Solid State Electronics EC210
Arab Academy for Science and Technology
AAST – Cairo
Spring 2016

Lecture 2
Bonding

Lecture Notes Prepared by:
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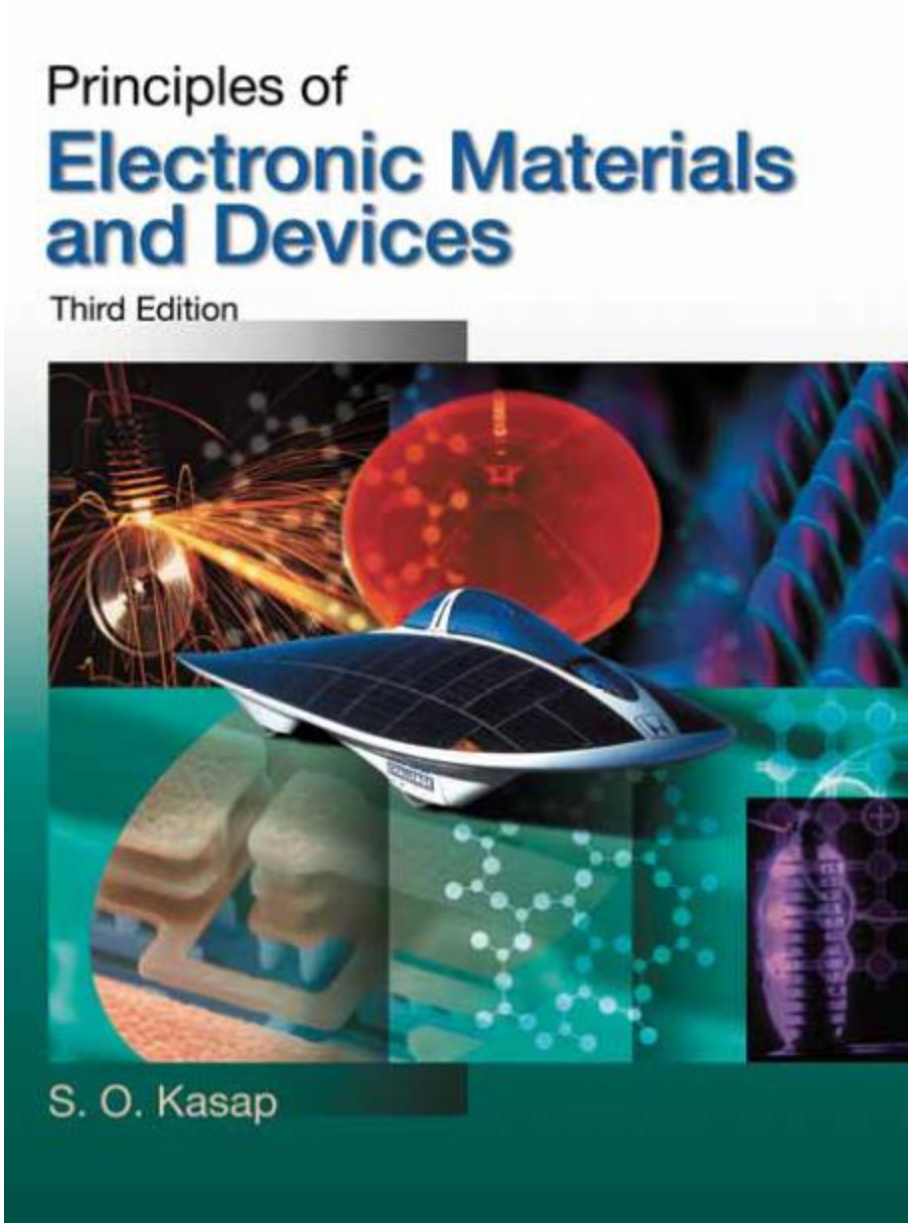

Pages (Kasap)

