PERIODIC CLASSIFICATION OF ELEMENTS

TOPIC 1

EARLY ATTEMPTS AT CLASSIFICATION OF ELEMENTS

The number of elements known to us is around 118. But around the year 1800, only 30 elements were known and their properties were also not known much. With the discovery of more elements, scientists gathered more and more information about the properties of these elements and looked for ways to organize them on the basis of similarities in their properties.

The earliest attempt to classify the elements resulted in grouping the then known elements as metals and non-metals. Later further classifications were tried out as our knowledge of elements and their properties increased.

Döbereiner's Triads

In the year 1817, Johann Wolfgang Döbereiner, a German chemist, identified some groups having three elements each which he called 'triads'.

Döbereiner showed that when the three elements in a triad were written in the order of increasing atomic masses, the atomic mass of the middle element was roughly the average of the atomic masses of the other two elements.

Döbereiner's Triads				
Group	**Elements and their Atomic Mass**			**Arithmetic mean of Atomic mass**
A	Lithium (Li)	Sodium (Na)	Potassium (K)	$\frac{6.9 + 39.0}{2}$ = 22.95 or 23.0
	6.9	23.0	39.0	
B	Calcium (Ca)	Strontium (Sr)	Barium (Ba)	$\frac{40.0 + 137.0}{2}$ = 88.5
	40.0	87.5	137.0	
C	Chlorine (Cl)	Bromine (Br)	Iodine(I)	$\frac{35.02 + 127.0}{2}$ = 81.0
	35.0	80.0	127.0	

Example: Consider the triad consisting of lithium (Li), sodium (Na) and potassium (K) with the respective atomic masses 6.9, 23.0 and 39.0. The atomic mass of sodium (23) is the mean of the masses of lithium and potassium.

Achievements of Döbereiner's Triads

This was a great step in predicting atomic mass and properties of middle element. The triads identified by Döbereiner are placed in the same group even in the Modern Periodic Table.

Newlands' Law of Octaves

In 1866, John Newlands, an English scientist, arranged the then known elements in the order of increasing atomic masses. He started with the element having the lowest atomic mass (hydrogen) and ended at thorium which was the 56^{th} element.

He found that every eighth element had properties similar to that of the first. He compared this to the octaves found in music. Therefore, he called it the 'Law of Octaves'. It is known as 'Newlands' Law of Octaves'. In Newlands' Octaves, the properties of lithium and sodium were found to be the same. Sodium is the eighth element after lithium. Similarly, beryllium and magnesium resemble each other.

Newlands' Octaves						
sa (do)	re (re)	ga (mi)	ma(fa)	pa (so)	da (la)	ni (ti)
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co and Ni	Cu	Zm	Y	In	As	Se
Br	Rb	Sr	Ce and La	Zr	—	—

Limitations of Newland's Law of Octaves

(1) The Law of Octaves was applicable only upto calcium, as after calcium every eighth element did not possess properties similar to that of the first.

(2) Newlands assumed that only 56 elements existed in nature and no more elements would be discovered in the future. But, later on, several new elements were discovered, whose properties did not fit into the Law of Octaves.

(3) In order to fit elements into his Table, Newlands adjusted two elements in the same slot, but also put some unlike elements under the same note.

Example:

- Cobalt and nickel are in the same slot and these are placed in the same column as fluorine, chlorine and bromine which have very different properties than these elements.
- Iron, which resembles cobalt and nickel in properties, has been placed far away from these elements.

(4) Newlands' Law of Octaves worked well with lighter elements only.

MOST LIKELY Questions

Short Answer Type-I Questions (SA-I)

[2 marks]

1. Can the following groups of elements be classified as Dobereiner's triad?

(A) Na, Si, Cl (B) Be, Mg, Ca

Atomic mass of Be 9; Na 23; Mg 24; Si 28; Cl 35; Ca 40.

Explain by giving reason.

Ans. For a group to be Dobereiner's triad, the atomic mass of the middle element must be average of the atomic masses of the first and the third elements.

(A) No. Na, Si, Cl cannot be classified as Dobereiner's triad because all these elements do not have similar properties, although the atomic mass of silicon is the average of the atomic masses of sodium (Na) and chlorine (Cl).

$$\text{Atomic mass of Si} = \frac{23 + 35}{2} = \frac{58}{2} = 29$$

(B) Yes. Be, Mg, Ca can be classified as Dobereiner's triad because they have similar properties and the mass of magnesium (Mg) is roughly the average of the atomic mass of Be and Ca.

$$\text{Atomic mass of Mg} = \frac{9 + 40}{2} = \frac{49}{2} = 24.$$

TOPIC 2

MENDELÉEV'S PERIODIC TABLE

The main credit for classifying elements goes to Dmitri Ivanovich Mendeléev, a Russian chemist. He was the most important contributor to the early development of a Periodic Table of elements wherein the elements were arranged on the basis of their fundamental property, the atomic mass, and also on the similarity of chemical properties.

