# CHAPTER 1
# Periodic Table
# Periodic Properties & Variations of Properties

**SYLLABUS – SCOPE OF SYLLABUS – in and after MARCH 2022**
**PERIODIC PROPERTIES & VARIATIONS OF PROPERTIES - PHYSICAL & CHEMICAL**

**I] PERIODIC PROPERTIES & THEIR VARIATIONS IN GROUPS & PERIODS.**

- ***Definitions & trends of the following periodic properties in groups & periods – should be studied:***
  - *Atomic size • Metallic character • Non-metallic character • Ionisation potential*
  - *Electron affinity • Electronegativity*

**II] PERIODICITY ON THE BASIS OF ATOMIC NUMBER FOR ELEMENTS.**

- ***The study of modern periodic table up to period 3*** *(students to be exposed to the complete modern periodic table but no questions will be asked on elements beyond period 3 -Argon);*
- ***Periodicity & other related properties to be explained on the basis of – nuclear charge & shells*** *[not orbitals].*
  *[Special reference to the alkali metals & halogen groups].*

***Note:*** According to the recommendation of International Union of Pure & Applied Chemistry (IUPAC)
- *The GROUPS are numbered from **1 to 18** - replacing the older notation of GROUPS IA.. VIIA, VIII, IB... VIIB & 0.* However, for the examination both notations will be accepted.

| Old notation | IA | IIA | IIIB | IVB | VB | VIB | VIIB | VIII | | | IB | IIB | IIIA | IVA | VA | VIA | VIIA | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New notation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |

## A. INTRODUCTION

1. Need arose to – *group elements* into families whose elements showed *maximum resemblance.*
2. On such an arrangement in the form of a table, *properties of elements* were seen to – *reappear at regular intervals* in the table.

### CLASSIFICATION – Of elements

*Early Chemists* – Arranged elements on basis of – ***valency, metallic & non-metallic character.***
- Method discarded as elements showed – ***variable valency and dual character.***

*Dobereiner [1815]* – Arranged elements in increasing order of – ***atomic weights.***
- Elements were arranged in groups of three called – ***triads.***
- At. wt. of the middle element was found generally to be – ***the average of the other two.***
- Method was discarded since it did not – ***hold true for all elements.***

*Newland [1864]* – Arranged elements in increasing order of – ***atomic weights.***
- Elements were arranged in a series of – ***eight.***
- Properties of every eight element was found to be a – ***repetition of the first element.***
- Method was discarded as it failed to leave – ***spaces for undiscovered elements.***

*Mendeleeff [1869]* – Arranged elements in increasing order of – ***atomic weights.***
- Elements were arranged in the form of a table called – ***Mendeleeff's Periodic Table.***
- He stated that properties of elements were – ***periodic functions of their atomic wts.***
- Method could not justify position of – ***certain elements, rare earths and isotopes.***

*Moseley [1912]* – Arranged elements in increasing order of – ***atomic numbers.***
- Elements were arranged in a modified table called – ***Modern Periodic Table.***
- He stated that properties of elements were – ***periodic function of their atomic nos.***
- Method removes most of the defects of – ***Mendeleeff's Periodic Table.***

# The Modern Periodic Table

Latest Modern Periodic Table

KEY

Symbol of element — Be — Name of element

4 — Atomic number

9 — Relative atomic mass

| | GROUP 1 IA | GROUP 2 IIA | GROUP 3 IIIB | GROUP 4 IVB | GROUP 5 VB | GROUP 6 VIB | GROUP 7 VIIB | GROUP 8 | GROUP 9 VIII | GROUP 10 | GROUP 11 IB | GROUP 12 IIB | GROUP 13 IIIA | GROUP 14 IVA | GROUP 15 VA | GROUP 16 VIA | GROUP 17 VIIA | GROUP 18 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PERIOD 1 | 1 H Hydrogen 1 | | | | | | | | | | | | | | | | 1 H Hydrogen 1 | 2 He Helium 4 |
| PERIOD 2 | 3 Li Lithium 7 | 4 Be Beryllium 9 | | | | | | | | | | | 5 B Boron 11 | 6 C Carbon 12 | 7 N Nitrogen 14 | 8 O Oxygen 16 | 9 F Fluorine 19 | 10 Ne Neon 20 |
| PERIOD 3 | 11 Na Sodium 23 | 12 Mg Magnesium 24 | | | | | | | | | | | 13 Al Aluminium 27 | 14 Si Silicon 28 | 15 P Phosphorus 31 | 16 S Sulphur 32 | 17 Cl Chlorine 35.5 | 18 Ar Argon 40 |
| PERIOD 4 | 19 K Potassium 39 | 20 Ca Calcium 40 | 21 Sc Scandium 45 | 22 Ti Titanium 48 | 23 V Vanadium 51 | 24 Cr Chromium 52 | 25 Mn Manganese 55 | 26 Fe Iron 56 | 27 Co Cobalt 59 | 28 Ni Nickel 59 | 29 Cu Copper 63.5 | 30 Zn Zinc 65 | 31 Ga Gallium 70 | 32 Ge Germanium 73 | 33 As Arsenic 75 | 34 Se Selenium 79 | 35 Br Bromine 80 | 36 Kr Krypton 84 |
| PERIOD 5 | 37 Rb Rubidium 85.5 | 38 Sr Strontium 88 | 39 Y Yttrium 89 | 40 Zr Zicronium 91 | 41 Nb Niobium 93 | 42 Mo Molybdenum 96 | 43 Tc Technetium 99 | 44 Ru Ruthenium 101 | 45 Rh Rhodium 103 | 46 Pd Palladium 106.5 | 47 Ag Silver 108 | 48 Cd Cadmium 112.5 | 49 In Indium 115 | 50 Sn Tin 119 | 51 Sb Antimony 122 | 52 Te Tellurium 128 | 53 I Iodine 127 | 54 Xe Xenon 131 |
| PERIOD 6 | 55 Cs Caesium 133 | 56 Ba Barium (137) | 57 * La Lanthanum 139 | 72 Hf Hafnium 178.5 | 73 Ta Tantalum 181 | 74 W Tungsten 184 | 75 Re Rhenium 186 | 76 Os Osmium 186 | 77 Ir Iridium 192 | 78 Pt Platinum 195 | 79 Au Gold 197 | 80 Hg Mercury 201 | 81 Tl Thallium 204 | 82 Pb Lead 207 | 83 Bi Bismuth (208.9) | 84 Po Polonium (209) | 85 At Astatine (210) | 86 Rn Radon (222) |
| PERIOD 7 | 87 Fr Francium (223) | 88 Ra Radium (226) | 89 ¶ Ac Actinium (227) | 104 Rf Rutherfordium (261) | 105 Db Dubnium (262) | 106 Sg Seaborgium (266) | 107 Bh Bohrium (264) | 108 Hs Hassium (269) | 109 Mt Meitnerium (268) | 110 Ds Darmstadtium 269 | 111 Rg Roentgenium 272 | 112 Cn Copernicium 277 | 113 Nh Nihonium – | 114 Fl Flerovium (289) | 115 Mc Moscovium – | 116 Lv Livermorium (298) | 117 Ts Tennessine – | 118 Og Oganesson – |

TRANSITION ELEMENTS

A B C

| Inner Transition Elements | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | *Lanthanide Series [rare earth elements] | 58 Ce Cerium 140 | 59 Pr Preseodymium 141 | 60 Nd Neodymium 144 | 61 Pm Promethium 145 | 62 Sm Samarium 150.5 | 63 Eu Europium 152 | 64 Gd Gadalinium 157 | 65 Tb Terbium 159 | 66 Dy Dysprasium 162.5 | 67 Ho Halmium 165 | 68 Er Erbium 167 | 69 Tm Thulium 169 | 70 Yb Ytterbium 173 | 71 Lu Lutetium 175 |
| 7 | ¶ Actinide Series [radioactive elements] | 90 Th Thorium 232 | 91 Pa Protactinium 231 | 92 U Uranium 238 | 93 Np Neptumium 237 | 94 Pu Pluromium 244 | 95 Am Americium 243 | 96 Cm Curium 247 | 97 Bk Berkelium 247 | 98 Cf Californium 251 | 99 Es Einsteinium 254 | 100 Fm Fermium 257 | 101 Md Mendelevium 258 | 102 No Nobelium 259 | 103 Lr Lawrencium 260 |

METALS

A ALKALI METALS | B ALKALINE EARTH METALS | C TRANSITION ELEMENTS (HEAVY METALS) | WEAK METALS | METALLOIDS | NON-METALS: NON-METALS | HALOGENS | NOBLE GASES

