COVID-19 AWARENESS

COVID-19: Caused by a virus known as Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2). Spreads very **easily** from person to person.

Signs and symptoms: Fever or chills, cough, difficulty in breathing, cold, headache, diarrhea, loss of taste/smell, and several non-specific symptoms.

Transmission: Respiratory droplets, airborne, contaminated surfaces.

Prevention: Adhere to the COVID-19 safety protocols

- Respiratory hygiene: Wear a nose mask, cough etiquettes
- Hand hygiene: Frequent hand washing, hand sanitizing
- Maintain 'safe' physical distancing
- Avoid crowds and confined/poorly ventilated spaces

Virus is changing itself so it is important we all adhere to the safety protocols

LECTURE THREE

Periodic Table and Periodic Properties of Elements

The Periodic Table

Mendeleev put forward the modern form of the periodic table.

All elements are arranged on the periodic table according to their atomic numbers. The elements can be divided into **groups**, **periods** and **blocks**.

Groups

This is a vertical arrangement of the elements on the periodic table. Elements in a group have the same valence electrons or similar atomic configurations.

${}_{3}Li = [He]\ \underline{2s^1},\ {}_{11}Na = [Ne]\ 3s^1,\ {}_{19}K = [Ar]\ 4s^1$

$11\ Na \rightarrow 1s^2\ \ 2s^2\ \ 2p^6\ \ \underline{3s^1}$

$19\ K \rightarrow 1s^2\ \ 2s^2\ \ 2p^6\ \ 3s^2\ \ 3p^6\ \ \underline{4s^1}$

The elements have 1 valence electron in their s-orbital. Similarly, the atomic configuration has only one electron outside a noble gas configuration.

Group elements have similar chemical properties.

In most elements the number of valence electrons is the same as the group number, where the group members share similar physical and chemical properties.

For example they could be considered as “a family”.

Example: Alkali metals consisting of Li, Na, K, Rb, Cs.

Halogen can also form a family: F, Cl, Br, I.

There is an isolated situation i.e. Group 4 or 14 are not family C, Si.

This is because elements in the same group have different n-numbers.

Periodic Table of the Elements

1 IA 11A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 **H** Hydrogen 1.008																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012											5 **B** Boron 10.811	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.998	10 **Ne** Neon 20.180
11 **Na** Sodium 22.990	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.982	14 **Si** Silicon 28.086	15 **P** Phosphorus 30.974	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
19 **K** Potassium 39.098	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.956	22 **Ti** Titanium 47.88	23 **V** Vanadium 50.942	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.938	26 **Fe** Iron 55.933	27 **Co** Cobalt 58.933	28 **Ni** Nickel 58.693	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.732	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.922	34 **Se** Selenium 78.09	35 **Br** Bromine 79.904	36 **Kr** Krypton 84.80
37 **Rb** Rubidium 84.468	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.906	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.906	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium 98.907	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.906	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.411	49 **In** Indium 114.818	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.6	53 **I** Iodine 126.904	54 **Xe** Xenon 131.29
55 **Cs** Cesium 132.905	56 **Ba** Barium 137.327	57-71	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.948	74 **W** Tungsten 183.85	75 **Re** Rhenium 168.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22	78 **Pt** Platinum 195.08	79 **Au** Gold 196.967	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.383	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.980	84 **Po** Polonium [208.982]	85 **At** Astatine 209.987	86 **Rn** Radon 222.018
87 **Fr** Francium 223.020	88 **Ra** Radium 226.025	89-103	104 **Rf** Rutherfordium [261]	105 **Db** Dubnium [262]	106 **Sg** Seaborgium [266]	107 **Bh** Bohrium [264]	108 **Hs** Hassium [269]	109 **Mt** Meitnerium [268]	110 **Ds** Darmstadtium [269]	111 **Rg** Roentgenium [272]	112 **Cn** Copernicium [277]	113 **Uut** Ununtrium unknown	114 **Fl** Flerovium [289]	115 **Uup** Ununpentium unknown	116 **Lv** Livermorium [298]	117 **Uus** Ununseptium unknown	118 **Uuo** Ununoctium unknown

