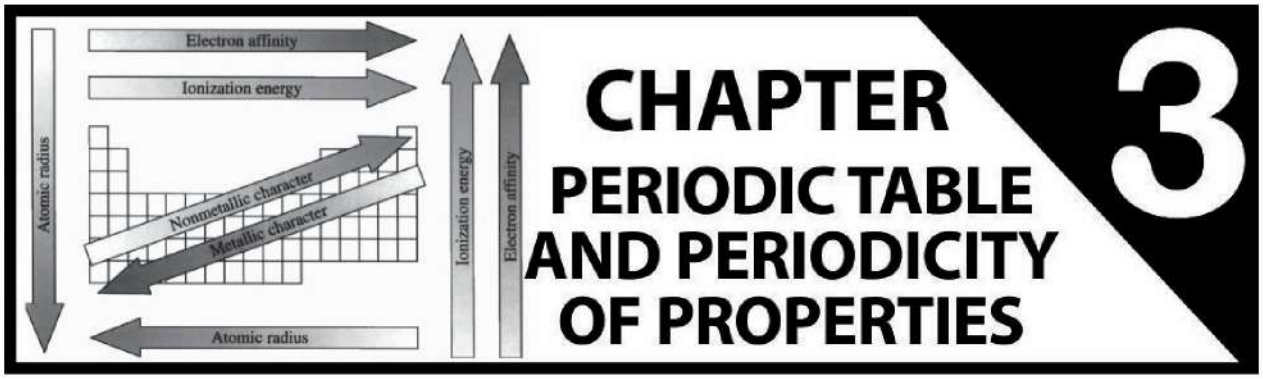

CHAPTER 3
PERIODIC TABLE AND PERIODICITY OF PROPERTIES

SUBJECTIVE PART

LONG QUESTION ANSWERS

Q.1 Describe Dobereiner's triads with the help of an example.

Ans: Dobereiner's Triads

Introduction:

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

Law of triads:

"In a triad the central or middle element had atomic mass average of the other two elements."

Example:

One triad group example is that of calcium (40), strontium (88) and barium (137). The atomic mass of strontium is the average of the atomic masses of calcium and barium.

Drawbacks:

i. Only a few elements could be arranged in this way.

ii. This classification did not get wide acceptance.

Cannizzaro:

He successfully determined the correct atomic masses of elements in 1860.

Q.2 Write a note on Newlands octaves.

Ans: Newlands Octaves

Introduction:

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

Statement

"According to law of Octaves there was a repetition in chemical properties of every eighth element if they were arranged by their increasing atomic masses."

He compared it with musical notes.

Drawbacks

i. His work could not get much recognition as no space was considered for undiscovered elements.

ii. The noble gases were also not known at that time.

Q.3 Explain the contributions of Mendeleev for the arrangement of elements in his periodic table.

Ans: Mendeleev's Periodic Table

Introduction:

A Russian chemist, 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. This arrangement of elements was called Periodic Table.

Mendeleev's Periodic law,

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

Demerits of Mendeleev's periodic table:

i. It did not explain the position of isotopes.

ii. 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.

Q.4 What is modern periodic law and modern periodic table?

Ans: Modern Periodic Law

Introduction:

In 1913 H. 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 elements in the periodic table

Periodic Law:

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

Note:

Atomic number of an element is equal to the number of electrons in neutral atom. So atomic number provides the basis of electronic configuration as well.

Q.5 Modern periodic table is based upon atomic number and periodicity?

Ans: Modern Periodic Table:

"A table obtained by arrangement of elements into groups and periods in increasing order of their atomic number is called modern periodic table."

Atomic number of an element is more fundamental property than atomic mass

i. It increases regularly from element to element.

ii. 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.

Basis of Modern Periodic Table:

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.

Example:

Sodium (Z=l1) 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.

Q.6 Why and how elements are arranged in the periodic table?

OR

What is the significance of atomic number in modern periodic table?

