Dobereiner's Traids

Newland's Law of Octave

Need of Classification

Mendeleev's Periodic Table

PERIODIC CLASSIFICATION OF ELEMENTS

Modern Periodic Table

Features

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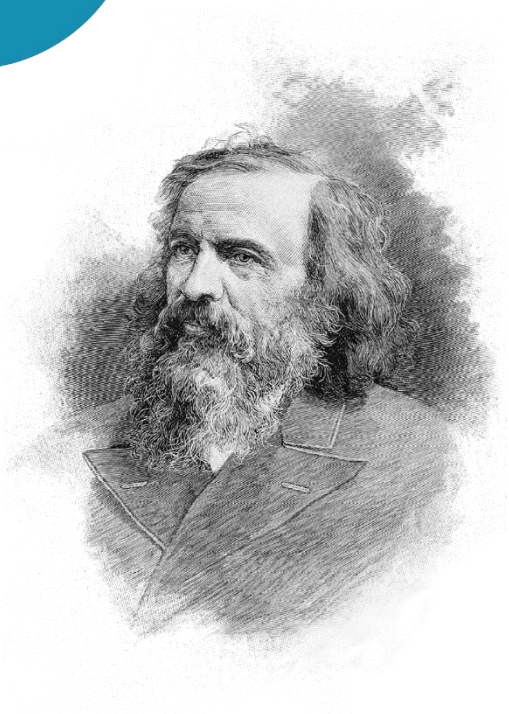


Periodic Classficiation of Elements

Döbereiner's Triads

(1817, Johann Wolfgang Döbereiner's Arranged according to increasing atomic masses)

Element	Atomic weight	Element	Atomic weight	Element	Atomic weight
Li	6.9	Ca	40.1	Cl	35.5
Na	23.0	Sr	87.6	Br	79.9
K	39.1	Ba	137.3	I	126.9

Newland's Law of Octave

(1866, John, Newland's Arranged in the order of increasing Atomic mass.)

Newlands' Arranged Elements in Octaves:

H	F	Cl	Co/Ni	Br	Pd	I	Pt/Ir
Li	Na	K	Cu	Rb	Ag	Cs	Tl
G	Mg	Ca	Zn	Sr	Cd	Ba/V	Pb
Bo	Al	Cr	Y	Ce/La	U	Ta	Th
C	Si	Ti	In	Zn	Sn	W	Hg
N	P	Mn	As	Di/Mo	Sb	Nb	Bi
O	S	Fe	Se	Ro/Ru	Te	Au	Os

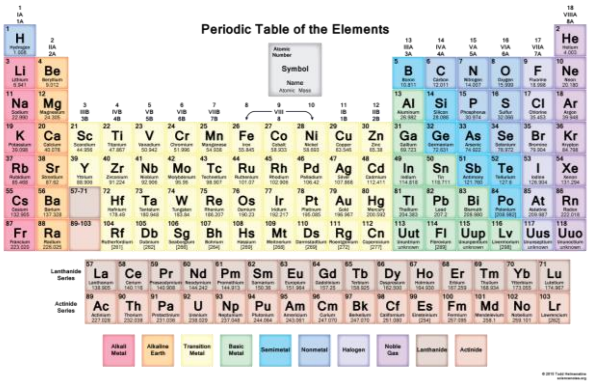
Mendeleev's Periodic Table

(Arranged according to incresing Atomic mass.)

Groups	I	II	III	IV	V	VI	VII	VIII
Oxides Hydrides	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	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 series
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 50.94 As 74.92	Cr 50.20 Se 78.96	Mn 54.94 Br 79.909	Fe 55.85 Co 58.93 Ni 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 101.07 Rh 102.91 Pd 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 180.95 Bi 208.98	W 183.85		Os 190.2 Ir 192.2 Pt 195.09

Modern Periodic Table

(In 1913, Henry Moseley) → Arranged in order of increasing atomic numbers



Need of Classification:

It is very difficult to study individually the chemistry of all the elements and millions of their compounds, hence to simplify and systematize the study of elements and their compounds, they have been arranged in a tabular form.

