2.Periodic Classification of Elements

- Elements and their classification
- Dobereiner's Triads
- Newlands Law of Octaves
- Mendeleev's Periodic Table
- Modern Periodic Table

Can you recall?

1. What are the types of matter?
2. What are the types of elements?
3. What are the smallest particles of matter called?
4. What is the difference between the molecules of elements and compounds?

Classification of elements

We have learnt in the previous standards that all the atoms of an element are of only one type. Today 118 elements are known to the scientific world. However, around year 1800 only about 30 elements were known. More number of elements were discovered in the course of time. More and more information about the properties of these elements was gathered. To ease the study of such a large number of elements, scientists started studying the pattern if any, in the vast information about them. You know that in the initial classification elements were classified into the groups of metals and nonmetals. Later on another class of elements called metalloids was noticed. As the knowledge about elements and their properties went on increasing different scientists started trying out different methods of classification.

Dobereiner's Triads

In the year 1817 a German scientist Dobereiner suggested that properties of elements are related to their atomic masses. He made groups of three elements each, having similar chemical properties and called them triads. He arranged the three elements in a triad in an increasing order of atomic mass and showed that the atomic mass of the middle element was approximately equal to the mean of the atomic masses of the other two elements. However, all the known elements could not be classified into the Dobereiner's triads.

Sr. No.	Triad	Element -1 Actual atomic mass(a)	Element - 2		Element - 3 Actual atomic mass (c)
			Mean = $\frac{a+c}{2}$	Actual atomic mass	
1	Li, Na, K	Lithium (Li) 6.9	Sodium $\frac{6.9 + 39.1}{2} = 23.0$	(Na) 23.0	Potassium (K) 39.1
2	Ca, Sr, Ba	Calcium (Ca) 40.1	Strontium $\frac{40.1 + 137.3}{2} = 88.7$	(Sr) 87.6	Barium (Ba) 137.3
3	Cl, Br, I	Chlorine (Cl) 35.5	Bromine $\frac{35.5 + 126.9}{2} = 81.2$	(Br) 79.9	Iodine (I) 126.9

2.1 Dobereiner's Triads

Can you tell?

Identify Dobereiner's triads from the following groups of elements having similar chemical properties.

1. Mg (24.3), Ca (40.1), Sr (87.6)
2. S (32.1), Se (79.0), Te (127.6)
3. Be (9.0), Mg (24.3), Ca (40.1)

Newlands' Law of Octaves

The English scientist John Newlands correlated the atomic masses of elements to their properties in a different way. In the year 1866 Newlands arranged the elements known at that time in an increasing order of their atomic masses. It started with the lightest element hydrogen and ended up with thorium. He found that every eighth element had properties similar to those of the first. For example, sodium is the eighth element from lithium and both have similar properties. Also, magnesium shows similarity to beryllium and chlorine shows similarity with fluorine. Newlands compared this similarity with the octaves in music. He called the similarity observed in the eighth and the first element as the **Law of octaves.**

Do you know ?

In the Indian music system there are seven main notes, namely, Sa, Re, Ga, Ma, Pa, Dha, Ni, and their collection is called 'Saptak'. The frequency of the notes goes on increasing from 'Sa' to 'Ni'. Then comes, the 'Sa' of the upper 'Saptak' at the double the frequency of the original 'Sa'. It means that notes repeat after completion of one 'Saptak'. The seven notes in the western music are Do, Re, Mi, Fa, So, La, Ti.

The note 'Do' having double the original frequency comes again at the eighth place. This is the octave of western notes. Music is created by the variety in the use of these notes.

Musical Note	Do (Sa)	Re (Re)	Mi (Ga)	Fa (Ma)	So (Pa)	La (Dha)	Ti (Ni)
Elements	H F Cl Co &Ni Br	Li Na K Cu Rb	Be Mg Ca Zn Sr	B Al Cr Y Ce & La	C Si Ti In Zr	N P Mn As	O S Fe Se

2.2 Newlands' Octaves

Many limitation were found in Newlands' octaves. This law was found to be applicable only up to calcium. Newlands fitted all the known elements in a table of 7 X 8 that is 56 boxes. Newlands placed two elements each in some boxes to accommodate all the known elements in the table. For example, Co and Ni, Ce and La. Moreover, he placed some elements with different properties under the same note in the octave. For example, Newlands placed the metals Co and Ni under the note 'Do' along with halogens, while Fe, having similarity with Co and Ni, away from them along with the nonmetals O and S under the note 'Ti'. Also, Newlands' octaves did not have provision to accommodate the newly discovered elements. The properties of the new elements discovered later on did not fit in the Newlands' law of octaves.