p. 49 to 56

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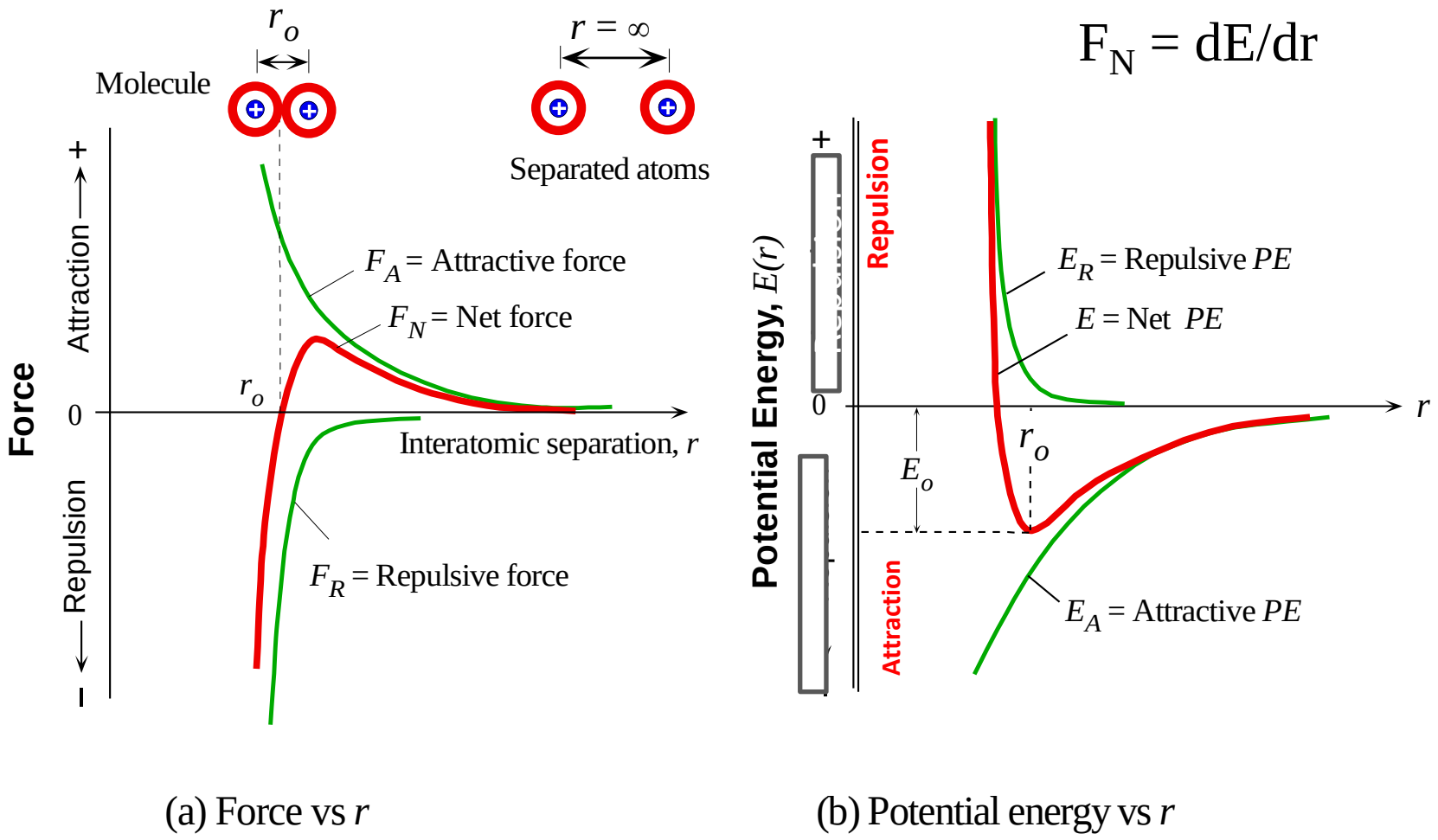
Bond Force and Potential Energy