Ans: Long form of periodic table:

Long form of the periodic table was first proposed by a Danish chemist Tulius Thomson in 1895. It is also known as Bohr's periodic table. It was developed by Rang modified by Warner and extended by Bury. The periodic table is arranged in 7 horizontal rows called periods and 18 vertical columns called groups.

The significance of atomic number

The significance of atomic number in the arrangement of elements in the modem 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

Periods:

Definition

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

The first element of each period is an alkali metal while the last element is noble gas.

Properties:

i. The elements in a period have continuously increasing atomic number i.e. continuously changing electronic configuration along a period.

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

iii. The number of valence electrons decides the position of an element in a period.

Examples:

i. Elements which have 1 electron in their valence shell occupies the left most position in the respective periods, such as alkali metals.

ii. Similarly the elements having 8 electrons in their valence shells such as noble gases always occupy the right most position in the respective periods.

Groups:

The vertical columns of elements in the periodic table are called groups.

Properties:

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

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

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

iv. But the elements of a group have similar electronic configuration i.e. same number of electrons are present in the valence shell.

Examples:

i. The first group elements have only 1 electron in their valence shells.

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

Note:

It is the reason elements of a group have similar properties.

Q.7 Discuss the important features of Long Form of Periodic Table.

Salient Features of Long Form of Periodic Table

The salient features of long form of periodic table are as follows:

Periods:

i. This table consists of seven horizontal rows called periods

ii. First period consists of only two elements. Second and third period consist of 8 elements each. Fourth and fifth period consist of 18 elements each. Sixth period has 32 elements while seventh period has 32 elements and is incomplete.

iii. Elements of a period show different properties.

Groups:

i. There are 18 vertical columns in the periodic table numbered 1 to 18 from left to right, which are called groups.

ii. The elements of a group show similar properties.

Blocks:

i. Elements are classified into four blocks depending upon the type of the sub- shell which gets the last electron.

Modern Periodic Table

Light metals | Heavy metals | Non-metals | Nobel gases

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.0079	2																2 He 4.00
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 15.99	9 F 18.99	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.08	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.09	20 Ca 40.08	21 Sc 44.95	22 Ti 47.87	23 V 50.94	24 Cr 51.99	25 Mn 54.94	26 Fe 55.84	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.90	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 97.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
6	55 Cs 132.90	56 Ba 137.33	*	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po 208.98	85 At 209.99	86 Rn 222.02
7	87 Fr 223.02	88 Ra 226.02	**	104 **Rf** 261.11	105 **Db** 262.11	106 **Sg** 263.12	107 **Bh** 262.12	108 **Hs** 265	109 **Mt** 266.14	110 **Ds** 269	111 **Rg** 272	112 **Uub** 277	113 **Uut** 284	114 **Uuq** 289	115 **Uun** 288	116 **Uuh** 292	117 **Uus** 293	118 **Uuo** 294
* Lanthanides			57 La 138.90	58 Ce 140.11	59 Pr 140.91	60 Nd 144.24	61 Pm 144.91	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.5	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97	
** Actinides			89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu 244.66	95 Am 243.06	96 Cm 247.07	97 Bk 247.07	98 Cf 251.08	99 Es 252.08	100 Fm 257.10	101 Md 258.10	102 No 259.10	103 Lr 262.11	

Key:

Colour of box of elements			Colour of symbol of elements		
Metals		Yellow	**Black**	=	Solid
Non-metals		Blue	**Blue**	=	Liquid
Metalloids		Green	**Red**	=	Gas
Nobel Gases		Pink	**Purple**	=	Synthetic

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

Q.8 What do you mean by blocks in the periodic table and why elements were placed in blocks?

Blocks of elements:

On the basis of completion of a particular sub shell, elements with similar sub shell electronic configuration are referred as a block of elements.