Mendeleev's Periodic table

The Russian scientist Dmitri Mendeleev developed the periodic table of elements during the period 1869 to 1872 A.D. Mendeleev's periodic table is the most important step in the classification of elements. Mendeleev considered the fundamental property of elements, namely, the atomic mass, as standard and arranged 63 elements known at that time in an increasing order of their atomic masses. Then he transformed this into the periodic table of elements in accordance with the physical and chemical properties of these elements.

Mendeleev organized the periodic table on the basis of the chemical and physical properties of the elements. These were the molecular formulae of hydrides and oxides of the elements, melting points, boiling points and densities of the elements and their hydrides and oxides. Mendeleev found that the elements with similar physical and chemical properties repeat after a definite interval. **On the basis of this finding Mendeleev stated the following periodic law.**

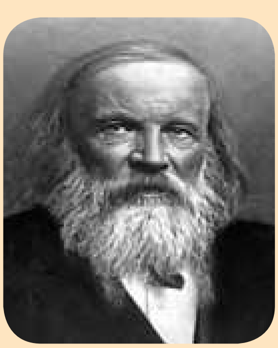
Properties of elements are periodic function of their atomic masses.

The vertical columns in the Mendeleev's periodic table are called groups while the horizontal rows are called periods.

Series ↓	Group I - R^2O	Group II - RO	Group III - R^2O^3	Group IV RH^4 RO^2	Group V RH^3 R^2O^5	Group VI RH^2 RO^3	Group VII RH R^2O^7	Group VIII - RO^4
1	H=1							
2	Li=7	Be=9.4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27.3	Si=28	P=31	S=32	Cl= 35.5	
4	K=39	Ca=40	- = 44	Ti= 48	V=51	Cr= 52	Mn=55	Fe=56, Co=59 Ni=59, Cu=63
5	(Cu=63)	Zn=65	-=68	-=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	-=100	Ru=104,Rh=104 Pd=106,Ag=108
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=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	Ti=204	Pb=207	Bi= 208	-	-	
12	-	-	-	Th=231	-	U=240	-	---

2.3 Mendeleev's Periodic Table

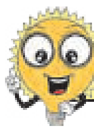
(The general molecular formulae of compounds shown as R^2O, R^2O^3, etc. in the upper part of Mendeleev's periodic table, are written as R_2O, R_2O_3,etc. in the present system.)



Dmitri Mendeleev

Introduction to scientist

Dmitri Mendeleev (1834-1907) was a professor in the St. Petersburg University. He made separate card for every known element showing its atomic mass. He arranged the cards in accordance with the atomic masses and properties of the elements which resulted in the invention of the periodic table of elements.



Think about it

1. There are some vacant places in the Mendeleev's periodic table. In some of these places the atomic masses are seen to be predicted. Enlist three of these predicted atomic masses along with their group and period.
2. Due to uncertainty in the names of some of the elements, a question mark is indicated before the symbol in the Mendeleev's periodic table. What are such symbols?

Merits of Mendeleev's periodic table

Science is progressive. There is a freedom in science to revise the old inference by using more advanced means and methods of doing experiments. These characteristics of science are clearly seen in the Mendeleev's periodic table.

While applying the law that the properties of elements are a periodic function of their atomic masses, to all the known elements, Mendeleev arranged the elements with a thought that the information available till then was not final but it could change. As a result of this, Mendeleev's periodic table demonstrates the following merits.

1. Atomic masses of some elements were revised so as to give them proper place in the periodic table in accordance with their properties. For example, the previously determined atomic mass of beryllium, 14.09, was changed to the correct value 9.4, and beryllium was placed before boron.
2. Mendeleev kept vacant places in the periodic table for elements not discovered till then. Three of these unknown elements were given the names eka-boron, eka-aluminium and eka-silicon from the known neighbours and their atomic masses were indicated as 44, 68 and 72, respectively. Not only this but their properties were also predicted. Later on these elements were discovered and named as scandium (Sc), gallium (Ga) and germanium (Ge) respectively. The properties of these elements matched well with those predicted by Mendeleev. See table 2.4. Due to this success all were convinced about the importance of Mendeleev's periodic table and this method of classification of elements was accepted immediately.