# B. MODERN PERIODIC TABLE – Long form of the Periodic Table

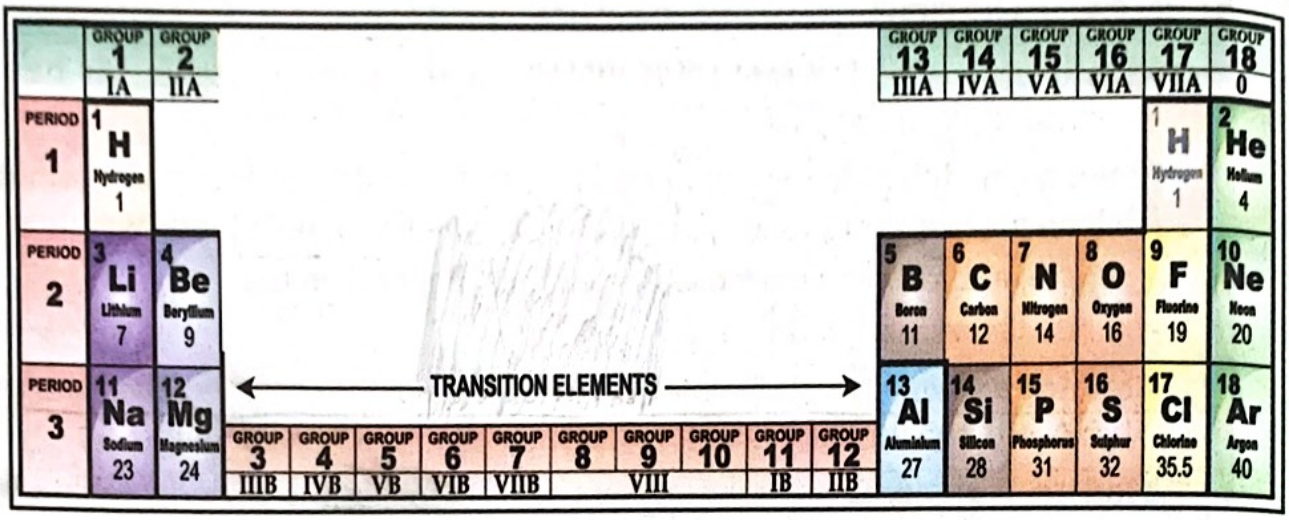
## 1. INTRODUCTION

- **Mendeleeff** – had arranged elements in the periodic table on basis of – *increasing atomic weights.*
- **Moseley**–modified Mendeleeff's periodic table & stated that the basis of classification of elements be according to *increasing atomic numbers* & not atomic weights since – *physical* and *chemical properties* of elements, depend on the – *number of electrons* and their *arrangement.*
- **Atomic number** – is equal to the no. of electrons in the energy shells of an atom. – hence atomic number is the *fundamental property* of an element.
- **Modern Periodic Law** – arrangement of elements in the periodic table is thus – based on the *Modern Periodic Law* which states that – 'Physical & chemical properties of elements are *periodic functions* of their at. no.'

## 2. SALIENT FEATURES – Of the Modern Periodic Table

| | |
|---|---|
| • CLASSIFICATION | • Periodic table based on basic fundamental property – **atomic number.** |
| • POSITION | • Correlates position of an element with its – **electronic configuration.** |
| • METHODICAL ARRANGEMENT | • Arranges elements in – **increasing order of atomic numbers** in – 'SEVEN' horizontal rows called – 'PERIODS' & – 'EIGHTEEN' vertical columns called 'GROUPS'. |
| – *PERIODS* | • Completion of each period is logical, since each period – *begins* with an element having – **one electron** in outermost shell & – *ends* with zero group element having – **completely filled** outer shell. |
| | • A transition from – **metallic** to **non-metallic** character – is thus seen across a period. |
| – *GROUPS* | • Each vertical column accommodates elements with the – ***same outer electronic configuration,*** hence having ***similar properties.*** |
| | • *'18'* vertical columns consists of groups – **1** to **17** & **18** [zero group]. |
| | – Groups **1, 2** & **13** to **17** [I A to VII A] are called 'NORMAL ELEMENTS'. |
| | – Groups **3** to **12** [I B to VII B & VIII] are called 'TRANSITION ELEMENTS'. |
| | – Group **18** [zero] at extreme right contains 'NOBLE OR INERT GASES'. |
| • SEPARATION OF ELEMENTS | • **Reactive metals** – are placed in group **1** [IA] and **2** [IIA]. |
| | • **Transition elements** – [metals] are placed in the ***middle.*** |
| | • **Non-metals** – are placed in the *upper right corner* of the periodic table. |
| • PERIODICITY OF ELEMENTS | • **Gradual change in properties** – is seen with – increase in atomic number in the periodic table. |
| | • **Periodicity in properties** – i.e. recurrence in properties are seen – with elements belonging to the same *subgroup* in the periodic table – after a difference of 2, 8, 18 or 32 in atomic numbers due to – recurrence of similar valence shell electronic configuration. |

## C. PERIODS – In The Modern Periodic Table




**THE FIRST THREE PERIODS – In the Modern Periodic Table**

- *PERIODS - SEVEN HORIZONTAL ROWS OF ELEMENTS – arranged in increasing order of at. nos.*
- *PERIOD NUMBERS* - **i.e. 1, 2, 3 etc. signifies** – *NO. OF ELECTRON SHELLS OF AN ELEMENT.*
  - *PERIOD-1* *ELEMENTS* e.g. [$^{1}$H] have – **1 shell** ;
  - *PERIOD-2* *ELEMENTS* e.g. [$^{3}$Li] have – **2 shells**
  - *PERIOD-3* *ELEMENTS* e.g. [$^{11}$Na] have – **3 shells** & so on.

### THE SEVEN PERIODS – of the Modern Periodic Table

| PERIOD NO. | TYPE OF PERIOD | NO. OF ELEMENTS | ATOMIC NUMBER | 1 IA | 2 IIA | 13 IIIA | 14 IVA | 15 VA | 16 VIA | 17 VIIA | 18 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SHORT [shortest] | 2 | 1 & 2 | 1 H 1e | | | | | | | 2 He ) 2e |
| 2 | SHORT | 8 | 3 to 10 | 3 Li ) ) 2e 1e | 4 Be ) ) 2e 2e | 5 B ) ) 2e 3e | 6 C ) ) 2e 4e | 7 N ) ) 2e 5e | 8 O ) ) 2e 6e | 9 F ) ) 2e 7e | 10 Ne ) ) 2e 8e |
| 3 | SHORT | 8 | 11 to 18 | 11 Na ) ) ) 2e 8e 1e | 12 Mg ) ) ) 2e 8e 2e | 13 Al ) ) ) 2e 8e 3e | 14 Si ) ) ) 2e 8e 4e | 15 P ) ) ) 2e 8e 5e | 16 S ) ) ) 2e 8e 6e | 17 Cl ) ) ) 2e 8e 7e | 18 Ar ) ) ) 2e 8e 8e |
| 4 | LONG | 18 | 19 to 36 | 19 K ) ) ) ) 2e 8e 8e 1e | | | | | | | 36 Kr |
| 5 | LONG | 18 | 37 to 54 | 37 Rb | | | | | | | 54 Xe |
| 6 | LONG | 32 | 55 to 86 | 55 Cs | 58 Ce to 71 Lu *LANTHANIDE SERIES [Rare Earth Elements] | | | | | | 86 Rn |
| 7 | LONG | 26 | 87 to 112 | 87 Fr | 90 Th to 103 Lr *ACTINIDE SERIES [Radioactive Elements] | | | | | | 112 UUb |

- **BRIDGE ELEMENTS – in Period 2**

  *Bridge elements* – show similarities in properties diagonally with the period of the next group.

| *GROUP* | 1[IA] | 2[IIA] | 13[IIIA] | 14[IVA] | |
|---|---|---|---|---|---|
| Period 2 | Li ↘ | Be ↘ | B ↘ | C | – Bridge elements |
| Period 3 | Na | Mg | Al | Si | – Typical elements |

## PERIODS – in the Modern Periodic Table [Contd.]

### • PROPERTY TRENDS OF ELEMENTS - From left to right in a period

| | | |
|---|---|---|
| • SIMILARITY | – *NUMBER OF ELECTRON SHELLS* [*Electrons enter* – K-shell (period-1), L-shell (period-2)] | *REMAIN – SAME* |
| • TRANSITION | – *VALENCE ELECTRONS* | *INCREASES – BY ONE* |
| | – *NON-METALLIC CHARACTER* [Transition from *metallic* to *non-metallic character*]. | *INCREASES* |

• ***PERIOD - 1*** – HYDROGEN [ $_1H$ – group 1 (IA) ] & HELIUM [ $_2He$ – group 18 (0) ]