Döbereiner's Triads (1817), Johan Wolfgang Döbereiner: [CBSE - 2020]

- First to classify elements into triads.
- When the three elements in triad were written in the order of increasing atomic masses, the Atomic mass of the middle elements was roughly the average of the atomic masses of the other two elements.

Li	Ca	Cl
Na	Sr	Br
K	Ba	I

	Atomic mass
Li	7
Na	23
K	39

$$\frac{7+39}{2} = 23$$

Ca	40
Sr	87
Ba	137

$$\frac{40+137}{2} = 88.5$$

- Döbereiner made the first observation on platinum as a catalyst and discovered similar triads of element which led to the development of periodic table of elements.

Limitations of Döbereiner Triads: [NCERT]

- Identified only three triads from the elements known at time.
- Large number of similar elements could not be grouped into triads.
  It was possible that quite dissimilar elements could be grouped in a triads.

Q. Can the following groups of elements be classified as Döbereiner's triad?
i) Na, Si, Cl ii) Be, Mg, Ca [CBSE – 2019]
Atomic mass of Be – 9, Na – 23, Mg – 24, Si – 28, Cl – 35, Ca – 40 Justify your Answer.

Sol. i) Na, Si, Cl have different properties, therefore they do not form Döbereiner's triads even though the atomic mass of the middle atom Si is approximately the average of the Atomic masses of Na and Cl.

Na (23) SI (28)

Cl (35)

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

ii) Be, Mg, Ca have many similar properties and also the atomic mass of the middle element Mg is approximately the average of the atomic masses of Be and Ca

Be (g); Mg(24); Ca(40)

$\frac{9+40}{2} = \frac{49}{2} = 24.5$

Newland's Law of Octaves (1866, John Newlands)

1. Newland arranged the known elements in order of increasing atomic masses and found that every eight element had properties similar to that of the first.
2. He compared this to the octave found in the musical notes, therefore, He called it the "law of octaves"
3. Properties of Li and Na were found to be the same sodium is the eight element after Lithium.

Sa	re	ga	ma	Pa	Da	Ni
(do)	(re)	(mi)	(fa)	(So)	(ea)	(ti)
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cu	Ti	Mn	Fe
Co & Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce and La	Zr	–	–

Limitations of Newland's Octave: [NCERT]

1. It was found that the law of octave was applicable only up to calcium, as after calcium every 8 element did not possess properties similar to that of the first.
   [Exemplar]
2. After discovery of Nobel gases, it become difficult to fit them in Newland's periodic table.
3. It was assumed by Newlands 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 octave.
4. In order to fit elements into his table, Newlands adjusted two elements in the same slot.
5. Co, Ni are in same slot and these are placed in the column as F, Cl, Br.
6. Fe, which resembles Co and Ni in properties, has been placed far away from these elements.

Mendeleev's Periodic Table (Dmitri Ivanovich Mendeleev)

- **Mendeleev's Periodic Law:** **[NCERT, Exemplar, CBSE:2020]**
  The physical and chemical properties of the elements are periodic function of their atomic masses. **[Exemplar]**
- Mendeleev's arranged 63 elements known at that time in order of increasing atomic masses.

Group	I	II	III	IV	V	VI	VII	VIII
Oxide	R_2O	RO	R_2O_3	RO_2	R_2O_5	RO_3	R_2O_7	RO_4
Hydride	RH	RH_2	RH_3	RH_4	RH_3	RH_2	RH	
Periods	A B	A B	A B	A B	A B	A B	A B	
1	H 1.008							
2	Li 6.93	Be 9.01	B 10.81	C 12.01	N 14.00	O 15.99	F 18.99	
3	Na 22.99	Mg 24.31	Al 26.98	Si 28.09	P 30.97	S 32.06	Cl 35.45	
4 1st Series	K 39.10	Ca 40.08	— 44	Ti 47.90	V 50.94	Cr 52.10	Mn 54.9	Fe Co Ni 55.85 58.93 58.71
2nd Series	Cu 63.5	Zn 65.4	— 68	— 72	As 74.9	Se 79.0	Br 79.9	
5 1st Series	Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.91	Mo 95.94	Tc 99.0	Ru Rh Pd 101.0 102.9 106.4
2nd Series	Ag 107.9	Cd 112.4	In 114.82	Sn 118.69	Sb 121.75	Te 127.60	I 126.9	
6 1st Series	Cs 132.9	Ba 137.3						
2nd Series	Au 196.97	Hg 200.59						