(1) When Mendeléev started his work, 63 elements were known.

(2) He examined the relationship between the atomic masses of the elements and their physical and chemical properties.

(3) Among chemical properties, Mendeléev concentrated on the compounds formed by elements with oxygen and hydrogen.

(4) He selected hydrogen and oxygen as they are very reactive and formed compounds with most elements. The formulae of the hydrides and oxides formed by an element were treated as one of the basic properties of an element for its classification.

(5) He then took 63 cards and on each card he wrote down the properties of one element.

(6) He sorted out the elements with similar properties and pinned the cards together on a wall.

(7) He observed that most of the elements got a place in a Periodic Table and were arranged in the order of their increasing atomic masses.

(8) It was also observed that there occurs a periodic recurrence of elements with similar physical and chemical properties.

Mendeléev Periodic Law: 'The properties of elements are the periodic function of their atomic masses'.

Group	I	II	III	IV	V	VI	VII	VIII
Oxide Hydride	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_3	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH	RO_4
Periods ↓	A B	A B	A B	A B	A B	A B	A B	Transition sries
1	H 1.008							
2	Li 6.939	Be 9.012	B 10.81	C 12.011	N 14.007	O 15.999	F 18.998	
3	Na 22.99	Mg 24.31	Al 29.98	Si 28.09	P 30.974	S 32.06	Cl 35.453	
4 First series : Second series	K 39.102 Cu 63.54	Ca 40.08 Zn 65.37	Sc 44.96 Ga 69.72	Ti 47.90 Ge 72.59	V 47.90 As 74.92	Cr 50.94 Se 78.96	Mn 54.94 Br 79.909	Fe Co Ni 55.85 58.93 58.71
5 First series : Second series	Rb 85.47 Ag 107.87	Sr 87.62 Cd 112.40	Y 88.91 In 114.82	Zr 91.22 Sn 118.69	Nb 92.91 Sb 121.75	Mo 95.94 Te 127.60	Tc 99 I 126.90	Ru Rh Pd 101.07 102.91 106.4
6 First series : Second series	Cs 132.90 Au 196.97	Ba 137.34 Hg 200.59	La 138.91 Tl 204.37	Hf 178.49 Pb 207.19	Ta 18095 Bi 208.98	W 183.85		Os Ir Pt 190.2 192.21 195.09

Features of Mendeléev's Periodic Table

(1) Mendeléev's Periodic Table contains vertical columns called 'groups' and horizontal rows called 'periods'.

(2) This table contains 8 groups and 6 periods.

(3) The formula for oxides and hydrides are written at the top of the columns of Mendeléev's periodic table, where the letter 'R' is used to represent any of the elements in the group. For example, the hydride of carbon, CH_4, is written as RH_4 and the oxide CO_2, as RO_2.

Achievements of Mendeléev's Periodic Table

(1) Mendeléev's periodic law predicted the existence of some elements that had not been discovered at that time. Mendeléev left some gaps in his Periodic Table. Mendeléev named them by prefixing a Sanskrit numeral, *Eka* (one) to the name of preceding element in the same group.

For example: Scandium, gallium and germanium, discovered later, have properties similar to Eka-boron, Eka-aluminium and Eka-silicon, respectively.

The properties of Eka-Aluminium predicted by Mendeléev and those of the element, gallium which was discovered later and replaced Eka aluminium, are listed as follows.

Property	Eka-Aluminium (Predicted)	Gallium (Actual)
Atomic Mass	68	69.7
Density	5.9 g/cm^3	5.94 g/cm^3
Melting Point	Low	30.2 °C (Low)
Formula of Chloride	ECl_3	$GaCl_3$
Formula of Oxide	E_2O_3	Ga_2O_3

(2) Mendeléev's periodic table could predict the properties of several elements on the basis of their positions in the periodic table.

(3) It could accommodate noble gases when these gases were discovered in a new group without disturbing the existing order.

Limitations of Mendeléev's Classification

Position of Hydrogen

The electronic configuration of hydrogen resembles that of alkali metals. Like alkali metals, hydrogen combines with halogens, oxygen and sulphur to form compounds having similar formulae. On the other hand, just like halogens, hydrogen also exists as diatomic molecules and it combines with metals and non-metals to form covalent compounds.

Thus, a correct position could not be assigned to hydrogen in the periodic table.