• ***PERIOD - 2***

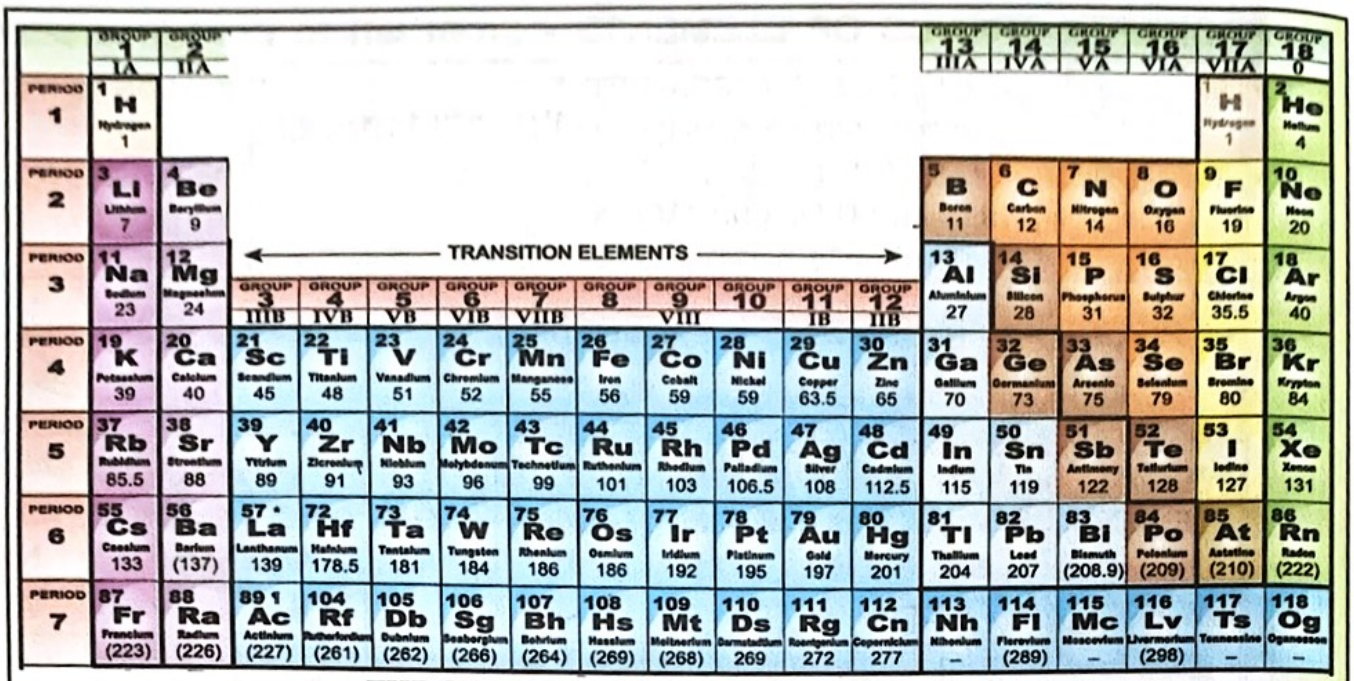
| Group | 1[IA] | 2[IIA] | 13[IIIA] | 14[IVA] | 15[VA] | 16[VIA] | 17[VIIA] | 18[0] |
|---|---|---|---|---|---|---|---|---|
| ELEMENT | LITHIUM **Li** | BERYLLIUM **Be** | BORON **B** | CARBON **C** | NITROGEN **N** | OXYGEN **O** | FLUORINE **F** | NEON **Ne** |
| • *At. number* | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| • *Elect. conf.* | 2, 1 | 2, 2 | 2, 3 | 2, 4 | 2, 5 | 2, 6 | 2, 7 | 2, 8 |
| • *State* | Metal | Metal | Metalloid | Non-metal | Non-metal | Non-metal | Non-metal | Noble gas |
| • *Valency* | 1 | 2 | 3 | 4 | 3 | 2 | 1 | 0 |

• ***PERIOD - 3***

| Group | 1[IA] | 2[IIA] | 13[IIIA] | 14[IVA] | 15[VA] | 16[VIA] | 17[VIIA] | 18[0] |
|---|---|---|---|---|---|---|---|---|
| ELEMENT | SODIUM **Na** | MAGNESIUM **Mg** | ALUMINIUM **Al** | SILICON **Si** | PHOSPHORUS **P** | SULPHUR **S** | CHLORINE **Cl** | ARGON **Ar** |
| • *At. number* | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| • *Elect. conf.* | 2, 8, 1 | 2, 8, 2 | 2, 8, 3 | 2, 8, 4 | 2, 8, 5 | 2, 8, 6 | 2, 8, 7 | 2, 8, 8 |
| • *State* | Metal | Metal | Metal | Metalloid | Non-metal | Non-metal | Non-metal | Noble gas |
| • *Valency* | 1 | 2 | 3 | 4 | 3 | 2 | 1 | 0 |
| | ← Electropositive character increases / Electronegative character increases → | | | | | | | |
| *CHLORIDE* | **$NaCl$** | **$MgCl_2$** | **$AlCl_3$** | **$SiCl_4$** | **$PCl_3/PCl_5$** | **$S_2Cl_2$** | – | – |
| • *Bonding* | Ionic | Ionic | Ionic, covalent | Covalent | Covalent | Covalent | – | – |
| • *State* | Solid | Solid | Solid | Liquid | Liquid/solid | Liquid | – | – |
| *OXIDE* | **$Na_2O$** | **$MgO$** | **$Al_2O_3$** | **$SiO_2$** | **$P_2O_5$** | **$SO_2, SO_3$** | **$Cl_2O_7$** | – |
| • *Bonding* | Electrovalent | Electrovalent | Electrovalent | Covalent | Covalent | Covalent | Covalent | – |
| • *Character* | Strongly basic | Basic | Amphoteric | Weakly acidic | Acidic | Acidic | Strongly acidic | – |
| *HYDROXIDE/ OXY-ACID* | **$NaOH$** | **$Mg(OH)_2$** | **$Al(OH)_3$** | **$H_2SiO_3$** | **$HPO_3$ $H_3PO_4$** | **$H_2SO_3$ $H_2SO_4$** | **$HClO_4$** | – |
| • *Character* | Strong base | Weak base | Amphoteric | Weak acid | Weak acid | Strong acid | Strong acid | – |
| *HYDRIDE* | **$NaH$** | **$MgH_2$** | **$AlH_3$** | **$SiH_4$** | **$PH_3$** | **$H_2S$** | **$HCl$** | – |
| • *Character* | Strong base | Weak base | Weaker base | Weaker base | Weaker base | Weak acid | Strong acid | – |

• $H_2SiO_3$ – metasilisic acid; $HClO_4$ – perchloric acid; $Cl_2O_7$ – chlorine heptoxide;
• $PH_3$ – phosphine; $HPO_3$ – metaphosphoric acid; $H_3PO_4$ – orthophosphoric acid

## D. GROUPS – In The Modern Periodic Table




THE GROUPS – MODERN PERIODIC TABLE

- **GROUPS** - *EIGHTEEN VERTICAL COLUMNS* – **[*with eight main groups*] in the periodic table.**
- **GROUP NUMBERS – signifies the** – *NUMBER OF VALENCE ELECTRONS OF AN ELEMENT.*
  [*valence electrons* — are electrons present in the outermost shell of an atom].
  - *GROUP* – 1 [IA] *ELEMENTS* e.g. $^{11}$Na [2,8,1] have – **1 valence electron**
  - *GROUP* – 2 [IIA] *ELEMENTS* e.g. $^{12}$Mg [2,8,2] have – **2 valence electrons** & so on.

*TRANSITION ELEMENTS* – also have – 2 *valence electrons* – e.g. $^{26}$Fe [2,8,*14*,2] , $^{30}$Zn [2,8,*18*,2].

### THE GROUPS - of the Modern Periodic Table

| GROUP NO. | TYPE OF ELEMENT | ELEMENTS |
|---|---|---|
| **1** [I A] | **ALKALI METALS** | $^{3}$**Li** *Light metals* to $^{87}$**Fr** |
| **2** [II A] | **ALKALINE EARTH METALS** | $^{4}$**Be** *Light metals* to $^{88}$**Ra** |
| **3 to 12** [IB to VIIB, VIII] | **TRANSITION ELEMENTS** | $^{21}$**Sc** *Heavy metals* to $^{30}$**Zn** |
| | *INNER TRANSITION ELEMENTS* | $^{39}$**Y** to $^{48}$**Cd** |
| *Period – 6* | • *LANTHANIDE SERIES* – Ce to Lu | $^{57}$**La**; $^{58}$**Ce to $^{71}$Lu** $^{72}$**Hf** to $^{80}$**Hg** |
| *Period – 7* | • *ACTINIDE SERIES* – Th to Lr | $^{89}$**Ac**; $^{90}$**Th to $^{103}$Lr** $^{104}$**Rf** to $^{112}$**Uub** |
| **13 to 16** [IIIA to VI A] | **POST TRANSITION ELEMENTS** | $^{13}$**Al** to $^{81}$**Ti**; $^{32}$**Ge** to $^{82}$**Pb**; $^{51}$**Sb** $^{83}$**Bi**; $^{84}$**Po** |
| **17** [VII A] | **HALOGENS** | $^{9}$**F** to $^{85}$**At** |
| **18** [0] | **NOBLE/INERT GASES** | $^{2}$**He** to $^{86}$**Rn** |

- **TRANSITION ELEMENTS** – [Metals] e.g. $^{21}$Sc [2,8,8,3]
  Lie between strongly electropositive metals on the left & least electropositive elements on the right. They all have similar properties. [*Electron change occurs in inner orbitals*]
- **INNER TRANSITION ELEMENTS** – [Metals] e.g. $^{58}$Ce, $^{90}$Th
  Two horizontal rows of metals at the bottom of the table.
  Form two series - *Lanthanide* [rare earths] & *Actinide* [radio active] of 14 elements each.
- **NOBLE GASES** – They are inert, unreactive, and have stable electronic configuration.

