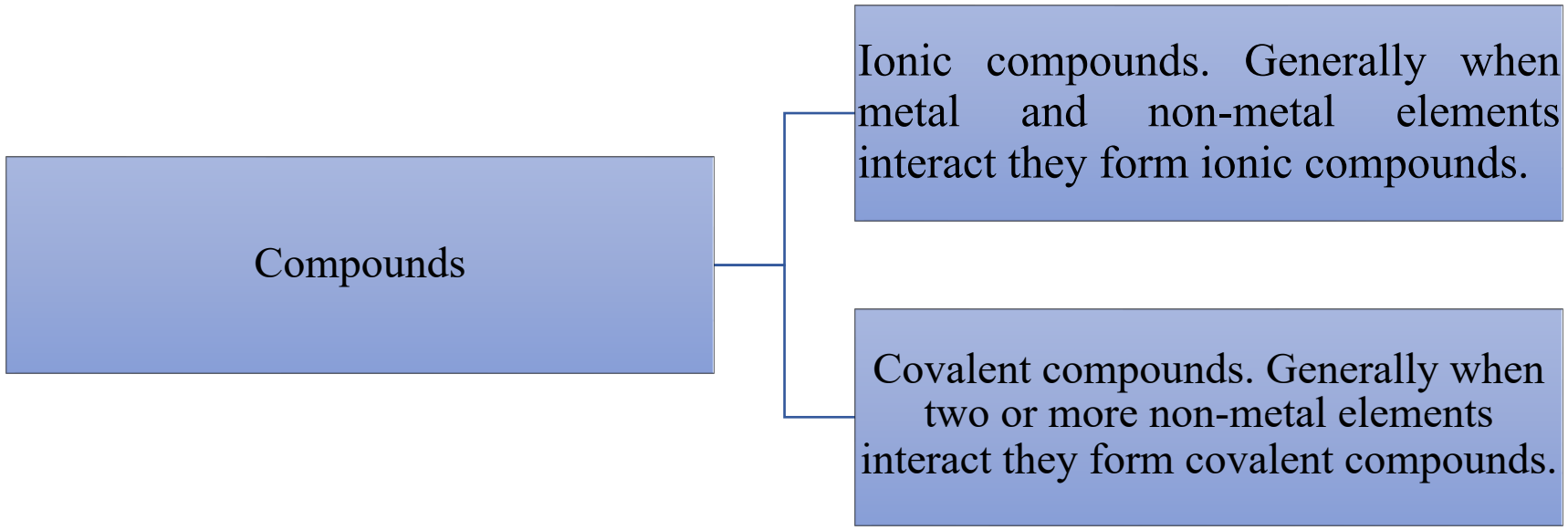
Chemical bonds

How do atoms bind to each other to form molecules?

A complete outer shell, ns^2np^6, is energetically more advantageous than an incomplete one.
We call it the RULE OF EIGTH: an atom tends to pick up or give away just enough electrons to make eight in its outer shell – AN ELECTRON OCTET. This rule works for elements in groups 1,2, 13,15-17.
Electrons in the outer shell (the highest main energy level) of an atom are called VALENCE ELECTRONS.

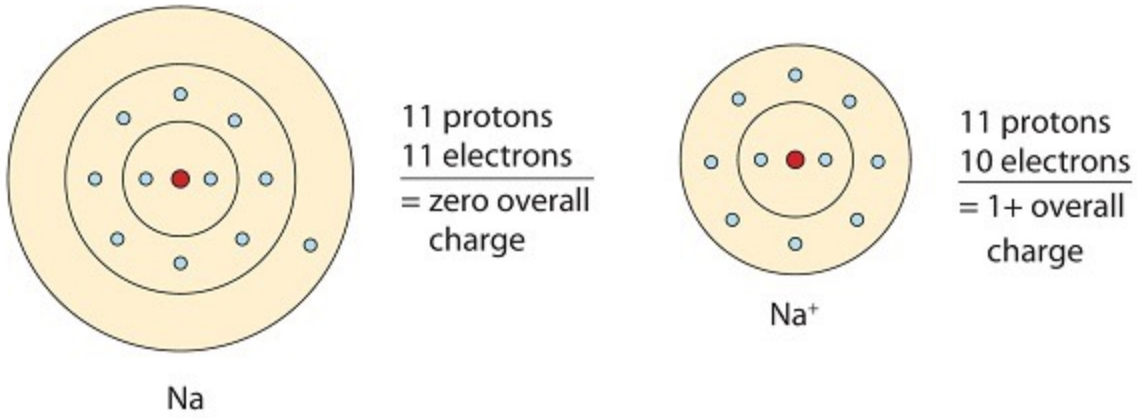
Electron donor and electron acceptor properties of atoms are related to the octet rule.
The donors tend to achieve the octet by giving up the electrons from their outer shell and the electron acceptors tend to get octet by accepting the electrons to their outer shells
Donors are atoms that just start filling their outer shells and strong acceptors almost finished building their octets.
Let's look at $_{11}Na$ and $_{9}F$:
F: $1s^2 2s^2 2p^5$
Na: $1s^2 2s^2 2p^6 3s^1$