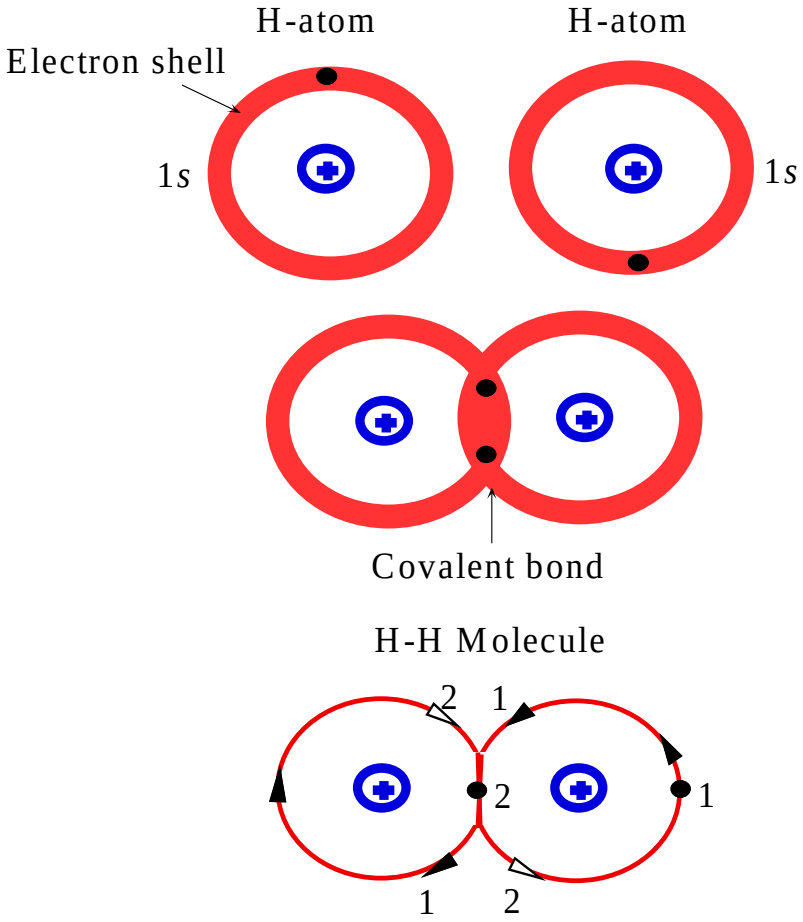


(a) Force vs r (b) Potential energy vs r

(a) Force vs interatomic separation and (b) Potential energy vs interatomic separation.

Fig 1.3

Covalent Bonding



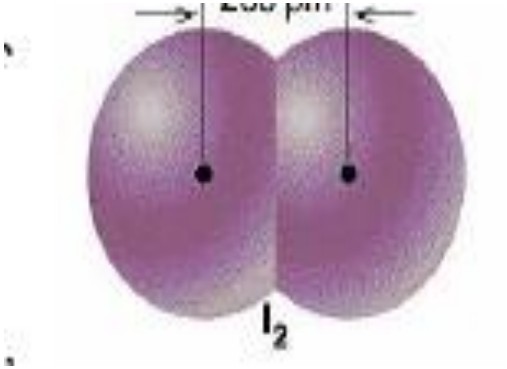


Fig. 1.4: Formation of a covalent bond between two H atoms leads to the H_2 molecule. Electrons spend majority of their time between the two nuclei which results in a net attraction between the electrons and the two nuclei which is the origin of the covalent bond .

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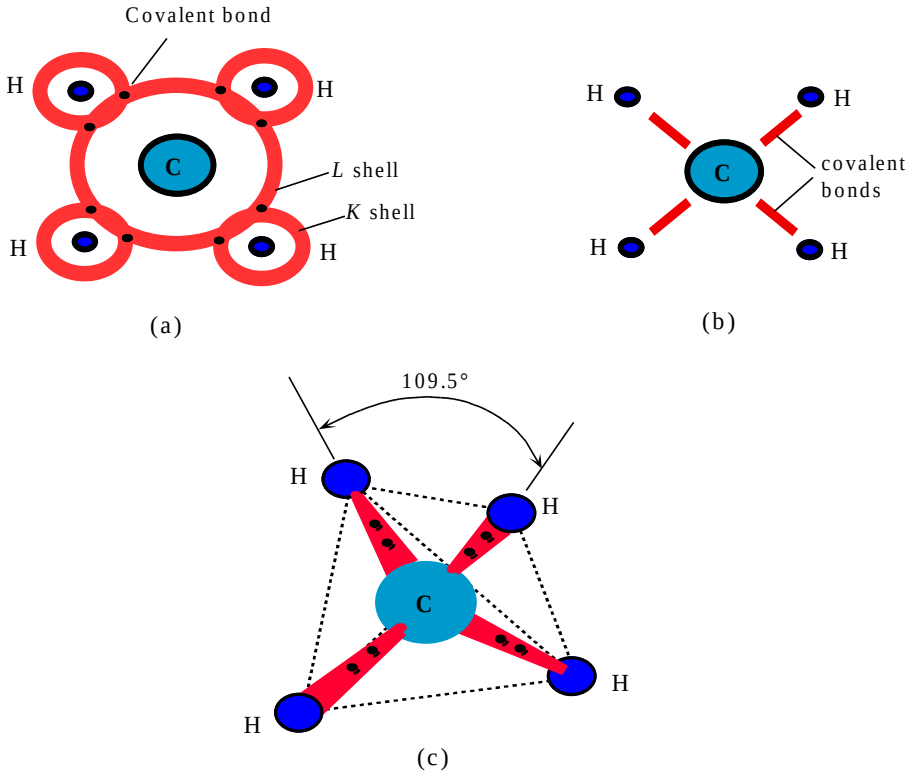
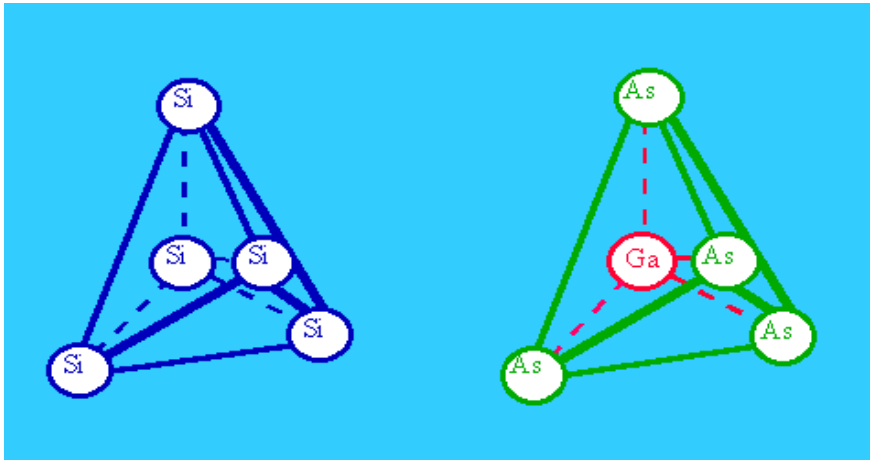
A covalent bond is formed when electrons are shared between atoms.