# GROUPS – In The Modern Periodic Table [Contd.]

## • PROPERTY TRENDS OF ELEMENTS – On moving down a – Subgroup

| Period | Group 1 [IA] | Group2 [IIA] | Group13 [IIIA] | Group17 [VIIA] |
|---|---|---|---|---|
| 1 | – | – | – | – |
| 2 | $^{3}Li$ 2, 1 | $^{4}Be$ | $^{5}B$ | $^{9}F$ |
| 3 | $^{11}Na$ 2, 8, 1 | $^{12}Mg$ | $^{13}Al$ | $^{17}Cl$ |
| 4 | $^{19}K$ 2, 8, 8, 1 | $^{20}Ca$ | $^{31}Ga$ | $^{35}Br$ |
| 5 | $^{37}Rb$ 2, 8, 18, 8, 1 | $^{38}Sr$ | $^{49}In$ | $^{53}I$ |
| 6 | $^{55}Cs$ 2, 8, 18, 18, 8, 1 | $^{56}Ba$ | $^{81}Tl$ | $^{85}At$ |
| 7 | $^{87}Fr$ 2, 8, 18, 32, 18, 8, 1 | $^{88}Ra$ | – | – |

| *Property Trends down a subgroup* | |
|---|---|
| • **SIMILARITY** – *VALENCE ELECTRONS* of elements in a sub-group. | *REMAIN SAME* |
| – *CHEMICAL PROPERTIES* of elements in a sub-group. *Chemical properties* – are dependent on outer electronic configuration. | *REMAIN SIMILAR [or vary gradually]* |
| • **TRANSITION** – *METALLIC CHARACTER* [electro-positive character]. | *INCREASES* |
| – *NO. OF ELECTRON SHELLS* | *INCREASES BY ONE* |

## • *ALKALI METALS* - GROUP 1 [IA] & *HALOGENS* - GROUP 17 [VIIA]

| | 1 [I A] *elements* | 17 [VII A] *elements* |
|---|---|---|
| • ELEMENTS | – Lithium, sodium, potassium rubedium, caesium, francium | – Fluorine, chlorine, bromine, iodine, astatine. |
| • VALENCY | – *Univalent* [1 valence electron] | – *Univalent* [7 valence electrons] |
| • NATURE | – Highly *reactive*,<br>– Highly *electropositive*,<br>– Light, soft *metals*. [Metallic in nature]<br>*Metals* – are soft and hence can be cut with a knife. | – Highly *reactive*,<br>– Highly *electronegative*,<br>– *Non-metals*. [Non-metallic in nature]<br>*Gaseous* – **F & Cl** , *Liquid* – **Br**<br>*Solid* at room temp. – **I** |
| • CONDUCTIVITY | – *Good* conductors of heat & electricity. | – *Bad* or *non*-conductors of heat & electricity. |
| • REDUCING/ OXIDISING NATURE | – Strong *reducing* agents. [alkali metals – *electron donors*]. Have one valence electron which is easily removed from outer shell. | – Strong *oxidising* agents. [halogens – *electron acceptors*]. |
| • ELECTRONEGATIVITY | – *Low* – electronegativity [Electropositive character – increases from Li to Cs] | – *High* – electronegativity [Electronegative character – decreases from F to I] |
| *REACTIONS WITH:-* | | |
| • NON-METALS | – *Electrovalent compounds* formed [e.g. NaCl, KBr] | – *Covalent compounds* formed [e.g. HCl, $PCl_3$, $S_2Cl_2$] |
| • HYDROGEN | – *Ionic hydrides* formed [e.g. LiH, NaH] | – *Covalent hydrides* formed [e.g. HF, HCl, HBr, HI] |

## E. PERIODIC PROPERTIES – Variation of Periodic Properties in Periods & Groups

- **PERIODICITY IN PROPERTIES – Of elements**

  The Modern Periodic Table which is an arrangement of elements in increasing order of their atomic numbers is based on the **Modern Periodic Law** which states that–

  • *'Properties of elements are periodic functions of their atomic numbers.'*

  ***Periodicity in properties of elements means –***

  – *Occurrence of characteristic properties* of elements
  – *at definite intervals in the modern periodic table*
  – *when elements are arranged in increasing order of their atomic numbers.*

  [In the modern periodic table the *definite intervals* are after difference of either 2 or 8 or 18 or 32 in atomic numbers.]

- **PERIODIC PROPERTIES**

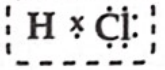
  The properties which appear at regular intervals in the periodic table are called **'periodic properties'** and the phenomenon **'periodicity in properties of elements.'**

  *Periodic properties :*

  • Atomic radii • Ionisation potential • Electron affinity • Electronegativity
  • Non-metallic and metallic character.
  • Density • Melting and boiling point • Nature of oxides, oxy-acids, hydrides.

- **REASONS FOR PERIODICITY – In Properties in Periods & Groups**

  – After definite intervals of at. no., *similar* valence shell electronic configuration occurs.
  – Properties of elements depend on the – *number & arrangement* of electrons in various shells including valence shell.
  – In the same period or subgroup, *increase* or *decrease* in a particular property – is due to the gradual change in electronic configuration in the arranged elements.

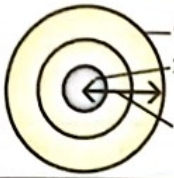
| PERIODIC PROPERTY | MEANING OF THE TERM | |
|---|---|---|
| 1. ATOMIC RADIUS | It is the ***distance*** between the – centre of the nucleus and the outer most shell of the atom. |  atomic radius |
| 2. IONISATION POTENTIAL [I.P.] | It is the ***amount of energy required*** – to ***remove an electron*** from the outer most shell of an isolated gaseous atom. | $M_{atom} \rightarrow M^+_{ion} + e^-_{electron}$ [i.e. $M - e^- \rightarrow M^+$] [*Energy required* - I. P.] |
| 3. ELECTRON AFFINITY [E.A.] | It is the ***amount of energy released*** – when an atom in the gaseous state ***accepts an electron*** to form an anion. | $X_{atom} + e^- \rightarrow X^-_{anion} + energy$ [*Energy released* - E.A.] |
| 4. ELECTRO-NEGATIVITY [E.N.] | It is the tendency of an atom – to ***attract electrons to itself*** when combined in a compound. |  covalent bond formed [*H* & *Cl* – small difference in – E.N.] |
| 5. NON-METALLIC & METALLIC CHARACTER | In terms of electron loss or gain – an element is a : *Non-metal* - if it *gains one or more electrons* *Metal* – if it *loses one or more electrons.* | $N + e^- \rightarrow N^-$ [*Non-metal* (*N*) – gains electrons] $M \rightarrow M^+ + e^-$ [*Metal* (*M*) – loses electrons] |

# F. PERIODIC TRENDS IN PROPERTIES – *Atomic Size*

## 1. *THE TERM* – Atomic size –

THE DISTANCE BETWEEN –
THE CENTRE OF THE NUCLEUS OF AN ATOM & IT'S OUTERMOST SHELL.

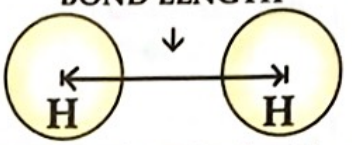
*ATOMIC RADIUS*




UNIT OF ATOMIC RADII

Angstron unit = A°

BOND LENGTH




[atomic radius determines bond length]

## 2. *FACTORS WHICH AFFECT* – The Atomic size

- NUMBER OF SHELLS – *Increases* – ATOMIC SIZE – *Increases*
  *Reason:* Number of shells increases – the distance of the outermost shell from the nucleus increases.
- NUCLEAR CHARGE – *Increases* – ATOMIC SIZE – *Decreases*
  *Reason:* Nuclear charge increases – the electrons in the outermost shell are attracted with increasing force.

*NUCLEAR CHARGE* – of an atom is the – *positive charge* on the nucleus of an atom. It is equivalent to the – *atomic number* of the element.

## 3. *TRENDS IN ATOMIC SIZE* – Across a period – From left to right

| *Elements* | Li 2, 1 | Be 2, 2 | B 2, 3 | C 2,4 | N 2, 5 | O 2, 6 | F 2, 7 | Ne 2, 8 |
|---|---|---|---|---|---|---|---|---|
| *Atomic radius* [A°] | 1.55 | 1.12 | 0.88 | 0.77 | 0.70 | 0.66 | 0.64 | 1.12 |

- NUMBER OF SHELLS – *Remain same* – ATOMIC SIZE – *Unaffected*
- NUCLEAR CHARGE – *Increases* – ATOMIC SIZE – *Decreases*

– In period-2 [*Li*] has the *largest atomic radius* & [*F*] the *smallest.*
– *Neon* [*Ne*] – *has a larger atomic radius since in inert gases* – the outer shell – is completely filled resulting in a *force of repulsion.* The effect of the nuclear pull over the valence shell electrons is not seen.

[A *Cation* (formed by loss of electron/s e.g. $Na - 1e^- \rightarrow Na^{1+}$) is smaller than the parent neutral atom since the remaining electrons in the cation are strongly attracted by the nucleus, thus decreasing the cation size.]

*ATOMIC SIZE [RADII]* $\xrightarrow{\text{DECREASES}}$ *ACROSS A PERIOD – LEFT TO RIGHT*

## 4. *TRENDS IN ATOMIC SIZE* – Down a Group

| Elements | Atomic radius | Trends in atomic radii – down a group | | *ATOMIC SIZE [RADII]* |
|---|---|---|---|---|
| Li 2, 1 | 1.55 | • NUMBER OF SHELLS – *Increases* [New shells added with increasing atomic no.] | – ATOMIC SIZE – *Increases* [Nuclear distance from valence electrons increases] | INCREASES ↓ |
| Na 2, 8, 1 | 1.91 | | | |
| K 2, 8, 8, 1 | 2.35 | • NUCLEAR CHARGE – *Increases* | – ATOMIC SIZE – *Should decrease* | |
| Rb 2, 8, 18, 8, 1 | 2.48 | – Increase in number of shells – *Dominates over* – Increase in nuclear charge ∴ Overall atomic radius – *Increases.* | | |
| Cs 2, 8, 18, 18, 8, 1 | 2.67 | | | *DOWN A GROUP* |

# PERIODIC TRENDS IN PROPERTIES – *Ionisation Potential [I.P.]*

## 1. *THE TERM* – Ionisation Potential or ionisation energy

THE AMOUNT OF ENERGY *REQUIRED* – TO *REMOVE* *A LOOSELY BOUND ELECTRON* FROM THE OUTERMOST SHELL OF AN ISOLATED GASEOUS ATOM.

*Energy required to remove 1st electron* – is called first I.P.

$M \rightarrow M^+ + e^-$ [first I.P. is less]
atom ion electron

*Energy required to remove 2nd electron* – is called second I.P.

