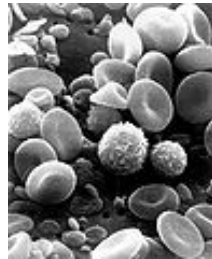


The microscopic world

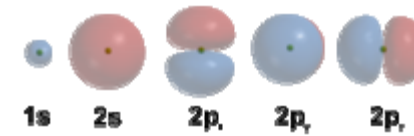
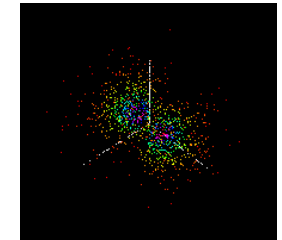
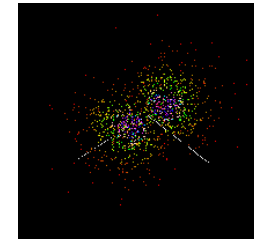
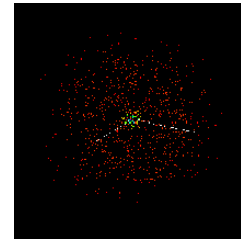
Multy-atomic systems



Irén Bárdos-Nagy

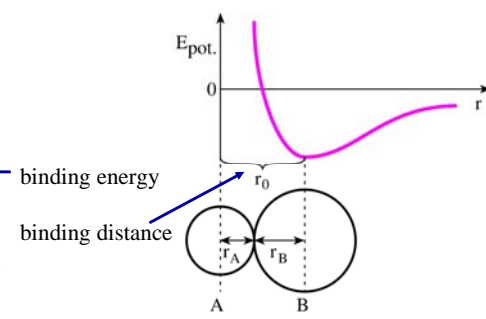
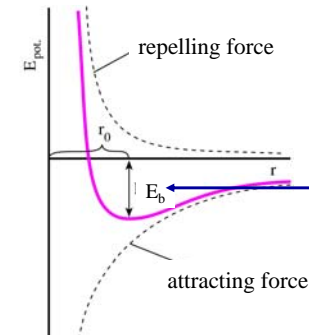
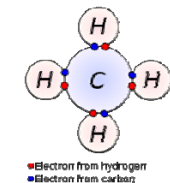
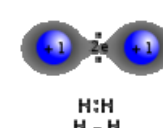


Electron clouds of the individual carbon atoms



Interaction between the atoms \rightarrow chemical binding
Primer (strong) chemical bonds (binding energy 100 – 200 kJ/mol few eV/bond)