Covalent Bonding





Examples: diamond, silicon, germanium, silicon carbide.

Fig. 1.5: (a) Covalent bonding in methane, CH_4, involves four hydrogen atoms sharing electrons with one carbon atom. Each covalent bond has two shared electrons. The four bonds are identical and repel each other. (b) Schematic sketch of CH_4 on paper. (c) In three dimensions, due to symmetry, the bonds are directed towards the corners of a tetrahedron.

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Covalent Bonding

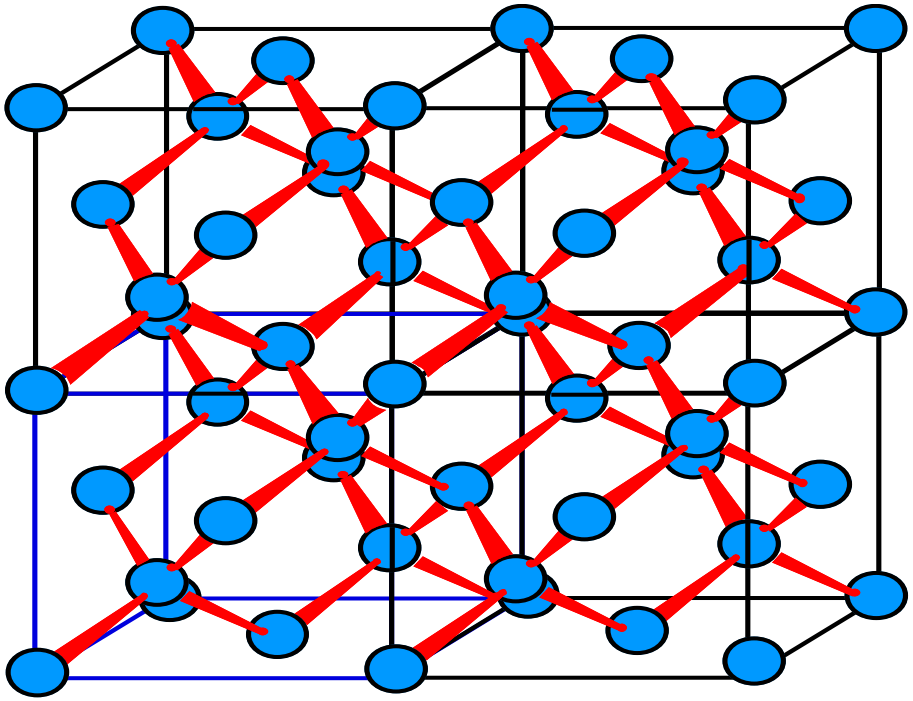

Fig. 1.6: The diamond crystal is a covalently bonded network of carbon atoms. Each carbon atom is bonded covalently to four neighbors forming a regular three dimensional pattern of atoms which constitutes the diamond crystal.