$M^+ \rightarrow M^{++} + e^-$ [second I.P. is more]

UNIT OF IONISATION POTENTIAL

Electron volt = e V

## 2. *FACTORS WHICH AFFECT* – The Ionisation potential

- ATOMIC SIZE – *Increases* – IONIZATION POTENTIAL – *Decreases*

  *Reason:* Atomic size increases –
  The nuclear attraction on the outer electrons – *decreases.*
  Hence the outer electrons are *loosely held.* ∴ I.P. decreases.

- NUCLEAR CHARGE – *Increases* – IONIZATION POTENTIAL – *Increases*

  *Reason:* Nuclear charge increases –
  The nuclear attraction on the outer electrons – *increases.*
  Hence the outer electrons are *more firmly held.* ∴ I.P. increases.

## 3. *TRENDS IN IONISATION POTENTIAL* – Across a period – From left to right

| *Elements* | Li 2, 1 | Be 2, 2 | B 2, 3 | C 2,4 | N 2, 5 | O 2, 6 | F 2, 7 | Ne 2, 8 |
|---|---|---|---|---|---|---|---|---|
| *I.P. [eV]* | 5.4 | 9.3 | 8.3 | 11.2 | 14.5 | 13.6 | 17.4 | 21.4 |

- ATOMIC RADII – *Decreases* [as discussed] – IONISATION POTENTIAL – *Increases*
- NUCLEAR CHARGE – *Increases* – IONISATION POTENTIAL – *Increases*

– *The element helium [He] has the highest ionisation potential while caesium [Cs] has the lowest.* (*Francium [Fr] is radioactive*)

– *Metals lose electrons & generally have low ionisation potential compared to non-metals.*

*IONISATION POTENTIAL* $\xrightarrow{\text{INCREASES}}$ *ACROSS A PERIOD – LEFT TO RIGHT*

## 4. *TRENDS IN IONISATION POTENTIAL* – Down a Group

| Elements | I.P. [eV] | Trends in ionisation potential – down a group | | *IONISATION POTENTIAL* |
|---|---|---|---|---|
| Li 2, 1 | 5.4 | • ATOMIC RADII – *Increases* | – IONISATION POTENTIAL – *Decreases* | ↓ DECREASES DOWN A GROUP |
| Na 2, 8, 1 | 5.1 | [No. of shells increases] | | |
| K 2, 8, 8, 1 | 4.3 | • NUCLEAR CHARGE – *Increases* | – IONISATION POTENTIAL – *Should increase* | |
| Rb 2, 8, 18, 8, 1 | 4.2 | – Increase in atomic radii – *Dominates over* – Increase in nuclear charge ∴ Overall ionisation potential – *Decreases.* | | |
| Cs 2,8,18,18,8,1 | 3.9 | | | |

# PERIODIC TRENDS IN PROPERTIES – *Electron Affinity [E.A.]*

## 1. *THE TERM* – Electron Affinity

**THE AMOUNT OF ENERGY *RELEASED* –**
**WHEN AN ATOM IN THE GASEOUS STATE ACCEPTS AN ELECTRON TO FORM AN ANION.**

| | |
|---|---|
| $X$ + $e^-$ → $X^-$ + energy liberated<br>atom electron anion [1st electron affinity.]<br>$Cl$ + $e^-$ → $Cl^-$ [–3.80 e V] | UNIT OF ELECTRON AFFINITY<br>Electron volt = e V<br>[represented with – ve sign] |

## 2. *FACTORS WHICH AFFECT* – The Electron Affinity

- **ATOMIC SIZE** – *Increases* – **ELECTRON AFFINITY** – *Decreases*
  ***Reason:*** Electron affinity is the tendency of an atom to accept electrons. A small atom takes up electrons *more readily* than a large atom – since nucleus has greater attraction on the electrons.
- **NUCLEAR CHARGE** – *Increases* – **ELECTRON AFFINITY** – *Increases*
  ***Reason:*** Nuclear charge increases – similarly *increases* the tendency of the atom to accept electrons.

## 3. *TRENDS IN ELECTRON AFFINITY* – Across a period – From left to right

| *Elements* | Li 2, 1 | Be 2, 2 | B 2, 3 | C 2,4 | N 2, 5 | O 2, 6 | F 2, 7 | Ne 2, 8 |
|---|---|---|---|---|---|---|---|---|
| *E.A.* [e V] | –0.61 | [exception] | –0.30 | –1.25 | [exception] | –1.48 | –3.6 | 0 |

- **ATOMIC RADII** – *Decreases* [as discussed] – **ELECTRON AFFINITY** – *Increases* [highest for halogens, least for alkali metals]
- **NUCLEAR CHARGE** – *Increases* – **ELECTRON AFFINITY** – *Increases*

– ***Neon [Ne] – has electron affinity zero since –*** inert gases with stable electronic configuration *find it difficult to accept electrons.*
[***Inert gases do not form ions*** – since their outermost shell is completely filled. They need not accept or donate any electrons & are already stable. They have no urge to destabilize themselves through gain or loss of electrons & hence do not form ions.]

– *Electron affinity is highest for halogens [group 17] & least for alkali metals [group 1]*

– *Greater the value of E.A., more electronegative or more oxidising is the element.*

*ELECTRON AFFINITY* $\xrightarrow{\text{INCREASES}}$ *ACROSS A PERIOD – LEFT TO RIGHT*

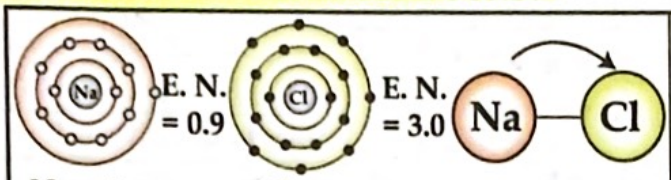
## 4. *TRENDS IN ELECTRON AFFINITY* – Down a Group

| Elements | E.A. [eV] | Trends in electron affinity – down a group | | *ELECTRON AFFINITY* |
|---|---|---|---|---|
| F 2, 7 | –3.60 | • ATOMIC RADII [Size] – *Increases* | – ELECTRON AFFINITY – *Decreases* | ↓ DECREASES |
| Cl 2, 8, 7 | –3.80 | [No. of shells increases] | | |
| Br 2, 8, 18, 7 | –3.50 | • NUCLEAR CHARGE – *Increases* | – ELECTRON AFFINITY – *Should increase* | |
| I 2, 8, 18, 18, 7 | –3.20 | – Increase in atomic radii – *Dominates over*<br>– Increase in nuclear charge<br>∴ Overall electron affinity – *Decreases.* | | *DOWN A GROUP* |

# PERIODIC TRENDS IN PROPERTIES – *Electronegativity [E.N.]*

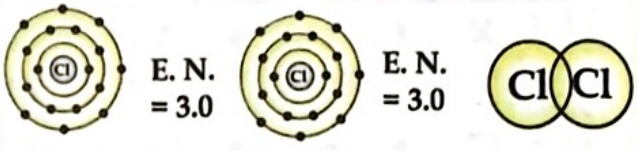
## 1. *THE TERM* – Electronegativity

**THE TENDENCY OF AN ATOM TO ATTRACT ELECTRONS TO ITSELF – WHEN COMBINED IN A COMPOUND.**




Na - atom Cl - atom

IONIC BOND – between combining atoms – if atoms *differ widely* in electronegativity.




Cl - atom Cl - atom

COVALENT BOND – between combining atoms if atoms have *nearly similar* electronegatives.

*Electronegativity* – indicates the net result of the tendency of elements *to attract the bond forming electron pair.*

## 2. *FACTORS WHICH AFFECT* – The Electronegativity

- ATOMIC SIZE – *Increases* – ELECTRONEGATIVITY – *Decreases*
  *Reason:* Reasons affecting electronegativity are – the same and in the same order as electron affinity.
- NUCLEAR CHARGE – *Increases* – ELECTRONEGATIVITY – *Increases*
  *Reason:* Reasons affecting electronegativity are – the same and in the same order as electron affinity.

## 3. *TRENDS IN ELECTRONEGATIVITY* – Across a period – From left to right

| *Elements* | 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 |
|---|---|---|---|---|---|---|---|---|
| *E.N.* | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.5 | 3.0 | – |

- ATOMIC RADII – *Decreases* [as discussed]
- NUCLEAR CHARGE – *Increases*

– ELECTRONEGATIVITY – *Increases* [Highest for halogens. Non-metallic character thus increases from left to right in a period].
– ELECTRONEGATIVITY – *Increases*

– *Elements with high electronegativity are usually – non-metallic.* [thus non-metals are electronegative while metals are electropositive]
– *Fluorine is the most electronegative element in the periodic table while caesium the least.*
– *Noble gases have complete octet and hence do not attract electrons to itself.*

*ELECTRONEGATIVITY* —INCREASES→ *ACROSS A PERIOD – LEFT TO RIGHT*

## 4. *TRENDS IN ELECTRONEGATIVITY* – Down a Group

| Elements | E.N. | Trend in electronegativity down a group | | *ELECTRO-NEGATIVITY* |
|---|---|---|---|---|
| F 2, 7 *most electronegative* | 4.0 | • ATOMIC RADII – *Increases* [No. of shells increases] | – ELECTRONEGATIVITY – *Decreases* | *DECREASES* ↓ *DOWN A GROUP* |
| Cl 2, 8, 7 | 3.0 | | | |
| Br 2, 8, 18, 7 | 2.8 | • NUCLEAR CHARGE – *Increases* | – ELECTRONEGATIVITY – *Should increase* | |
| I 2, 8, 18, 18, 7 | 2.5 | – Increase in atomic radii – *Dominates over*<br>– Increase in nuclear charge<br>∴ Overall electronegativity – *Decreases.* | | |

