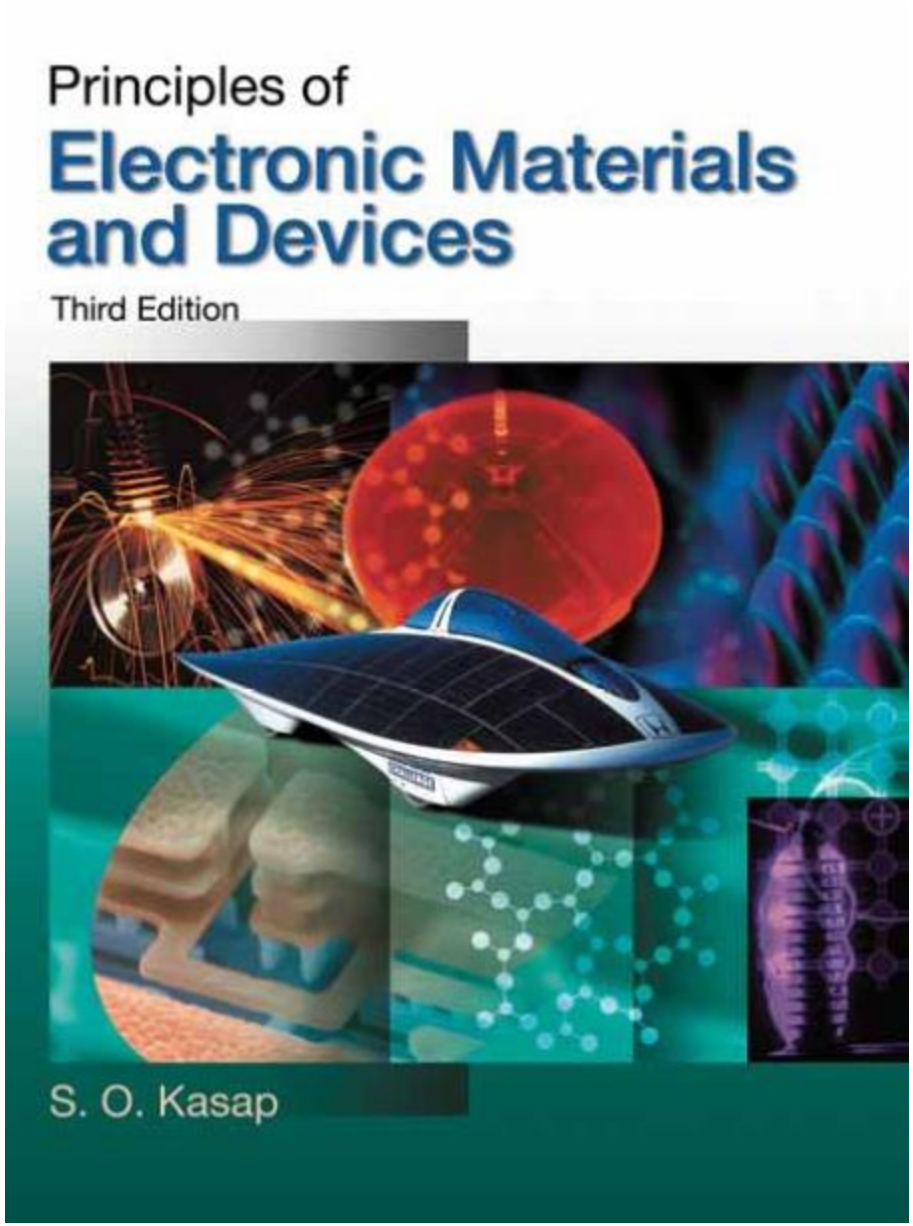
EC210 _Cairo

Spring 2014

Solid State Electronics

Lec. 3 Part I: Bond Types

Lec. 3 Part II: Waves



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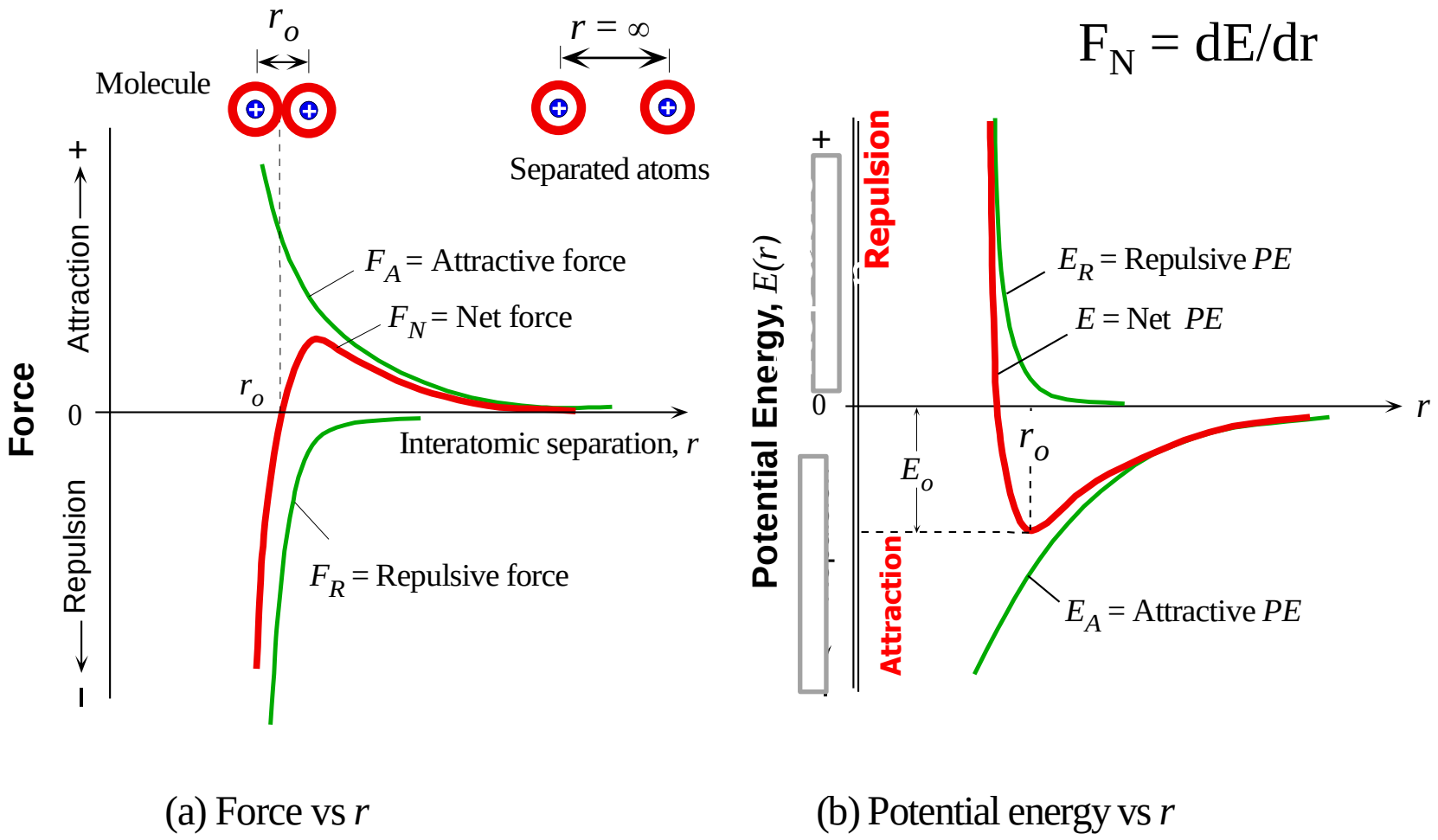
Kasap

