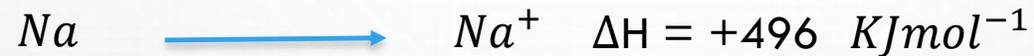
Ionization Energy

The ionization energy is the amount of energy required to remove the most loosely bound electron from the valence shell of an isolated gaseous atom.

of energy needed to remove successive electrons present in an atom increases.

only 1 electron in the valence shell, the energy required to remove it will be called first ionization energy.

For example, the first ionization energy of sodium atom is $+ 496 \text{ KJmol}^{-1}$.



But when there are more than one electrons in the valence shell, they can be removed one by one by providing more and more energy.

Such as group 2 and 3 elements have more than one electrons in their shells. Therefore, they will have more than one ionization energy values.

If we move from left to right in a period, the value of ionization energy increases.

It is because the size of atoms reduces and valence electrons are held strongly by the electrostatic force of nucleus.

Therefore, elements on left side of the periodic table have low ionization energies as compared to those on right side of the periodic table as shown for the 2 period.



Ionization energy increasing in a period

2 nd period elements	³ Li	⁴ Be	⁵ B	⁶ C	⁷ N	⁸ O	⁹ F	¹⁰ Ne
Ionization Energy <i>KJmol⁻¹</i>	520	899	801	1086	1402	1314	1681	2081

As we move down the group more and more shells lie between the valence shell and the nucleus of the atom,

these additional shells reduce the electrostatic force felt by the electrons present in the outermost shell.

Resultantly the valence shell electrons can be taken away easily.

Therefore, ionization energy of elements decreases from top to bottom in a group.

1 st Group Elements	Ionization Energy <i>KJmol⁻¹</i>
³ Li	520
¹¹ Na	496
¹⁹ K	419
³⁷ Rb	403
⁵⁵ Cs	377



Ionization energy decreasing in a group

As we move down the group more and more shells lie between the valence shell and the nucleus of the atom, these additional shells reduce the electrostatic force felt by the electrons present in the outermost shell.

Resultantly the valence shell electrons can be taken away easily. Therefore, ionization energy of elements decreases from top to bottom in a group.

Electron Affinity

Electron Affinity is defined as the amount of energy released when an electron is added in the outermost shell of an isolated gaseous atom.

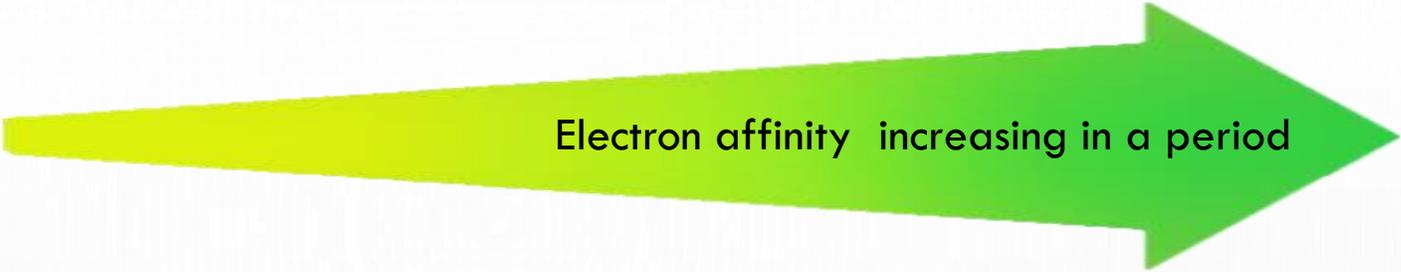


Affinity means attraction. Therefore, electron affinity means tendency of an atom to accept an electron to form an anion.

For example, the electron affinity of fluorine is -328 kJ mol^{-1} i.e. one mole atom of fluorine release 328 kJ of energy to form one mole of fluoride ions.

Let us discuss the trend of electron affinity in the periodic table. Electron affinity values increase from left to right in the period.

2 nd period elements	³ Li	³ Be	⁵ B	⁶ C	⁷ N	⁸ O	⁹ F	¹⁰ Ne
Electron affinity (KJmol^{-1})	-60	>0	-29	-122	0	-141	-328	0



Electron affinity increasing in a period

The reason for this increase is, as the size of atoms decreases in a period, the attraction of the nucleus for the incoming electron increases.

That means more is attraction for the electron, more energy will be released.

In a group electron affinity values decrease from top to bottom because the size of atoms increases down the group.

With the increase in size of atom shielding effect increases that results in poor attraction for the incoming electron i.e. less energy is released out.