# PERIODIC TRENDS IN PROPERTIES – *Metallic or Non-metallic Character*

## 1. *THE TERM* – Metallic and non-metallic character

| METALLIC CHARACTER [electropositive] | NON-METALLIC CHARACTER |
|---|---|
| In terms of electron losing property – an atom is said to be a – *METAL*<br>IF IT *LOSES* – ONE OR MORE ELECTRONS WHEN SUPPLIED WITH ENERGY.<br>$M \rightarrow M^+ + e^-$<br>Metal → ion + electron<br>[M, a metal atom loses an electron] | In terms of electron gaining property – an atom is said to be a – *NON-METAL*<br>IF IT *GAINS* – ONE OR MORE ELECTRONS WHEN SUPPLIED WITH ENERGY.<br>$N + e^- \rightarrow N^-$<br>Non-metal → ion<br>[N, a non-metal gains an electron] |

## 2. *FACTORS INFLUENCING* – Metallic & non-metallic character

| | *METALLIC CHARACTER* | *NON-METALLIC CHARACTER* |
|---|---|---|
| • ATOMIC RADII – *Increases*<br>• IONIZATION POTENTIAL – *Increases* | *Increases*<br>*Decreases* | *Decreases*<br>*Increases* |

- METALLIC ATOMS – *present on the left side of the periodic table have*
  - *Large – atomic radii* & *Low – ionisation potential* value & tend to *Lose – electrons.*
- NON-METALLIC ATOMS – *present on the right side of the periodic table have*
  - *Small – atomic radii* & *High – ionisation potential* value & tend to *Gain – electrons.*
  - *Metals* are good *reducing agents* while *non-metals* are good *oxidizing agents.*

[Greater the tendency to *lose electron/s*, the greater is the ***reactivity of the metal.*** In case of non-metals, the greater the tendency to *gain electrons* the greater is the reactivity of the same.]

## 3. *TRENDS IN CHARACTER* – Across a period from left to right

| *Elements* | Na<br>2, 8, 1 | Mg<br>2, 8, 2 | Al<br>2, 8, 3 | Si<br>2, 8, 4 | P<br>2, 8, 5 | S<br>2, 8, 6 | Cl<br>2, 8, 7 | Ar<br>2, 8, 8 |
|---|---|---|---|---|---|---|---|---|
| *Character* | Metal | Metal | Metal | Metalloid | Non-metal | Non-metal | Non-metal | Noble gas |

| In a period from left to right as discussed | *METALLIC CHARACTER* | *NON-METALLIC CHARACTER* |
|---|---|---|
| • ATOMIC RADII – *Decreases* | *Decreases* | *Increases* |
| • IONIZATION POTENTIAL – *Increases* | *Decreases* | *Increases* |

*METALLIC CHARACTER* —DECREASES→ *NON-METALLIC CHARACTER* —INCREASES→ *ACROSS A PERIOD*

## 4. *TRENDS IN CHARACTER* – Down a Group e.g. group – 14

| Elements | Character | Trend in metallic and non-metallic character – down a group | | |
|---|---|---|---|---|
| | | | *METALLIC CHARACTER* | *NON-METALLIC CHARACTER* |
| C<br>2, 4 | Non-metal | *Down a group as discussed* | | |
| Si<br>2, 8, 4 | Metalloid | • ATOMIC RADII<br>*Increases* | *Increases* | *Decreases* |
| Ge<br>2, 8, 18, 4 | Metalloid | • IONIZATION POTENTIAL<br>*Decreases* | *Increases* | *Decreases* |
| Sn<br>2, 8, 18, 18, 4 | Metal | *ELEMENTS AT THE BOTTOM OF A GROUP* – are most metallic, have large atomic size, lowest I.P., electrons are thus loosely held & *will form ions from metals most readily & thus are more reactive.* | | |
| Pb<br>2, 8, 18, 18, 18, 4 | Metal | | | |

*METALLIC CHARACTER* —INCREASES→ *NON-METALLIC CHARACTER* —DECREASES→ *DOWN A GROUP*

# PERIODIC TRENDS IN PROPERTIES – Other Physical & Chemical Properties

## 1. PHYSICAL PROPERTIES – Density, Melting & Boiling point – in which periodicity is seen

a] *ACROSS A PERIOD* – **Density & m.p.** of elements - increase gradually [slight decrease thereafter].

| | Li | Be | B | C | N | O | F | Na | Mg | Al | Si | P | S | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Density** [g./ml.] | 0.5 | 1.8 | 2.3 | 2.2 | – | – | – | 1.0 | 1.7 | 2.7 | 2.3 | 1.8 | 2.1 | – |
| **m.p.** [°C] | 181 | 1277 | 2030 | 3727 | -210 | -219 | -220 | 98 | 650 | 660 | 1410 | 44 | 119 | -101 |

b] *DOWN A GROUP* – **Density** increases gradually & **m.p. & b.p.** of elements - decreases gradually.

| Group 1[IA] | Density [g./ml.] | Melting Point [°C] | Boiling Point [°C] |
|---|---|---|---|
| Li | 0.54 | 181 | 1347 |
| Na | 0.97 | 98 | 880 |
| K | 0.86 | 63 | 766 |

## 2. CHEMICAL PROPERTIES – Periodicity in properties of compounds of elements

| | Varies from – ACROSS A PERIOD | | DOWN A GROUP | |
|---|---|---|---|---|
| *Oxides* | Strongly basic | to Strongly acidic | Acidic | to Basic |
| *Hydroxides* | Strongly basic | to Amphoteric | Less basic | to Strongly basic |
| *Oxy-acids* | Weak oxy-acids | to Strong oxy-acids | Strong oxy-acids | to Weak oxy-acids |
| *Hydrides* | Strongly basic | to Strongly acidic | Less acidic | to More acidic |

*REFERENCE – Arrangement of stable & unstable elements in the Periodic Table*

| Element | Symbol | Atomic no. [Z] | Mass no. [A] | No. of protons p = Z | No. of neutrons n = A – Z | $^{n}/_{p}$ ratio |
|---|---|---|---|---|---|---|
| Sodium | $^{23}_{11}Na$ | 11 | 23 | 11 | 12 | $^{12}/_{11}$ = 1.1 |
| Potassium | $^{39}_{19}K$ | 19 | 39 | 19 | 20 | $^{20}/_{19}$ = 1.1 |
| *Uranium* | $^{236}_{92}U$ | 92 | 236 | 92 | 144 | $^{144}/_{92}$ = >1.5 |



***Light metals*** – Elements arranged in the periodic table having a – $^{n}/_{p}$ (neutron/proton) ratio around 1 are ***stable elements.*** e.g. *light metals*, Na and K.

***Heavy metals*** – Elements with a – $^{n}/_{p}$ ratio above 1.5 are considered as radioactive ***unstable elements.*** e.g. *heavy metal*, uranium.

*REFERENCE – Values of - Atomic size, Ionisation potential, Electron affinity, Electronegativity*

| PERIOD | ATOMIC SIZE [A°] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | H 0.37 | | | | | | | He 0.31 |
| 2 | Li 1.55 | Be 1.12 | B 0.88 | C 0.77 | N 0.70 | O 0.66 | F 0.64 | Ne 1.12 |
| 3 | Na 1.91 | Mg 1.61 | Al 1.44 | Si 1.18 | P 1.10 | S 1.06 | Cl 0.99 | Ar 1.28 |

| PERIOD | IONISATION POTENTIAL [eV] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | H 13.1 | | | | | | | He 24.5 |
| 2 | Li 5.4 | Be 9.3 | B* 8.3 | C 11.2 | N* 14.5 | O 13.6 | F 17.4 | Ne 21.4 |
| 3 | Na 5.1 | Mg* 7.6 | Al 5.8 | Si 8.1 | P* 10.1 | S 9.9 | Cl 12.5 | Ar 15.2 |

| PERIOD | ELECTRON AFFINITY [eV] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | H -0.72 | | | | | | | He 0 |
| 2 | Li -0.61 | Be* | B* -0.30 | C -1.25 | N* | O -1.48 | F -3.6 | Ne 0 |
| 3 | Na -0.55 | Mg* | Al* -0.49 | Si -1.39 | P* -0.80 | S -2.0 | Cl -3.8 | Ar 0 |

| PERIOD | ELECTRONEGATIVITY | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | H 2.1 | | | | | | | He – |
| 2 | Li 1.0 | Be 1.5 | B 2.0 | C 2.5 | N 3.0 | O 3.5 | F 4.0 | Ne – |
| 3 | Na 0.9 | Mg 1.2 | Al 1.5 | Si 1.8 | P 2.1 | S 2.5 | Cl 3.0 | Ar – |

*[Values may show variation with reference to experimental verification or calculation]* *[* = exception]*