a./ the covalent bond



PERIODIC TABLE OF THE ELEMENTS

<http://www.kf-split.hr/periodnu/>

GROUP	IA	IIA	RELATIVE ATOMIC MASS (1)										IIIA	IVA	VA	VIA	VIIA	VIIIA		
PERIOD	1	2	GROUP IUPAC		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	H 1.0079 HYDROGEN														B 10.811 BORON	C 12.011 CARBON	N 14.007 NITROGEN	O 15.999 OXYGEN	F 18.998 FLUORINE	Ne 20.180 NEON
2	Li 6.941 LITHIUM	Be 9.0122 BERYLLIUM													Al 26.982 ALUMINUM	Si 28.086 SILICON	P 30.974 PHOSPHORUS	S 32.065 SULFUR	Cl 35.453 CHLORINE	Ar 39.948 ARGON
3	Na 22.990 SODIUM	Mg 24.305 MAGNESIUM																		
4	K 39.098 POTASSIUM	Ca 40.078 CALCIUM	Sc 44.956 SCANDIUM	Ti 47.867 TITANIUM	V 50.942 VANADIUM	Cr 51.996 CHROMIUM	Mn 54.938 MANGANESE	Fe 55.845 IRON	Co 58.933 COBALT	Ni 58.693 NICKEL	Cu 63.546 COPPER	Zn 65.39 ZINC	Ga 69.723 GALLIUM	Ge 72.64 GERMANIUM	As 74.922 ARSENIC	Se 78.96 SELENIUM	Br 79.904 BROMINE	Kr 83.80 KRYPTON		
5	Rb 85.460 RUBIDIUM	Sr 87.62 STRONTIUM	Y 88.905 YTTRIUM	Zr 91.224 ZIRCONIUM	Nb 92.906 NIOBNIUM	Mo 95.94 MOLYBDENUM	Tc 98.906 TECHNETIUM	Ru 101.07 RUTHENIUM	Rh 102.91 RHODIUM	Pd 106.42 PALLADIUM	Ag 107.87 SILVER	Cd 112.41 CADMIUM	In 114.82 INDIUM	Sn 118.71 TIN	Sb 121.76 ANTIMONY	Te 127.60 TELLURUM	I 126.90 IODINE	Xe 131.29 XENON		
6	Cs 132.91 CAESIUM	Ba 137.33 BARIUM	La-Lu 138.905 LANTHANIDE	Hf 178.49 HAFNIUM	Ta 180.95 TANTALUM	W 183.84 WOLFRAM	Re 186.21 RHENIUM	Os 190.23 OSMIUM	Ir 192.22 IRIDIUM	Pt 195.08 PLATINUM	Au 196.97 GOLD	Hg 200.59 MERCURY	Tl 204.38 THALLIUM	Pb 207.2 LEAD	Bi 208.98 BISMUTH	Po 209 POLONIUM	At 210 ASTATINE	Rn 222 RADON		
7	Fr 223 FRANCIUM	Ra 226 RADIUM	Ac-Lr 227 ACTINIDE	Rf 261 RUFORDIUM	Db 262 DUBNIUM	Sg 266 SEABORGIUM	Bh 264 BOHRIUM	Hs 277 HASSIUM	Mt 268 MEITNERIUM	Un 271 UNBIBIUM	Uu 272 UNUNBIUM	Uub 285 UNUBIUM	Uut 289 UNUNTRIUM	Uuq 293 UNUNQUADIUM						

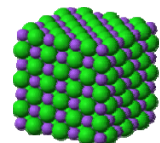
(1) Pure Appl. Chem., 73, No. 1, 657-683 (2001)

Relative atomic mass is shown with few significant figures. For elements having no stable isotopes, the value enclosed in brackets indicates the mass number of the longest-lived nuclear isotope of the element.

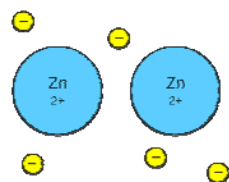
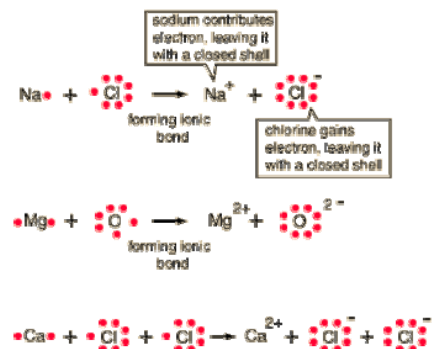
However these cover elements (Fr, Ra, and U) do not have a characteristic chemical composition, and for these an atomic weight is given.

Editor: Ashish Vashishth (ashishvashishth@gmail.com)