Property	Eka- aluminium(E) (Mendeleev's prediction)	Gallium (Ga)(actual)
1. Atomic mass	68	69.7
2. Density (g/cm^3)	5.9	5.94
3. Melting point(^0C)	Low	30.2
4. Formula of chloride	ECl_3	$GaCl_3$
5. Formula of oxide	E_2O_3	Ga_2O_3
6. Nature of oxide	Amphoteric oxide	Amphoteric oxide

2.4 Actual and predicted properties of gallium.

3. There was no place reserved for noble gases in Mendeleev's original periodic table. However, when noble gases such as helium, neon and argon were discovered towards the end of nineteenth century, Mendeleev created the ' zero' group without disturbing the original periodic table in which the noble gases were fitted very well.

Use your brain power !

Chlorine has two isotopes,viz, C1-35 and C1-37. Their atomic masses are 35 and 37 respectively. Their chemical properties are same. Where should these be placed in Mendeleev's periodic table? In different places or in the same place?

Demerits of Mendeleev's periodic table

1. The whole number atomic mass of the elements cobalt (Co) and nickel (Ni) is the same. Therefore there was an ambiguity regarding their sequence in Mendeleev's periodic table.
2. Isotopes were discovered long time after Mendeleev put forth the periodic table. As isotopes have the same chemical properties but different atomic masses, a challenge was posed in placing them in Mendeleev's periodic table.
3. When elements are arranged in an increasing order of atomic masses, the rise in atomic mass does not appear to be uniform. It was not possible, therefore, to predict how many elements could be discovered between two heavy elements.
4. Position of hydrogen : Hydrogen shows similarity with halogens (group VII). For example, the molecular formula of hydrogen is H_2 while the molecular formulae of fluorine and chlorine are F_2 and Cl_2, respectively. In the same way, there is a similarity in the chemical properties of hydrogen and alkali metals (group I). There is a similarity in the molecular formulae of the compounds of hydrogen alkali metals (Na, K, etc.) formed with chlorine and oxygen. On considering the above properties it can not be decided whether the correct position of hydrogen is in the group of alkali metals (group I) or in the group of halogens (group VII).

Compounds of H	Compounds of Na
HCl H_2O H_2S	NaCl Na_2O Na_2S

2.5 Similarity in hydrogen and alkali metals

Element (Molecular formula)	Compounds with metals	Compounds with nonmetals
H_2 Cl_2	NaH NaCl	CH_4 CCl_4

2.6 : Similarity in hydrogen and halogens

Use your brain power !

1. Write the molecular formulae of oxides of the following elements by referring to the Mendeleev's periodic table. Na, Si, Ca, C, Rb, P, Ba, Cl, Sn.
2. Write the molecular formulae of the compounds of the following elements with hydrogen by referring to the Mendeleev's periodic table. C, S, Br, As, F, O, N, Cl

Modern Periodic Law

The scientific world did not know anything about the interior of the atom when Mendeleev put forth the periodic table. After the discovery of electron, scientists started exploring the relation between the electron number of an atom and the atomic number. The atomic number in Mendeleev's periodic table only indicated the serial number of the element.

In 1913 A.D. the English scientist Henry Moseley demonstrated, with the help of the experiments done using X-ray tube, that the atomic number (Z) of an element corresponds to the positive charge on the nucleus or the number of the protons in the nucleus of the atom of that element. This revealed that 'atomic number' is a more fundamental property of an element than its atomic mass. Accordingly the statement of the modern periodic law was stated as follows:

Properties of elements are a periodic function of their atomic numbers.

Modern periodic table : long form of the periodic table

The classification of elements resulting from an arrangement of the elements in an increasing order of their atomic numbers is the modern periodic table. The properties of elements can be predicted more accurately with the help of the modern periodic table formed on the basis of atomic numbers. The modern periodic table is also called the long form of the periodic table.

In the modern periodic table the elements are arranged in accordance with their atomic number. (see table 2.7) As a result, most of the drawbacks of Mendeleev's periodic table appear to be removed. However, the ambiguity about the position of hydrogen is not removed even in the modern periodic table.

We have seen in the previous standard that the electronic configuration of an atom, the way in which the electron are distributed in the shells around the nucleus, is determined by the total number of electrons in it; and the total number of electrons in an atom is same as the atomic number. The relation between the atomic number of an element and its electronic configuration is clearly seen in the modern periodic table.

Structure of the Modern Periodic Table

The modern periodic table contains seven horizontal rows called the periods 1 to 7. Similarly, the eighteen vertical columns in this table are the groups 1 to 18. The arrangement of the periods and groups results into formation of boxes. Atomic numbers are serially indicated in the upper part of these boxes. Each box corresponds to the place for one element.

Use your brain power !

Position of the elements in the periodic elements......