# SUMMARY CHART – Periodic properties

## I TRENDS – IN PERIODIC PROPERTIES – Across a Period

| | GROUP - 1 | GROUP - 2 | GROUP - 13 | GROUP - 14 | GROUP - 15 | GROUP - 16 | GROUP - 17 | GROUP - 18 |
|---|---|---|---|---|---|---|---|---|
| PERIOD – 1 | $^{1}H$ 1 | | | | | | | $^{2}He$ 2 |
| PERIOD – 2 | $^{3}Li$ 2, 1 | $^{4}Be$ 2, 2 | $^{5}B$ 2, 3 | $^{6}C$ 2, 4 | $^{7}N$ 2, 5 | $^{8}O$ 2, 6 | $^{9}F$ 2, 7 | $^{10}Ne$ 2, 8 |
| PERIOD – 3 | $^{11}Na$ 2, 8, 1 | $^{12}Mg$ 2, 8, 2 | $^{13}Al$ 2, 8, 3 | $^{14}Si$ 2, 8, 4 | $^{15}P$ 2, 8, 5 | $^{16}S$ 2, 8, 6 | $^{17}Cl$ 2, 8, 7 | $^{18}Ar$ 2, 8, 8 |
| ATOMIC SIZE | LARGEST | | | Decreases → | | | SMALLEST | LARGER |
| IONISATION POTENTIAL [I.P.] | LOWEST | | | Increases → | | | | HIGHEST |
| ELECTRON AFFINITY [E.A.] | LOWEST | | | Increases → | | | HIGHEST | ZERO |
| ELECTRO NEGATIVITY [E.N.] | LOWEST | | | Increases → | | | HIGHEST | – |
| METALLIC CHARACTER | HIGHEST | → | | Decreases | → | → | LEAST | – |

## II TRENDS – IN PERIODIC PROPERTIES – Down a Group

| PERIOD | GROUP 1 | GROUP 2 | GROUP 13 | AT. SIZE | I. P. | E. A. | E. N. | METALLIC CHARACTER | VALENCE ELECTRONS | NO. OF SHELLS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | $^{1}H$ | | | SMALLEST | HIGHEST | HIGHEST | HIGHEST | LEAST | REMAINS | INCREASES |
| 2 | $^{3}Li$ | $^{4}Be$ | $^{5}B$ | ↓ Increases | ↓ Decreases | ↓ Decreases | ↓ Decreases | ↓ Increases | ↓ | ↓ |
| 3 | $^{11}Na$ | $^{12}Mg$ | $^{13}Al$ | | | | | | | |
| 4 | $^{19}K$ | $^{20}Ca$ | $^{31}Ga$ | | | | | | | |
| 5 | $^{37}Rb$ | $^{38}Sr$ | $^{49}In$ | LARGEST | LOWEST | LOWEST | LOWEST | HIGHEST | SAME | BY ONE |

## III REASONS – FOR TRENDS IN PERIODIC PROPERTIES – Across a period

| CHANGE – in periodic properties | | REASON – for periodic trend in property across a period |
|---|---|---|
| • *Atomic size* | DECREASES → | Nuclear charge – *Increases* . No. of shells – *Remains same* |
| • *Ionisation potential* | Increases → | Nuclear charge – *Increases* . Atomic radii – *Decreases* |
| • *Electron affinity* | Increases → | Nuclear charge – *Increases* . Atomic radii – *Decreases* |
| • *Electronegativity* | Increases → | Nuclear charge – *Increases* . Atomic radii – *Decreases* |
| • *Non-metallic character* | Increases → | Ionisation potential – *Increases* . Atomic radii – *Decreases* |
| • *Metallic character* | DECREASES → | Ionisation potential – *Increases* . Atomic radii – *Decreases* |

## IV REASONS – FOR TRENDS IN PERIODIC PROPERTIES – Down a group

| CHANGE – in periodic properties | | REASON – for periodic trend in property down a group |
|---|---|---|
| • *Atomic size* | ↓ INCREASES | Nuclear charge – *Increases* . No. of shells – *Increases* |
| • *Ionisation potential* | D | Nuclear charge – *Increases* . Atomic radii – *Increases* |
| • *Electron affinity* | e | Nuclear charge – *Increases*. Atomic radii – *Increases* |
| • *Electronegativity* | c | Nuclear charge – *Increases* . Atomic radii – *Increases* |
| | r | *For above reasons – NUCLEAR CHARGE EFFECT IS DOMINATED BY – INCREASE IN NUMBER OF SHELLS OR INCREASE IN ATOMIC RADII.* |
| • *Non-metallic character* | ↓ e | Ionisation potential – *Decreases* . Atomic radii – *Increases* |
| • *Metallic character* | ↓ INCREASES | Ionisation potential – *Decreases* . Atomic radii – *Increases* |

*GROUP – 18 ELEMENTS*

- Atomic radii more than group 17 – *[outer shell is completely filled resulting in force of repulsion, increasing atomic size].*
- Electron affinity is – zero *[elements with stable electronic configuration find it difficult to accept electrons].*

METALS – COMPARED TO NON-METALS

- *Metals* lose electrons – have large atomic radii – & have less *I.P., E.A. & E.N. – compared to non-metals.*

# QUESTIONS

**2009**

1. Among Period-2 elements - Lithium; Carbon; Fluorine; Neon - State the one which has high electron affinity. [pg.11,15]
2.

| Group numbers | IA 1 | IIA 2 | IIIA 13 | IVA 14 | VA 15 | VIA 16 | VIIA 17 | O 18 |
|---|---|---|---|---|---|---|---|---|
| | Li | | D | | | O | J | Ne |
| | A | Mg | E | Si | | H | K | |
| | B | C | | F | G | | | L |

Some elements are given in the above table in their own symbol & position in the periodic table, while others [shaded] are shown with a letter. With reference to the table.
i] Which is the most electronegative ii] How many valence electrons are present in G[pg.12,15] [pg.5]
iii] Write the formula of the compound between B and H. [$B_2H$]
iv] In the compound between F and J, what type of bond will be formed [pg.5]
v] Draw the electron dot structure for the compound formed between C and K. [pg.25-27]
3. Define the following term – Ionization potential. [pg.8]

**2010**

1. *Select the correct answer:* i] The no. of electrons in the valence [outermost] shell of a halogen is - *A : 1, B : 3, C : 5, D : 7*
ii] Electronegativity across the period - *increases/decreases*
iii] Non-metallic character down the group - *increases/decreases* [pg.5, 7, 12, 13]
2. Atomic number of an element is 16. State i] To which period it belongs [pg.5]
ii] The number of valence electrons in the element iii] Is the element a metal or a non-metal [pg.8]
3. Define the terms i] Ionisation potential ii] Electron affinity.

**2011**

1. Give reasons – The oxidising power of elements increases from left to right along a period. [pg.13,133]
2. Select the correct answer – i] Across a period, the ionization potential ____ [increases, decreases, remains same]. ii] Down the group, electron affinity ____ [increases, decreases, remains same]. [pg.10,11,15]
3. *Choose the correct answer* : In the periodic table alkali metals are placed in group – A : 1, B : 11, C : 17, D : 18
*Which of the following properties:* do not match with elements of the halogen family –
A : They have seven electrons in their valence shell, B : They are highly reactive chemically,
C : They are metallic in nature, D : They are diatomic in their molecular form. [pg.6,7]
4. State the group & period, of the element having three shells with three electrons in valence shell. [pg.5]

**2012**

1. *Select the element* in period 3 whose electron affinity is zero — A : Neon, B : Sulphur, C : Sodium, D : Argon [pg.11,15]
2. Give reasons : i] I.P. of elements increases across a period. ii] Alkali metals are good reducing agents. [pg.10,15, 7,130]
3. There are three elements E, F, G with atomic numbers 19, 8 & 17 respectively – [pg.4,5]
Classify the above elements as metals & non-metals. [pg.4]
4. Name : A metal present in period 3, group I of the periodic table.

**2013**

1. Among Period-2 elements - Lithium; Carbon; Chlorine; Flourine - State the one which has high electron affinity. [pg.11,15]
2.

| Group No. | 1 - IA | 2 - IIA | 13 - IIIA | 14 - IVA | 15 - VA | 16 - VIA | 17 - VIIA | 18 - 0 |
|---|---|---|---|---|---|---|---|---|
| *2nd period* | Li | | D | | | O | J | Ne |
| *3rd period* | A | Mg | E | Si | | H | M | |
| *4th period* | R | T | I | | Q | u | | y |

*In the above table* – H does not represent hydrogen. Some elements are in their own symbol & position in the periodic table while others are shown with a letter. *Identify* i] The most electronegative element. [pg.12]
ii] The most reactive element of group I. iii] The element from period 3 with least atomic size. [pg.13, 9]
iv] The noble gas of the fourth period. v] How many valence electrons are present in Q. [pg.4, 6, 5]
vi] Which element from group 2 would have the least ionization energy. [pg.10]
vii] In the compound between A & H what type of bond is formed & give its molecular formula. [pg.25]
3. Identify: The element which has the highest ionization potential. [pg.10,15]

**2014**

1. *Choose the correct answer* : i] Ionisation Potential increases over a period from left to right because the: [pg.10,15]
A: Atomic radius & nuclear charge increases B: Atomic radius & nuclear charge decreases
C: Atomic radius increases & nuclear charge decreases D: Atomic radius decreases & nuclear charge increases.
ii] An element A belonging to Period 3 & Group II will have — A: 3 shells & 2 valence electrons
B: 2 shells & 3 valence electrons C: 3 shells & 3 valence electrons D: 2 shells & 2 valence electrons [pg.4, 6]
2. Atomic number of element Z is 16. i] State the period & group to which Z belongs. ii] Is Z a metal or a non-metal. iii] State the formula of the compound between Z & Hydrogen. What kind of compound is this. [pg.5]
3. In the activity series of metals - M is a metal above hydrogen in the activity series & its oxide has the formula $M_2O$. $M_2O$ when dissolved in water forms the corresponding hydroxide which is a good conductor of electricity.
i] What kind of combination exists between M & O. ii] State the no. of electrons in the outermost shell of M. [pg.5 (pg.134)]
iii] Name the group to which M belongs. [pg.5]
4. *Give a phrase for:* Amount of energy *released* when an atom in the gaseous state *accepts* an electron to form an anion. [pg11]
5. *Match the option* – A: Metal *or* B: Iron – with the statements i] & ii]: [pg.6 (64)]
i] The metal that forms two types of ions ii] An element with electronic configuration 2,8,8,3

**2015**

1. *The element with the least electronegativity is*: A: Lithium B: Carbon C: Boron D: Fluorine [pg.15, (12)]
2. Arrange the elements as per the *instructions*: i] Cs, Na, Li, K, Rb *[increasing order of metallic character]*. [pg.15(13)]
   i] Mg, Cl, Na, S, Si *[decreasing order of atomic size]*. [pg.15(9)]
   ii] Na, K, Cl, S, Si *[increasing order of ionization energy]*. [pg.15(10)]
   iii] Cl, F, Br, I *[increasing order of electron affinity]*. [pg.15(11)]
3. Select a covalent oxide of a metalloid from the following - $SO_2$, $SiO_2$, $Al_2O_3$, MgO, CO, $Na_2O$. [pg.5]
4. The metals of Group 2 in the periodic table from top to bottom are - Be, Mg, Ca, Sr, & Ba. [pg.13, 7]
   i] Which one of these elements will form ions most readily. Give reasons.
   ii] State the common feature in the electronic configuration of all these elements given.

