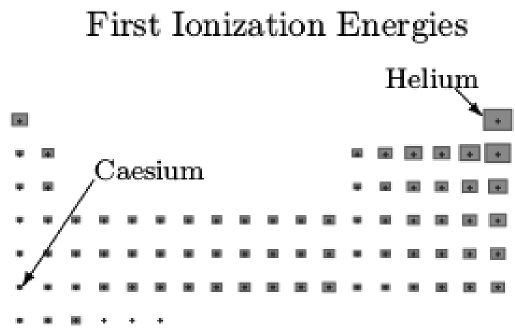
به نامِ خدا

دانش‌گاهِ صنعتیِ اصفهان ـ دانش‌کده‌یِ فیزیک

تصاویر فصل ۶



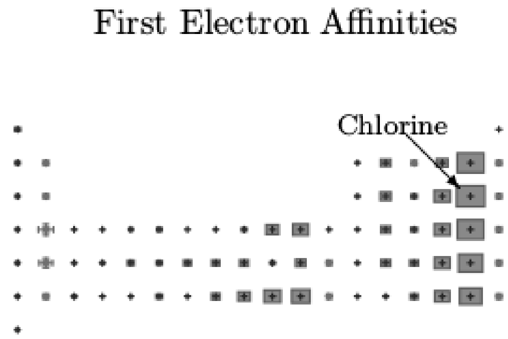


Fig. 6.1 Pictorial periodic tables of first ionization energies (top) and first electron affinities (bottom). The word "first" here means that we are measuring the energy to lose or gain a first electron starting with a neutral atom. The linear size of each box represents the magnitude of the energies (scales on the two plots differ). For reference the largest ionization energy is helium, at roughly 24.58 eV per atom, the lowest is caesium at 3.89 eV. The largest electron affinity is chlorine which gains 3.62 eV when binding to an additional electron. The few elements marked with lighter shaded crosses (including Ca and Sr) have *negative* electron affinities.

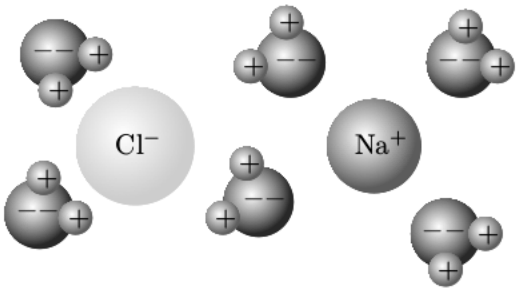
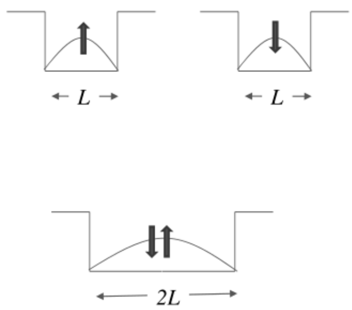


Fig. 6.2 Salt, NaCl, dissolved in water. Ionic compounds typically dissolve easily in water since the polar water molecules can screen the highly charged, but otherwise stable, ions.

Fig. 6.3 Particle in a box picture of covalent bonding. Two separated hydrogen atoms are like two different boxes each with one electron in the lowest eigenstate. When the two boxes are pushed together, one obtains a larger box—thereby lowering the energy of the lowest eigenstate—which is known as the *bonding* orbital. The two electrons can take opposite spin states and can thereby both fit in the bonding orbital. The first excited state is known as the *antibonding* orbital