For example, as the size of iodine atom is bigger than chlorine, its electron affinity is less than iodine, as given in the adjacent table.

17 th group elements	Electron affinity (kJmol^{-1})
${}^9\text{F}$	-328
${}^{17}\text{Cl}$	-349
${}^{35}\text{Br}$	-325
${}^{53}\text{I}$	-295



Electron affinity decreasing in a group

Electronegativity

The ability of an atom to attract the shared pair of electrons towards itself in a molecule, is called electronegativity.

It is an important property especially when covalent type of bonding of elements is under consideration. The trend of electronegativity is same as of ionization energy and electron affinity.

It increases in a period from left to right because higher Z shortens distance eff from the nucleus of the shared pair of electrons.

This enhances the power to attract the shared pair of electrons. For example, electronegativity values of group 2 are as follow:

2 nd period elements	³ Li	⁴ Be	⁵ B	⁶ C	⁷ N	⁸ O	⁹ F
Electronegativity	1.0	1.6	2.0	2.6	3.0	3.4	4.0

Electronegativity increasing in a period

Electronegativity decreasing in a group

It generally decreases down a group because size of the atom increases. .

Thus attraction for the shared pair of electrons weakens. For example, electronegativity values of group 17 (halogens) are presented here.

17 th group elements	electro negativity
⁹ F	4.0
¹⁷ Cl	3.2
³⁵ Br	3.0
⁵³ I	2.7

i. Define atomic radius? ii. What are SI units of atomic radius? iii. Why the size of atoms decreases in a period? iv. Define ionization energy. v. Why the 2nd ionization energy of an element is higher than first one? vi. What is the trend of ionization energy in a group? vii. Why the ionization energy of sodium is less than that of magnesium? viii. Why is it difficult to remove an electron from halogens? ix. What is shielding effect? x. How does shielding effect decrease the forces of electrostatic attractions between nucleus and outer most electrons? xi. Why does the bigger size atoms have more shielding effect? xii. Why does the trend of electron affinity and electronegativity is same in a period? xiii. Which element has the highest electronegativity?



Test your self
3.3

Answers *Test yourself? 3.3*

i. Define atomic radius?

Answer: The half of the distance between the nuclei of the two bonded atoms is called the atomic radius of the atom .

ii. What are SI units of atomic radius?

Answer: The SI units of atomic radius are nanometer and picometer

$$1 \text{ nm} = 10^{-9} \text{ m} ; 1 \text{ pm} = 10^{-12} \text{ m}$$

iii. Why the size of atoms decreases in a period?

Answer: It is because with the increase of atomic number , the effective nuclear charge increases gradually with the Addition of more and more protons in the nucleus . This force pulls down and contracts the outermost shell towards the nucleus

iv. Define ionization energy.

Answer:

"The amount of energy required to remove the most loosely bonded electron from the valence shell of an isolated gaseous atom is called ionization energy."

v. Why the 2nd ionization energy of an elements is higher than first one?

Answer: The 2nd ionization energy is higher because after the removal of an electron from an atom, the number of electron decreases , so nuclear charge becomes dominant and the remaining electrons are attracted more strongly towards the nucleus. Thus more energy is required to knock out other electron. That is why the 2nd ionization energy value

of an element is higher than first one. e.g. $Mg_{(g)} \rightarrow Mg_{(g)}^{+} + 1e^{-}$ $I.E_1 = +738KJmol^{-1}$



vi. What is the trend of ionization energy in a group?

Answer: The ionization energy of elements decreases from top to bottom in a group.

vii. Why the ionization energy of sodium is less than that of magnesium?

Answer: The it is because of the following three reasons

1. Higher atomic size of Na than Mg
2. Lower nuclear charge (Na=11) than Mg(Mg=12)
3. Less stable configuration than Mg

Viii. Why is it difficult to remove an electron from halogens?

Answer: It is due to;

1. Decrease in atomic size
2. Increase in nuclear charge

ix. What is shielding effect?

Answer: The effect of decrease in forces of attraction between the nucleus and valence electrons due to the increase in inner shells or inner shell electrons between them is called shielding effect

x. How does shielding effect decrease the forces of electrostatic attractions between nucleus and outermost electrons?

Answer: The shielding effect decreases the forces of electrostatic attractions between nucleus and outermost electrons by partially cancelling or blocking the nuclear attraction for outermost electrons.

xi. Why do the bigger sized atoms have more shielding effect?

Answer: The bigger sized atoms have a greater number of inner shell electrons and thus, have more shielding effect.

Xii Why does the trend of electron affinity and electronegativity is same in a period?