1. How is the problem regarding the position of cobalt (^{59}Co) and nickel (^{59}Ni) in Mendeleev's periodic table resolved in modern periodic table?
2. How did the position of ${}^{35}_{17}$Cl and ${}^{37}_{17}$C1 get fixed in the modern periodic table?
3. Can there be an element with atomic mass 53 or 54 in between the two elements, chromium ${}^{52}_{24}$Cr and manganese ${}^{55}_{25}$Mn ?
4. What do you think? Should hydrogen be placed in the group 17 of halogens or group 1 of alkali metals in the modern periodic table?

Apart from these seven rows, two rows are shown separately at the bottom of the periodic table. These are called lanthanide series and actinide series, respectively. There are 118 boxes in the periodic table including the two series. It means that there are 118 places for elements in the modern periodic table. Very recently formation of a few elements was established experimentally and thereby the modern periodic table is now completely filled. All the 118 elements are now discovered.

The entire periodic table is divided into four blocks,viz, s-block, p-block, d-block and f-block. The s-block contains the groups 1 and 2. The groups 13 to 18 constitute the p-block. The groups 3 to 12 constitute the d-block, while the lanthanide and actinide series at the bottom form the f-block. The d-block elements are called transition elements. A zig-zag line can be drawn in the p-block of the periodic table. The three traditional types of elements can be clearly shown in the modern periodic table with the help of this zig-zag line. The metalloid elements lie along the border of this zig-zag line. All the metals lie on the left side of the zig-zag line while all the nonmetals lie on the right side.

Modern periodic Table and electronic Configuration of Elements

Within a period the neighbouring elements differ slightly in their properties while distant elements differ widely in their properties. Elements in the same group show similarity and gradation in their properties. These characteristics of the groups and periods in the modern periodic table are because of the electronic configuration of the elements. It is the electronic configuration of an element which decides the group and the period in which it is to be placed.

Characteristics of Groups and Periods

The characteristics of the groups and periods in the periodic table are understood by comparison of the properties of the elements. Various properties of all the elements in a group show similarity and gradation. However, the properties of elements change slowly while going from one end to the other (for example, from left to right) in a particular period.

Groups and electronic configuration

Can you tell?

1. Go through the modern periodic table (table no. 2.7) and write the names one below the other of the elements of group 1.
2. Write the electronic configuration of the first four elements in this group.
3. Which similarity do you find in their configuration?
4. How many valence electrons are there in each of these elements?

You will find that the number of valence electrons in all these elements from the group 1, that is, the family of alkali metals, is the same. Similarly, if you look at the elements from any other group, you will find the number of their valence electrons to be the same. For example, the elements beryllium (Be), magnesium (Mg) and calcium (Ca) belong to the group 2, that is, the family of alkaline earth metals. There are two electrons in their outermost shell. Similarly, there are seven electrons in the outermost shell of the elements such as fluorine (F) and chlorine (Cl) from the group 17, that is, the family of halogens. While going from top to bottom within any group, one electronic shell gets added at a time. From this we can say that the electronic configuration of the outermost shell is characteristic of a particular group. However, as we go down a group, the number of shells goes on increasing.

Do you know ?

Uranium has atomic number 92. All the elements beyond uranium (with atomic numbers 93 to 118) are manmade. All these elements are radioactive and unstable, and have a very short life.

In the modern periodic table.......

1. Elements are arranged in an increasing order of their atomic numbers.
2. Vertical columns are called groups. There are 18 groups. The chemical properties of the elements in the same group show similarity and gradation.
3. Horizontal rows are called periods. There are in all 7 periods. The properties of elements change slowly from one end to the other in a period.

2.7 Table : Modern Periodic Table

s- block | d- block | p- block

Atomic No.
Symbol
Name
Atomic mass

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H Hydrogen 1.008																	2 He Helium 4.003
2	3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
3	11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4	19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.972	35 Br Bromine 79.904	36 Kr Krypton 83.798
5	37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294
6	55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 *	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
7	87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 #	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

f- block

*	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.242	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
#	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

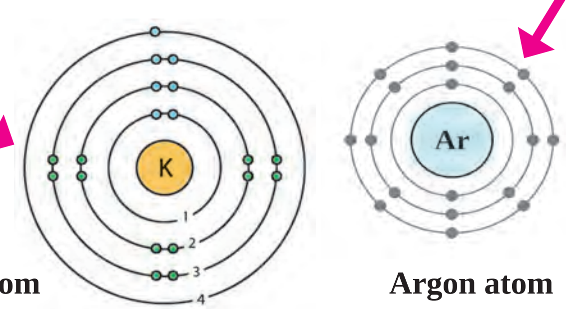
Periods and electronic configuration

Can you tell?

