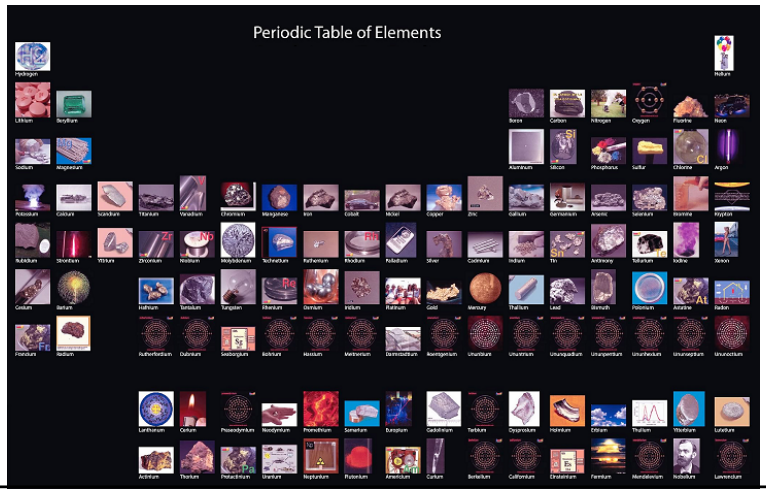
Periodic Relationships Among the Elements

Chapter 8



The Periodic Table

- The modern periodic table (PT) represents the arrangements of elements according to the building up (**Aufbau principle**), where each element has one electron more than the previous element.
- The periodic table can be classified in many different ways:

➢ **Metallic character:**

metals, **nonmetals**, and **metalloids**.

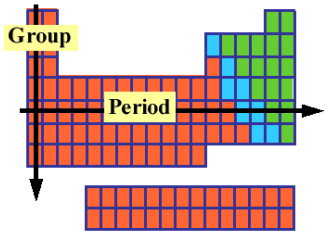


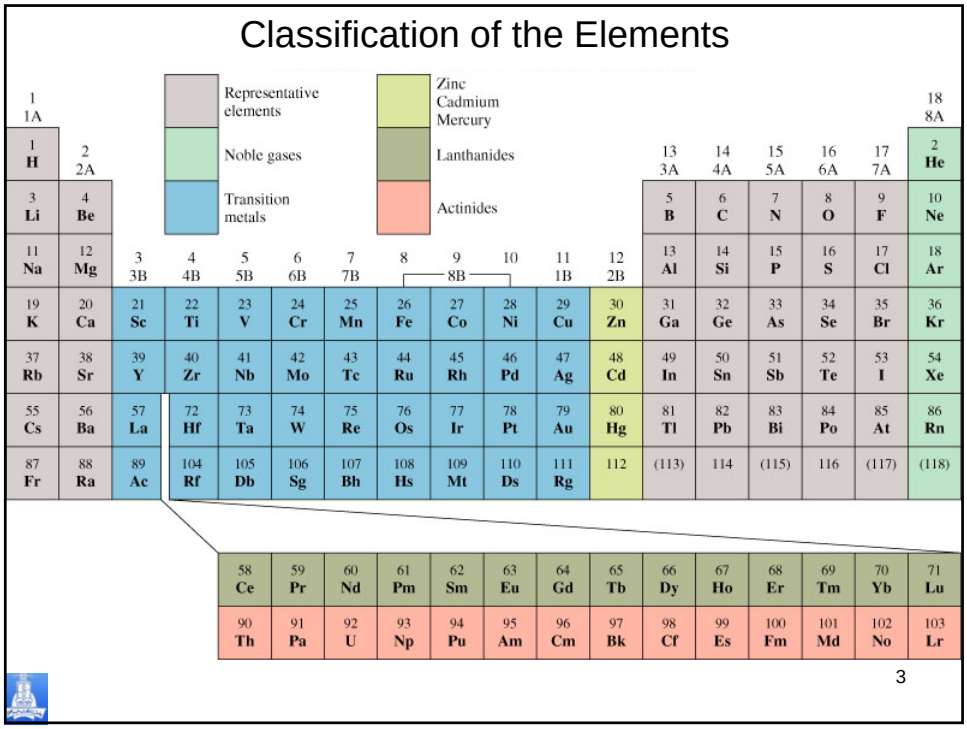
Fig. 5.1 The periodic table classification