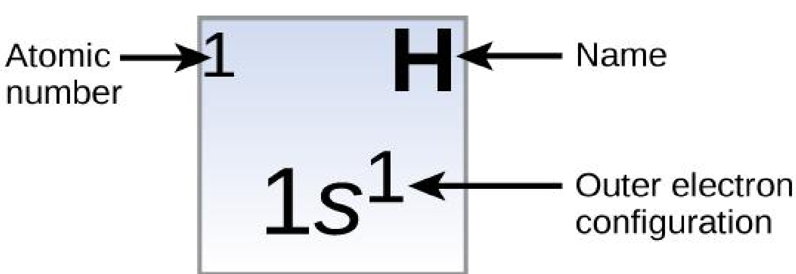
Lanthanide Series	57 **La** Lanthanum 138.906	58 **Ce** Cerium 140.115	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.24	61 **Pm** Promethium 144.913	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.966	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.967
Actinide Series	89 **Ac** Actinium 227.028	90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium 237.048	94 **Pu** Plutonium 244.064	95 **Am** Americium 243.061	96 **Cm** Curium 247.070	97 **Bk** Berkelium 247.070	98 **Cf** Californium 251.080	99 **Es** Einsteinium [254]	100 **Fm** Fermium 257.095	101 **Md** Mendelevium 258.1	102 **No** Nobelium 259.101	103 **Lr** Lawrencium [262]

Alkali Metal | Alkaline Earth | Transition Metal | Semimetal | Nonmetal | Basic Metal | Halogen | Noble Gas | Lanthanide | Actinide

Electron Configuration Table

Period	Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H $1s^1$																	2 He $1s^2$
2	3 Li $2s^1$	4 Be $2s^2$											5 B $2s^22p^1$	6 C $2s^22p^2$	7 N $2s^22p^3$	8 O $2s^22p^4$	9 F $2s^22p^5$	10 Ne $2s^22p^6$
3	11 Na $3s^1$	12 Mg $3s^2$											13 Al $3s^23p^1$	14 Si $3s^23p^2$	15 P $3s^23p^3$	16 S $3s^23p^4$	17 Cl $3s^23p^5$	18 Ar $3s^23p^6$
4	19 K $4s^1$	20 Ca $4s^2$	21 Sc $4s^23d^1$	22 Ti $4s^23d^2$	23 V $4s^23d^3$	24 Cr $4s^13d^5$	25 Mn $4s^23d^5$	26 Fe $4s^23d^6$	27 Co $4s^23d^7$	28 Ni $4s^23d^8$	29 Cu $4s^13d^{10}$	30 Zn $4s^23d^{10}$	31 Ga $4s^23d^{10}4p^1$	32 Ge $4s^23d^{10}4p^2$	33 As $4s^23d^{10}4p^3$	34 Se $4s^23d^{10}4p^4$	35 Br $4s^23d^{10}4p^5$	36 Kr $4s^23d^{10}4p^6$
5	37 Rb $5s^1$	38 Sr $5s^2$	39 Y $5s^24d^1$	40 Zr $5s^24d^2$	41 Nb $5s^14d^4$	42 Mo $5s^14d^5$	43 Tc $5s^14d^6$	44 Ru $5s^14d^7$	45 Rh $5s^14d^8$	46 Pd $4d^{10}$	47 Ag $5s^14d^{10}$	48 Cd $5s^24d^{10}$	49 In $5s^24d^{10}5p^1$	50 Sn $5s^24d^{10}5p^2$	51 Sb $5s^24d^{10}5p^3$	52 Te $5s^24d^{10}5p^4$	53 I $5s^24d^{10}5p^5$	54 Xe $5s^24d^{10}5p^6$
6	55 Cs $6s^1$	56 Ba $6s^2$	57 La * $6s^25d^1$	72 Hf $6s^24f^{14}5d^2$	73 Ta $6s^24f^{14}5d^3$	74 W $6s^24f^{14}5d^4$	75 Re $6s^24f^{14}5d^5$	76 Os $6s^24f^{14}5d^6$	77 Ir $6s^24f^{14}5d^7$	78 Pt $6s^14f^{14}5d^9$	79 Au $6s^14f^{14}5d^{10}$	80 Hg $6s^24f^{14}5d^{10}$	81 Tl $6s^24f^{14}5d^{10}6p^1$	82 Pb $6s^24f^{14}5d^{10}6p^2$	83 Bi $6s^24f^{14}5d^{10}6p^3$	84 Po $6s^24f^{14}5d^{10}6p^4$	85 At $6s^24f^{14}5d^{10}6p^5$	86 Rn $6s^24f^{14}5d^{10}6p^6$
7	87 Fr $7s^1$	88 Ra $7s^2$	89 Ac ** $7s^26d^1$	104 Rf $7s^25f^{14}6d^2$	105 Db $7s^25f^{14}6d^3$	106 Sg $7s^25f^{14}6d^4$	107 Bh $7s^25f^{14}6d^5$	108 Hs $7s^25f^{14}6d^6$	109 Mt $7s^25f^{14}6d^7$	110 Ds $7s^25f^{14}6d^8$	111 Rg $7s^25f^{14}6d^9$	112 Cn $7s^25f^{14}6d^{10}$	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