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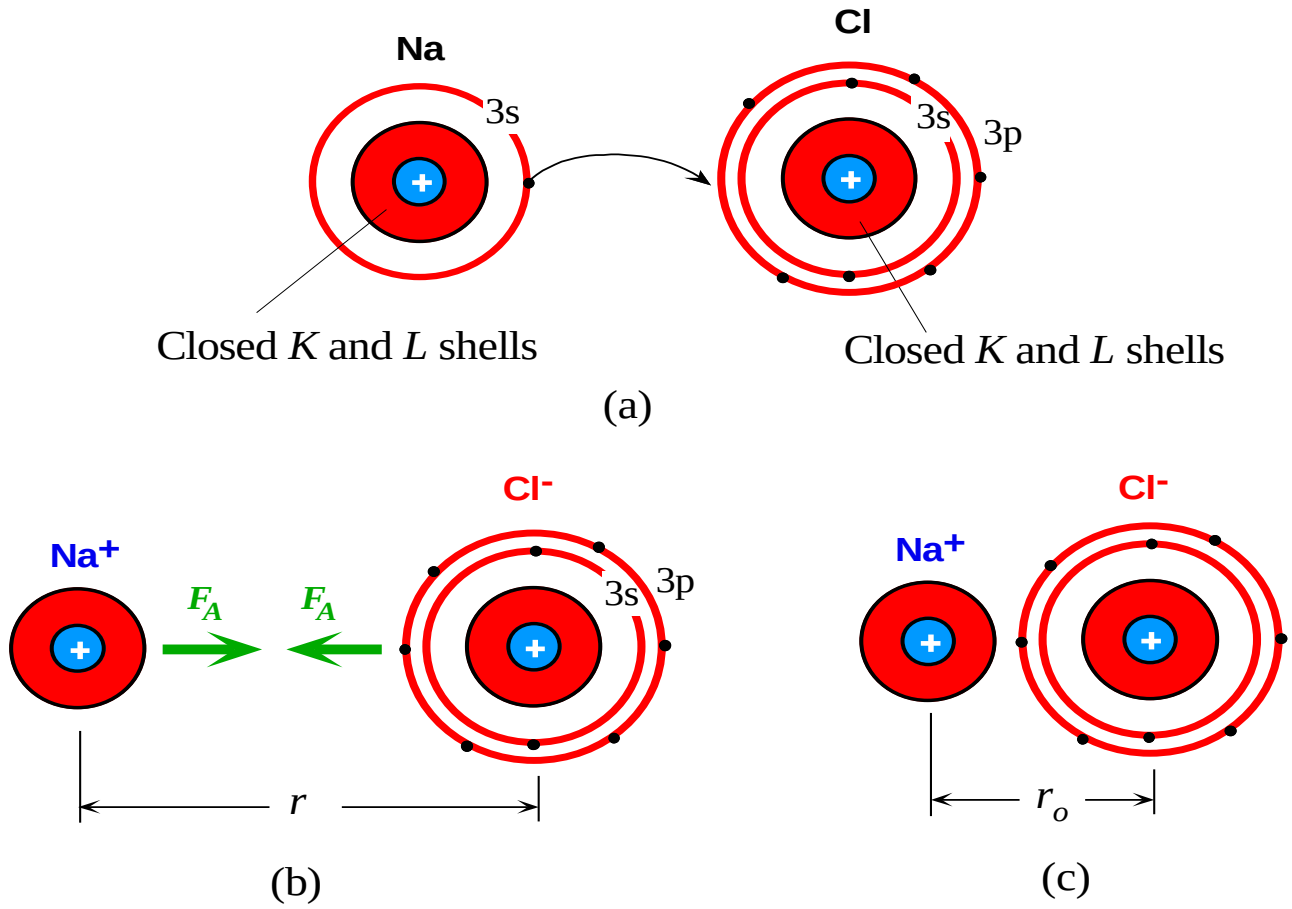
Ionic Bond



An ionic bond is formed when electrons are transferred from one atom to the other.

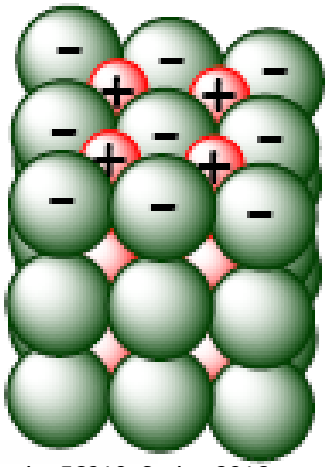


Fig. 1.8: The formation of an ionic bond between Na and Cl atoms in NaCl. The attraction is due to coulombic forces.