Position of Isotopes

The position of isotopes could not be explained since the elements are arranged according to their atomic masses and isotopes are atoms of the same element having similar chemical properties but different atomic masses.

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

Position of isotopes, which were discovered much later, could not be explained as they were placed in the same group.

Wrong Order of Atomic Masses

There were a few instances where Mendeléev had to place an element with a slightly greater atomic mass before an element with a slightly lower atomic mass. The sequence was inverted so that elements with similar properties could be grouped together.

For example, cobalt (atomic mass 58.9) appeared before nickel (atomic mass 58.7).

Wrong order of atomic masses of some elements could not be explained.

Non-uniform Variation of Atomic Masses

Another problem was that the atomic masses do not increase in a regular manner in going from one element to the next. So it was not possible to predict how many elements could be discovered between two elements — especially when we consider the heavier elements.

MOST LIKELY Questions

Short Answer Type-I Questions (SA-I)

[2 marks]

2. In Mendeléev's periodic table, why was there no mention of noble gases like helium, neon and argon?

Ans. Noble gases were not known at that time. So, there was no group of noble gases in Mendeléev's original periodic table.

Short Answer Type-II Questions (SA-II)

[3 marks]

3. List any two observations which posed a challenge to Mendeléev periodic law.

Ans. Two observations that posed a challenge to Mendeléev's periodic law:

(1) The position of isotopes could not be explained since the elements are arranged according to their atomic masses.

(2) Wrong order of atomic masses of some elements could not be explained. For example, cobalt (atomic mass 58.9) appeared before nickel (atomic mass 58.7).

(3) A correct position could not be assigned to hydrogen in the periodic table.

(4) The atomic masses do not increase in a regular manner in going from one element to the next.

(Any 2 of 4 points can be written to get full marks)

Case Based Questions

[4 marks]

4. *A student tried to assign a correct position to hydrogen in Mendeléev's Periodic Table by looking at its resemblance to alkali metals and the halogen family.*

Another student wondered where she would place the isotopes of chlorine, Cl-35 and Cl-37 as they were atoms of the same element.

(A) No fixed position could be given to hydrogen in the Mendeléev's Periodic Table. Why?

(B) The formula of hydrides of elements belonging to a group of Mendeelev's Periodic Table is RH_2. What is the group number to which the element belongs?

(C) (i) What is the formula of oxides and hydrides of elements belonging to different group 1 of the Mendeléev's Periodic Table

(ii) Mendeléev left some gaps in his Periodic Table as he predicted the existence of some elements that had not been discovered at that time. Which element discovered later, have properties similar to Eka-boron?

Ans. (A) As Mendeléev's periodic table was based on atomic mass, no fixed position could be assigned to hydrogen. However, it has one valence electron just like alkali metals Li, Na, K etc. Moreover, hydrogen combines with halogens, oxygen and sulphur just like alkali metals do.

However, hydrogen combines with metals and non-metals to form covalent bonds by sharing of electrons and exists as diatomic molecules like halogens.

(B) The formula of hydrides of elements belonging to group VI of Mendeleev's periodic table is RH_2.

(C) (i) The formula of hydrides and oxides of elements belonging to group I of Mendeléev's table is R_2O and RH respectively. For example, formula of oxide and hydride of element Li will be Li_2O and LiH respectively.

(ii) Scandium, which was discovered later had properties similar to Eka-boron.

Apart from scandium, gallium and germanium, discovered later, have properties similar to Eka-aluminium and Eka-silicon, respectively.

TOPIC 3

THE MODERN PERIODIC TABLE

In 1913, Henry Moseley showed that the atomic number of an element is a more fundamental property than its atomic mass. Accordingly, Mendeléev's Periodic Law was modified and atomic number was adopted as the basis of Modern Periodic Table.

Modern Periodic Law: 'Properties of elements are a periodic function of their atomic number.'

Elements, when arranged in order of increasing atomic number, lead us to the classification known as the Modern Periodic Table. Prediction of properties of elements could be made with more precision when elements were arranged on the basis of increasing atomic number.

Note: See the table on the next page.

Features of Modern Periodic Table

The Modern Periodic Table has 18 vertical columns known as 'groups' and 7 horizontal rows known as 'periods'.

Position of Elements in the Modern Periodic Table

In order to find the position of an element in the modern periodic table, the group number and period number of the element is to be found out from its electronic configuration.

Period

(1) The period number of an element is equal to the number of electron shells in its atom.

If an atom has two occupied shells, it will belong to the second period.

(2) The number of elements in a period is fixed by the maximum number of electrons which can be accommodated in the different shells of an atom.

(3) The maximum number of electrons that can be accommodated in a shell is given by the formula $2n^2$, where n is the shell number.

