CLASSIFICATION

Definition:

The arrangement of elements having same properties in the same group and separating them from elements with different properties is called classification of elements.

Significance of Classification:

With the increase in the number of elements discovered, an attempt was made to arrange them on the basis of the similarities in their physical and chemical properties.

Such grouping of elements was useful because

- ♣ It made their study easy.
- ♣ It enabled the scientists to understand the reasons for such similarities in their properties.

DOBEREINER'S CLASSIFICATION (LAW OR RULE OF TRIADS)

In 1829 Dobereiner classified the chemically similar elements in group of three. He noticed that the atomic mass of the middle element is almost the arithmetic mean of the other two. The group of three elements was called the law or rule of triads.

Statement:

Central atom of each set of triad had an atomic mass almost equal to the arithmetical mean of the atomic masses of the other two elements.

Examples:

- ♣ The atomic masses of Li and K are 7 and 39 respectively. The average of these two numbers is 23 which is the atomic mass of Na.
- ♣ The atomic masses of Cl and I are 35.5 and 126.5 respectively. The average of these two numbers is 81 which is the atomic mass of Br.
- ♣ The atomic masses of Ca and Be are 40 and 137 respectively. The average of these two numbers is 80 which is the atomic mass of sr.

DOBEREINER TRIADS:

Elements	Atomic Mass	First & third's average	Elements	Atomic Mass	First & third's average
Li	7		Cl	35	
Na	23	$\frac{7+39}{2} = 23$	Br	80	$\frac{35+127}{2} = 81$
K	39		I	127	
Ca	40		S	32	
Sr	88	$\frac{40+137}{2} = 88.5$	Se	79	$\frac{32+128}{2} = 80$
Ba	137		Te	128	

Drawbacks:

This law or rule cannot be extended to the classification of all the elements, because it is true only in the cases of very few elements.

NEWLAND'S LAW OF OCTAVE

In 1864 and English chemist, Newland's proposed that if the elements are arranged in ascending order of their atomic masses, every eighth element will have properties similar to the first .

Statement:

If elements are arranged in the order of increasing atomic masses, the eighth element starting from a given one, has similar properties as first one i.e. its properties are kind of repetition of the first , like the eighth note in an octave of music.

Example:

- ♣ Lithium (Li) and Sodium (Na) resemble with each other.
- ♣ Beryllium (Be) resembles magnesium (Mg)
- ♣ Fluorine (F) resembles Chlorine (Cl).

Element	Li	Be	B	C	N	O	F
Atomic Mass	7	9	11	12	14	16	19
Element	Na	Mg	Al	Si	P	S	Cl
Atomic Mass	23	24	27	28	31	32	35.5

Drawbacks:

This law failed because it held good for the first sixteen elements but did not work after seventeenth element. Moreover hydrogen was not included in this sequence.

LOTHER MEYER CLASSIFICATION

- **Group:**

In december 1869 Julius Lother Meyer, a German scientist published a periodic table in which he arranged 56 elements on the basis of their atomic masses in nine vertical coulmns or groups I to IX. He laid down emphasis on the physical properties of elements.

- **Atomic Volume:**

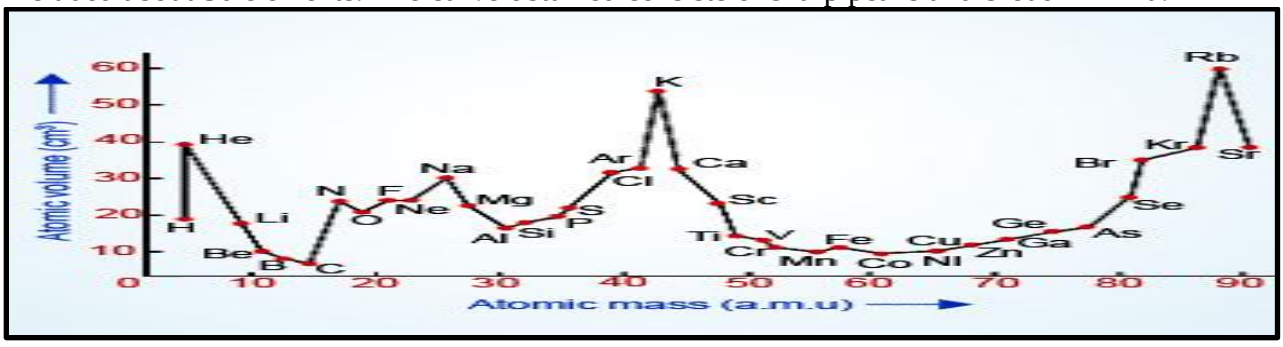
Lother Meyer calculated the atomic voulmes of elements. The atomic volume of an element is the volume which would be occupied by 1 gram Atomic weight (1 mole) of atoms of elements of it were a solid.