Types of blocks:

i. There are four blocks in the periodic table named after the name of the sub shell which is in the process of completion by the electrons.

ii. These are s, p, d and f blocks in the periodic table.

a. s-block:

The elements in which valence electrons are present in the s-subshell are called s-block elements."

"Elements of group l and 2 have valence electrons in 's' subshell. Therefore, they are

called s-block elements."

b. p-block:

The elements in which valence electrons are present in the p-subshell are called p-block elements."

"Elements of group 13 to 18 have their valence electrons in 'p' sub shell. Therefore, they are referred as p-block elements."

c. d-block:

The elements in which valence electrons are present in the d-subshell are called d-block elements."

"The elements of group 3 to group 12 have their valence electrons in d subshell. Therefore they are called d-block elements.

The d-block constitutes period 4, 5 and 6. Each period in d-block consists of ten groups starting from group 3 to group 12. These are called transition metals."

d. f-block:

The elements in which valence electrons are present in the f-subshell are called f-block elements."

"f-block lies separately at the bottom of the periodic table. It consists of lanthanides and actinides.

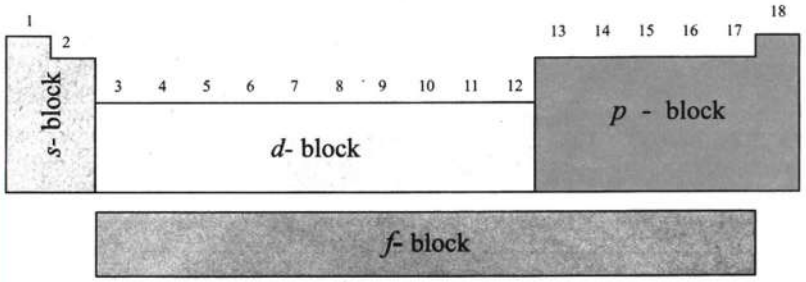

Fig. 3.2 Modern Periodic Table showing four blocks.

DO YOU KNOW

Alchemists:

Group of Muslim scientists who tried to convert cheaper metals into gold and to give eternal life to the people is called alchemist and this branch of chemistry is called alchemy.

Alchemy:

For thousand of years alchemy remained field of interest for the scientists.

Main objective of Alchemists:

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 anyone element, new substances can be formed.

Disadvantages and Advantages:

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.

Q.9 Write in detail the periods of periodic table.

Ans: Periods:

"Horizontal rows of elements in the periodic table are called periods."

There are seven periods in the modern periodic table. The period number of an element

represents number of shells in the element.

First period:

It is called short period. It consists of only two elements, hydrogen and helium.

Second and third periods:

These 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:

These are called long periods. Each one of them consists of eighteen elements.

Sixth and seventh periods:

These are called very long periods. Sixth period contains 32 elements whereas seventh period is incomplete.

Lanthnides and actinides:

In sixth and seventh period after atomic number 57 and 89, two series of fourteen elements each, were accommodated.

a. Why lanthanides and actinides are placed separately?

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

b. Why lanthanides and actinides are called so?

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.

Starting and ending of a period:

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.

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

Q.10 Write a detailed note on the groups of periodic table.

Ans: Groups:

"The vertical columns of elements in the periodic table are called groups."

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.

Family Name:

Elements of group are also called family because normal elements of a group have similar chemical properties and similar electronic configuration in their valence shells.

Important Groups:

Group 1: It consists of hydrogen (H), Lithium (Li), Sodium (Na), potassium (K), rubidium (Rb), cesium (Cs) and francium. They are generally called alkali metals.

Group 2: It consists of beryllium (Be), magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba) and Radium (Ra). They are called alkaline earth metals.

Group 17: It consists of Fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I) and astatine (At). The elements of this group are called halogens.

Group 18: The gaseous elements of group 18 or zero group are called noble gases. It consists of helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe) and Radon (Rn). The elements of this group are called noble gases.

Groups of Normal elements: (Representative or typical elements)

All s-block and p-block elements excluding noble gases are called normal elements. The groups 1,2 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 outermost (valence) shell.