Shell Number (n)	Shell	Maximum Number of Electrons
n = 1	K	$2\times(1)^2 = 2$
n = 2	L	$2\times(2)^2 = 8$
n = 3	M	$2\times(3)^2 = 18$

(4) Each period marks a new electronic shell getting filled.

(5) If two or more elements have the same number of valence shells, then they belong to the same period of the periodic table.

1st period contains 2 elements and is called very short period.

2nd period contains 8 elements and is called short period.

3rd period contains 8 elements and is called short period .

4th period contains 18 elements and is called long period.

5th period contains 18 elements and is also called long period.

6th period contains 32 elements and is called very long period.

7th period contains rest of the elements and is incomplete.

Groups

(1) The group number of an element having upto two valence electrons is equal to the number of valence electrons.

(2) The group number of an element having more than 2 valence electrons is equal to the number of valence electrons + 10.

Elements having 1 valence electron are placed in Group 1.

Elements having 2 valence electrons are placed in Group 2.

Elements having 3 valence electrons are placed in Group 13.

Elements having 4 valence electrons are placed in Group 14.

Elements having 5 valence electrons are placed in Group 15.

Elements having 6 valence electrons are placed in Group 16.

Elements having 7 valence electrons are placed in Group 17.

Elements having 8 valence electrons are placed in Group 18.

(3) The elements in a group do not have consecutive atomic numbers.

(4) All the elements in a group have similar electronic configurations and show similar properties. All elements contain the same number of valence electrons. Groups in the Periodic Table signify an identical outer shell electronic configuration.

(5) The number of shells increases as we go down the group.

(6) If two or more elements have the same number of valence electrons, then they belong to the same group of the periodic table.

The zigzag line separates the metals from the non-metals.

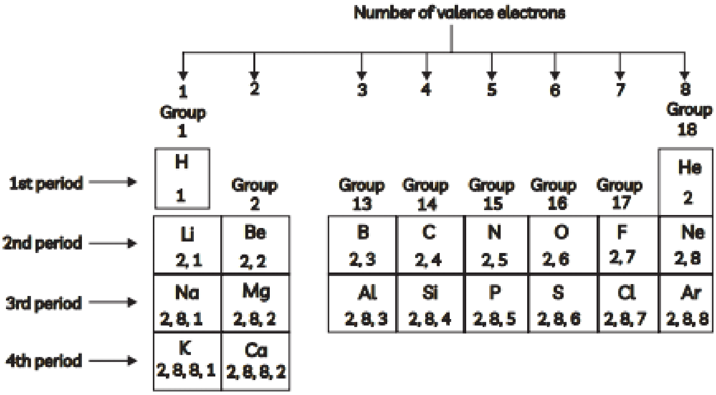
Metals | Metalloids | Non-metals

GROUP NUMBER

PERIODS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 **H** Hydrogen 1.0																	2 **He** Helium 4.0
2	3 **Li** Lithium 6.9	4 **Be** Beryllium 9.0											5 **B** Boron 10.8	6 **C** Carbon 12.0	7 **N** Nitrogen 14.0	8 **O** Oxygen 16.0	9 **F** Fluorine 19.0	10 **Ne** Neon 20.2
3	11 **Na** Sodium 23.0	12 **Mg** Magnesium 24.3											13 **Al** Aluminium 27.0	14 **Si** Silicon 28.1	15 **P** Phosphorus 31.0	16 **S** Sulphur 32.1	17 **Cl** Chlorine 35.5	18 **Ar** Argon 33.9
4	19 **K** Potassium 39.1	20 **Ca** Calcium 40.1	21 **Sc** Scandium 45.0	22 **Ti** Titanium 47.8	23 **V** Vanadium 50.9	24 **Cr** Chromium 52.0	25 **Mn** Manganese 54.9	26 **Fe** Iron 55.9	27 **Co** Cobalt 58.9	28 **Ni** Nickel 58.7	29 **Cu** Copper 63.5	30 **Zn** Zinc 65.4	31 **Ga** Gallium 69.7	32 **Ge** Germanium 72.0	33 **As** Arsenic 74.9	34 **Se** Selenium 79.0	35 **Br** Bromine 79.9	36 **Kr** Krypton 81.8
5	37 **Rb** Rubidium 85.5	38 **Sr** Strontium 87.6	39 **Y** Yurium 88.9	40 **Zr** Zirconium 91.2	41 **Nb** Niobium 92.9	42 **Mo** Molybdenum 95.9	43 **Tc** Technetium (99)	44 **Ru** Ruthenium 101.1	45 **Rh** Rhodium 102.3	46 **Pd** Palladium 106.4	47 **Ag** Silver 107.9	48 **Cd** Cadmium 112.4	49 **In** Indium 114.8	50 **Sn** Tin 118.7	51 **Sb** Antimony 121.8	52 **Te** Tellurium 127.6	53 **I** Iodine 128.9	54 **Xe** Xenon 133.3
6	55 **Cs** Caesium 132.9	56 **Ba** Barium 137.3	57 **La*** Lanthanum 138.9	72 **Hf** Hafnium 178.5	73 **Ta** Tantalum 181.0	74 **W** Tungsten 183.9	75 **Re** Rhenium 186.2	76 **Os** Osmium 190.2	77 **Ir** Iridium 192.2	78 **Pt** Platinum 195.1	79 **Au** Gold 197.0	80 **Hg** Mercury 200.6	81 **Tl** Thallium 204.4	82 **Pb** Lead 207.2	83 **Bi** Bismuth 209.0	84 **Po** Polonium (210)	85 **At** Astatine (210)	86 **Rn** Radon (222)
7	87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac**** Actinium (227)	104 **Rf** Rutherfordium (267)	105 **Db** Dubnium (268)	106 **Sg** Seaborgium (269)	107 **Bh** Bohrium (270)	108 **Hs** Hassium (277)	109 **Mt** Meitnerium (278)	110 **Ds** Darmstadtium (281)	111 **Rg** Roentgenium (282)	112 **Cn** Copernicium (285)	113 **Nh** Nihonium (286)	114 **Fl** Flerovium (289)	115 **Mc** Moscovium (290)	116 **Lv** Livermorium (293)	117 **Ts** Tennessine (294)	118 **Og** Oganesson (294)