Features of Mendeleev's Periodic Table

- Consists 8 vertical column, called groups, each group is divided into two sub-groups and 6 horizontal rows, called period.
- In every period, elements are arranged in increasing order of their atomic masses.
- He predicted the atomic masses and properties of several elements that were not known at that time **[Exemplar]**

Eka – Boron = Scandium
Eka – Aluminium = Gallium
Eka – Silicon = Germanium

Property	**Eka – Aluminium**	**Gallium**
Atomic mass	68	69.7
Formula of oxide	E_2O_3	Ga_2O_3 **[NCERT, CBSE - 2019]**
Formula of Chloride	ECl_3	$GaCl_3$ **[Exemplar]**

- Left gaps for the elements not discovered at that time and named by prefixing a Sanskrit numeral Eka (one)
- When Noble gases like He, Ne were discovered, they could be placed in a New group without disturbing the existing order. **[Exemplar]**

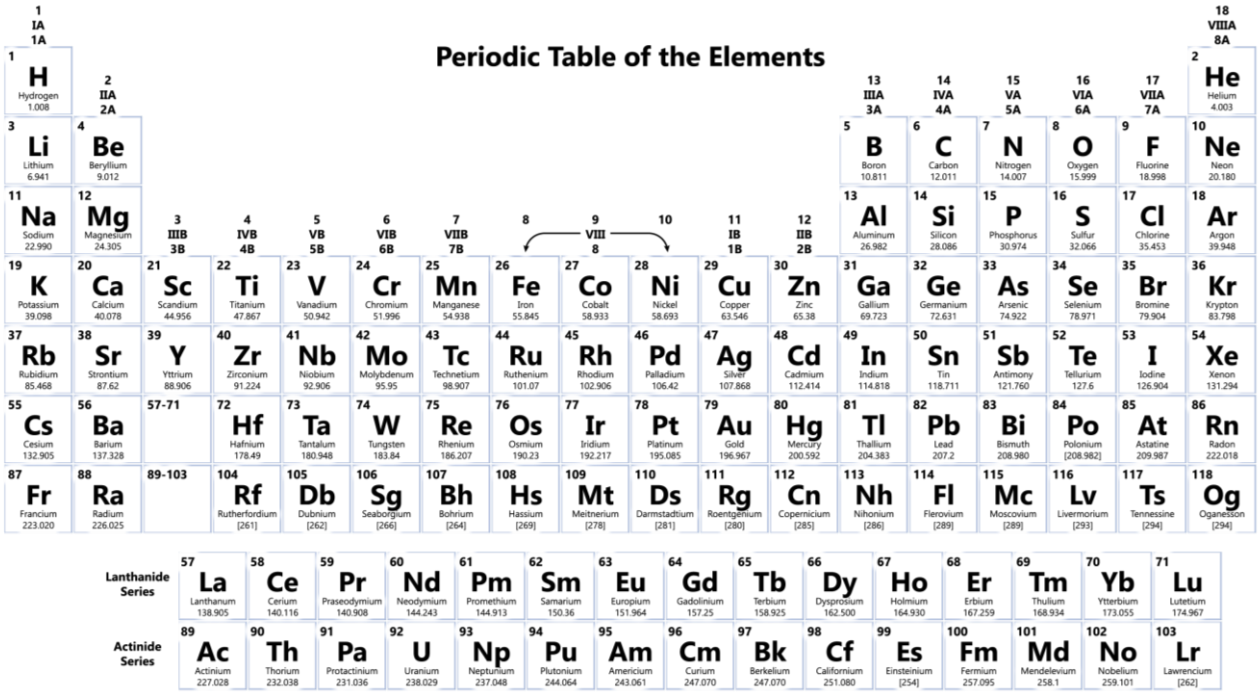
Limitations of Mendeleev's periodic table

1. Elements with dissimilar properties were kept in same group
2. Position of Hydrogen was not fixed in periodic table
3. Elements with similar properties were kept in diff groups
4. Heavier elements were kept before the lighter elements.