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Ionic Bonding

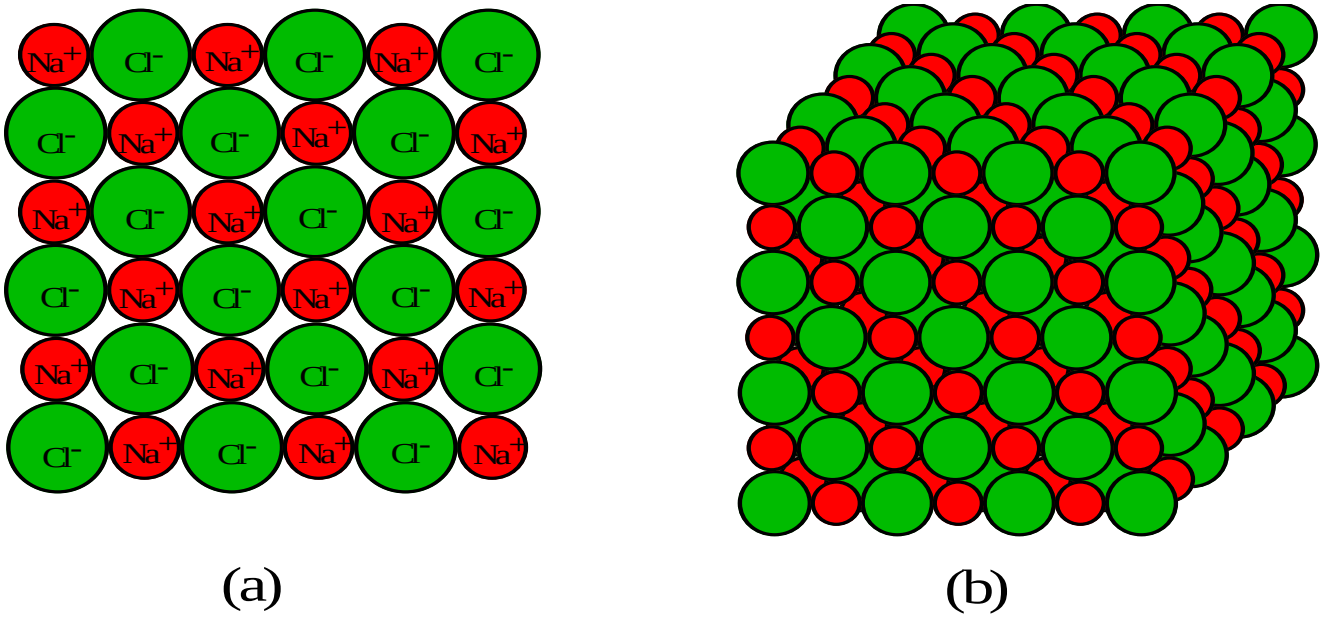

Fig. 1.9: (a) A schematic illustration of a cross section from solid NaCl. NaCl solid is made of Cl^- and Na^+ ions arranged alternatingly so that the oppositely charged ions are closest to each other and attract each other. There are also repulsive forces between the like-ions. In equilibrium the net force acting on any ion is zero. (b) Solid NaCl.