*Lanthanoides	58 **Ce** Cerium 140.1	59 **Pr** Praseodymium 140.9	60 **Nd** Neodymium 144.2	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.4	63 **Eu** Europium 152.0	64 **Gd** Gadolinium 157.3	65 **Tb** Terbium 158.9	66 **Dy** Dysprosium 162.5	67 **Ho** Holmium 164.9	68 **Er** Erbium 167.3	69 **Tm** Thulium 168.9	70 **Yb** Ytterbium 173.0	71 **Lu** Lutetium 175.5
**Actinoides	90 **Th** Thorium 232.0	91 **Pa** Protactinium (231)	92 **U** Uranium 238.1	93 **Np** Neptunium (127)	94 **Pu** Plutonium (242)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **BK** Berkelium (145)	98 **Cf** Californium (251)	99 **Es** Einsteinium (254)	100 **Fm** Fermium (253)	101 **Md** Mendelevium (250)	102 **No** Nobelium (154)	103 **Lr** Lawrencium (257)

Arrangement of elements in the modern periodic table on the basis of the electronic configurations of their atoms



Position of Hydrogen: There is an anomaly when it comes to the position of hydrogen because it can be placed either in group 1 or group 17 in the first period.

Hydrogen has been placed at the top of Group I, above the alkali metals because the electronic configuration of hydrogen is similar to those of alkali metals. Both have 1 valence electron each. Since the size of hydrogen atom is much smaller than that of alkali metals, many properties of hydrogen are different from those of alkali metals.

Explanation of the Anomalies of Mendeléev's Classification of Elements

(1) **Explanation of the position of hydrogen:** A unique position has been given to hydrogen. It has been placed at the top left corner in group 1, period 1 because of its unique characteristics.

(2) **Explanation for the position of isotopes:** Since all the isotopes of an element have the same atomic number, they are put at one place in the same group of the periodic table.

(3) **Explanation for the Position of Cobalt and Nickel:** Since the elements are arranged according to their atomic number, and the atomic number of cobalt is 27 while that of nickel is 28, so cobalt with lower atomic number should come first and nickel with higher atomic number should come later.

Comparison of Mendeléev's Periodic table and Modern periodic table

Mendeléev's Periodic Table	Modern Periodic Table
Mendeléev's periodic table is based on atomic mass.	Modern periodic table is based on atomic number.
There were gaps for undiscovered elements.	Modern periodic table maintains uniformity.
Noble gases were not placed (as they are not discovered at that time)	Noble gases in a separate group named as group-18.
There are a total of 8 groups and 6 periods	There are a total of 18 groups and 7 periods

Trends in the Modern Periodic Table

Valency

The valency of an element is its combining capacity with other atoms in order to attain the nearest inert gas configuration. It is related to the number of valence electrons present in the atom of an element.

Variation along a period: On moving from left to right, the valency increases from 1 to 4 and then decreases to 0 from group 15 to 18 as the valency is determined by the number of valence electrons.