- **Formula:**

$$\text{Atomic mass} = \frac{\text{Gram atomic weight}}{\text{Density}}$$

- **Graph:**

He plotted a graph between atomic volume against increasing atomic masses of the elements. He included about 50 elements. The curve obtained consists of sharp peaks and broad minima.



FACTS SEEN BY THE STUDY OF GRAPH

- ♣ **Similar Physical Properties:**
  The elements with physical properties like boiling points occupy similar positions on the curve.
- ♣ **Position Of Alkali Metals:**
  Alkali metals like lithium (Li), Sodium (Na), potassium (K), rubidium (Rb), cesium (Cs) occupy the peaks of the curves showing that these elements have largest atomic volume.

Periodicity:
Similar elements were located at the similar positions of the curves. The regular spacing of the highest positions confirms the idea of periodicity.

MENDELEEV'S PERIODIC LAW

Statement:
The physical and chemical properties of elements are a periodic function of their atomic weight.

Mendeleev's Periodic Table:
In mendeleev's periodic table, the elements were arranged in the increasing order of their atomic masses in such a way that similar elements were repeated after regular intervals and were placed one above the other.

SALIENT FEATURES OF MENDELEEV'S PERIODIC TABLE:

- **Periods And Groups:**
  In the table 12 horizontal rows from left to right are called periods. The 8 vertical rows are called groups.
- **Similar Properties:**
  Elements in each vertical coulms have similar properties.
- **Vacant Spaces For Undiscovered Elements:**
  Mendeleev's left certain vacant spaces in his table to place similar undiscovered elements in the same group. He proposed their names as eka-boron, eka-aluminum and eka-silicon.
- **Vacant Number:**
  The group number indicates the highest valency number that can be attained by elements of that group.

Row	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
1	H=1							
2	Li=7	Be=9	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27.3	Si=28	P=32	S=32	Cl=35.5	
4	K=39	Ca=40	___=44	Ti=48	B=51	Cr=52	Mn=55	Fe=56,Co=59 Ni=59,Cu=63
5	Cu=63	Nz=65	___=68	___=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	Yt=88	Zr=90	Nh=94	Mo=96	___=100	Ru=104,Rh=104 Pb=106,Ag=108
7	Ag=108	Cd=112	In=113	Sn=118	Sb=122	Te=125	I=127	
8	Cs=133	Be=137	Di=138	Ce=140	---	---	---	
9	---	---	---	---	---	---	---	
10	---	---	Er=178	La=180	Ta=182	W=184	---	Os=195,Ir=197 Pt=198,Au=199
11	Au=199	Hg=200	Tl=204	Pb=207	Bi=208	---	---	
12	---	---	---	Th=231	---	U=240	---	

ADVANTAGES OF MENDELEEV'S PERIODIC TABLE:

- **Periodicity:**

It helped in systematic study of elements for example the study of sodium helps means toa large extant in predicting the properties of other alkali metals as potassium, rubidium and cesium. It proved the concept of periodicity.

- **Prediction Of New Elements:**

Prediction of new elements was made possible example the physical and chemical properties of eka-boron, eka-aluminum and eka silicon were predicted by Mendeleev.

This helped in their discovery. These have been named as scandium, gallium and germanium. Their properties are the same as were predicted by Mendeleev.

- **Correction Of Atomic Masses:**
  Mendeleev's periodic table helped in correcting many doubtful atomic masses.
- **Gradual Change In Physical Properties:**

In Mendeleev's table elements of any group resembled chemically with each other, but there was a gradual change in physical properties going down the group.
Example:
The melting point of alkali metals in group I decrease gradually from top to the bottom.

DEFECTS IN MENDELEEV'S PERIODIC TABLE:

- **Arrangements Of Six Pair Of Elements:**

There is three pair of elements i.e. elements of higher atomic masses placed before elements of lower atomic masses i.e.
Argon (40) placed before Potassium (39)
Cobalt (59.9) placed before Nickel (58.6)
Tellurium (127.6) placed before Iodine (126.9)

- **No Place For Isotopes:**

No place for the isotopes of the elements was left in the table.