There are two main types of chemical bonding – ionic and covalent

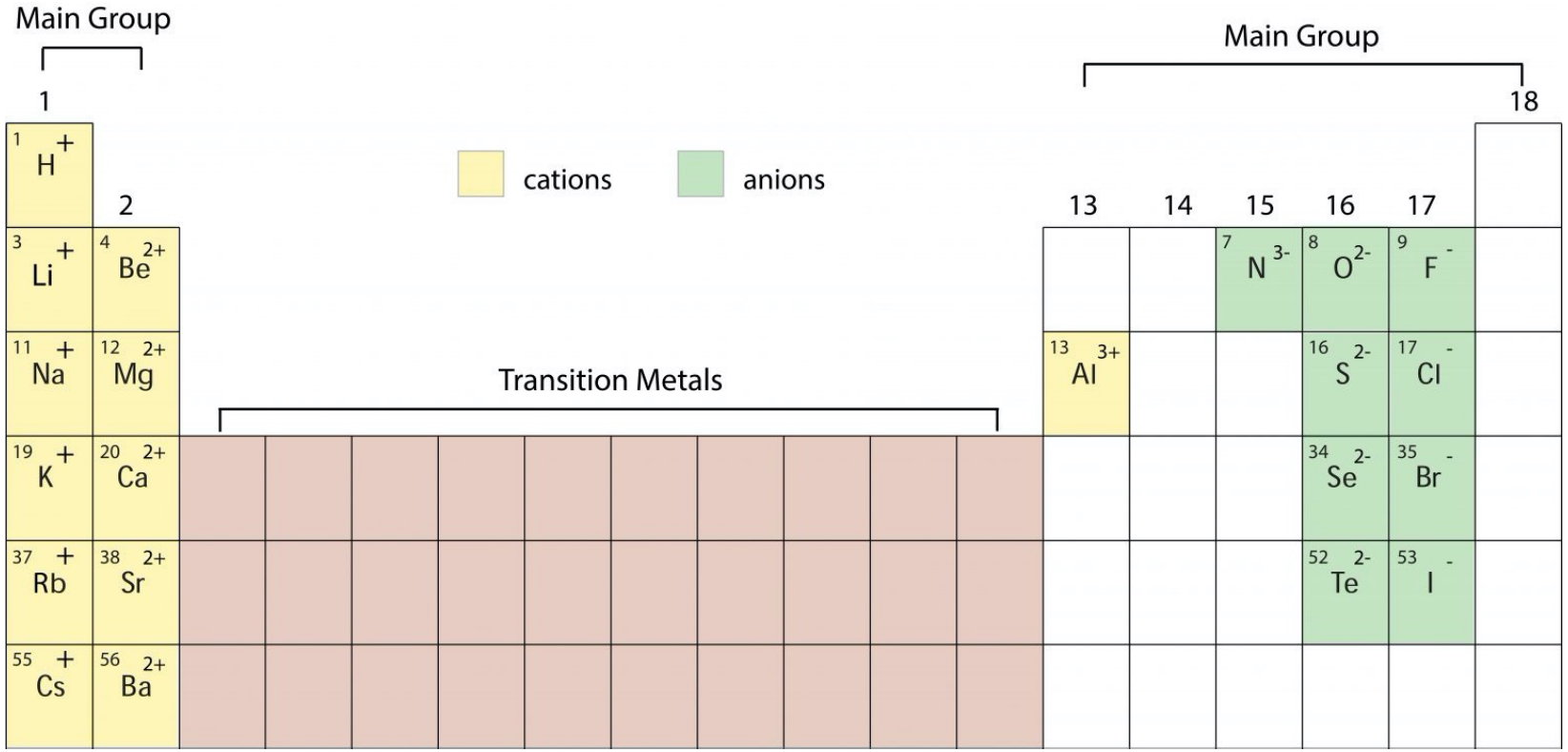


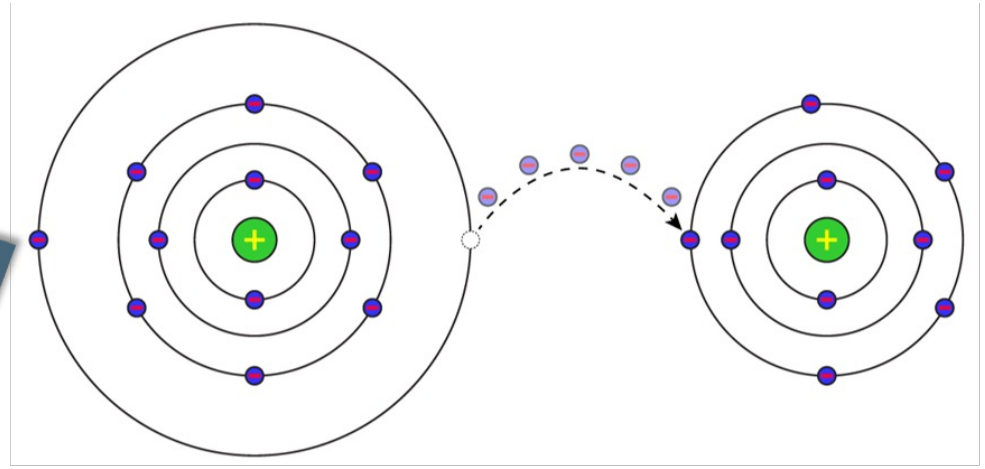
IONIC BOND.

When metallic elements lose their outer shell electrons, they form positive ions. Negative ions are usually formed by non-metal, when they gain electrons.

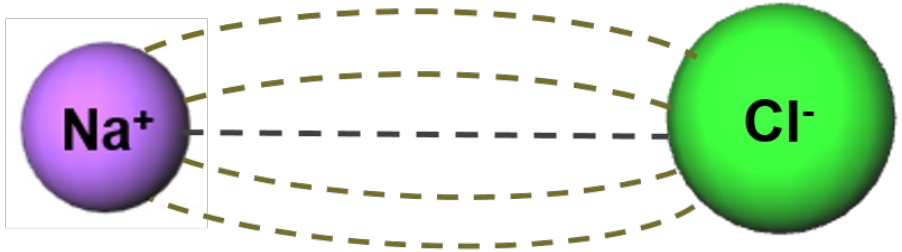