5. Position of isotopes and isobars could not be explained.

Modern Periodic Table (1913), Henry Moseley

Henry Moseley worked on X-Ray spectra of element and established the modern periodic law.



Description of groups:

Family of Elements	Groups
Representative Elements	1 and 2 (left) 13 – 18 (Right)
Alkali Metals	1
Alkaline earth Metals	2
Boron Family	13
Carbon Family	14
Nitrogen Family/Pnictogens	15
Chalcogens	17
Inert gases	18
Transition Elements	3, 4, 5, 6, 7, 8, 9, 10, 11, 12

Modern Periodic Law: [Exemplar, CBSE - 2020]

The properties of elements are the periodic function of their atomic numbers, Properties of elements depend upon their electronic configuration.

Features of Modern Periodic Table:

1. 18 vertical column, known as groups and 7 Horizontal rows, known as periods.
2. The elements present in a group have the same number of valence electrons.
3. Elements of period have same no. of shells but do not have same no. of electrons.
4. The number of shells increases as we go down the groups.

5. Modern periodic table is divided into 4 Blocks (s-Block, p-Block, D-Block, F-Block)
6. s-Block → group I and II
   p-Block → group 13 to 18
   d-Block → group 3 to 12
7. Number of elements present in a period can be explained how electrons are filled into various shells
   For Example:-

   K – Shell – $2 \times (1)^2 = 2$, Hence first period has 2 elements
   L – Shell – $2 \times (2)^2 = 8$, Second period has 8 elements
   M – Shell $-2 \times (3)^2 = 18$, but the outermost shell can have only 8 electrons, so the third period also has only 8 elements.

Trends in Modern Periodic Table:

1. **Valency:** *"Valency is the combining capacity of an element"*

   The valency of an element is determined by the number of valence electrons present in the outermost shell of its atom. Valency of atoms of s-Block and p-Block elements are generally given by the number of valency electron or eight minus the number of valence electrons where as in d-Block and f-Block valency is not determined on the basis of valence electrons, general valencies are 2 and 3 **[Delhi – 2012, 2011]**

   Valency of Na, Li, K etc = (1)
   Valency of Mg, Ba etc = (2)
   Valency of Cl, F, Br = 8 – 7 = (1)