*	58 Ce $6s^24f^2$	59 Pr $6s^24f^3$	60 Nd $6s^24f^4$	61 Pm $6s^24f^5$	62 Sm $6s^24f^6$	63 Eu $6s^24f^7$	64 Gd $6s^24f^75d^1$	65 Tb $6s^24f^9$	66 Dy $6s^24f^{10}$	67 Ho $6s^24f^{11}$	68 Er $6s^24f^{12}$	69 Tm $6s^24f^{13}$	70 Yb $6s^24f^{14}$	71 Lu $6s^24f^{14}5d^1$
**	90 Th $7s^26d^2$	91 Pa $7s^25f^26d^1$	92 U $7s^25f^36d^1$	93 Np $7s^25f^46d^1$	94 Pu $7s^25f^6$	95 Am $7s^25f^7$	96 Cm $7s^25f^76d^1$	97 Bk $7s^25f^86d^1$	98 Cf $7s^25f^{10}$	99 Es $7s^25f^{11}$	100 Fm $7s^25f^{12}$	101 Md $7s^25f^{13}$	102 No $7s^25f^{14}$	103 Lr $7s^25f^{14}6d^1$



Periods

This is the horizontal arrangement of elements on the periodic table.

One element to the next as the atomic number increases by 1.

There are 7 periods, i.e.. Length of the period is not uniform but varies.

The shortest period has 2 elements and the longest period has 32 elements.

The period number refers to the main energy level that the valence electron occupies.

P1 (1s) - total number of elements 2

P2 (2s, 2p) - total number of elements is 8 (i.e.. 2+6= 8).

P3 (3s, 3p) - total number of elements is 8

P4 (4s, 3d, 4p) - total number of elements is18

P5 (5s, 4d, 5p) - total number of elements is18

P6 (6s, 4f, 5d, 6p) - total number of elements is32

For clumsy arrangement, the elements with their valence electron filling the 4f- orbitals are placed in a separate row at the bottom of the periodic table.

The row forms Lanthanides, where it starts from Cerium, Ce (58) ---- Lutetium, Lu (71).

Similar situation is observed for valence electrons filling 5f orbitals which are placed below the Lanthanides.

These are the Actinides, it starts from Th (Thorium) 90 ---- Lr (Lawrencium) 103.

Blocks

These are groups of elements with their valence electrons occupying the same orbital.

Valence electrons in s-orbitals for both G1 and G2 elements are therefore said to be s-blocks elements.

Second period elements starting from Gp3 - Gp0 elements.

i.e.. B, C, N, O, F, Ne

$_{5}B \rightarrow 1s^2\ 2s^2\ 2p^1$

$_{6}C \rightarrow 1s^2\ 2s^2\ 2p^2$

$_{7}N \rightarrow [He]\ 2s^2\ 2p^3$

$_{8}O \rightarrow [He]\ 2s^2\ 2p^4$

$_{9}F \rightarrow [He]\ 2s^2\ 2p^5$

$_{10}Ne \rightarrow [He]\ 2s^2\ 2p^6$

From group 3 to group 0 elements, all the valence electrons are found in the p-orbital. The group 3 to group 0 elements are therefore called p-block elements.

d- block elements (transition elements) valence electrons filled d-orbitals.
4th period Sc - Zn : 1st transition series
5th period Y - Cd; 2nd transition series.
6th period L - Hg: 3rd transition series

F block elements, valence electrons filling the f-orbital i.e.. Lanthanides and Actinides.

NB: the s and p blocks are the main group elements.

Periodic Properties

These are physical and chemical properties of atoms which reoccur on the periodic table. Examples include:

- **Atomic/Ionic radius**
- **Ionization energy**
- **Electron affinity**
- **Electronegativity**

To investigate the above properties, the following terms must be understood.

- **Valence electrons**: the outermost electrons involved in bond formation.

- **Core electrons**: It is the innermost electrons.

- **Effective nuclear charge**: the net attraction of proton in the nucleus for the valence electrons.

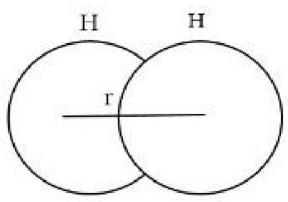
- **Screening effects**: it is the decreased attraction of protons for valence electrons by the core electrons.

- **Across a period, there is increase in effective nuclear charge**. **Why?**

Down a group, there is an increase in the screening effect due to added new shell.

Atomic radius

Illustration



$1/2d = r$

The size of an atom is dependent on how strongly the protons in the nucleus attract the valence electrons. Across a period, screening effect due to electrons in the same shell almost remain constant but increase in the atomic number, even by 1 is very significant. Therefore, the greater the attraction for valence electrons, the smaller the size of the atom.

NB: From Halogen to rare gases, there is an increase in atomic size due to repulsion among the electrons in the outer shell.