➢ **Position in the periodic table:**

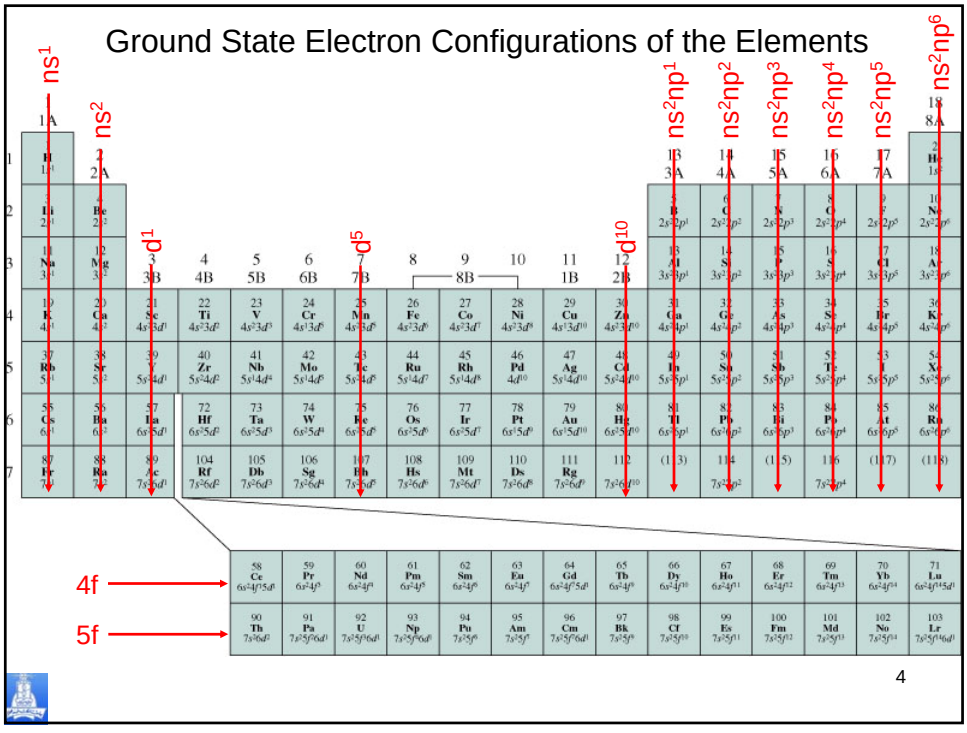
horizontal rows (**Periods**)

vertical columns (**Groups**)

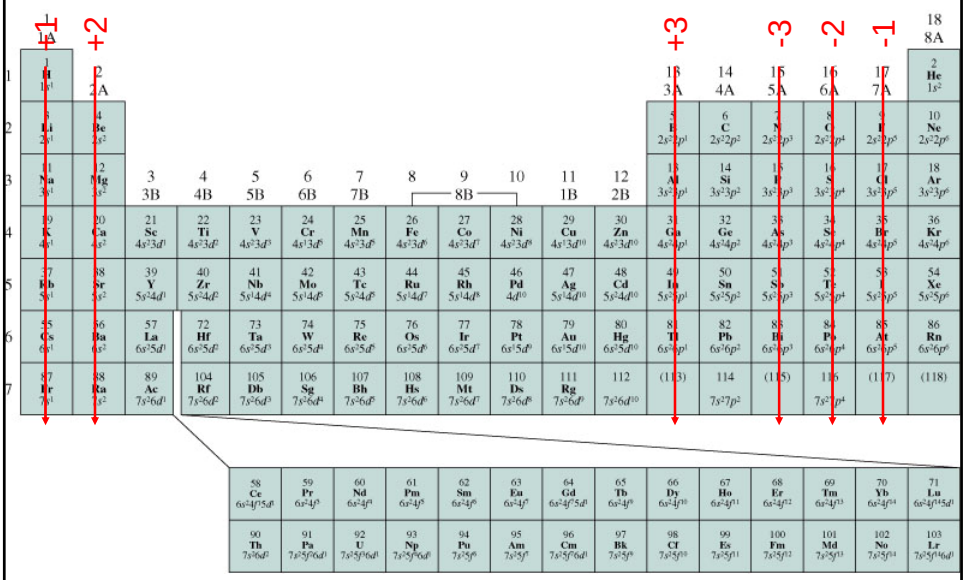
Classification of the Elements



Ground State Electron Configurations of the Elements



Cations and Anions Of Representative Elements



Electron Configurations of Cations and Anions Of Representative Elements

Na	$[Ne]3s^1$	Na^+	[Ne]
Ca	$[Ar]4s^2$	Ca^{2+}	[Ar]
Al	$[Ne]3s^23p^1$	Al^{3+}	[Ne]

Atoms lose electrons so that cation has a noble-gas outer electron configuration.

Atoms gain electrons so that anion has a noble-gas outer electron configuration.

H	$1s^1$	H^-	$1s^2$ or [He]
F	$1s^22s^22p^5$	F^-	$1s^22s^22p^6$ or [Ne]
O	$1s^22s^22p^4$	O^{2-}	$1s^22s^22p^6$ or [Ne]
N	$1s^22s^22p^3$	N^{3-}	$1s^22s^22p^6$ or [Ne]

Na^+: [Ne] Al^{3+}: [Ne] F^-: $1s^2 2s^2 2p^6$ or [Ne]

O^{2-}: $1s^2 2s^2 2p^6$ or [Ne] N^{3-}: $1s^2 2s^2 2p^6$ or [Ne]

Na^+, Al^{3+}, F^-, O^{2-}, and N^{3-} are all ***isoelectronic*** with Ne

What neutral atom is isoelectronic with H^- ?

H^-: $1s^2$ same electron configuration as He

Periodic properties of elements

(1) Atomic radius:

- The atomic radius for an atom is measured from the length of a bond between this atom and other one divided by 2.