   ↓

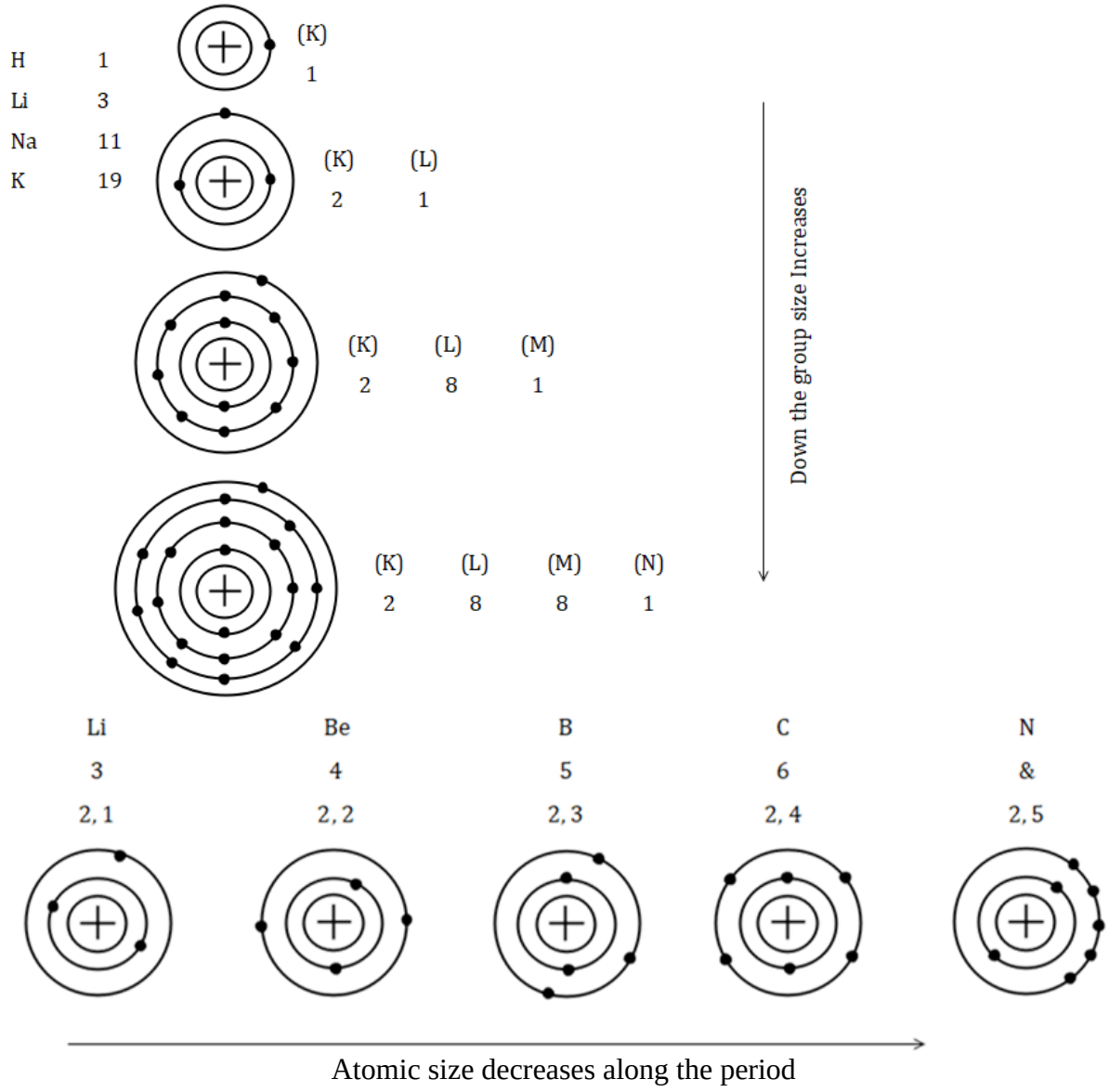
   Valence $e^{\ominus}s$

2. **Atomic Size:**

   The term atomic size refers to the Radii of an atom, that is the distance between the centre of the nucleus and outermost shell

   Atomic size increases down the group due to addition of new shells.

   [Exemplar, Delhi – 2012, 2011]



Atomic size decreases on moving from Left to Right along the period

Q. Arrange the following elements in increasing order of atomic size. [Exemplar]

Sol. i. **Li, Be, F, N →** F < N < Be < Li

ii. **Cl, At, Br, I →** Cl < Br < I < At

3. Metallic and Non – Metallic Properties: [AI – 2017, Delhi – 2015]

Metallic character decreases across a period and increase down the group, because as we go down the group size increases so, it is easy for a atom to lose electron effective nuclear charge acting on the valence shell electrons increases across a period and decreases down the group.

Example: Be < Mg < Ca (Metallic character) **[Exemplar]**

Non – metallic character how ever increases across a period and decreases down the group.

Metalloids or Semi – Metals → Metals which exhibits both the properties of Metal and Non-Metal; Metalloids are also known as borderline elements e.g. Po, Te, Sb etc.

Q. Among [Cs, Rb, K, Li, Na] which one is most metallic?

Sol. Cs is the most metallic, as we know, down the group atomic size increases and therefore metallic character increases.

4. Electronegativity:

The electronegativity of the element increases along a period, since the non-metallic character increases. Similarly, it decreases down the group, since the Non-metallic character decreases.

Q. Which atom is most electronegative along the period 4?

a) K **b) Rb** **c) Sr** **d) Ca**

Sol. (d) Ca

Q. Arrange in increasing order of electronegativity F, Br, Cl, I

Sol. We know that electronegativity increases along the period and decreases down the group

I < Br < Cl < F

You Know What!

Döbereiner's triads also exist in the column of Newland octaves e.g. Li, Na and Potassium constitute a Döbereiner's triads. Now if we consider Li as the First element, then the eight element from it is K similarly, Döbereiner's triad consisting of the elements Be, Mg, Ca is also included in the column of Newland Octaves. **[Exemplar]**

Q. From the elements Li, K, Mg, C, Al, S identify the

i) Element belonging to the same group

ii) Element which has the tendency to lose two electrons

iii) Element which prefer sharing of electrons to complete it octet.