Answer: The electron affinity and the electronegativity increase on moving from left to right in a period. This is because of the increase in nuclear charge and decrease in atomic size this increases the force of attraction between the nucleus and the valence electrons. As a result, the atom has greater tendency to gain additional electron from the outside the nuclear charge increases from left to right while electrons enter the same shell.

The increased nuclear charge attracts the shared pair of electrons more strongly. This results in higher electronegativity.

xiii. Which element has the highest electronegativity?

Answer: Fluorine has the highest electronegativity (4.0).

Multiple Choice Questions

Put a (✓) on the correct answer

1. The atomic radii of the elements in Periodic Table:

- (a) increase from left to right in a period
(b) increase from top to bottom in a group
(c) do not change from left to right in a period
(d) decrease from top to bottom in a group

2. The amount of energy given out when an electron is added to an atom is called:

- (a) lattice energy (b) ionization energy (c) electronegativity (d) electron affinity

3. Mendeleev Periodic Table was based upon the:

- (a) electronic configuration (b) atomic mass (c) atomic number (d) completion of a subshell

4. Long form of Periodic Table is constructed on the basis of:

- (a) Mendeleev Postulate (b) atomic number (c) atomic mass (d) mass number

5. 4th and 5th periods of the long form of Periodic Table are called:

- (a) short periods (b) normal periods (c) long periods (d) very long periods

6. Which one of the following halogen has lowest electronegativity? (a) fluorine (b) chlorine (c) bromine (d) iodine ✓

7. Along the period, which one of the following decreases:

✓ (a) atomic radius (b) ionization energy (c) electron affinity (d) electronegativity

8. Transition elements are: (a) all gases (b) all metals ✓ (c) all non-metals (d) all metalloids

9. Mark the incorrect statement about ionization energy:

(a) it is measured in kJmol^{-1} (b) it is absorption of energy ✓ (c) it decreases in a period (d) it decreases in a group

10. Point out the incorrect statement about electron affinity:

(a) it is measured in kJmol^{-1} (b) it involves release of energy ✓ (c) it decreases in a period (d) it decreases in a group



Short answer questions.

1. Why are noble gases not reactive?
 2. Why Cesium (at. no.55) requires little energy to release its one electron present in the outermost shell?
 3. How is periodicity of properties dependent upon number of protons in an atom?
 4. Why shielding effect of electrons makes cation formation easy?
 5. What is the difference between Mendeleev's periodic law and modern periodic law?
 6. What do you mean by groups and periods in the Periodic Table?
 7. Why and how are elements arranged in 4 period?
 8. Why the size of atom does not decrease regularly in a period?
 9. Give the trend of ionization energy in a period.
- 

Short Questions (Exercise)

1. Why are noble gases not reactive?

Answer: The Noble gases do not have valence electrons in their outer shells that's why they are not reactive.

2. Why Cesium (at. no.55) requires little energy to release its one electron present in the outermost shell?

Answer: this is because the force of attraction between the nucleus and outermost electron is decreased due to the atomic size

3. How is periodicity of properties dependent upon number of protons in an atom?

Answer: It depends upon the number of protons in an atom they vary when we move left to right across a period or from top to bottom in any group

4. Why shielding effect of electrons makes cation formation easy?

Answer: The greater the shielding effect, the greater the chances of atoms losing electrons and forming cations. This is due to decrease of nuclear charge on outermost electrons. Low ionization energy with more shielding effect makes the cation formation easy

6. What is the difference between Mendeleev's periodic law and modern periodic law?

Answer:

Mendeleev's periodic law	Modern periodic law
1. based on atomic masses	1. Based on atomic number
2."properties of the elements are periodic functions of their atomic masses"	2."properties of the elements are periodic functions of their atomic numbers"

7. What do you mean by groups and periods in the Periodic Table?

Answer: Groups;

Vertical columns of elements in a periodic table are called groups.

periods;

horizontal rows of elements in a periodic table are called periods.

8. Why and how are elements arranged in 4th period

Answer: The number of elements in 4th period is equal to the number of electrons required to fill the 4th shell. The maximum Number of electrons which can be accommodated in 4th shell is 18. thus 4th period contains 18 elements.

9. Why the size of atom does not decrease regularly in a period

Answer: The size of atoms does not increase regularly in a period because of the poor shielding effect.

10. Give the trend of ionization energy in a period

Answer: The ionization energy increases from left to right in a period

The image features a light gray background with a subtle gradient. In the top-left and bottom-right corners, there are several realistic water droplets of various sizes, rendered with soft shadows and highlights to give them a three-dimensional appearance. The text 'THE END' is centered in the middle of the frame.

THE END