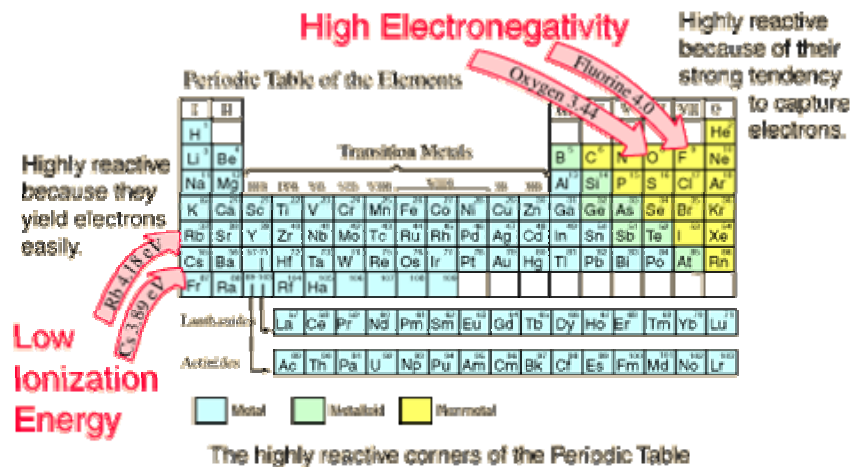
b./ the ionic bond



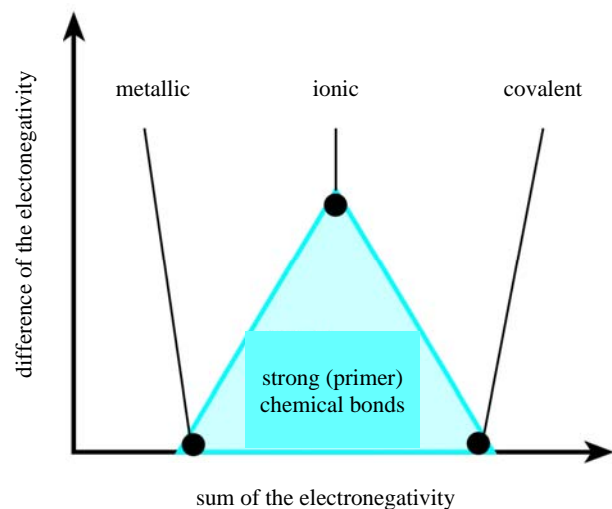
c./ the metallic bond



Characteristics of the atoms on the basis of their electron structure

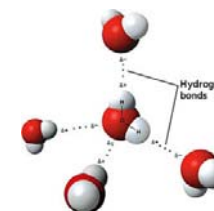


Influence of the electronegativity on the type of the chemical bond



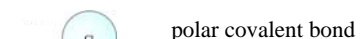
secondary (week) chemical bonds (binding energy less than 20 kJ/mol few 0.2 eV/bond)

a./ the H – bond (~20 kJ, 0.3 eV) (water, hydrogen-fluoride)

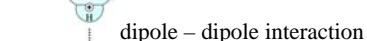


b./ electrostatic interaction

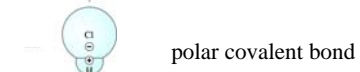
ion – dipole (few kJ/mol, 0.05 eV)



dipole – dipole (~ 2 kJ/mol, 0.01 eV)



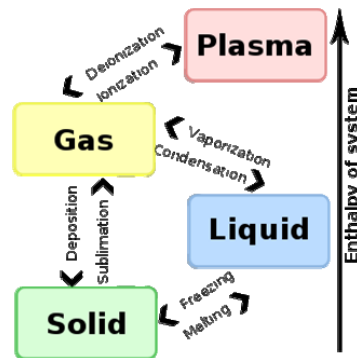
dispersion (~ 0.1 kJ/mol, 0.001 eV) (Noble gases, F₂, H₂, Cl₂ molecules)



The broad states of matter: gas
liquid
(liquid – crystal)
solid

General phase transitions

phase: physically and chemically homogeneous part of the material



Macroscopic properties of different phases:

gas: no definite volume and shape (there is no (or very weak) interaction between the particles)

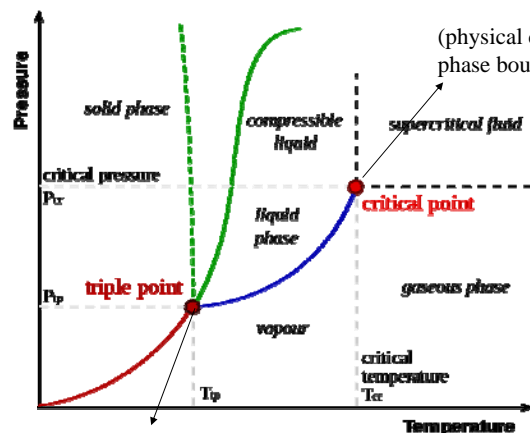
liquid: the volume is definite, the shape is changing, short range order (secondary interactions between the molecules)

liquid – crystal: special shape of individual molecules, relatively long range of order, anisotropy (intermediate phase between liquids and crystals)

solid: definite shape and volume (strong (primary) bonds between the particles)
macroscopic range order (crystals)
periodic crystal structure, symmetry, frequent anisotropy
low degree of translational motion

A typical phase diagram

phase diagram: graphical presentation of stable phases as a function of different parameters