Sol. i) Li and K because both have same outermost electronic configuration.

ii) Mg due to presence of $2e^-$ in outer most shell.

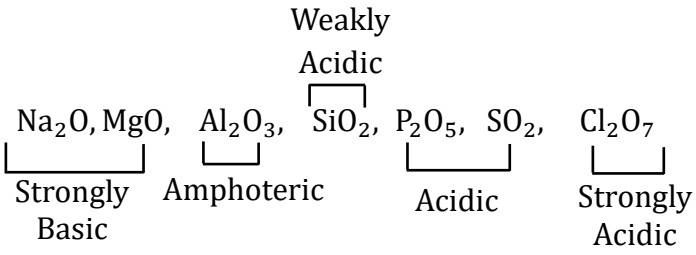
iii) Carbon due to tetravalency

Q. List any two distinguishing features between Mendeleev's Periodic table and the modern periodic table.

Sol.

Mendeleev's Periodic Table	**Modern Periodic Table**
1) In the Mendeleev's Periodic table, the elements were arranged in increasing order of their Atomic masses.	1) In modern periodic table, the elements are arranged in the increasing order of their atomic number.
2) It consists of 8 groups and 6 periods	2) Contains 18 groups and 7 periods.

5. **Nature of Oxides:**
On moving from left to right in a period, due to increase in Non-Metallic character, basic nature of oxides decreases, while acidic nature increases.



Unique Position of Hydrogen in Modern Periodic table: **[Exemplar]**

1. Hydrogen and alkali metals have similar outer electronic configuration, as both have one electron in the valence shell, hence some of the properties of Hydrogen are similar to those of alkali metals and hence, it can be placed in group – 1

2. Both Hydrogen and Halogens have similar outer electronic configuration, Therefore, some of the properties of hydrogen are similar to those of halogen, hence it can be placed in group – 17 along with halogen.

Important NCERT Questions

Q1. How it can be proved that the basic structure of the modern periodic table is based on the electronic configuration of atoms of different elements? [CBSE – 2019]

Sol. Electronic configuration of an element decides it's position in modern periodic table.

If we take an example of sodium (Na), which has atomic number = 11 i.e. its electronic configuration is 2, 8, 1; As Sodium contains 1 electron in its outermost shell, this mean that it belongs to group – I and sodium contain 3 shells so, it belong to period number 3.

Q2. The electronic configuration of an element is 2, 8, 4 state it. [Delhi – 2019]

a) Groups and period in the modern periodic table

b) Name and write its one physical property.

Sol. a) The element belongs to group 14 and 3rd period of modern periodic table.

b) The element is silicon. It is Non – lustrous

Q3. An element 'x' belongs to 3rd period and group 17 of the periodic table. State it's [AI – 2012]

a) Electronic Configuration

b) Valency

Justify your answer with reason

Sol. As element (x) belong to group 17, it will have 7 electron in its outermost shell. Moreover 'x' belongs to period number 3, so it will have 3 shells

a) Electronic Configuration of x = 2, 8, 7

b) Valency of element x

= 8 – (Number of Valence electrons)

= 8 – 7 = 1

Q4. The position of three elements A, B, C in the modern periodic table is as follow:

[CBSE – 2020]

Group → / Period ↓	1	2	13	14	15	16	17	18
1	**B**							
2							**A**	
3						**C**		

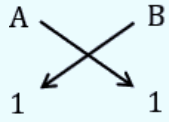
a) Write formula of compound formed between:

i) B and A **ii) B and C**

b) Is any of the three elements a metal? Give reason to justify your answers.

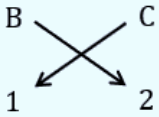
Sol. a) Element B belong to group no. 1 so it's valency is one

i) Element A belong to group no. 17 so its valency is one



AB

ii) C belong to group 16, hence its valency is also 2



B_2C

b) As 'B' belongs to group 1, has one valence electron which can easily lost so, 'B' is a metal.

Q5. An element X (atomic number = 17) reacts with an element Y (atomic number = 20) to form a divalent halide. **[NCERT Exemplar]**

a) Where in the periodic table are element X and Y placed?

b) Classify X and Y metals, non-metals or metalloids?

c) What will be the Nature of oxide of element Y?

d) Draw the electron dot structure of the divalent halide.