Transition elements:

"Elements in which 'd' or 'f' subshell are in the process of completion are called transition elements."

The elements of groups 3 to 12 and lanthanides as well as actinides are called transition elements. They belong to periods 4,5, 6 and 7.

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

Fireworks

Beautiful fireworks display are common on celebrations like Pakistan Day or even on marriages. It is dangerous but careful use of various elements and particularly metal salts of different composition give beauty and colors to the fireworks.

Invention of fireworks:

A technology invented in China is used all over the world.

Composition of fireworks:

Elements like magnesium, aluminium are used in powdered form. Usually nitrates and chlorates are used. Other chemicals are added to give brilliance and different shades.

Salt	Colour Imparted
Sodium salt	Yellow
Calcium salt	Red
Strontium salt	Scarlet
Barium salt	Green
Copper salt	Bluish green

Precautions:

Because of fire hazard and risk to life and property, only skilled professionals use them.

Q.11 What is meant by atomic size? Give its units of measurements and explain its trends in modern periodic table.

Ans: Atomic size or atomic radius:

"*The half of the distance between the nuclei of the two bonded atoms is referred as the atomic radius of the atom.*

Example:

The distance between the nuclei of two carbon atoms in its elemental form is 154 pm, it means its half 77 pm is radius of carbon atom.

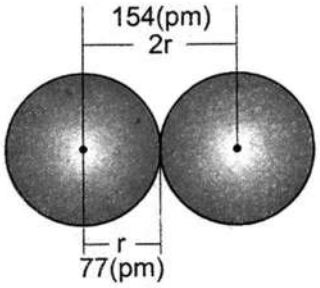

Fig. 3.3 The radius of carbon atom.

Units:

The units of atomic radius are as follows.

i. Nanometer (10^{-9}m)

ii. Picometer (10^{-12}m)
iii. Angstrom (10^{-10}m)

Trends of atomic radius and atomic size in periods:

The atomic radii gradually decrease from left to right in a period.

Reasons:

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

Example:

Atomic size in period 2 decreases from Li (152 pm) to Ne (69 pm)

Trend of Atomic Radius and Atomic size in Groups:

The atomic radii increase from top to bottom in a group.

Reason:

The number of shells increases in the successive elements. The distance between the nucleus and valence shells increases, the effective nuclear charge decreases and atomic radius increases.

Q.12 What is shielding effect? Write down its trend in modern periodic table.

Ans: Shielding Effect

"The decrease in attractive force exerted by the nucleus on the valence shell electrons due to the presence of electrons lying between the nucleus and valence shell is called shielding effect."

Effective nuclear charge

The attraction of outer electrons toward nucleus is partially reduced because of presence of inner electrons. As a result an atom experiences less nuclear charge than that of the actual charge, which is called effective nuclear charge (Z_{eff}).

Explanation:

The shielding effect decreases the forces of electrostatic attractions between nucleus and outermost electrons by partially concealing or blocking the nuclear attraction for the outer most electrons. In fact the electrons present between the nucleus and the outer most shell of an atom reduce the effective nuclear charge felt by the electrons present in the outermost shell.

Trend of shielding effect in groups:

The shielding effect increases down the group in the periodic table.

Reason:

This is because the number of inner shells increases from top to bottom in a group.

For example:

Due to greater size of the atom it is easy to take away electron from potassium (z=19) than from sodium (z =11) atom.

Trends of shielding effect in periods:

The shielding effect does not change in a period.

Reason:

This is because the number of inner shells remain the same from left to right in the periods.

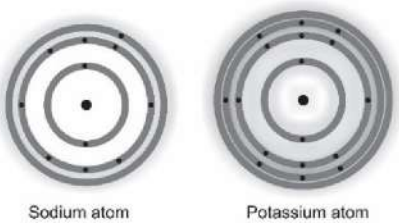

Fig. 3.4: Shielding effect is more in potassium atom than that of sodium atom.