$$E = \frac{\hbar^2 \pi^2}{2mL^2}$$

$$E_{bonding} = \frac{\hbar^2 \pi^2}{2m(2L)^2}$$

$$E_{anti-bonding} = \frac{\hbar^2 (2\pi)^2}{2m(2L)^2}$$

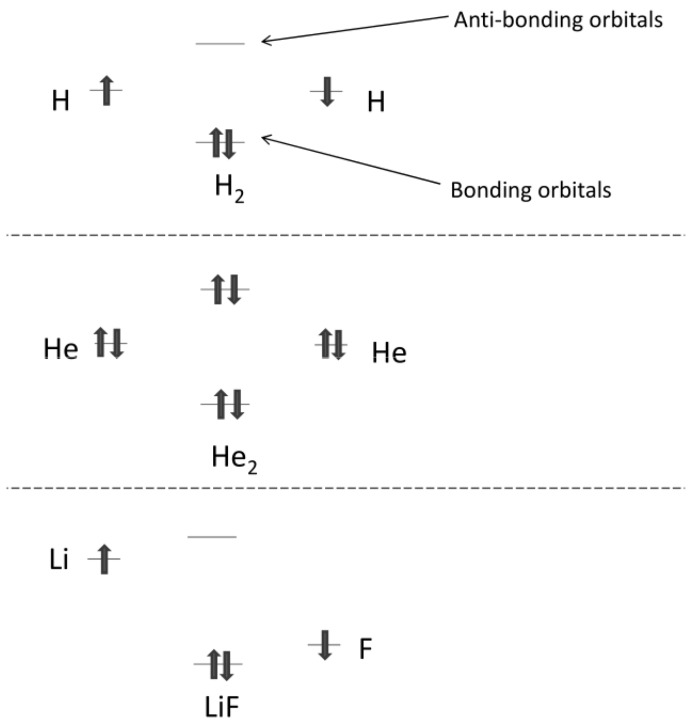


Fig. 6.4 Molecular orbital picture of bonding. In this type of picture, on the far left and far right are the orbital energies of the individual atoms well separated from each other (energy is the vertical axis). In the middle of the diagram are the orbital energies when the atoms come together to form a molecule. **Top:** Two hydrogen atoms (one having a spin-up electron and one having spin-down) come together to form a H_2 molecule. In the particle-in-a-box picture, the lowest-energy eigenstate is reduced in energy when the atoms come together and both electrons go into this bonding orbital. **Middle:** In the case of helium, since there are two electrons per atom, the bonding orbitals are filled, and the antibonding orbitals must be filled as well. The total energy is not reduced by the two helium atoms coming together (thus helium does not form He_2). **Bottom:** In the case of LiF, the energies of the lithium and the fluorine orbitals are different. As a result, the bonding orbital is mostly composed of the orbital on the F atom—meaning that the bonding electrons are mostly transferred from Li to F—forming a more ionic bond. See Exercise 6.3.

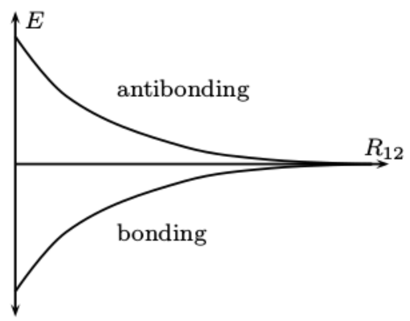


Fig. 6.5 Model tight binding energy levels as a function of distance between the nuclei of the atoms.

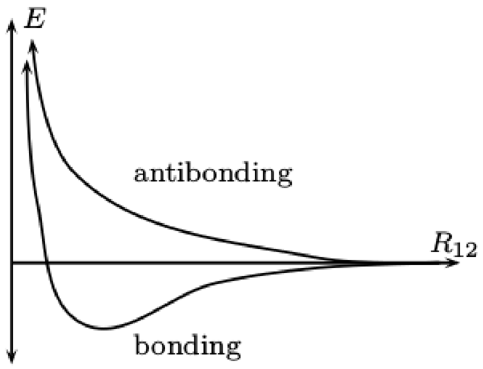


Fig. 6.6 More realistic energy levels as a function of distance between the nuclei of the atoms.

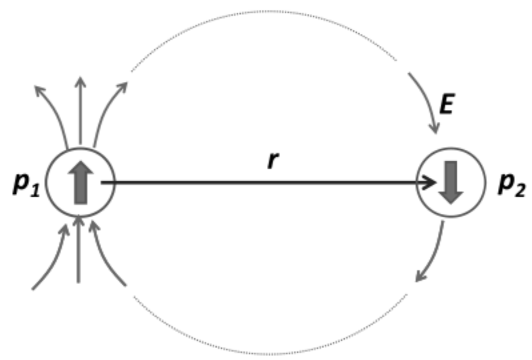


Fig. 6.7 An atom with a polarization p_1 induces a polarization p_2 in a second atom.

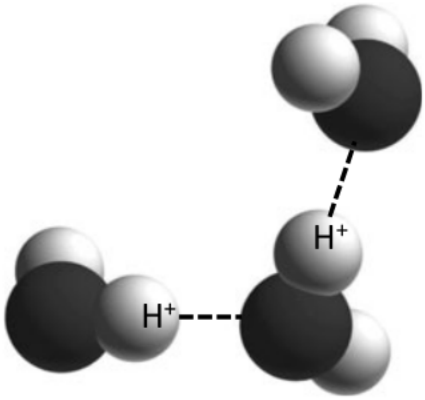


Fig. 6.8 Hydrogen bonds in H_2O. A hydrogen on one water molecule is attracted to an oxygen on another molecule forming a weak hydrogen bond. These bonds are strong enough to form ice below the 273.15 K.

Chapter Summary (Table)

Type of Bonding	Description	Typical of which compounds	Typical Properties
Ionic	Electron is transferred from one atom to another, and the resulting ions attract each other.	Binary compounds made of constituents with very different electronegativity: e.g., group I–VII compounds such as NaCl.	• Hard, very brittle • High melting temperature • Electrical insulator • Water soluble
Covalent	Electron is shared between two atoms forming a bond. Energy lowered by delocalization of wavefunction.	Compounds made of constituents with similar electronegativities (e.g., III–V compounds such as GaAs), or solids made of one element only such as diamond (C).	• Very hard (brittle) • High melting temperature • Electrical insulators or semiconductors
Metallic	Electrons are delocalized throughout the solid forming a glue between positive ions.	Metals. Left and middle of periodic table.	• Ductile, malleable (due to non-directional nature of bond). Can be hardened by adding certain impurities. • Lower melting temperature • Good electrical and thermal conductors
Molecular (van der Waals, fluctuating dipole)	No transfer of electrons. Dipole moments on constituents align to cause attraction. Bonding strength increases with size of molecule or polarity of constituent.	Noble gas solids, solids made of non-polar (or slightly polar) molecules binding to each other (wax).	• Soft, weak • Low melting temperature • Electrical insulators
Hydrogen	Involves hydrogen ion bound to one atom but still attracted to another. Special case because H is so small.	Important in organic and biological materials. Holds together ice.	• Weak bond (stronger than vdW though) • Important for maintaining shape of DNA and proteins

Table 6.1 Types of bonds. This table should be thought of as providing rough rules. Many materials show characteristics intermediate between two (or more!) classes. Chemists often subdivide each of these classes even further.