- **Placement Of Dissimilar Elements In The Same Group:**

Dissimilar elements placed in the same group i.e. Alkali metals (Li, Na, K, Rb Cs, Fr) were placed with the coinage metals (Ag, Cu Au)

- **Placements Of Similar Elements In Dissimilar Group:**
  Similar elements placed in different groups for example Barium (Ba) and Lead (Pb) resembles in many properties but they are placed in separate groups.
- **No Idea Of Atomic Structure:**
  It filled to give the idea of atomic structure.

MODERN PERIODIC TABLE:

Modern periodic table is the result of the discovery of the atomic number by Moseley in 1914.

Statement:
The physical and chemical properties of all elements are periodic function of their atomic number.

Bohr's Long Form Of Periodic Table:
Modern periodic table is also known as Bohr's long form of periodic table in which the elements are arranged in order of their increasing atomic number. The elements having similar properties are repeated after regular intervals. The modern periodic table contains seven horizontal rows called periods and sixteen vertical columns called groups.

PERIODS:
The modern periodic table contains seven horizontal rows called periods.

Characteristics:

- The elements with a period have dissimilar properties from left to right across any period.
- The physical and chemical properties of elements change from metallic to nonmetallic along a period.
- All periods except the firs starts with an alkali metal with one electron in their valence shell end up with zero group elements with valence shell having eight electron except helium He which has only two electrons.

The First Period (Shortest Period)

- It contains only two elements i.e. H and He.
- This period signifies the completion of K shell or first orbit.
- It is the shortest period with two elements.

The Second And The Third Periods (Short Period)

- Each of these contains eight elements.
- They signify the filling of L shell and M shell respectively.
- The second period starts with Lithium Li and end up with Ne whereas the third period starts with Na and ends at Ar.

The Fourth And The Fifth Period (Long Period)

- Each of these contains eighteen elements.
- In these periods electrons fill M and N shells.
- Fourth periods start from K and ends at Kr
- Fifth period start from Rb and ends at Xe.

The Sixth Period (Longest Period)

- It contains thirty two elements.
- It starts from Cs and ends with Rn.
- Besides fourteen elements called lanthanides are placed at the bottom of the periodic table.

The Seventh Period (Incomplete Period)

- It starts with Francium Fr. This period is incomplete as to date about 109 elements have been discovered.
- This period also includes a group of fourteen elements starting from actinium. These elements are called actinides. They are also placed at the bottom of the table.

GROUPS:

Vertical columns in the periodic table are called groups.

Group IA (the Alkali Metals) or (Lithium Family)

- Their valence shell contains one electron only and on reaction they lose this electron and form univalent positive ions (M^{+1}).
- They are highly reactive metals with low melting points.
- Fr is radioactive.
- Their atomic radii, atomic volumes, ionic radii increases from Li to Cs due to the addition of extra shell to each elements and due to same reason, the melting and the boiling points decreases downward.
- They are called alkali metals because they form water soluble base such as NaOH and KOH.

Elements:

- Li (Lithium)
- Na (Sodium)
- K (Potassium)
- Rb (Rubidium)
- Cs (Caesium)
- Fr (Francium

Group IIA (The Alkaline Earth Metals) (Beryllium Family)

- Their valence shell contains two electrons.
- On reaction they lose these two electrons and form divalent positive ions (M^{+2}).
- Ra is radioactive.

- These elements are bit harder, having higher melting and boiling points than the alkali metals, but they have similar atomic, ionic radii and atomic volume.
- Down the group they do not show a regular trend in melting and boiling points and densities.

Elements:

- Be (Beryllium)
- Mg (Magnesium
- Ca (Calcium)
- Sr (Strontium
- Ba (Barium)
- Ra (Radium)

Group IIIA (The Boron Family)

- Their valence shell contains three electrons.
- They exhibit a valence of 3and form M^{+3} ions.
- Except boron they are highly electropositive elements i.e. having metallic character which increases down the group due to increase in atomic volume.
- Boron is metalloid. A metalloid is an element which has some properties of metals and some properties of nonmetals.