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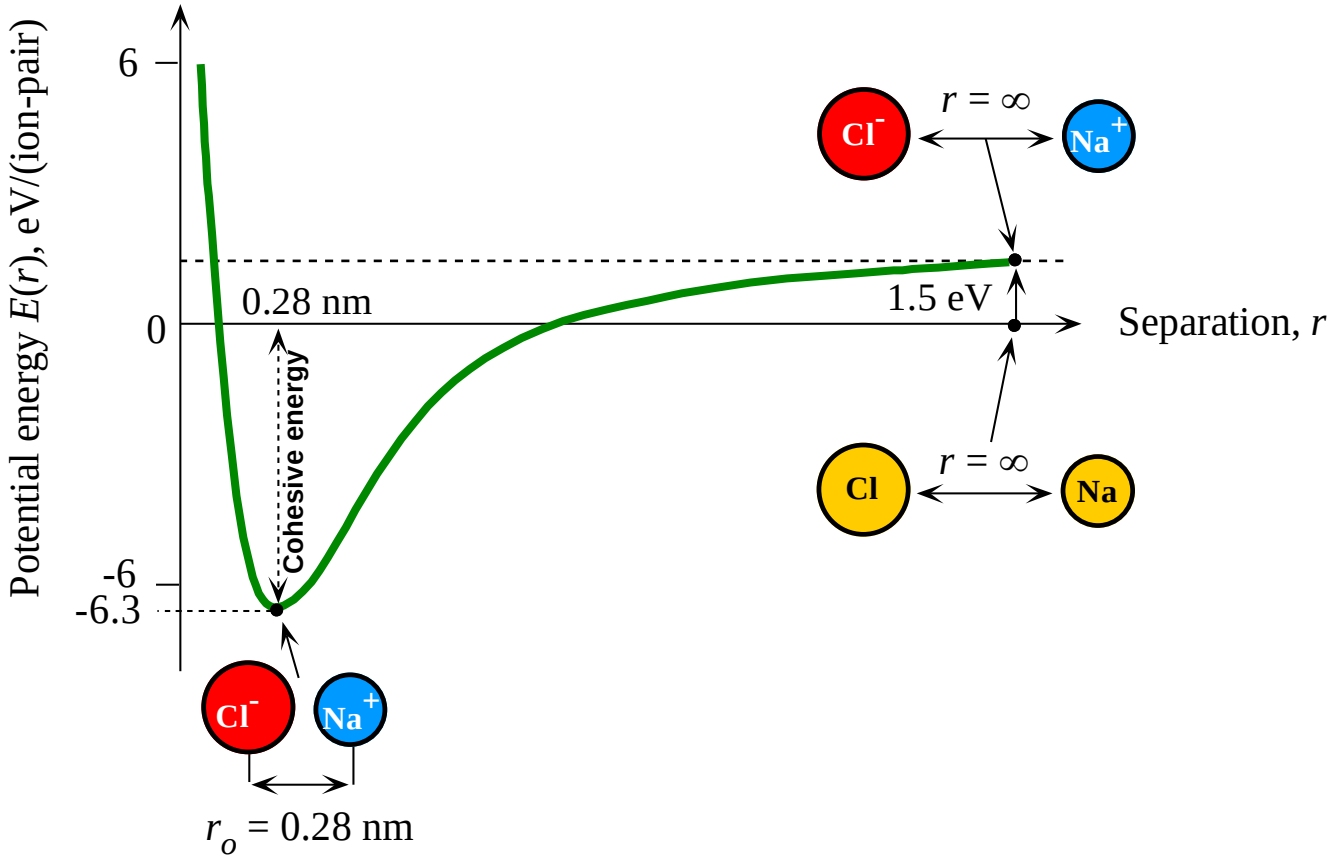
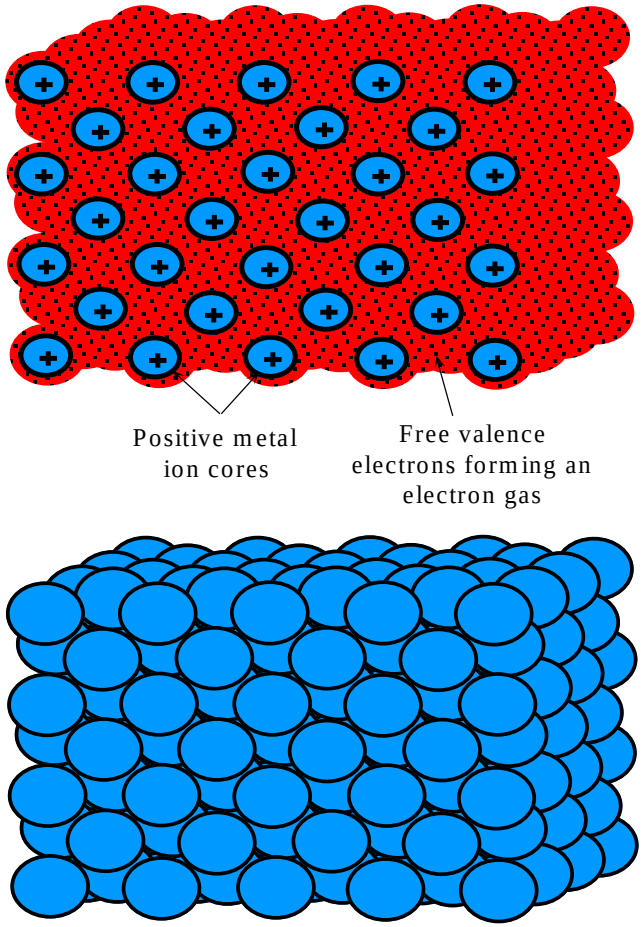
Ionic Bond



Sketch of the potential energy per ion-pair in solid NaCl. Zero energy corresponds to neutral Na and Cl atoms infinitely separated.

Metallic Bonding



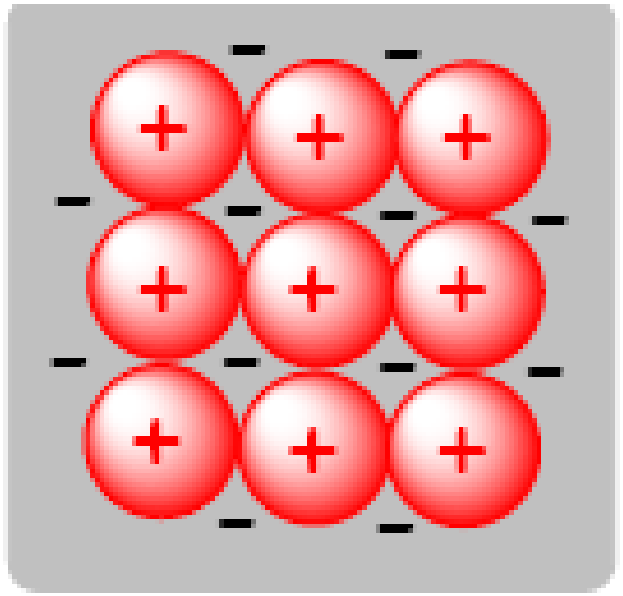


Fig. 1.7: In metallic bonding the valence electrons from the metal atoms form a "cloud of electrons" which fills the space between the metal ions and "glues" the ions together through the coulombic attraction between the electron gas and positive metal ions.