Ionic radius

Cation: Li --- Li^{+} (He)

Na ----- Na^{+} (Ne)

They are isoelectronic with the noble gas. The cations are smaller in size than their parent atoms.

The reasons are that they have fewer electrons than protons, which leads to increase in effective nuclear charge. Cationic radius decreases across a period but increases down a group.

Anion: The anions are larger in size than their parent atoms because there are more electrons than protons and decrease in effective nuclear charge. Anion radius increases across the period and decreases down the group.

IONIZATION ENERGY (Ei)

This is the energy required to remove the most loosely bound electrons from a gaseous atom. The determining factors include:

- **Atomic radius**

- **Shielding effect**

- **Stability of electronic configuration**

- **Penetrative effect**

Down a group, there is a decrease in ionization energy because there is increase in atomic radius, increase in screening effect and decrease in penetrative effect.

Therefore less energy is required to remove valence electrons.

Across the period, there is increase in ionization energy (Ei) because there is decrease in atomic radius, screening effect remain almost the same and increase in penetrative effect, therefore high energy is required to remove valence electrons.

Discrepancy: (Best explained using stability of electronic configuration)

Be and B.

Be= $1s^2\ 2s^2$ > B= $1s^2\ 2s^2\ 2p^1$

2p electrons are at higher energy level than 2s electrons.

The higher the energy level the less stable the electron, thus making the removal of electrons from 2p much easier. **Why?**

The s-electrons are also closer to the nucleus than the p- electrons therefore the 2s electrons have a greater penetrative power (effective nuclear charge) than the 2p electrons.

In totality, there is greater stability with an outermost orbital which is fully filled as in Be.

$_7N$ and $_8O$

$_7N = 1s^2, 2s^2, 2p^3 > {}_8O = 1s^2, 2s^2, 2p^4$

2p orbitals in N is half filled implying high stability as single electrons in p-orbital are spread out reducing repulsion.

There is lower ionization energy of oxygen due to instability resulting from repulsion between the two electrons which become paired up in the p – orbital.

To remove 2nd, 3rd electrons in an atom, the input of 2nd and 3rd ionization energy will be increasing.

Where a noble gas electronic configuration is involved, an unusual high ionization energy is required because of stability of the configuration.

Electron affinity (Ea)

It is the energy change when an electron is added to a gaseous atom.

Examples:

$Cl_{(g)} + e^- \text{-------} Cl^-_{(g)}$ Eea= -348 KJ/mol

$O_{(g)} + e^- \text{-------} O^-_{(g)}$ Eea= -141 KJ/mol

$O^-_{(g)} + e^- \text{-------} O^{2-}_{(g)}$ Eea= +798 KJ/mol

The 2nd electron in the oxygen was added against the repulsive force of negatively charged oxygen.

Therefore, the need for energy input leading to positive electron affinity value.

Down the group, there is a decrease in electron affinity because there is decrease attraction for added electrons, increase atomic size and decrease effective nuclear charge.

The trend is clear with the more electronegative element. Across the same period, there is increase in electron affinity. The reason is the opposite.

Discrepancy: Unexpected lower negative electron affinity of fluorine (F) which is caused by its very small size which created very strong repulsive field for any incoming electron.

Factors that affect Electron affinity include:

- Atomic radius
- Stability of electronic configuration
- Charge carried by anion.

For unexpected values, this may be due to more stable electronic configuration and repulsive forces of electrons.

Discrepancy on period 2

$B + e^- \text{-----} B^-$ Eea = -27 KJ/mol

$B = 1s^2\ 2s^2\ 2p^1$

$C + e^- \text{-----} C^-$ Eea = -122 KJ/mol

$C = 1s^2\ 2s^2\ 2p^2$

$N + e^- \text{-----} N^-$ Eea = 0 KJ /mol

$N = 1s^2\ 2s^2\ 2p^3$

ELECTRONEGATIVITY

This is the ability of an electron in a molecule to attract bonded/shared electrons to itself.

An atom of a molecule which tends to attract more electrons to itself is described as more electronegative atom.

The main determinant of electronegativity is atomic radius. The smaller the atomic radius, the higher its electronegativity. Let's discuss

NB: For gaseous isolated atoms, the electron affinity is measured directly. However, for electronegativity, the atoms in the molecule are measured indirectly by a comparative scale.

The scale gives a quantitative measure of an atom's ability to attract electrons. There is no unit for electronegativity.

Values are negative and given accordingly to Pauling's scale.

On that scale, the highest value is 4.0 which is fluorine, while the lowest value is francium, 0.7.

Most electronegative elements are reactive non-metals (Halogens). The least electronegative elements are reactive metals (Alkali).

NB: Standard enthalpy of formation is the energy change when one mole of a compound is formed from elements in their standard states.

Question Time