The number of electrons lost or gained is determined by electron configuration of an element. Generally, the elements from groups 1, 2, 13 (13-10=the number of electron lost), 15-17(18-group number = the number of electron gained) will lose or gain electrons to achieve electron configuration of the nearest noble gas.

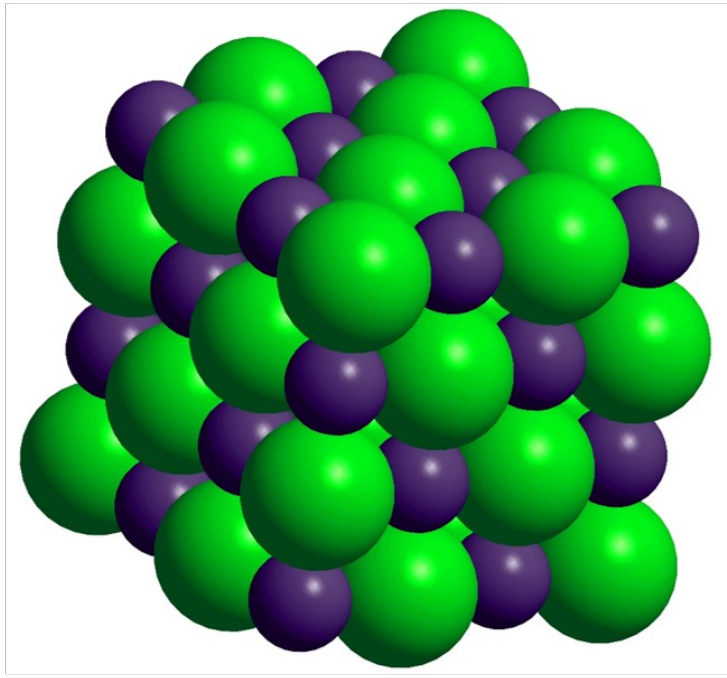




Electron Transfer between sodium, and chlorine.



Electrostatic attraction between sodium cation and chlorine anion.

