Periodic Table

Periodic Laws:

Mendeleev's Periodic Law: In 1869, **Dmitri Mendeleev** states that, "when the elements are arranged in order of increasing atomic mass, certain sets of properties recur periodically."

Mosley's Periodic Law: In 1913 **Henry G.J. Moseley** states that, "Similar properties recur periodically when elements are arranged according to increasing atomic number."

Information:

- In periodic table the vertical columns are termed as **groups**.
- In periodic table the horizontal rows are termed as **periods**.
- Periodic table has **7 periods** and **18 groups**.
- Atoms of group 1-2 and group 13-18 are known as **main group elements**.
- Atoms of group 3-12 are known **transition metals**.
- Atoms of group-1 are known as **alkali metals**.
- Atoms of group-2 are known as **alkali earth metals**.
- Atoms of group-16 are known as **chalcogen**.
- Atoms of group-17 are known as **halogen**.
- Atoms of group-18 are known as **noble gas/inert gas**.
- There are also two series **lanthanide** and **actinide** series. Commonly atoms of this series are known as **inner-transition metal**.

S-block elements: If the last electron of an atom enters into s-subshell then the atom is said to be as s-block element. The general electronic configuration of s-block elements is, ns^{1-2}.

P-block elements: If the last electron of an atom enters into p-subshell then the atom is said to be as p-block element. The general electronic configuration of p-block elements is, $ns^2\ np^{1-6}$.

D-block elements: If the last electron of an atom enters into d-subshell then the atom is said to be as d-block element. The general electronic configuration of d-block elements is, $ns^{1-2}\ (n-1)d^{1-10}$.

Determining Group Number and Period Number from Electronic Configuration:

1. Each electronic configuration consists of one or more subshell. Each subshell has one n value. Highest n value will be its Period number.
2. Total electron number of outer most shell will be its Group number.
3. If the last electron enters into p-subshell, then to get its Group number we have to add 10 with the total electron number of outer most shell.
4. Example:
   $_{12}$**Mg:** $1s^2\ 2s^2\ 2p^6\ 3s^2$
   Here, there are 4 subshells, i.e. 1s, 2s, 2p and 3s. Among them highest n value is 3. Hence Period number is 3.
   There is only one subshell in 3^{rd} shell. That is 3s and it contains total of 2 electrons. Hence Group number is 2.

$_{16}$S: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$
Here, there are 5 subshells, i.e. 1s, 2s, 2p, 3s and 3p. Among them highest n value is 3. Hence Period number is 3.
There are two subshells in 3rd shell. That is 3s, 3p and they contain total of 6 electrons. Though electron enters into p-subshell. Hence Group number is 6+10 = 16.

$_{24}$Cr: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^5$
Here, there are 7 subshells, i.e. 1s, 2s, 2p, 3s, 3p, 4s and 3d. Among them highest n value is 4. Hence Period number is 4.
There are two subshells in 4th shell. That is 4s and 3d and they contain total of 6 electrons. Hence Group number is 6.

Periodic Properties:

Properties	Along Period (From Left to Right)	Along Group (From Top to Bottom)
Metallic Property	Decreases	Increases
Non-metallic Property	Increases	Decreases
Atomic Size	Decreases	Increases
Ionization Energy	Increases	Decreases
Electron Affinity	Increases	Decreases
Electronegativity	Increases	Decreases

Ionization Energy: The energy required by one mole of atoms to remove one mole of electrons by one electron from each atom is called the **ionization energy** of that atom.

Q. Which one has higher ionization energy in each pair?

i. N and O
ii. Na^+ ion and Na atom
iii. Na^+ ion and Mg^+ ion

Answer:

i. Ionization energy of nitrogen is found to be greater than oxygen. The explanation is given below-

Electronic configuration of Oxygen is - $1s^2\ 2s^2\ 2p_x^2\ 2p_y^1\ 2p_z^1$
Electronic configuration of Nitrogen is - $1s^2\ 2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^1$

We know that an atom containing half-filled or fully filled subshells are very stable. Nitrogen has a half filled 2p subshell. So when it is already stable, it doesn't want to lose an electron upon supplying energy and become unstable. This is why one requires large amounts of energy to ionize the nitrogen atom.