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Van der Waals Hydrogen Bonding

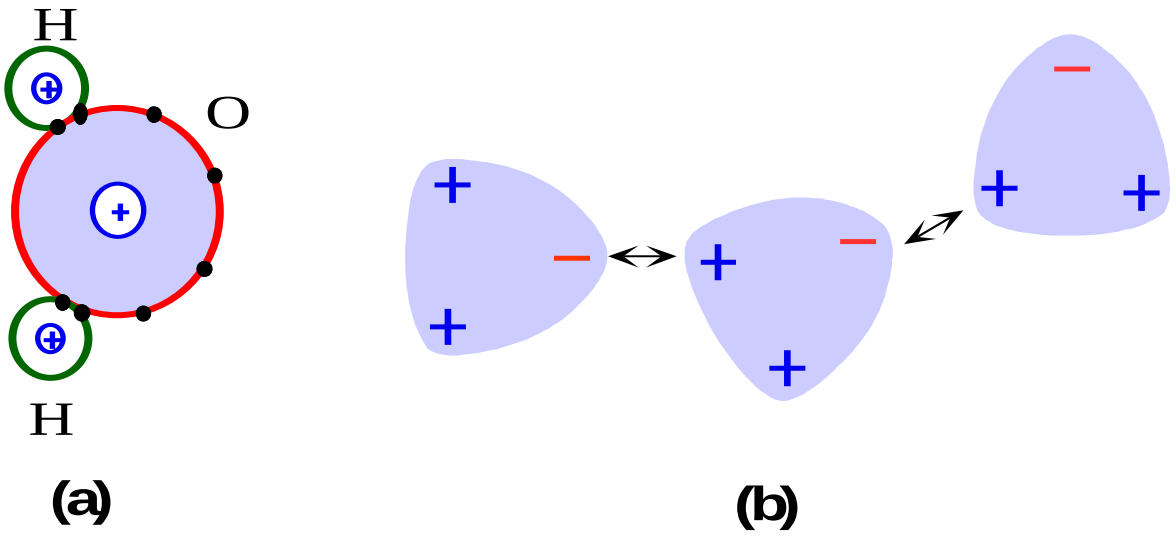

Fig. 1.12: The origin of van der Waals bonding between water molecules. (a) The H_2O molecule is polar and has a net permanent dipole moment. (b) Attractions between the various dipole moments in water gives rise to van der Waals bonding.

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Van der Waals Bonding

Even inert gases become liquids and even form crystals at low temperatures.

What force holds the molecules together?

- "Van der Waals Hydrogen bonding," Asymmetry of the molecule gives rise to a non uniform charge distribution and a polarity.

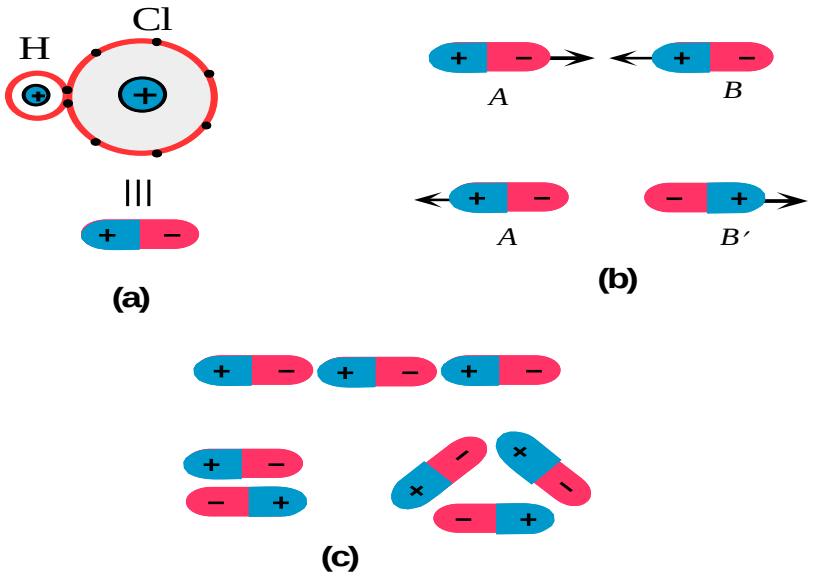

Fig. 1.11: (a) A permanently polarized molecule is called a an electric dipole moment. (b) Dipoles can attract or repel each other depending on their relative orientations. **c** Suitably oriented dipoles attract each other to form van der Waals bonds.

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