1. On going through the modern periodic table it is seen that the elements Li, Be, B, C, N, O, F and Ne belong to the period-2. Write down electronic configuration of all of them.
2. Is the number of valence electrons same for all these elements?
3. Is the number of shells the same in these ?

You will find that the number of valence electrons is different in these elements. However, the number of shells is the same. You will also find that, while going from left to right, within the period, the atomic number increases by one at a time and the number of valence electrons also increases by one at a time.

	1	2	13	14	15	16	17	18
1	H 1							He 2
2	Li 2,1	Be 2,2	B 2,3	C 2,4	N 2,5	O 2,6	F 2,7	Ne 2,8
3	Na 2,8,1	Mg 2,8,2	Al 2,8,3	Si 2,8,4	P 2,8,5	S 2,8,6	Cl 2,8,7	Ar 2,8,8
4	K 2,8,8,1	Ca 2,8,8,2						
5		Sr						
6		Ba						
7		Ra						



Potassium atom   Argon atom

2.8 New period new shell

We can say that the elements with the same number of shells occupied by electrons belong to the same period. The elements in the second period, namely, Li, Be, B, C, N, O, F and Ne have electrons in the two shells, K and L. The elements in the third period, namely, Na, Mg, Al, Si, P, S, Cl and Ar have electrons in the three shells; K, L and M. Write down the electronic configuration of these elements and confirm. In the modern periodic table, electrons are filled in the same shell while going along a period from left to right, and at the beginning of the next period a new electron shell starts filling up (See the table 2.8).

The number of elements in the first three periods is determined by the electron capacity of the shells and the law of electron octet. (See the Table 2.9)

Can you recall ?

1. What are the values of 'n' for the shells K, L and M?
2. What is the maximum number of electrons that can be accommodated in a shell? Write the formula.
3. Deduce the maximum electron capacity of the shells K, L and M.

As per the electron holding capacity of shells 2 elements are present in the first period and 8 elements in the second period. The third period also contains only eight elements due to the law of electron octet. There are few more factors which control the filling of electrons in the subsequent periods which will be considered in the next standards.

Shell	n	$2n^2$	Electron Capacity
K	1	$2x1^2$	2
L	2	$2x2^2$	8
M	3	$2x3^2$	18
N	4	$2x4^2$	32

2.9 Electron Capacity of Electron shells

The chemical reactivity of an element is determined by the number of valence electrons in it and the shell number of the valence shell. The information on these points is obtained from the position of the element in the periodic table. That is, the modern periodic table has proved useful for study of elements.

Periodic trends in the modern periodic table

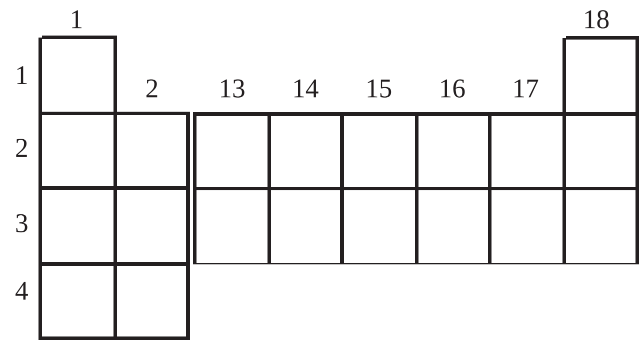
When the properties of elements in a period or a group of the modern periodic table are compared, certain regularity is observed in their variations. It is called the periodic trends in the modern periodic table. In this standard we are going to consider the periodic trends in only three properties of elements; namely, valency, atomic size and metallic- nonmetallic character.

Valency : You have learnt in the previous standard that the valency of an element is determined by the number of electrons present in the outermost shell of its atoms, that is, the valence electrons.

Think about it

1. What is the relationship between the electronic configuration of an element and its valency?
2. The atomic number of beryllium is 4 while that of oxygen is 8. Write down the electronic configuration of the two and deduce their valency from the same.
3. The table on the next page is made on the basis of the modern periodic table. Write in it the electronic configuration of the first 20 elements below the symbol, and write the valency (as shown in a separate box).
4. What is the periodic trend in the variation of valency while going from left to right within a period? Explain your answer with reference to period 2 and period 3.
5. What is the periodic trend in the variation of valency while going down a group? Explain your answer with reference to the group 1, group 2 and group 18.