- P. 9 to P. 23
- Section 1.3.1, 1.3.2, 1.3.3, 1.3.4, 1.3.5 (1.3.6 is not included)

Molecules and General Bonding Principles

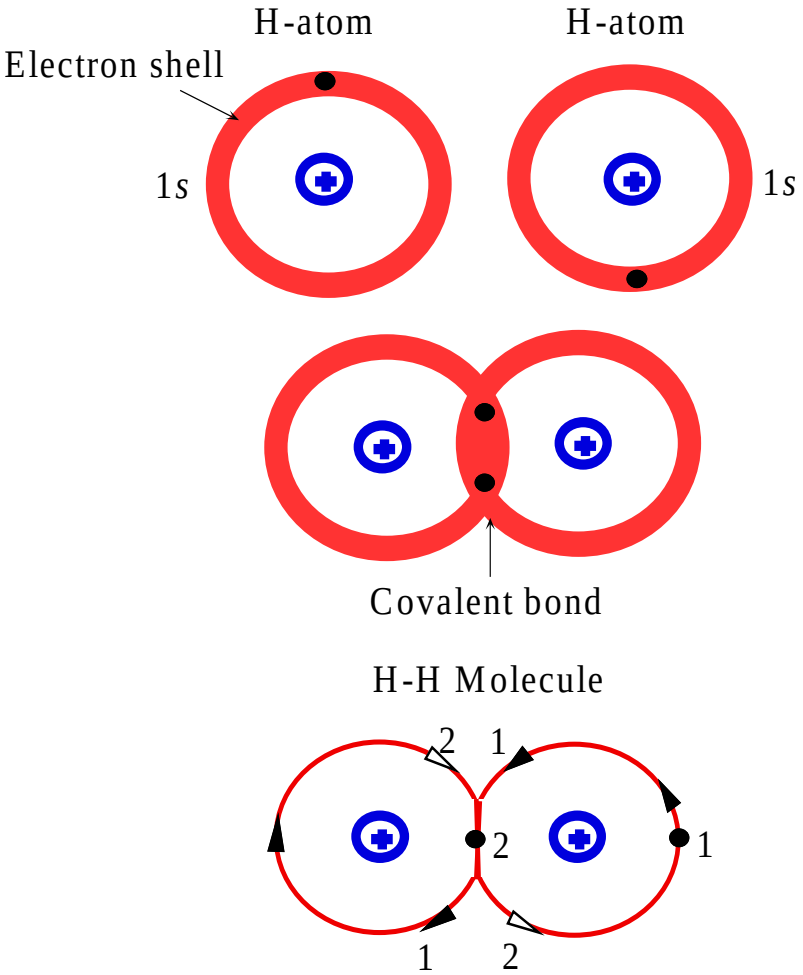


(a) Force vs r (b) Potential energy vs r

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

Fig 1.3

Covalent Bonding



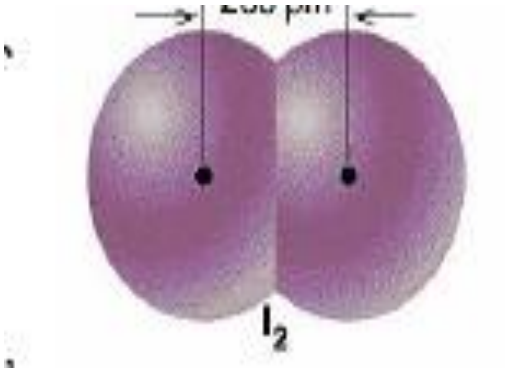
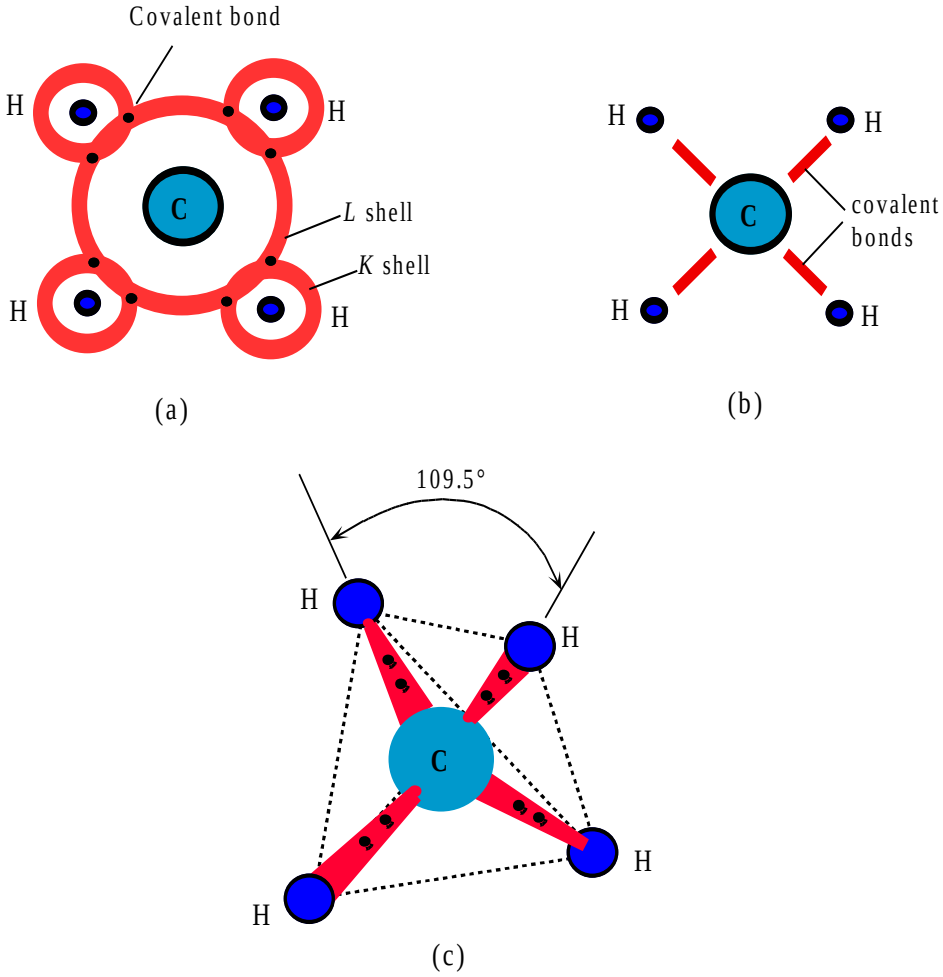