On the other hand, since Oxygen is already unstable relative to Nitrogen, by losing one electron it attains a stable half-filled 2p subshell. So oxygen undergoes ionization at a relatively lower energy. This is why nitrogen has a higher ionization energy than oxygen.

ii. Ionization energy of Na^+ ion is found to be greater than Na atom. The explanation is given below-

Electronic configuration of Na^+ ion is - $1s^2\ 2s^2\ 2p_x^2\ 2p_y^2\ 2p_z^2$
Electronic configuration of Na atom is - $1s^2\ 2s^2\ 2p^6\ 3s^1$

We know that an atom containing half-filled or fully filled subshells are very stable. Na^+ ion has a fully filled 2p subshell. So when it is already stable, it doesn't want to lose an electron upon supplying energy and become unstable. This is why one requires large amounts of energy to ionize the Na^+ ion.

On the other hand, since Na is already unstable relative to Na^+ ion, by losing one electron it attains a stable fully-filled 2p subshell. So Na undergoes ionization at a relatively lower energy. This is why Na^+ ion has a higher ionization energy than Na atom.

iii. Ionization energy of Na^+ ion is found to be greater than Mg^+ ion. The explanation is given below-

Electronic configuration of Na^+ ion is - $1s^2\ 2s^2\ 2p_x^2\ 2p_y^2\ 2p_z^2$
Electronic configuration of Mg^+ ion is - $1s^2\ 2s^2\ 2p^6\ 3s^1$

We know that an atom containing half-filled or fully filled subshells are very stable. Na^+ ion has a fully filled 2p subshell. So when it is already stable, it doesn't want to lose an electron upon supplying energy and become unstable. This is why one requires large amounts of energy to ionize the Na^+ ion.

On the other hand, since Mg^+ ion is already unstable relative to Na^+ ion, by losing one electron it attains a stable fully-filled 2p subshell. So Mg^+ ion undergoes ionization at a relatively lower energy. This is why Na^+ ion has a higher ionization energy than Mg^+ ion.

Electron Affinity: The energy released by one mole of atoms to add one mole of electrons by one electron to each atom is called the **electron affinity** of that atom. Electron affinity series for halogens are – Cl>F>Br>I.

Q. Why Cl has higher electron affinity than F?

Answer: Fluorine is the most electronegative element but still its electron affinity is less than that of chlorine. It is because of the smaller size and also greater charge density of fluorine. All the electrons in the F atom repels the incoming electron significantly. This nullify the effect of higher electronegativity of fluorine over chlorine.

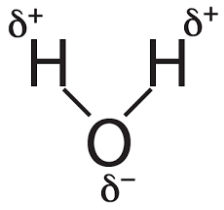
Electronegativity: Electronegativity is a measure of an atom's ability to attract the shared electrons of a covalent bond to itself.

If atoms bonded together have the same electronegativity, the shared electrons will be equally shared. If the electrons of a bond are more attracted to one of the atoms (because it is more electronegative), the electrons will be unequally shared. If the difference in electronegativity is

large enough, the electrons will not be shared at all. Electronegativity series for halogens are – F>Cl>Br>I.

Q. Prove that H_2O is a polar compound.

Answer: There are 2 hydrogen atoms and 1 oxygen atom in water, which form covalent bond among themselves. O is an electronegative atom but H is electropositive. Hence O attracts the bonding pair of electrons towards itself. Hence partial positive charge generates over H and partial negative charge generates over O. Though partial charge generates, H_2O is a polar compound.



Uses of Inert Gases:

Helium:

1. Helium is much less dense (lighter) than air and is used in balloons and blimps.
2. A mixture of helium and oxygen is used in place of natural air for divers and others who work under high air pressure.
3. Helium is used in industry to provide an inert atmosphere in electric arc welding of metals.
4. Helium has the lowest boiling point of any known substance, 4.1 K, therefore, its chief scientific use is in cryogenics.

Neon:

1. Neon is used in the familiar “neon sign” used in advertisement.

Argon:

1. It is used in filament bulbs because the metal filament will not burn in argon.
2. Argon is also used in electric arc welding of metals as a shielding gas, to produce an inert atmosphere.