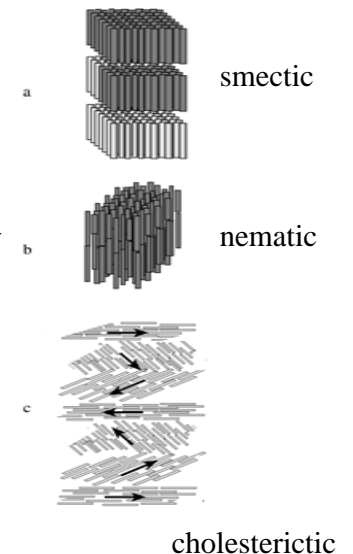
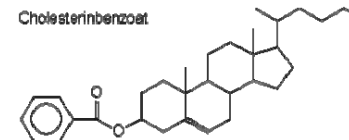
simultaneous transition of Ar from solid to liquid and to gas

Liquid crystals: a mesomorphous state of matter

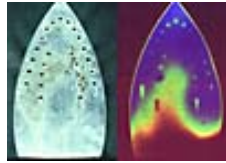
Thermotropic - lyotropic

General properties

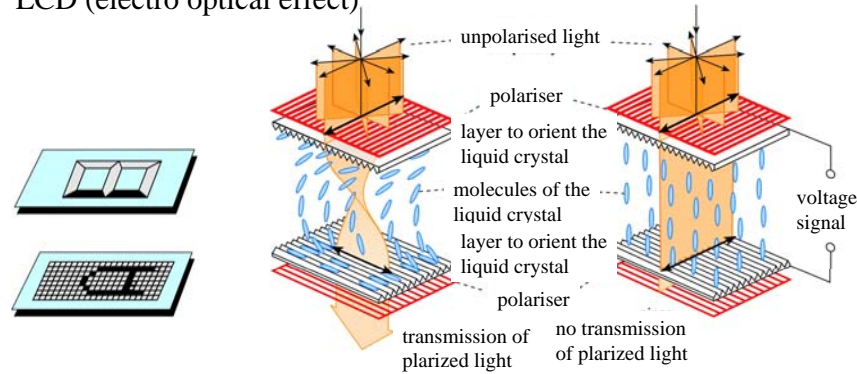
- elongated shape of molecules
- relatively long range order stabilized by secondary bonds
- fluidity, deformability
- anisotropy in fluid state



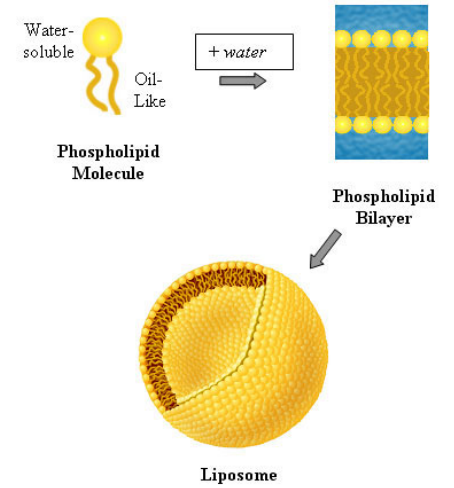
Use of thermotropic liquid crystals



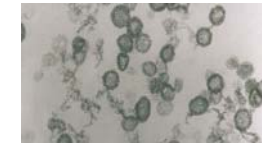
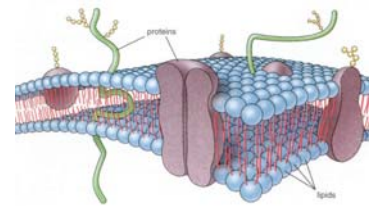
LCD (electro optical effect)