Q.13 What is ionization energy? Describe its trends in modern periodic table.

Ans: Ionization Energy (I.E)

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

Units of I.E:

The units of ionization energy are KJ mol^{-1} and ev/atom.

First Ionization Energy:

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

Example:

The first ionization energy of sodium atom is + 495.8 $kJmol^{-1}$

$$Na \longrightarrow Na^{+} + 1e^{-}$$
$$\Delta H = +495.8 \text{ KJ mol}^{-1}$$

Second ionization energy:

"The amount of energy required to remove the second electron from the valence shell of an isolated gaseous monopositive ion is called second ionization energy."

When there are more than one electrons in valence shell they can be removed one by one providing more and more energy. Such as group 2 and 3 elements have more than one electron in their valence shells. Therefore, they will have more than one ionization energy values.

For example:

$$Mg \longrightarrow Mg^{+} + 1e^{-} \qquad \Delta H = +738 \text{ KJ mol}^{-1}$$
$$Mg^{+1} \longrightarrow Mg^{+2} + 1e^{-} \qquad \Delta H = +1450 \text{ KJ mol}^{-1}$$

Third ionization energy:

"The amount of energy required to remove the third electron from the valence shell of an isolated gaseous di-positive ion is called third ionization energy."

Trends along groups

Ionization energy of elements decreases from top to bottom in a group.

Reason:

i. The number of shells increases

ii. The distance between the nucleus and valence shells increases.

iii. Shelling effect increases.

iv. Nuclear attraction on valence electrons decreases.

Therefore, ionization energy decreases from top to bottom in the groups of the periodic table.

Trend along periods

Ionization energy values of elements increase from left to right in a period

Reason:

i. The number of shells remains same.

ii. Shieding effect remains same.

iii. The effective nuclear charge on valence electrons increases.

iv. The distance between nucleus and valence shells decreases.

v. Nuclear attraction on valence electrons increases.

Therefore, ionization energy increases from left to right in periods of the periodic table.

1st group elements	Ionization (KJ/mol)
$_{3}Li$	520
$_{11}Na$	496
$_{19}K$	419
$_{37}Rb$	403
$_{55}Cs$	377

2nd period elements	$_3$Li	$_4$Be	$_5$B	$_6$C	$_7$N	$_8$O	$_9$F	$_{10}$Ne
Ionization energy ($kJmol^{-1}$)	520	899	801	1086	1402	1314	1681	2081

Q.14 Define electron affinity? Why it increases in a period and decreases in a group?

Ans: Electron Affinity

"The amount of energy released when an electron is added up in the outermost shell of an isolated gaseous atom is called electron affinity."

Example:

The electron affinity of fluorine is -328 kJ mol^{-1} i.e. one mole atom of fluorine releases 328 kJ of energy to form one mole of fluoride ions.

$$F + 1e^- \longrightarrow F^- \qquad \Delta H = -328 \text{ KJ mol}^{-1}$$

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

Units of electron affinity:

The units of electron affinity are $KJmol^{-1}$ and eV/atom.

Trend of electron affinity along period:

Electron affinity values increase from left to right in the period. .

Reason:

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.

Trend of electron affinity along group:

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

Reason:

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 chlorine.

2nd period elements	$_3$Li	$_4$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

Q.15 What is electronegativity? Write down its trends in modern periodic table.

Ans: Electronegativity:

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

Explanation:

It is an important property especially when covalent type of bonding of elements is under consideration.

Trends in periods:

Electronegativity increases from left to right in the periodic table. The trend of electro negativity is same as of ionization energy and electron affinity. It increases in a period from left to right.

Reason:

Because higher (Z_{eff}) shortens distance from the nucleus of the shared pair of electrons. Thus, enhances the power to attract the shared pair of electrons.

Example:

Electronegativity values of group 17 are given as follows:

Trend in groups:

Electronegativity decreases from top to bottom in the 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