Symbol	$_{19}K$
Electronic configuration	2, 8, 8, 1
Valency	1



Atomic size

You have seen in the previous standards that size/volume is a fundamental property of matter. The size of an atom is indicated by its radius. Atomic radius is the distance between the nucleus of the atom and its outermost shell.

Atomic radius is expressed in the unit picometer (pm) which is smaller than nanometer (1 pm = 10^{-12} m).

Some elements and their atomic radii are given here.

Element :	O	B	C	N	Be	Li
Atomic radius (pm) :	66	88	77	74	111	152

Use your brain power !

1. By referring to the modern periodic table find out the periods to which the above elements belong.
2. Arrange the above elements in a decreasing order of their atomic radii.
3. Does this arrangement match with the pattern of the second period of the modern periodic table?
4. Which of the above elements have the biggest and the smallest atom?
5. What is the periodic trend observed in the variation of atomic radius while going from left to right within a period?

You will find that atomic radius goes on decreasing while going from left to right within a period. The reason behind this is as follows. While going from left to right within a period, the atomic number increases one by one, meaning the positive charge on the nucleus increases by one unit at a time. However, the additional electron gets added to the same outermost shell. Due to the increased nuclear charge the electrons are pulled towards the nucleus to a greater extent and thereby the size of the atom decreases.

Element :	K	Na	Rb	Cs	Li
Atomic radius (pm):	231	186	244	262	152

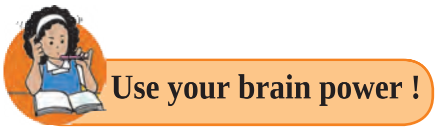
Some elements and their atomic radii are given here.

Use your brain power !

1. By referring to the modern periodic table find out the groups to which above the elements belong.
2. Arrange the above elements vertically downwards in an increasing order of atomic radii.
3. Does this arrangement match with the pattern of the group 1 of the modern periodic table?
4. Which of the above elements have the biggest and the smallest atom?
5. What is the periodic trend observed in the variation of atomic radii down a group?

You will find that while going down a group the atomic size goes on increasing. This is because while going down a group a new shell is added. Therefore the distance between the outermost electron and the nucleus goes on increasing. As a result of this the atomic size increases in spite of the increased nuclear charge.

Metallic- Nonmetallic Character

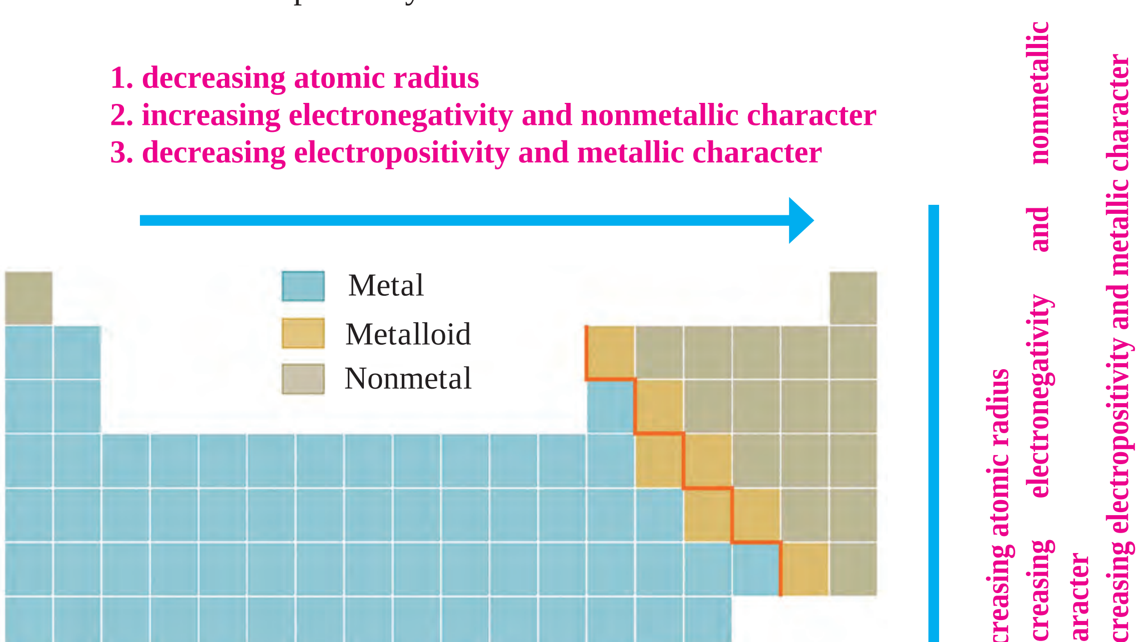


1. Look at the elements of the third period. Classify them into metals and nonmetals.
2. On which side of the period are the metals? Left or right?
3. On which side of the period did you find the nonmetals?