Example: Valency of Na (Z = 11) is 1 as its electronic configuration is 2, 8, 1 and it attains its nearest inert gas configuration by losing one electron.

Valency of O (Z = 8) is 2, as its electronic configuration is (2, 6) and it requires two electrons to attain its nearest inert gas configuration.

Variation along a group: All elements in a group have the same valency as elements in the same group have the same number of valence electrons.

Valency of group 1 elements = Number of valence electrons = 1

Valency of group 2 elements = Number of valence electrons = 2

Valency of group 13 elements = Number of valence electrons = 3

Valency of group 14 elements = Number of valence electrons = 4

Valency of group 15 elements = 8 - Number of valence electrons = 3

Valency of group 16 elements = 8 - Number of valence electrons = 2

Valency of group 17 elements = 8 - Number of valence electrons = 1

Valency of group 18 elements = 8 - Number of valence electrons = 0

Example: Elements Li, Na and K belong to group 1 as they all have one valence electron and hence have valency 1.

Li: 2, 1

Na: 2, 8, 1

K: 2, 8, 8, 1

Elements F, Cl and Br belong to group 17 as they as they all have seven valence electrons and hence have valency 1 (8 – 7).

F: 2, 7

Cl: 2, 8, 7

Br: 2, 8, 8, 7

Atomic size

The size of an atom refers to the radius of atom and is the distance between the centre of the nucleus and the outermost shell of an isolated atom. It is expressed in picometer.

1 picometer = 10^{-12} m

Variation along a period: On moving from left to right in a period, the size of atoms decreases.

Reason: When we move from left to right in a period, the number of electrons and protons increases. Due to the large positive charge on the nucleus, electrons are pulled more strongly towards the nucleus.

Variation along a group: The size of an atom (radius) increases as we go down in a group

Reason: When going from top to bottom in a group, a new shell is added to the atoms which increases the distance between the valence electrons and the nucleus. So, the effective nuclear charge experienced by the valence electrons decreases.

Metallic and Non-metallic Character

Metals are the elements that have 1, 2 or 3 electrons in their valence shell and lose electrons easily to form positive ions or cations. They are present on the left side and centre of the periodic table. They are called electropositive elements as they have a tendency of losing electrons.

Non-Metals are the elements that have 4, 5, 6 or 7 electrons in their valence shell and gain electrons to form negative ions or anions. They are present on the right side of the periodic table. They are called electronegative elements as they have a tendency of gaining electrons.

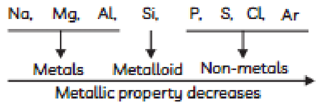
Metalloids: There are some elements known as metalloids that exhibit properties of both metals and non-metals.

In the Modern Periodic Table, a zig-zag line separates metals from non-metals. The border line elements – boron, silicon, germanium, arsenic, antimony, tellurium and polonium – are intermediate in properties and are called metalloids or semi-metals.

Variation along a period: The metallic character decreases and non-metallic character increases as we move from left to right in a period.

Reason: When we move from left to right in a period, the electropositive character of elements decreases, but the electronegative character increases. Due to the large positive charge on the nucleus, electrons are pulled more strongly towards the nucleus.

Example: Consider the elements of 3rd period. The variation of metallic character is shown below:



Variation along a group: The metallic character increases and non-metallic character decreases as we move from top to bottom in a group.

Reason: When we go down a group, the electropositive character of elements increases as the tendency of an atom to lose electrons increases as the effective nuclear charge experienced by the valence electrons decrease. The electronegative character decreases down a group as the tendency to gain electrons decreases.

Chemical Reactivity

The chemical reactivity of an element depends upon the electronic configuration of the atom of the alement.

Variation along a period: The chemical reactivity of elements first decreases and then increases when we move from left to right in a period.

Variation along a group: The chemical reactivity of metals increases on going down in a group.

The chemical reactivity of non-metals decreases on going down in a group.

Nature of Oxides

Variation along a period: The basic nature of oxides decreases and the acidic nature increases as we move from left to right as metal oxides are basic in nature and oxides of non-metals are acidic in nature.

Variation along a group: There is no change in the nature of oxides as we go down in a group as all elements of the same group have similar chemical nature.

Merits of the Modern Periodic Table

(1) It is based on the atomic number of elements which is the most fundamental property of elements.

(2) It helps us understand why elements in a group show similar properties but elements in different groups show different properties.

(3) It explains the reasons for the periodicity in properties of elements.

(4) The modern periodic table tells us why the properties of elements are repeated after 2, 8, 18 and 32 elements.

(5) There are no anomalies in the arrangement of elements in the modern periodic table.