Elements

- B (Boron)
- Al (Aluminum)
- Ga (Gallium)
- In (Indium)
- Ti (Titanium)

Group IVA (Carbon Family)

- Their valence shell contains four electron, C, Si and Se form covalent compounds whereas Sn and Pb exhibit a variable valence of 2 and 4.
- Of these elements C is nonmetal, Si and Ge are metalloids, Sn and Pb are metals.
- Down the group atomic radii increases due to addition of a new shell and for the same reason metallic character increases down the group.
- C and Sn exist in different allotropic forms.

Elements:

- C (Carbon)
- Si (Silicon)
- Ge (Germanium)
- Sn (Tin)
- Pb (Lead)

Group V (Nitrogen Family)

- Of these elements N and P are nonmetals, As and Sb are metalloids and Bi is a metal.
- Their valence shell contains five electrons.
- There is a large variation of properties as we go down the group.
- Nitrogen exists as diatomic molecules (N_2) and forms a number of oxides as NO and N_2O
- Due to small atomic size and large ionization potential, nitrogen has a tendency to accept three electrons to form nitride ion (N^{-3})
- Phosphorous exists as P_4 molecule.
- Except nitrogen all exists in more than one allotropic form.

Elements:

- N (Nitrogen)
- P (Phosphorus)
- As (Arsenic)
- Sb (Antimony)
- Bi(Bismuth)

Group VIA (Oxygen Family)

- Of these oxygen and sulphur are nonmetals, selenium, tellurium are metalloids and polonium is metal.
- All the elements exhibit the property of allotropy. For example allotropic forms of oxygen (O_2) and ozone (O_3).
- Oxygen and sulphur form divalent negative ions O^{-2} and S^{-2}. Their valence shell contains six electrons.

Elements:

- O (Oxygen)
- S (Sulphur)
- Se (Selenium)
- Te (Tellurium)
- Po (Polonium)

Group VIIA (Halogen)

- Except astatine (which is metalloid) all others are nonmetals and exist as diatomic molecules.
- At room temperature F_2 and Cl_2 are gases, bromine is a liquid and iodine is a solid.
- Their valence shell contains seven electrons.
- They have, high ionization energies and large negative electrons affinities hence they easily accept an electron to form halide ion (X^{-1}) i.e. (F^{-1}, Cl^{-1}, Br^{-1}, I^{-1})

Elements:

- F (Fluorine)
- Cl(Chlorine)
- Br (Bromine)
- I (Iodine)
- At (Astatine)

Groups VIIIA (Inert And Noble Gases)

- Their valence shell contains eight electrons, except helium which has two electrons.
- With the exception of krypton and Xenon (which have large atomic volume so slightly reactive under drastic conditions) the rest of these elements are totally inert chemically. The reason is that these have completely filled outer shells, a condition that represents greater stability.

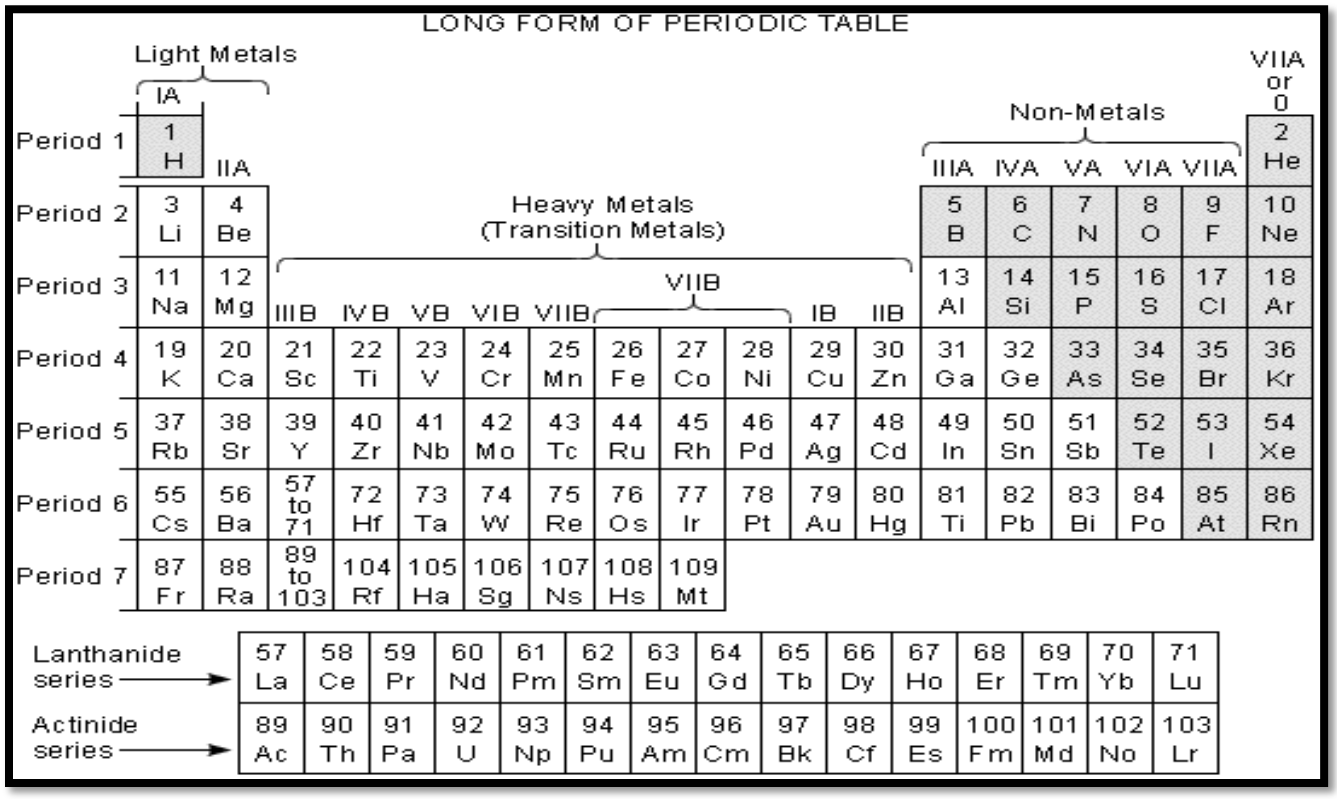
Elements:

- He (Helium)
- Ne (Neon)
- Kr (Krypton)
- Xe (Xenon)
- Rn (Radon)

Group IB To VIII B (Transition Elements)

Characteristics:

- These are metals.
- In these elements, besides the valence shell penultimate shell is also incomplete.
- They show more than one valence in chemical reaction.
- These elements in compounds have characteristic colors.



METALS

Characteristics:

- They are electropositive elements i.e. they lose electrons to form cat ion.
- They form basic oxides.
- All of them have luster and are malleable (i.e. can be spread out into sheet) and ductile (i.e. can be drawn into wire), are good conductors of heat and electricity.

Examples:

In the periodic table elements of group IA, IIA and all transition elements are metals. Some of the elements of group IIA, IVA, VA, and VIA are also metals. Sodium, Calcium, Iron, Gold, Silver etc.

NON METALS

Characteristics:

- They are electronegative elements i.e. they gain electrons to form an ions.
- They form acidic oxides.
- They are bad conductor of heat and electricity.
- Most of them are gases.

Examples:
In the periodic table, majority of elements of p-block i.e. group IIIA, IVA, VA, VIA, VIIA and VIIIA are nonmetals.
Chlorine, Oxygen, Bromine, Sulphur, Carbon etc.

METALLOIDS

Characteristics:
These are the elements which exhibit dual characters. That is they show the properties of both metals as well as nonmetals. Their oxides are amphoteric i.e. have basic as well as acidic nature.
Examples:
- Boron (B) of group IIIA.
- Silicon (Si) and Germanium (Ge) of group IVA.
- Arsenic (As) and Antimony (Sb) of group VA.
- Tellurium (Te) and Polonium (Po) of group VIA.
- Astatine (At) of group VIIA.

DIFFERENCE BETWEEN GROUP IA AND VIIA

GROUP IA	GROUP VIIA
Group IA contains Lithium (Li) Sodium (Na), Potassium (K), Rubidium (Rb), Cesium (Cs) and Francium (Fr).	Group VIIA contains Fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I) and Astatine (At).
Elements of this group are called alkali metals.	Elements of this group are called halogens.
They contain one electron in their outer most shell.	They contain seven electrons in their outer most shell.
They form only ionic bonds.	They form ionic as well as covalent bonds.
They exist in monoatomic form e.g. Li, Na, K.	They exist in diatomic form e.g. Cl_2, Br_2, I_2
They have tendency to lose their single electron.	They have tendency to gain electron.
They are strongly electropositive.	They are highly electronegative.
Their oxides give strong alkali when dissolve in water $Na_2O + H_2O \longrightarrow 2NaOH$	Their oxides are acidic in nature. $Cl_2O + H_2O \longrightarrow 2HOCl$

PERIODIC PROPERTIES

The physical properties of elements that exhibit periodicity in the periodic table i.e. the physical properties vary from element to element with the change in atomic number from left to right in periods or from top to bottom in group are called Periodic Properties.