It is seen that the metallic elements like sodium, magnesium are towards the left. The nonmetallic elements such as sulphur, chlorine are towards the right. The metalloid element silicon lies in between these two types. A similar pattern is also observed in the other periods.

It is seen that the zig- zag line separates the metals from nonmetals in the periodic table. Elements appear to have arranged in such a way that metals are on left side of this line, nonmetals on the right side and metalloids are along the border of this line. How did this happen?

Let us compare the characteristic chemical properties of metals and nonmetals. It is seen from the chemical formulae of simple ionic compounds that the cation in them is formed from a metal while the anion from a nonmetal. From this it is understood that metal atoms have a tendency to form a cation by losing its valence electron, this property is called electropositivity of an element. On the other hand an atom of a nonmetal has a tendency to form an anion by accepting electrons from outside into its valence shell. We have already seen that ions have a stable electronic configuration of a noble gas. How is the ability to lose or accept electrons in the valence shell determined? All the electrons in any atom are held by the attractive force exerted on them by the positively charged nucleus. Electrons in the inner shells lie in between the valence shell and the nucleus. Because of their presence the effective nuclear charge exerting an attractive force on the valence electrons is somewhat less than the actual nuclear charge. Thus, the number of valence electrons in metals is small (1 to 3). Also the effective nuclear charge exerting attractive force on the valence electrons is small. As a combined effect of these two factors metals have a tendency to lose the valence electrons to form cations having a stable noble gas configuration. This tendency of an element called electropositivity is the metallic character of that element.



2.10 Periodic Trends in elements

The periodic trend in the metallic character of elements is clearly understood from their position is the modern periodic table. Let us first consider the metallic character of elements belonging to the same group. While going down a group a new shell gets added, resulting in an increase in the distance between the nucleus and the valence electrons. This results in lowering the effective nuclear charge and thereby lowering the attractive force on the valence electrons. As a result of this the tendency of the atom to lose electrons increases. Also the penultimate shell becomes the outermost shell on losing valence electrons. The penultimate shell is a complete octet. Therefore, the resulting cation has a special stability. Due to this, the tendency of the atom to lose electrons increases further. The metallic character of an atom is its tendency to lose electrons. Therefore, the following trend is observed : The metallic character of elements increases while going down the group.

While going from left to right within a period the outermost shell remains the same. However, the positive charge on the nucleus goes on increasing while the atomic radius goes on decreasing and thus the effective nuclear charge goes on increasing. As a result of this the tendency of atom to lose valence electrons decreases within a period from left to right (See Table 2.10).

The two factors namely, the increasing nuclear charge and decreasing atomic radius as we go from left to right within a period, are responsible for increasing the effective nuclear charge. Therefore, the valence electrons are held with greater and greater attractive force. This is called electronegativity of an atom. Due to increasing electronegativity from left to right within a period, the ability of an atom to become anion by accepting outside electrons goes on increasing. The tendency of an element to form anion or the electro negativity is the nonmetallic character of an element.

Use your brain power !

1. What is the cause of nonmetallic character of elements?
2. What is the expected trend in the variation of nonmetallic character of elements from left to right in a period?
3. What would be the expected trend in the variation of nonmetallic character of elements down a group?

Always remember

1. While going downwards in any group the electropositivity of elements goes on increasing while their electronegativity goes on decreasing.
2. While going from left to right in any period the electronegativity of elements goes on increasing while their electropositivity goes on decreasing.
3. Larger the electropositivity or electronegativity of the element higher the reactivity.

Gradation in Halogen Family

The group 17 contains the members of the halogen family. All of them have the general formula X_2. A gradation is observed in their physical state down the group. Thus, fluorine (F_2) and chlorine (Cl_2) are gases, bromine (Br_2) is a liquid while iodine (I_2) is a solid.

Internet my friend

Collect the information & mail it

1. Inert gas elements.
2. Uses of various elements.

Read the following reference books from your library.

1. Understanding chemistry - C.N.R. Rao
2. The Periodic Table Book: A Visual Encyclopedia of the Elements

Do you know ?

$M + 2H_2O \longrightarrow M(OH)_2 + H_2$

A general chemical equation indicating the reaction of alkaline earth metals is given above. While going down the second group as Be$\rightarrow$ Mg $\rightarrow$Ca$\rightarrow$Sr$\rightarrow$Ba, the gradation in this chemical property of the alkaline earth metals is seen. While going down the second group the reactivity of the alkaline earth metals goes on increasing and thereby the ease with which this reaction takes place also goes on increasing. Thus beryllium (Be) does not react with water. Magnesium (Mg) reacts with steam, while calcium (Ca), strontium (Sr) and barium (Ba) react with water at room temperature with increasing rates.