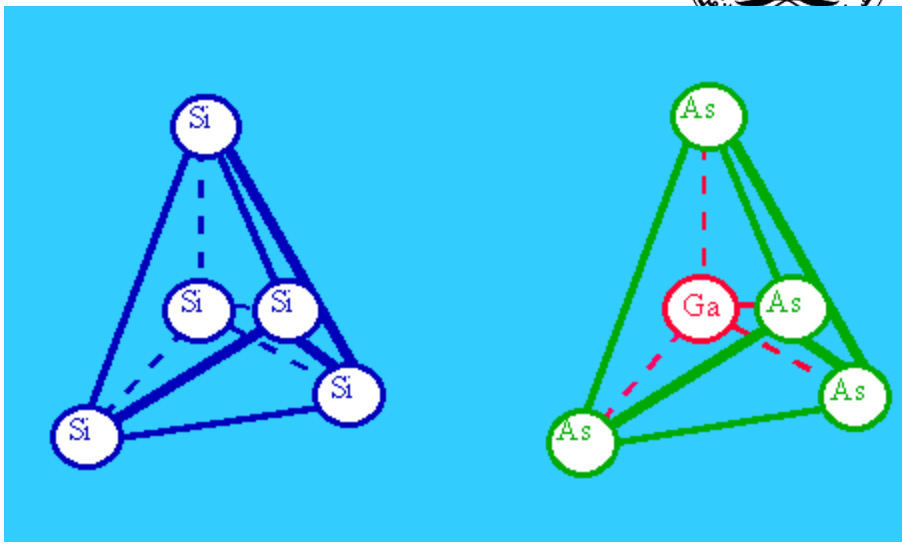


Fig. 1.4: Formation of a covalent bond between two H atoms leads to the H_2 molecule. Electrons spend majority of their time between the two nuclei which results in a net attraction between the electrons and the two nuclei which is the origin of the covalent bond .

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.