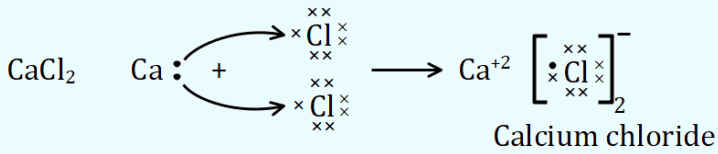
Sol. a) The electronic configuration of element X with atomic no. 17 is 2, 8, 7. Since, it has 7 valence electrons therefore, it lies in group 17(10 + 7), Since in element X third shell is being filled, it lies in third period. X is chlorine.

The electronic configuration of Y with atomic number 20 is 2, 8, 8, 2, 2. Since, it has 2 valence electrons, it lies in group 2; Y is calcium (Ca)

b) Since, element X is Cl has seven electrons in the valence shell and needs one more electron to complete its octet. Therefore, it is a non-metal. Further, the element Y has two electrons in the valence shell, that can be easily lost to achieve the stable electronic configuration of the nearest inert gas, therefore it is a metal.

c) Element 'Y' is a metal, therefore, it's oxide must be basic in nature. Metals and Non-metals form ionic compounds therefore, the bonding in calcium oxide is ionic.

d) Electronic Configuration of $_{20}Ca = 2,8,8,2$ Electronic Configuration of $_{17}Ca = 2,8,7$



Calcium chloride

Q6. An element X is forming an acidic oxide it's position in Modern periodic table will be.

a) Group 1 and period 3 **b) group 2 and period 3**

c) group 13 and period 3 **d) group 16 and period 3**

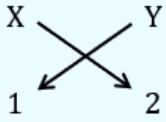
Sol. Oxides of Non-metals are Acidic in Nature group 1 and group 2 consists of metals' while group 13 consists of Amphoteric Oxides.

Q7. An element 'X' with atomic number 11 forms a compound with element 'Y' with a atomic number 8. The formula of compound formed is
[CBSE - 2020]

a) XY **b) X_2Y** **c) XY_2** **d) X_2Y_3**

Sol. X = 11 so its electronic configuration will be 2, 8, 1

Y = 8 its electronic configuration will be 2, 6



X_2Y

Q8. Define Electro positivity. **[CBSE - 2020]**

Sol. Electro positivity is the measure of the ability of elements to donate electrons to form positive ions.

Q9. Write any one difference in the electronic configuration of group – 1 and group – 2 elements. **[Delhi - 2014]**

Sol. Group – I elements have one electron in their outermost shell and group – 2 element have two electrons in their outermost shell.

Q10. Write the atomic numbers of two elements 'X' and 'Y' having electronic configuration 2, 8, 2 and 2, 8, 6 respectively. **[AI - 2014]**

Sol. Electronic configuration of 'X' = 2, 8, 2

Atomic number = 2 + 8 + 2

= 12

Similarly,

Electronic configuration of 'Y' = 2, 8, 6

Atomic number = 2 + 8 + 6

= 16

Q11. The electronic configuration of an element is 2, 8, 4 state its **[Delhi - 2019]**

i) group and period in the modern periodic table.

ii) Name and write its one physical property.

Sol. i) The element belongs to group 14 and 3^{rd} period of the modern periodic table.

ii) The element is silicon. It is non-lustrous.

Q12. F, Cl and Br are the elements each having seven valence electrons. Which of these

i) has largest atomic radius **[Delhi - 2012]**

ii) is most reactive? Justify your answer stating reason for each.

Sol. i) F, Cl and Br all have seven valence electrons so, they belong to the same group on moving down the group, the atomic size of the element increases due to addition of extra shells at each successive element due to this the average distance between nucleus and outermost shell increases. Thus Br is largest in size among F, Cl and Br. (Br > Cl > F)

b) Fluorine is the most reactive element because the chemical reactivity of Non-metals decreases on going down the group.

Q13. Name the scientist who first of all showed that atomic number of an element is more fundamental property than its atomic mass. **[CBSE - 2018]**

Sol. Henry Moseley