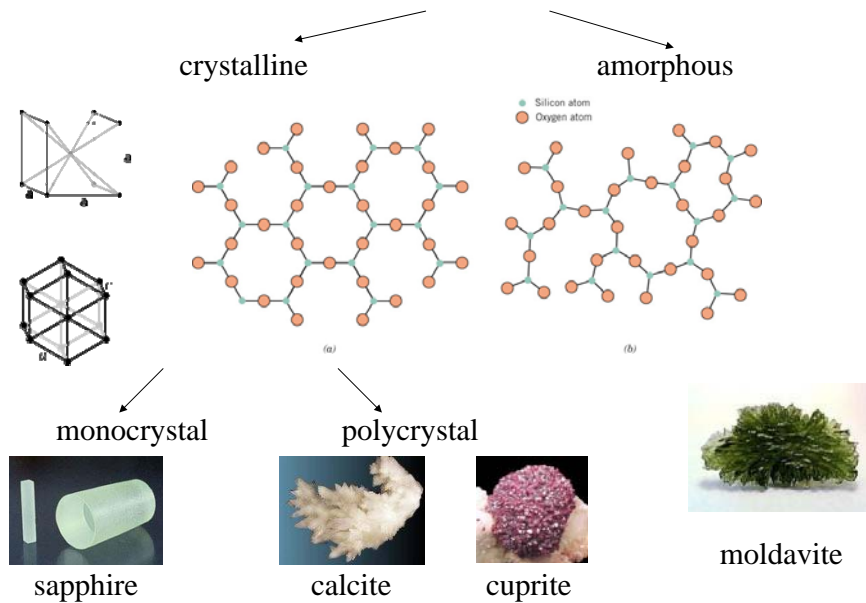
Liotropic liquid crystals



Cellular bi-layer membranes

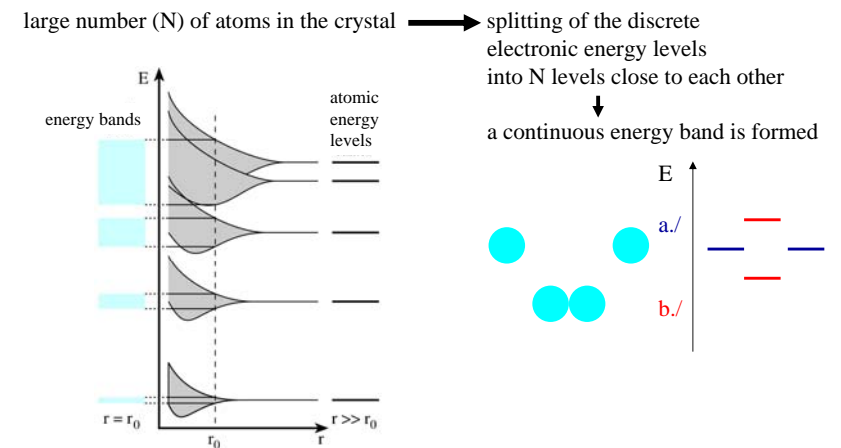


Classification of solid materials

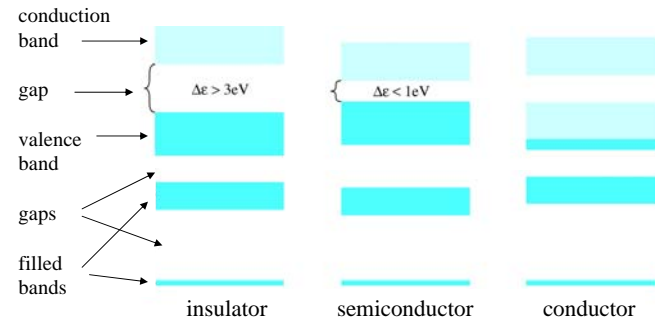


The electron states of atoms structured in crystalline order

basic rules: energy minimum concept
number of electrons on a given orbital
Pauli principle

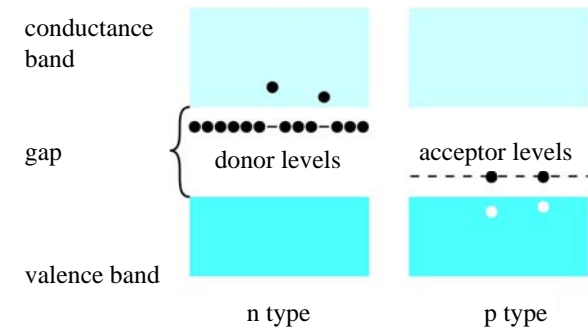


Classification of solid state materials based on their band structure



Doped semiconductores:

semiconductores (Si, Ge) + electron acceptor (B, Al) **p** type conductance
 + electron donor (As, In) **n** type conductanc
 (the concentration of doping material is very small)



Chapters in the text book (Medical biophysics)

I/2. atomic interactions

I/3.2.1. gases

I/3.3. solid materials

I/3.4. liquids, liquid crystals

I/4.1.2. the H-bond