MOST LIKELY Questions

Short Answer Type-I Questions (SA-I)

[2 marks]

5. The atomic radii of three elements A, B and C of a periodic table are 186 pm, 104 pm and 143 pm respectively. Giving a reason, arrange these elements in the increasing order of atomic numbers in the period.

Ans. Since atomic size decreases along a period and the atomic number increases. So, the element with smaller radii, has the highest atomic number.

Hence, B has the highest atomic number followed by C and A

i.e. A < C < B

Explanation: The atomic size is the distance between the centre of the nucleus and the outermost shell of an isolated atom. The atomic radius is measured in picometre, (1 pm = 10^{-12} m).

The atomic radius decreases in moving from left to right along a period. This is due to:

As the atomic number increases, the nuclear charge increases. Increase in nuclear charge tends to pull the electrons closer to the nucleur and reduce the size of the atom.

6. The position of three elements *A*, *B* and *C* in the Modern periodic table is as follows:

Group→ Period↓	1	2	13	14	15	16	17	
1								
2								
3								

(A) Write formula of compound formed between:

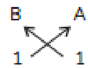
(i) B and A (ii) B and C

(B) Is any of the three elements a metal? Give reason to justify your answer.

Ans.

Element	Group no.	Period Number	Atomic number	Electronic configu-ration
B	1	1	1	1
A	17	2	9	2, 7
C	16	2	16	2, 8, 6

(A) (i) Formula between *B* and *A*.

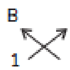


Or it can be written as

or *B*–*A* or *BA*

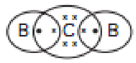
Explanation: '*B*' element has one valence electron. It needs only one electron to complete its duplet *i.e.* *K* shell. '*A*' element has 7 valence electrons it also needs one electron to complete its octet *i.e.* *L* shell. These two elements will share electrons and form covalent bond.

(ii) *B* and *C*



Or

B_2C



or *B*—*C*—*B* or B_2C

Explanation: '*C*' element has 6 valence electrons and it needs two electrons to complete its octet *i.e.* M shell. So it will share two electrons with two atoms of *B* and form B_2C and the bonding is covalent bonding.

Related Theory

- *In compound BA there is one single covalent bond whereas in B_2C there are two single covalent bonds. Both the compounds are saturated hydrocarbons.*
- *Saturated hydrocarbons are compounds of carbon which have only single covalent bonds between carbon atoms and usually thee compounds are not very reactive none of the three elements is a metal though H forms H^+.*

(B) The position of *B* is controversial as it resembles alkali metals in its electronic configuration (1 electron in valance shell) and some other properties. '*B*' element also resembles halogens in its electronic configuration (has one electron less than the nearest noble gas configuration). But '*B*' differs from both alkali metals and halogens. So its position remains to be controversial even in modern periodic table. However, '*B*' element has been placed in group 1 and period 1 as it has lowest atomic number.

7. An element belongs to third period and second group of the periodic table:

(A) State the number of valence electrons in it.

(B) Is it a metal or a non-metal?

(C) Name the element.

(D) Write the formula of its oxide.

Ans. (A) As the element belongs to the second group of the periodic table, it has 2 valence electrons.

(B) It is a metal since it can lose its valence electrons and form a cation.

(C) Element belonging to third period has three occupied shells (K, L and M) and as it belongs to group 2, it has 2 electrons in the M shell. Its electronic configuration is 2, 8, 2 and atomic number is 12. The element is therefore magnesium (Mg).

(D) Formula of its oxide is MgO, as it has a valency of 2.

Short Answer Type-II Questions (SA-II)

[3 marks]

8. Why is atomic number considered to be a more appropriate parameter than atomic mass for the classification of elements in a periodic table? How does the metallic character of elements vary as we move (i) from left to right in a period, and (ii) top to bottom in a group in the modern periodic table? Give reasons to justify your answers.

Ans. When elements were arranged on the basis of increasing atomic number, prediction of their properties could be made with more precision. Moreover, many anomalies of the Mendeleev's periodic table, such as position of isotopes, position of elements such as Cobalt and Nickel, could be explained.

(1) The metallic character decreases as we move from left to right in a period. Because when we move from left to right in a period, the effective nuclear charge acting on the valence shell electrons increases and therefore the tendency to lose electrons also decreases.

(2) The metallic character increases as we move from top to bottom in a group because when we go down a group, the effective nuclear charge experienced by valence electrons decreases since distance of valence electrons from the nucleus increases.

(i) Position of isotopes : All the isotopes of an element have the same atomic number. Therefore, They can be place at one place is the same group of the periodic table. *e.g.* C-12, C-14 are placed is group 14.

(ii) Anomalous position of some pairs of elements.