Covalent Bonding

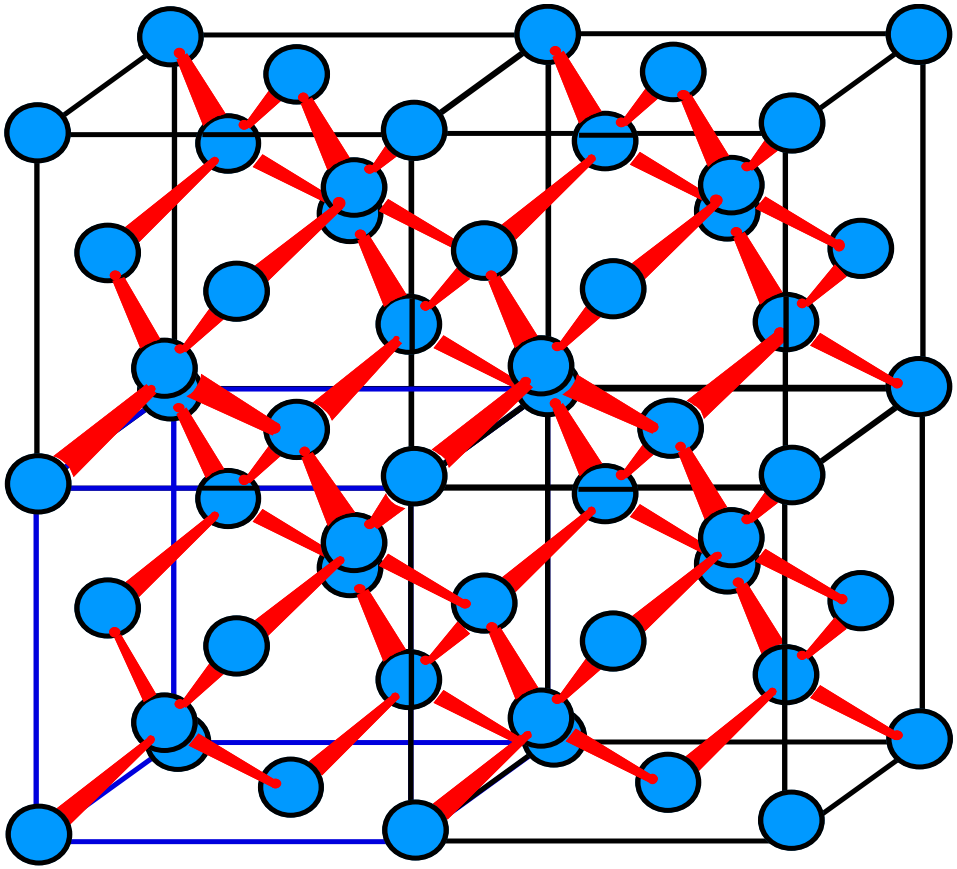


Fig. 1.6: The diamond crystal is a covalently bonded network of carbon atoms. Each carbon atom is bonded covalently to four neighbors forming a regular three dimensional pattern of atoms which constitutes the diamond crystal.

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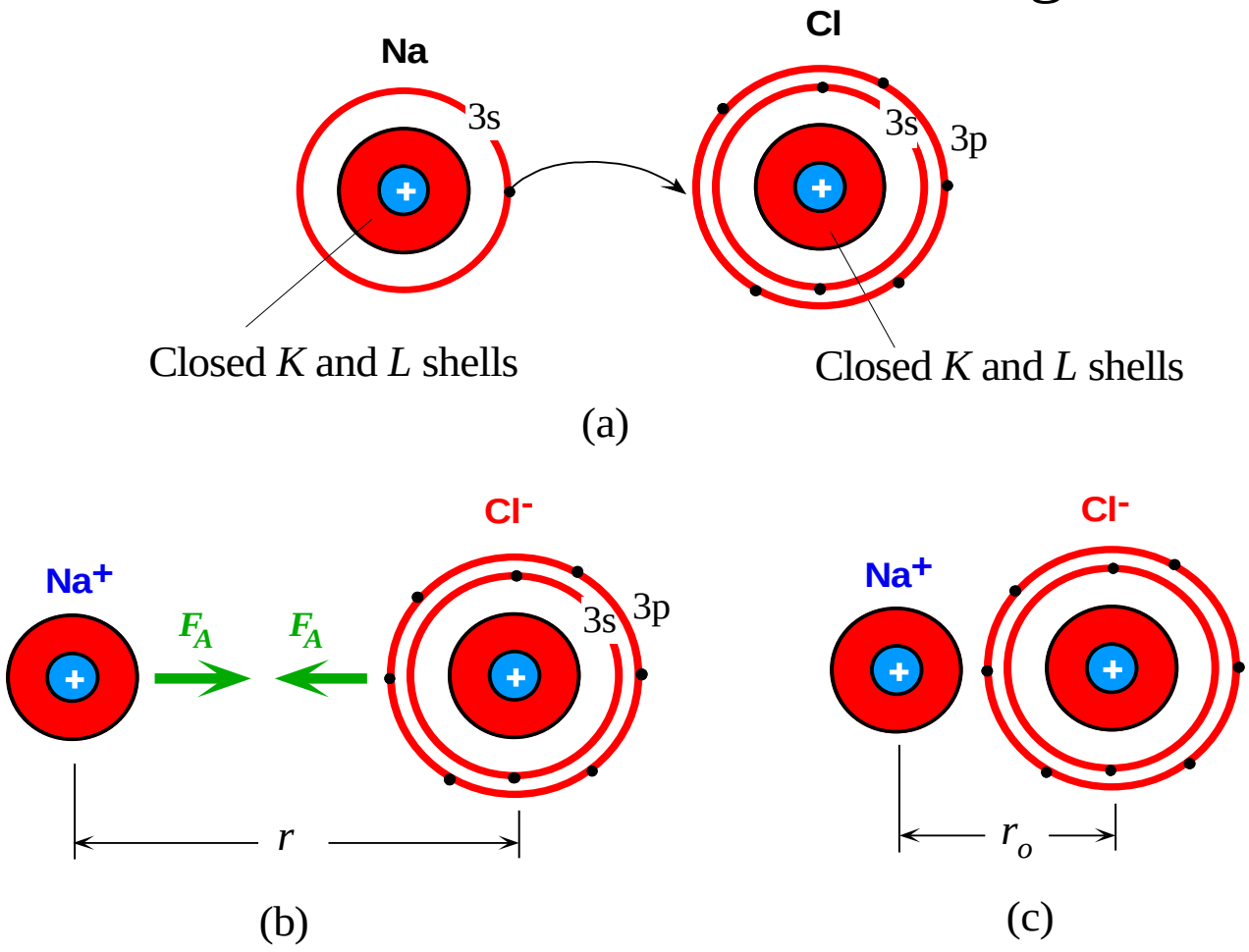
Ionic Bonding



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

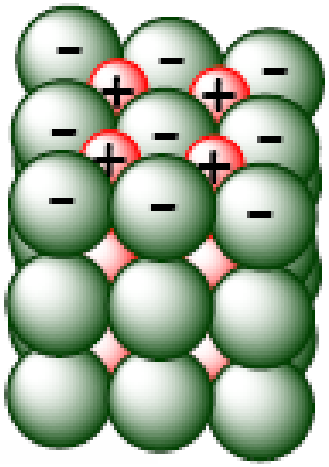


Fig. 1.8: The formation of an ionic bond between Na and Cl atoms in NaCl. The attraction is due to coulombic forces.