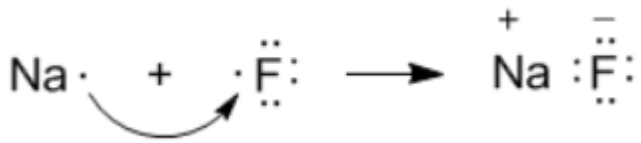


Ionic Solid: Sodium Chloride. (Table Salt)

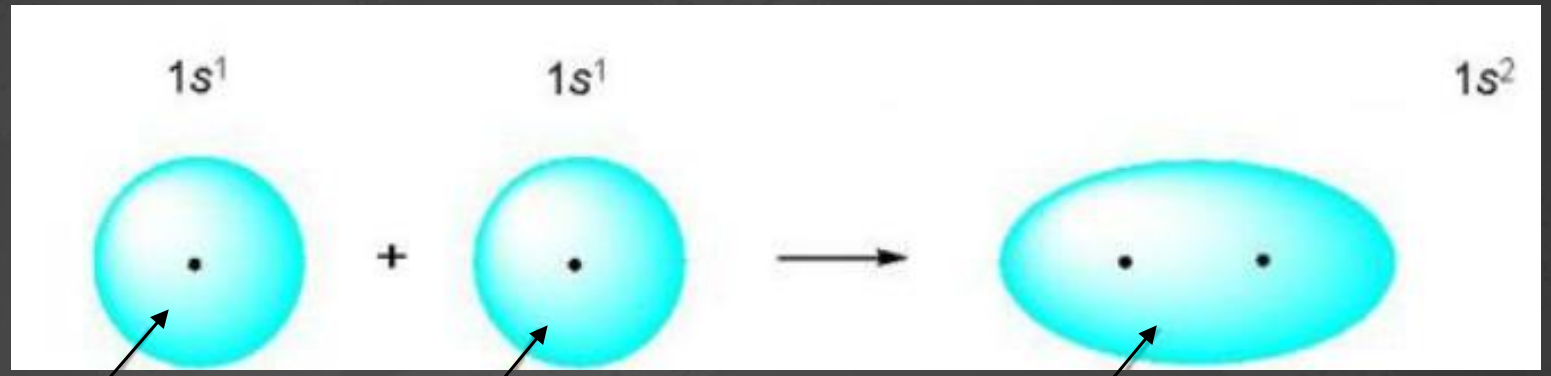
Ionic bond

Let’s consider interactions between $_{11}$Na and $_{9}$F The electron configurations of these elements are:

- Na:
- F:
- When Na and F bind they acquire electron configuration of the noble gas Ne ● The electron configuration of the noble gas $_{10}$Ne is:
- Ne:
- In electron formula we need to consider only outer shells



Covalent bond



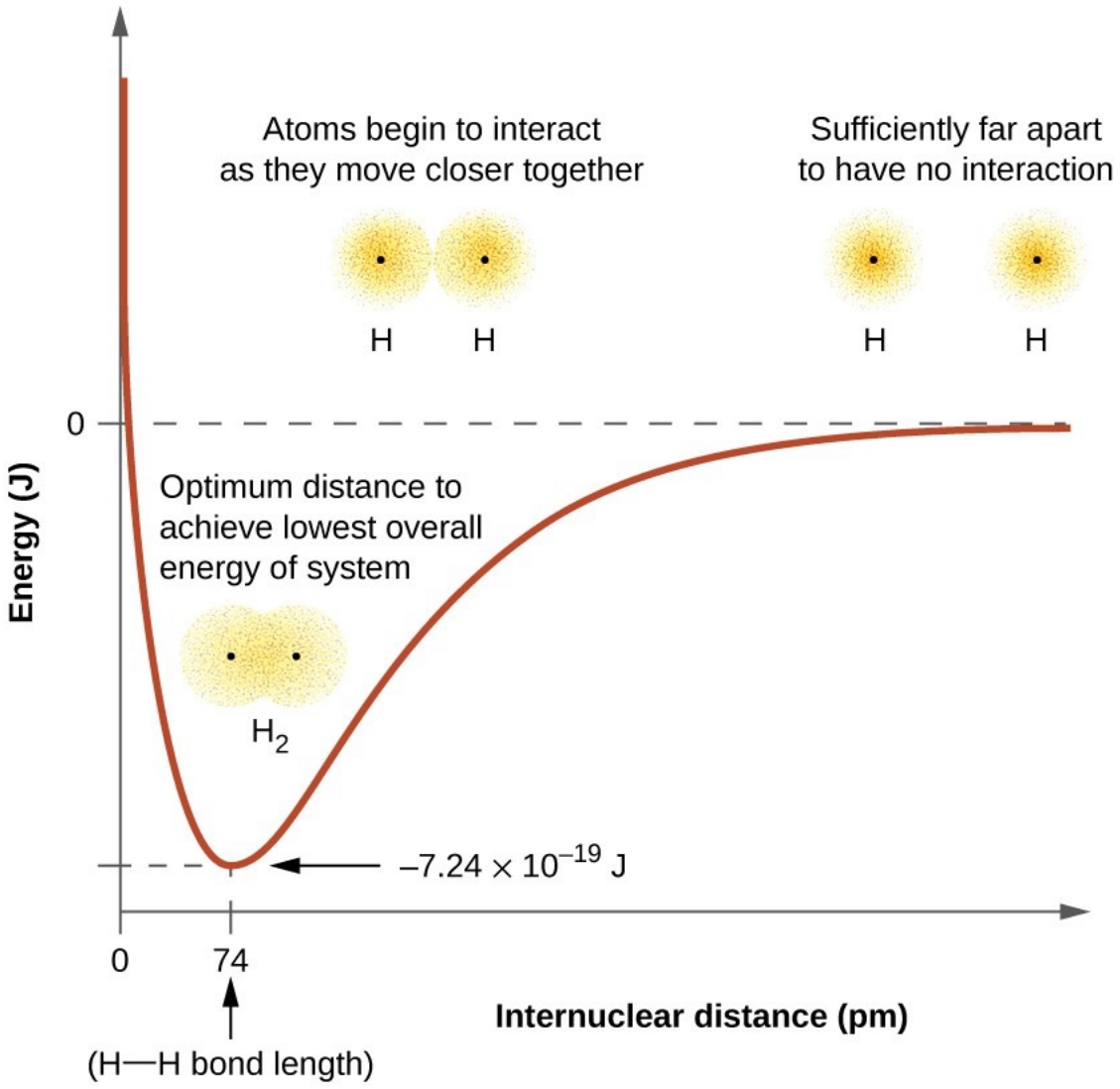
Alone, hydrogen atom has an unpaired electron. When one hydrogen encounters another, their electrons naturally pair up in a single shared orbital