**2016**

1. *Select the correct answer from A, B, C & D:* An element with the atomic number 19 will most likely combine chemically with the element whose atomic number is: A: 17 B: 11 C: 18 D: 20 [pg.4]
2. *Identify the term in each of the following:* i] The tendency of an atom to attract electrons to itself when combined in a compound. ii] The electrons present in the outermost shell of an atom. [pg.12, pg.6]
3. Write the correct symbol: > [*greater than*] or < [*less than*] in the statements: i] The ionization potential of potassium is__ that of sodium. ii] The electronegativity of iodine is ___ that of chlorine. [pg.10(15), pg.12]
4. Use the **letters only** written in the Periodic Table below to answer the questions : [pg.5, 5, 13(15), 4(15)]

| Periods | I | II | III | IV | V | VI | VII | 0 |
|---|---|---|---|---|---|---|---|---|
| | Groups | | | | | | | |
| 1 | | | | | | | | L |
| 2 | Q | | E | G | J | Z | M | |
| 3 | R | | | | | | | |
| 4 | T | | | | | | | |

   i] State the number of *valence electrons* in atom **J**.
   ii] Which element shown forms *ions* with a single negative charge.
   iii] Which *metallic element* is more reactive than **R.**
   iv] Which element has its electrons arranged in *four shells*.
5. Fill in the blanks by selecting the correct word: i] If an element has a low ionization energy then it is likely to be _____ [*metallic / non metallic*]. ii] If an element has seven electrons in its outermost shell then it is likely to have the _____ [*largest / smallest*] atomic size among all the elements in the same period. [pg.10(15), pg9(15)]

**2017**

1. Select the correct answer — The energy required to remove an electron from a neutral isolated gaseous atom & convert it into a positively charged gaseous ion is called _____. [electron affinity, ionisation potential electronegativity] pg.10]
2. Match the atomic number 2, 4, 8, 15 & 19 with each of the following — i] A solid non-metal belonging to the third period. ii] A metal of valency 1. iii] A gaseous element with valency 2 iv] An element belonging to Group 2. v] A rare gas. [pg.4, 5]
3. Arrange as per the instruction — i] He, Ar, Ne [*Increasing order of the number of electron shells*] ii] Na, Li, K [*Increasing ionisation energy*]. iii] F, Cl, Br [*Increasing electronegativity*]. iv] Na, K, Li [*Increasing atomic size*]. [pg.4, 10, 12, 9]

**2018**

1. Give one word or a phrase for the following statement: The energy released when an electron is added to a neutral gaseous isolated atom to form a negatively charged ion. [pg.11]
2. Give *reasons*: i] *Inert gases* do not form ions. ii] *Ionisation potential* increases across a period - left to right. [i) pg.11, ii) pg.10]
3. In Period 3 of the Periodic Table, element **B** is placed to the left of element **A**. On the basis of this information, choose the correct word from the brackets – to complete the following statements.
   i] The element **B** would have [lower/higher] metallic character than **A**. [pg.13, 15]
   ii] The element **A** would probably have [lesser/higher] electron affinity than **B**. [pg.11, 15]
   iii] The element **A** would have [greater/smaller] atomic size than **B**. [pg.9, 15]

**2019**

1. *Choose the correct answer* from the options **A, B, C & D** given: The most electronegative element from the following elements is: **A:** Magnesium **B:** Chlorine **C:** Aluminium **D:** Sulphur [pg. 12 (15)]
2. *Fill in the blank*: In period 3, the *most metallic* element is _____. [sodium/magnesium/aluminium] [pg.13(15)]
3. *Give the appropriate term defined by the statement given*: The tendency of an atom to attract electrons towards itself when combined in a covalent compound. [pg.12]
4. Arrange the following: i] Li, K, Na, H [In the decreasing order of their ionization potential]. [pg.15 (14)]
   ii] F, B, N, O [In the increasing order of electron affinity] [pg.15 (11)]
5. Study the extract of the Periodic Table given below and answer the questions. Give the alphabet corresponding to the element in question. *Do not repeat* an element. State which element:

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | C | | D | E | | |
| | B | | | | | | | | | | | | | | | G | F |
| | | | | | | | | | | | | | | | | | |

   i] Forms an electrovalent compound with G. [pg.5]
   ii] Is non-metallic and has a valency of 2. [pg.5]
   iii] Is an inert gas. [pg.5]
   State the ion of which element will migrate:
   Towards the cathode during electrolysis. [pg.5(110, 114)]

**2020**

1. Choose the correct answer from the options given: The element with *highest* ionization potential, is: [pg.10(14)]
   **A.** Hydrogen **B.** Caesium **C.** Radon **D.** Helium
2. *Give one word or a phrase for*: The tendency of an atom to attract electrons to itself when combined in a compound. [pg.12(8)]
3. The question represents the elements P, Q, R and their atomic numbers.
   Answer the following using only the alphabets given - P = 13; Q = 7; R = 10.
   i] Which element combines with hydrogen to form a basic gas. [pg.5 (167)]
   ii] Which element has an electron affinity zero. [pg.5 (11)]
   iii] Name the element, which forms an ionic compound with chlorine. [pg.5 (25)]
4. *Name the element:* An alkaline earth metal present in group 2 and period 3. [pg.5, 6]

# UNIT TEST PAPER 1 – Periodic Table

30 marks

**Q.1 In period 2, element 'A' is to the right of element 'B'.** [5]

1. The element 'A' would probably have a _____ [smaller/larger] atomic size than 'B'.
2. The element 'B' would probably have _____ [lower/higher] ionisation potential than 'A'.
3. The element 'A' would have _____ [lesser/higher] electron affinity than 'B'.
4. Nuclear charge of element 'B' would be _____ [less/more] than element 'A'.
5. If an element 'C' had a *low* electronegativity and ionisation potential it would have more tendency to _____ [gain/lose] electrons.

**Q.2 With reference to period 3 of the periodic table – State:** [5]

1. The type of bonding of the element with electronic configuration 2, 8, 7.
2. The formula of the chloride of the element with electronic configuration 2, 8, 4.
3. The nature of the oxide of the alkaline earth metal in the period.
4. The number of electrons in the penultimate shell of the element with valency –1.
5. The electronic configuration of the element whose hydroxide is a weak base.

**Q.3 With reference to group 1 [IA] of the periodic table – fill in the blanks with the correct word:** [5]

The elements are _____ [light/heavy] _____ [metals/non-metals] since their atomic size is _____ [large/small]. The energy binding the atoms is _____ [high/low] and hence the elements have _____ [high/low] melting points. The melting points of the elements _____ [increases/decreases] down the subgroup. The electropositive character _____ [increases/decreases] down the subgroup and the elements are strong _____ [reducing/oxidizing] agents. The element with electronic configuration 2,8,1 will have _____ [higher/lower] electronaffinity and _____ [smaller/larger] atomic size than the element with electronic configuration 2,1.

**Q.4 Match the elements in column 'X' with the correct group they belong from column 'Y'.** [5]

| | 'X' | 'Y' | |
|---|---|---|---|
| 1. | Element with atomic number 19 | A: Group 18 | [0 group] |
| 2. | Element with electronic configuration 2 | B: Group 16 | [VIA] |
| 3. | Element with a valency of –2 | C: Group 1 | [IA] |
| 4. | Element 'P' which loses 3 electrons to form a cation | D: Group 17 | [VIIA] |
| 5. | Element 'Q' in period-3 which has the highest electron affinity | E: Group 13 | [IIIA] |

**Q.5 Give reasons for the following :** [5]

1. Occurrence of characteristic properties of elements takes place at definite intervals in the modern periodic table.
2. Properties of elements are periodic functions of their atomic numbers and not atomic weights.
3. Atomic size of an element depends on the nuclear charge of that element.
4. Down a group electronegativity should increase with increase in nuclear charge but it is seen that the electronegativity decreases.
5. If combining atoms have nearly similar electronegativities the bond between them is covalent.

**Q.6 Arrange the following elements as per the guidelines in brackets.** [5]

1. Na, Cl, Mg, P [in decreasing order of atomic size] Na, Mg, P, Cl
2. C, Li, F, N [in increasing order of electronegativity]
3. Cl, Al, Na, S [in increasing order of ionisation potential]
4. Li, F, C, O [in increasing order of electron affinity]
5. Ar, He, Ne [in increasing order of number of electron shells]