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Ionic Bonding

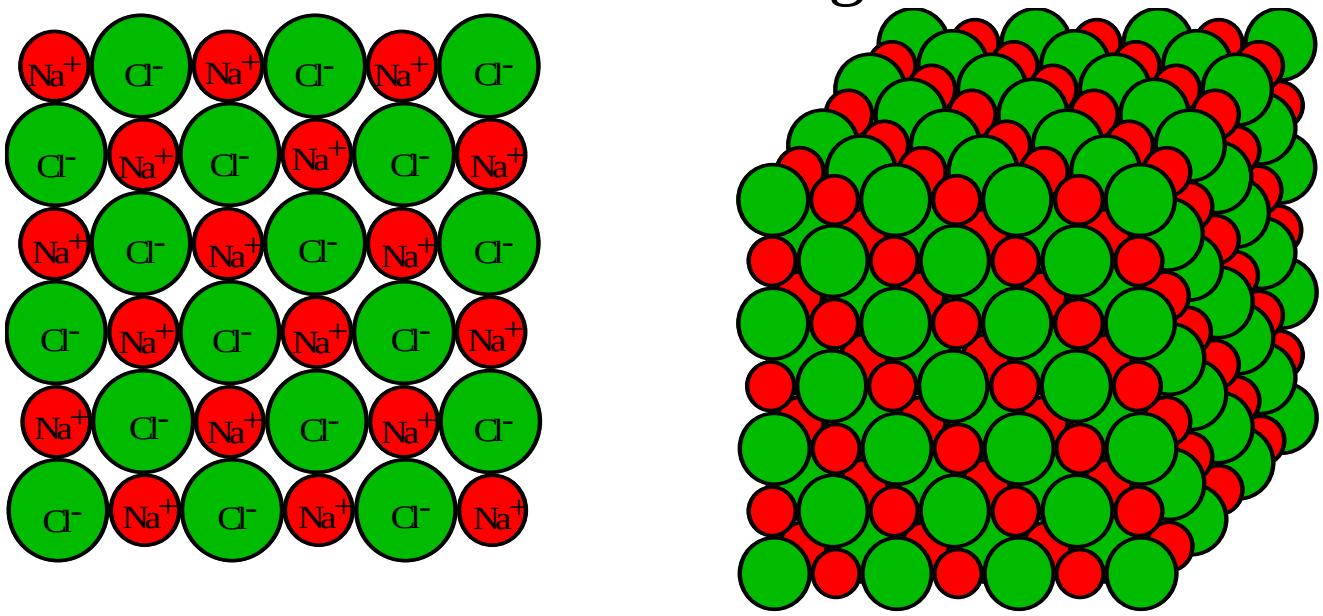
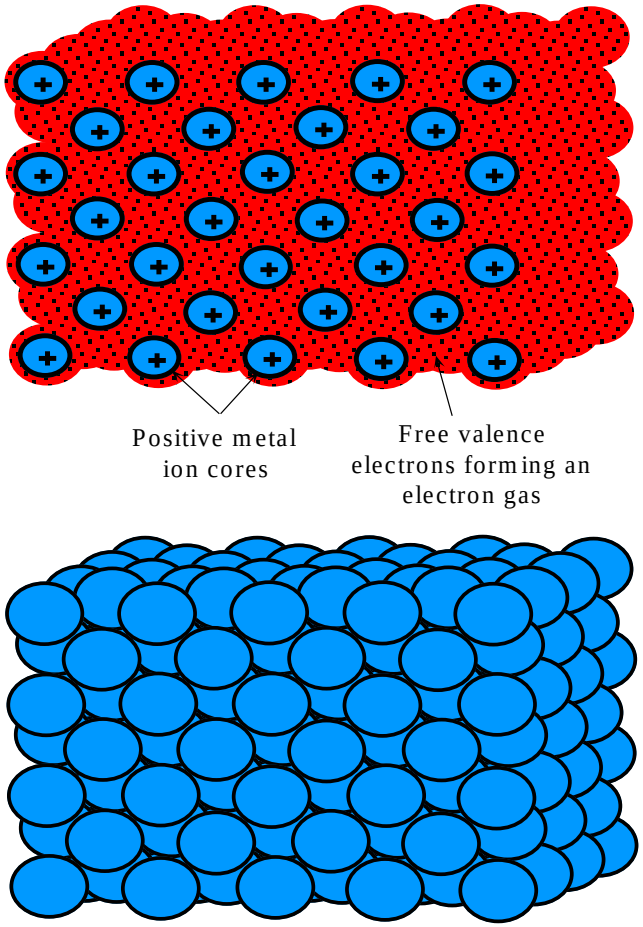


Fig. 1.9: (a) A schematic illustration of a cross section from solid NaCl. NaCl solid is made of Cl^- and Na^+ ions arranged alternatingly so that the oppositely charged ions are closest to each other and attract each other. There are also repulsive forces between the like-ions. In equilibrium the net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

Metallic Bonding



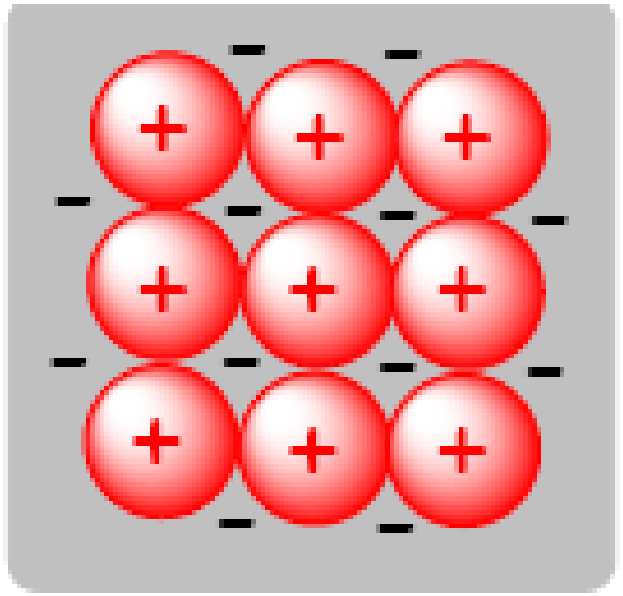


Fig. 1.7: In metallic bonding the valence electrons from the metal atoms form a "cloud of electrons" which fills the space between the metal ions and "glues" the ions together through the coulombic attraction between the electron gas and positive metal ions.