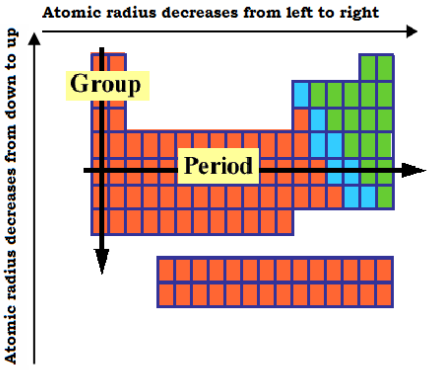
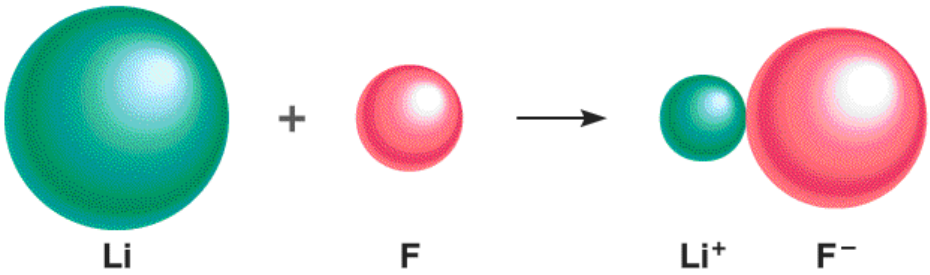


Fig. 5.3 Trends in the atomic radii within the Periodic Table.



Cation is always smaller than atom from which it is formed.
Anion is always larger than atom from which it is formed.

Periodic properties of elements

(2) Ionization energy (IE)

The energy required to remove the most loosely held electron from an isolated gaseous atom in its ground state.

$$A(g) \rightarrow A^{+}(g) + e^{-}$$

- Atoms of metals with low IE because tend to lose electrons and become positive ions in chemical reactions.
- Atoms of non-metals with high IE because tend to accept electrons.
- The IE of noble gases atoms is high and they are stable.

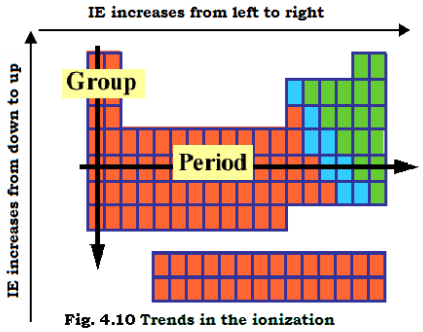


Fig. 4.10 Trends in the ionization energy within the Periodic Table.

- The second IE for an atom is higher than the first one because of increasing of the attraction of electrons by higher positive charge of the nucleus.
- For example, Mg

$$Mg\,(g) \rightarrow Mg^{+}(g) + e^{-}, IE_{1st} = +738\,kJ/mol$$

$$Mg^{+}(g) \rightarrow Mg^{2+}(g) + e^{-}, IE_{2nd} = +1450\,kJ/mol$$

$$Mg^{2+}(g) \rightarrow Mg^{3+}(g) + e^{-}, IE_{3rd} = +7731\,kJ/mol$$

Arrange the following elements according to their (a) atomic radius and (b) IE: P, N, O, F.

(a) according to the atomic radius, F< O < N < P

(b) according to the IE, F< N< O< P

There is exception between O and N, because higher energy is required to remove an electron from the half-filled p orbital in nitrogen atom

Periodic properties of elements

(3) Electron affinity (EA)

The energy associated with the process in which an electron is added to an atom in its ground state.

Energy is usually evolved in these processes (negative signs)

•Few elements have electron affinity

•EA Increases (the negative value) from the left to right across a period.

* EA increases from down to up in a group.

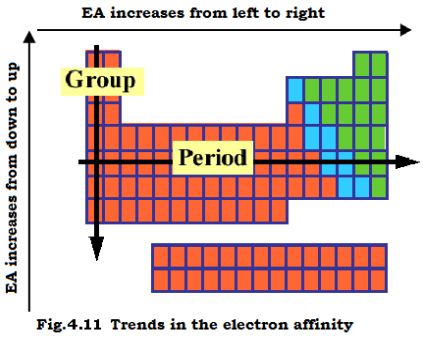


Fig.4.11 Trends in the electron affinity within the Periodic Table.

Periodic properties of elements

(4) Electronegativity (EN)

- The ability of an atom to attract electrons in a molecule

Energy is usually evolved in these processes (negative signs)

•EN across a period increases from left to right

•EN within the group increases from down to up

•EN for metals is low while it is high for non-metals

* The fluorine is the highest electronegative element followed by oxygen.

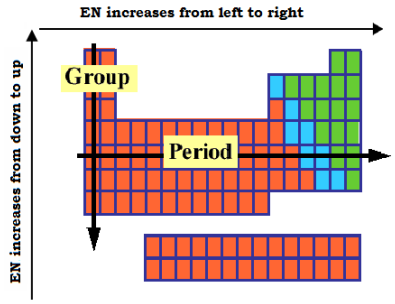


Fig. 4.12 Trends in the electronegativity within the Periodic Table.