Element	Atomic mass	Atomic Number
Cobalt	58.93 μ	27
Nickel	58.71 μ	28

9. Name two elements you would expect to show chemical reactions similar to magnesium. What is the basis for your choice?

Ans. Magnesium (Mg) belongs to group 2, known as alkaline earth family. The two other elements belonging to the same group are Calcium (Ca) and Strontium (Sr) which are expected to show chemical reactions similar to Magnesium (Mg). The basis of choice is the electronic distribution in the valence shell of these elements. All of them have two valence electrons each.

Explanation: Since chemical properties are due to valence electrons, they show same chemical reactions.

	K	L	M	N	O
Mg (Z = 12)	2	8	2	-	-
Ca (Z = 20)	2	8	8	2	-
Sr (Z = 38)	2	8	18	8	2

Case Based Questions

[4 marks]

10. *The following table shows a part of the periodic table in which the elements are arranged according to their atomic numbers. (The letters given here are not the chemical symbols of the elements):*

a	b		c	d	e	f	g	h
3	4		5	6	7	8	9	10
i	j		k	l	m	n	o	p
11	12		13	14	15	16	17	18

(A) Which element has a bigger atom, a or f?

(B) Which element has a higher valency, k or o?

(C) (i) Which element is more metallic, i or k?

(ii) Select a letter which represents a non-metal of valency 2.

Ans. (A) a (size decreases from left to right in a period).

(B) k (valency of k = 3; valency of o = 1).

(C) (i) i (metallic character decreases from left to right in a period).

Explanation:

Element	Atomic Number	Electronic Configuration
i	11	2, 8, 1
k	13	2, 8, 3

i has to lose only one electron to acquire metallic character whereas k has to lose 3 electrons which requires a lot of energy as compared to i element so element i is more metallic.

(ii) f (or n)

11. *Atoms of eight elements A, B, C, D, E, F, G and H have the same number of electron shells but different number of electrons in their outermost shells. It was found that elements A and G combine to form an ionic compound. This ionic compound is added in a small amount to almost all vegetables and dishes during cooking. Oxides of elements A and B are basic in nature while those of elements E and F are acidic. The oxide of element D is, however, almost neutral.*

Based on the above information, answer the following questions:

(A) To which group or period of the periodic table do these elements belong?

(B) What would be the nature of compound formed by a combination of elements B and F?

(C) (i) Which two of these elements could definitely be metals and which would be non metals?

(ii) Which one of the eight elements is most likely to be found in gaseous state at room temperature?

Ans. (A) They all belong to the 3^{rd} period.

(B) The compound between B and F will be ionic in nature.

(C) (i) A and B are metals as they form basic oxides, E and F are non metals as they form acidic oxides.

(ii) Element H will be found in gaseous state at room temperature as it is the 8^{th} element of the group so it would have 8 electrons in its outermost shell which is the electronic configuration of a nobel gas.

Related Theory

- *Sodium chloride is used in almost all vegetables and dishes during cooking. It means A is sodium and G is chlorine.*
- *Metals are one present on the left hand side of modern periodic table and non-metals on the right hand side. As we know oxides of metals are basic in nature and oxides of non-metals form acidic oxide. The elements given one.*

A	B	C	D	E	F	G	H
Na	Mg	Al	Si	P	S	Cl	Ar

12. *Valency of an element is the combining capacity of an atom of the element. The valency of an element is related to how many electrons are in the outer shell. The chemical formula for a substance shows how many atoms of each element are present in a molecule, or the proportion of atoms of each element. The formula can be worked out using the valency. The molecular formula of a compound can be predicted knowing the valency of the constituting atoms. Knowledge of valency is useful in calculating equivalent weight of elements, writing down chemical equations and in checking the structures of molecules. Some elements show variable valency and the valency determines the properties of elements.*

The table below gives atomic number of five elements written as P, Q, R, S and T, which are not their real chemical symbols.

Element	Atomic Number
P	4
Q	9
R	14
S	18
T	20

(A) What is the valency and group number of P and S in Modern Periodic Table.

(B) What is the electronic configuration of the element T?

(C) As per the table given, which element(s) which will form only covalent bonds. Give reason for your answer.

Ans. (A) Element P: Valency = 2, Group number = 2

Element S: Valency = 0, Group number = 18

Explanation: The valency and position of elements in the periodic table is related to the atomic number of the element.

(B) The atomic number of element T is 20. Therefore, its electronic configuration will be:

	K	L	M	N
Ca	2	8	8	2

(C) Covalent bonds are formed by group 14 elements. However, Covalent bonds are also formed between non-metals belonging to groups 15 to 17. However, these elements also form ionic bonds with metals. As element R (atomic number = 14) belongs to group 14, it will form only covalent bonds.