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Van der Waals Hydrogen Bonding

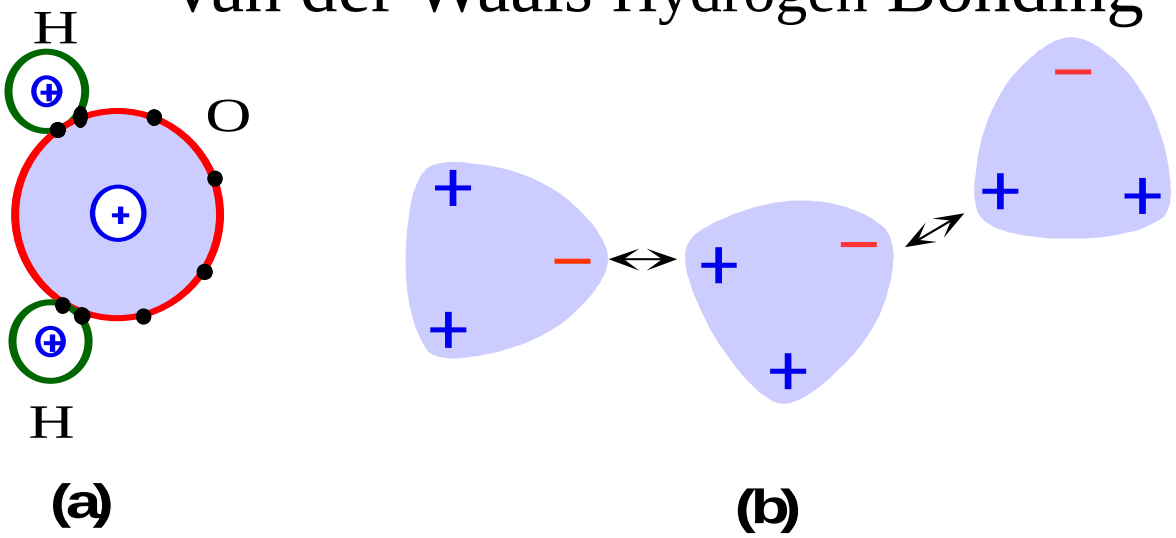

Fig. 1.12: The origin of van der Waals bonding between water molecules. (a) The H_2O molecule is polar and has a net permanent dipole moment. (b) Attractions between the various dipole moments in water gives rise to van der Waals bonding.

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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.

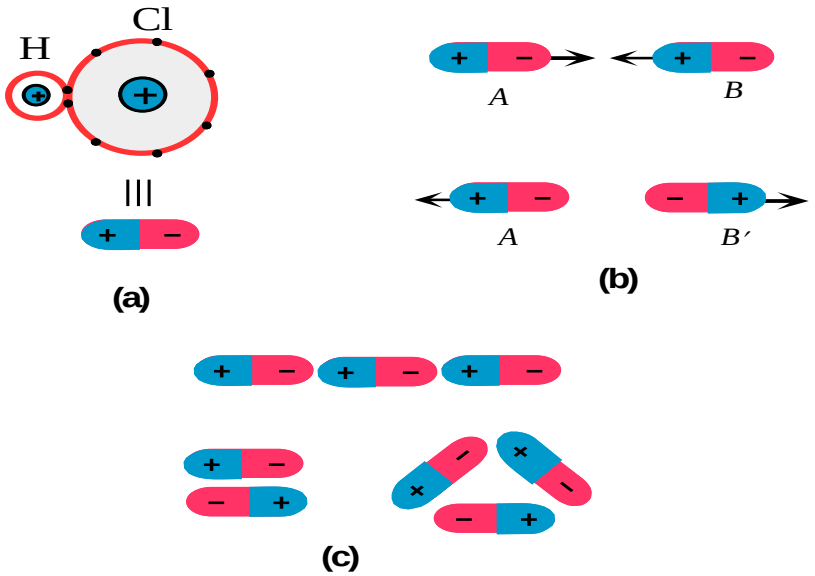

Fig. 1.11: (a) A permanently polarized molecule is called a an electric dipole moment. (b) Dipoles can attract or repel each other depending on their relative orientations. **c** Suitably oriented dipoles attract each other to form van der Waals bonds.