The pair of electrons pulls on both nuclei, so it holds the atoms together. The bond is called covalent. Because both atoms contribute equally. Each hydrogen got 2 electrons, so the resulting molecule H_2 is stable.

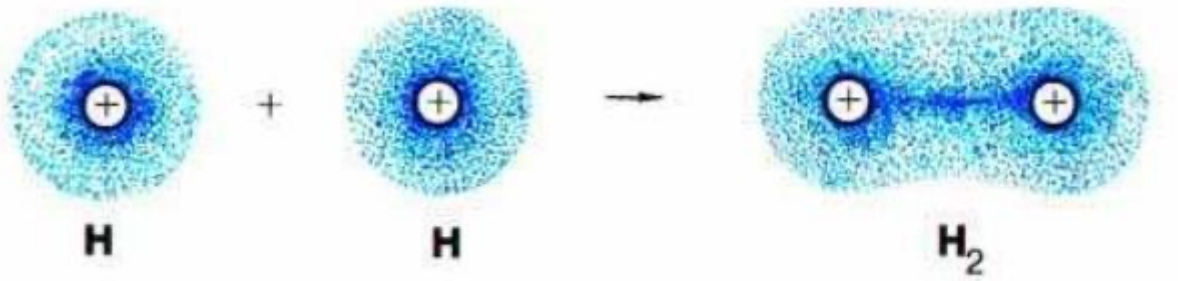
The plot shows energy E of two hydrogen atoms as a function of the distance r between them. We can understand its key features by thinking of the two possible limits. Let us begin with r (distance between atoms)=infinity when the two atoms are very far from each other. They do not feel each other and move independently. Now think about the opposite limit of r=0 when we try to bring one hydrogen very close to another, basically squashing them against each other. This is not possible as hydrogen nuclei (protons) strongly repel each other (they are both positively charged) and hydrogen electrons repel each other too (they are both negatively charged).

It turns out that between these two very different limits there is an optimal distance when hydrogens attract each other while maintaining some distance between them. This attraction takes place because electrons of two atoms get "mixed up" in the space between hydrogen atoms. Positively charged protons are attracted to negatively charged electrons between them and therefore are attracted to each other! The mixing of two electrons is known as covalent bonding which describes the process of electrons sharing their respective orbitals with an electron from an "other" atom.

The attraction between two hydrogens means that their energy is lower (negative) when they are at the optimal distance from each other. Graphically, it looks like a minimum on the E versus r plot, as the figure shows.



Lewis structures



Atoms form chemical bonds by combining such number of electrons that allows them to obtain an electron configuration of noble elements

- Hydrogen binds into a molecule resulting in the electron configuration of helium ($1s^2$)
- Oxygen combines into a molecule with the electron configuration of argon ($...3s^23p^6$). Each atom now has 8 electrons.