Exercise

1. Rearrange the columns 2 and 3 so as to match with the column 1.

Column 1	Column 2	Column 3
i. Triad	a. Lightest and negatively charged particle in all the atoms	1. Mendeleev
ii. Octave	b. Concentrated mass and positive charge	2. Thomson
iii. Atomic number	c. Average of the first and the third atomic mass	3. Newlands
iv. Period	d. Properties of the eighth element similar to the first	4. Rutherford
v. Nucleus	e. Positive charge on the nucleus	5. Dobereiner
vi. Electron	f. Sequential change in molecular formulae	6. Moseley

2. Choose the correct option and rewrite the statement.

a. The number of electrons in the outermost shell of alkali metals is......

(i) 1 (ii) 2 (iii) 3 (iv) 7

b. Alkaline earth metals have valency 2. This means that their position in the modern periodic table is in .....

(i) Group 2 (ii) Group16

(iii) Period 2 (iv) d-block

c. Molecular formula of the chloride of an element X is XCl. This compound is a solid having high melting point. Which of the following elements be present in the same group as X.

(i) Na (ii) Mg (iii) Al (iv) Si

d. In which block of the modern periodic table are the nonmetals found?

(i) s-block (ii) p-block

(iii) d-block (iv) f-block

3. An element has its electron configuration as 2,8,2. Now answer the following questions.

a. What is the atomic number of this element?

b. What is the group of this element?

c. To which period does this element belong?

d. With which of the following elements would this element resemble? (Atomic numbers are given in the brackets)

N (7), Be (4) , Ar (18), Cl (17)

4. Write down the electronic configuration of the following elements from the given atomic numbers. Answer the following question with explanation.

a. ${}_{3}Li$, ${}_{14}Si$, ${}_{2}He$, ${}_{11}Na$, ${}_{15}P$ Which of these elements belong to be period 3?

b. ${}_{1}H$, ${}_{7}N$, ${}_{20}Ca$, ${}_{16}S$, ${}_{4}Be$, ${}_{18}Ar$ Which of these elements belong to the second group?

c. ${}_{7}N$, ${}_{6}C$, ${}_{8}O$, ${}_{5}B$, ${}_{13}A1$ Which is the most electronegative element among these?

d. ${}_{4}Be$, ${}_{6}C$, ${}_{8}O$, ${}_{5}B$, ${}_{13}A1$ Which is the most electropositive element among these?

e. ${}_{11}Na$, ${}_{15}P$, ${}_{17}C1$, ${}_{14}Si$, ${}_{12}Mg$ Which of these has largest atoms?

f. ${}_{19}K$, ${}_{3}Li$, ${}_{11}Na$, ${}_{4}Be$ Which of these atoms has smallest atomic radius?

g. ${}_{13}A1$, ${}_{14}Si$, ${}_{11}Na$, ${}_{12}Mg$, ${}_{16}S$ Which of the above elements has the highest metallic character?

h. ${}_{6}C$, ${}_{3}Li$, ${}_{9}F$, ${}_{7}N$, ${}_{8}O$ Which of the above elements has the highest nonmetallic character?

5. Write the name and symbol of the element from the description.

a. The atom having the smallest size.
b. The atom having the smallest atomic mass.
c. The most electronegative atom.
d. The noble gas with the smallest atomic radius.
e. The most reactive nonmetal.

6. Write short notes.

a. Mendeleev's periodic law.
b. Structure of the modern periodic table.
c. Position of isotopes in the Mendeleev's and the modern periodic table.

7. Write scientific reasons.

a. Atomic radius goes on decreasing while going from left to right in a period.
b. Metallic character goes on decreasing while going from left to right in a period.
c. Atomic radius goes on increasing down a group.
d. Elements belonging to the same group have the same valency.
e. The third period contains only eight elements even through the electron capacity of the third shell is 18 .

8. Write the names from the description.

a. The period with electrons in the shellsK, L and M.
b. The group with valency zero.
c. The family of nonmetals having valency one.
d. The family of metals having valency one.
e. The family of metals having valency two.
f. The metalloids in the second and third periods.
g. Nonmetals in the third period.
h. Two elements having valency 4.

Project

Find out the applications of all the inert gases, prepare a chart and display it in the class.

HZGUU3