ATOMIC RADII

The atomic radii may be defined as half the distance between two adjacent nuclei of two similar atoms in touch with each other.
Unit:
It is measured in Angstrom unit (A° or A.U)
$1A° = 10^{-8}$ cm $= 10^{-10}$ m
Dependence:
The atomic radii depend upon the number of shells and nuclear charge in an atom.
Trend In Groups:
In the periodic table the atomic radii increases down the group due to addition of new shell in each atom.

Element of group IIA	Be	Mg	Ca	Sr	Ba
Atomic Radii in Aº	1.12	1.36	1.97	2.15	2.22

Trend In Period:

In a period the atomic radii decreases from left to right due to increase in number of protons i.e. increase in nuclear charge, which results in stronger pull on orbiting electrons by the nucleus.

Element	Na	Mg	Al	Si	P	S	Cl
Atomic Radii in Aº	1.51	1.36	1.25	1.17	1.10	1.04	0.99

IONIZATION ENERGY

It is defined as the minimum energy required to removes an electron from a gaseous atom in its ground state.

Unit:

It is measured in KJ/mole or electron volt (e.v) per atom.

Dependence:

Ionization energy depends upon atomic size and nuclear charge. The higher the ionization energy the more difficult is to remove an electron. The ionization energy of hydrogen is 1312 KJ/mole i.e.

$H_{(g)} + \text{energy} \longrightarrow H^+ + e^-$ I.E = +1312 KJ/mol.

Trend In A Group:

Down a group in the periodic table, the ionization energy decreases because the addition of new shell decreases the hold of nucleus on valence electron.

Trend In Period:

Ionization energy increases from left to right in a period because the addition of protons in the nucleus increases the nuclear charge there by increasing the forces of attraction on electrons.

ELECTRON AFFINITY

Definition:

Electron affinity is defined as the energy change that occurs when an electron is gained by an atom in the gaseous state.

Electron affinity for the addition of first electron is negative i.e. energy is released but for further addition of electron. It is positive because energy is added to over come repulsion between negative ion and electron, as shown below:

$O_{(g)} + e^- \longrightarrow O^-_{(g)}$ E.A = –142KJ/mole (Exothermic)

$O^- + e^- \longrightarrow O^{2-}_{(g)}$ E.A = +780 KJ/mole (Endothermic)

Unit:

It is measured in KJ/mol or in e.v per atom.

Dependence:

Electron affinity depends upon the atomic size and nuclear charge.

Trend In A Group:

Down a group in the periodic table, electron affinity decreases because the addition of new shell to each atom decreases its force of attraction.

Element	F	Cl	Br	I
Electron Affinity In KJ/Mole	-333	-348	-324	-295

Trend In A Period:

In a period the electron affinity increases from left to right because successive atoms have higher nuclear charge and attract the incoming electron move towards itself.

Element	Li	Be	B	C	N	O	F	Ne
Electron Affinity In KJ/Mol	-58	0	-23	-123	0.2	-142	-333	0

ELECTRONEGATIVITY

Definition:
Electronegativity is defined as the relative tendency of an atom in a molecule to attract shared pair of electron to itself. It is denoted by a number.
Unit:
It has no unit.
Trend In Group:
Down a group the electro negativity decreases. Due to addition of new shell, the power of a nucleus to attract electron decreases.
Trend In A Period:
In a period from left to right it increases in nuclear charge.

LANTHANIDE

In the 6^{th} period, after Lanthanum ($_{57}La$) there are fourteen elements with atomic numbers 58 to 71. These elements have six electronic shells. The electron is gradually added in the 4f orbitals of the 4^{th} shell of these elements. The first member of the series is Lanthanum so all the 14 elements are called Lanthanides. All lanthanides resemble with each other.

ACTINIDES

In the 7^{th} period after actinium ($_{89}Ac$) there are 14 elements with atomic number 90 to 103. These elements have seven electronic shells. Electrons are gradually added in the 5f orbitals of the 5^{th} shell. Lanthanides and actinides are f-block elements.

FILL IN THE BLANKS

i) Dobereiner ii) periodicity iii) 6^{th} , 32
iv) metalloids v) 18, 7 vi) mass number.