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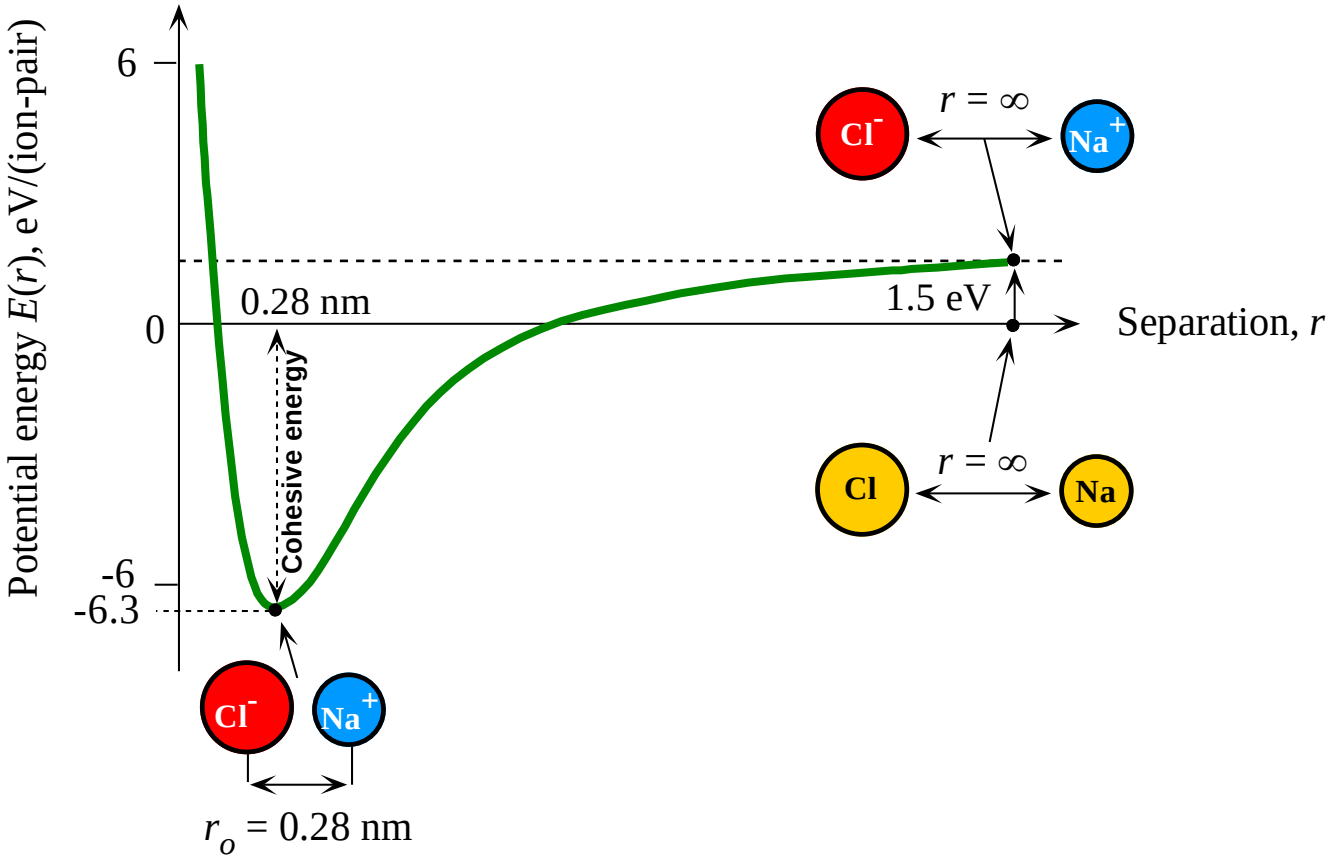


Sketch of the potential energy per ion-pair in solid NaCl. Zero energy corresponds to neutral Na and Cl atoms infinitely separated.

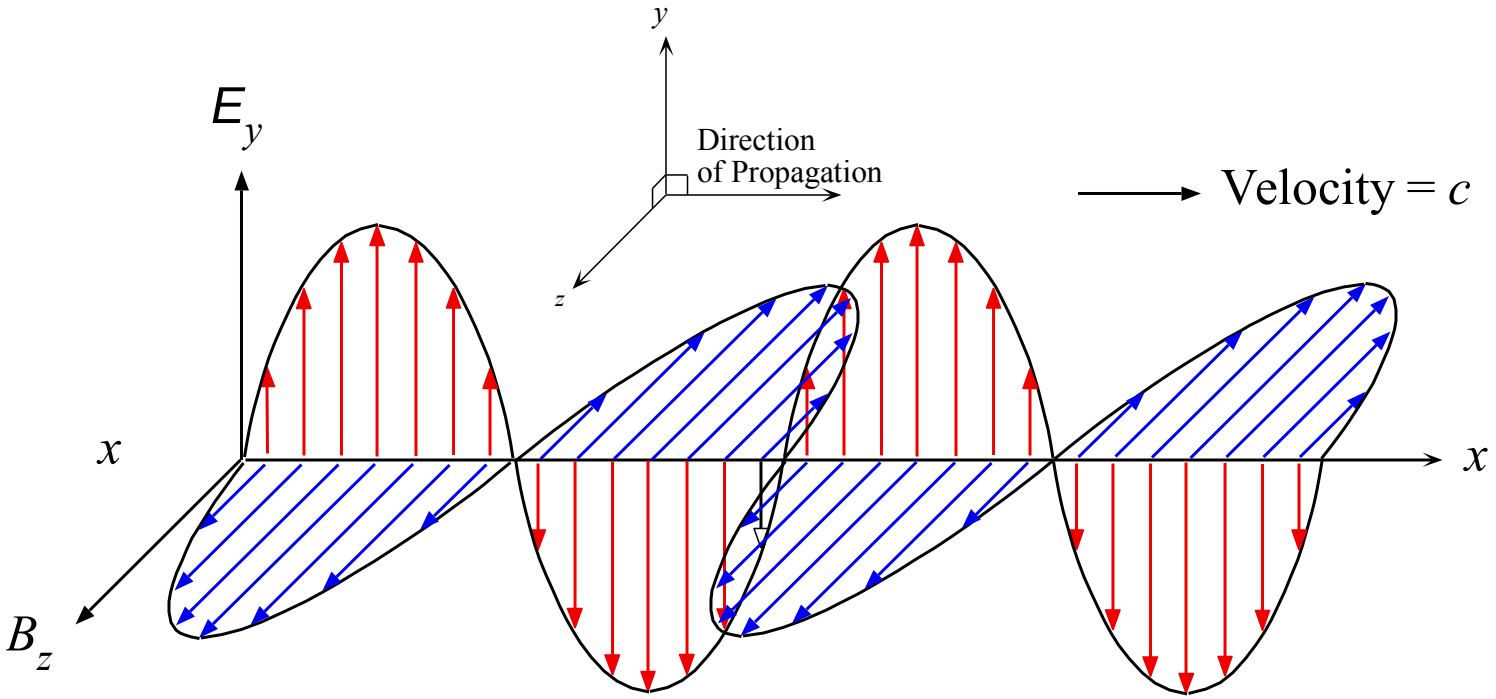
Fig 1.10

Elementary Quantum Physics: Introduction to Light Waves

(Kasap)

- Chapter 3
- p. 191 – 193

Light as an Electromagnetic wave (EMW)



The classical view of light as an electromagnetic wave. An electromagnetic wave is a travelling wave which has time varying electric and magnetic fields which are perpendicular to each other and to the direction of propagation.

Fig 3.1

The electric field is described by:

$$E_y(x,t) = E_o \sin(k x - \omega t)$$

$$k = \text{wave number} = 2\pi / \lambda$$

$$\nu = \omega / 2\pi$$

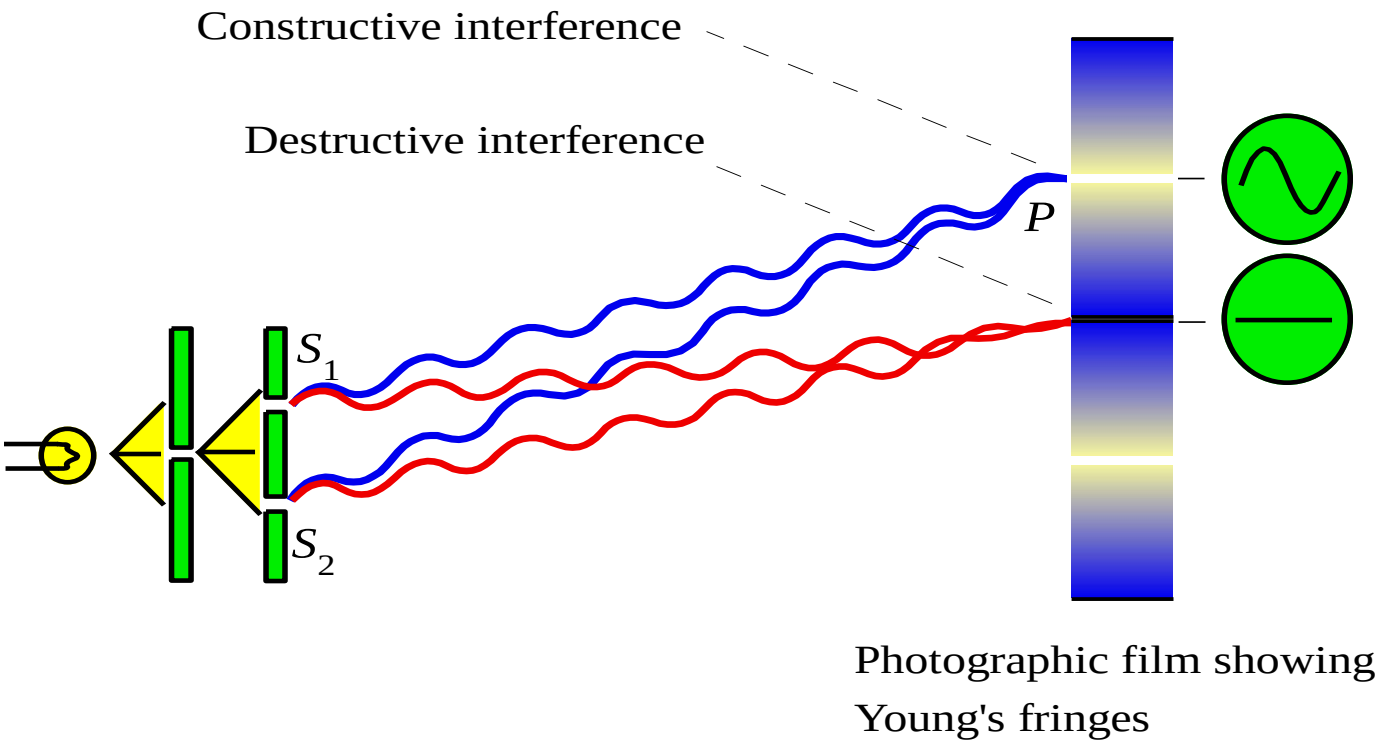
$$c = \omega / k = \nu \lambda$$

Intensity

Intensity = Energy/unit area/unit time

$$I = (\tfrac{1}{2})\, c\, \varepsilon_o\, E_o^{\,2}$$

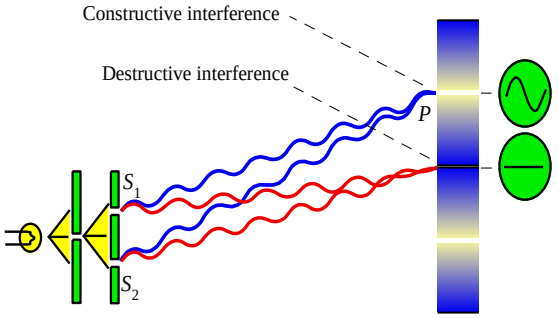
Wave Interference: Young's Experiment



Schematic illustration of Young's double slit experiment.

Fig 3.2

Wave Interference: Young's Experiment



Photographic film showing Young's fringes

Schematic illustration of Young's double slit experiment.

In-Phase: (Constructive Interference)

$$S_1P - S_2P = n\,\lambda$$

Out-of-Phase: (Destructive Interference)

$$S_1P - S_2P = (n + \tfrac{1}{2})\,\lambda$$