2 The Nature of the Covalent Bond

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Learning Goals and Reading Recommendations

- **organic chemistry is the basis of polymer science and soft matter research**
  - organic chemistry deals with molecular compounds of carbon
  - carbon is always tetravalent but forms single, double, triple bonds to other atoms
  - therefore, a vast array of binding options, molecular geometries
- **electrons in atoms and molecules are described by wavefunctions ψ**
  - allowed stationary states ψ are solutions to the Schrödinger equation
  - atomic orbitals represent space of non-zero probability $|\psi|^2$ for an electron
- **covalent bond described by linear combination of atomic or hybrid orbitals**
  - bond energy is stabilization of filled bonding orbital σ
  - antibonding orbital σ* energetically destabilized but remains empty
  - multiple bonds can be described as distinct σ bond plus one or two π bonds
- **“conjugated” multiple bonds interact, and electrons become delocalized**
  - electron delocalization particularly pronounced for “aromatic” cyclic systems
  - delocalization can be represented by resonance structures

2.1 Carbon as the Basis of Organic Chemistry

Reading Recommendations

- Clayden, Greeves, Warren, *Organic Chemistry*, Oxford University Press, 2nd ed., **2012**, *pp* 1–11.
- Jamart, Bodiguel, Brosse, *Les cours de Paul Arnaud - Cours de chimie organique*, Dunod, 19th ed., **2015**, *pp* XVI.

Carbon in the Periodic System of the Elements

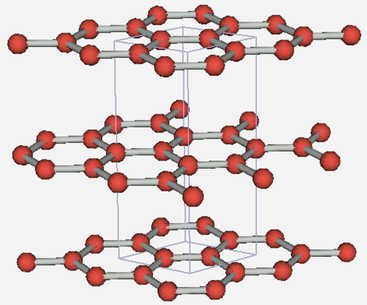
group 4

	Ia	IIa	IIIa	IVa	Va	VIa	VIIa	VIII			Ib	IIb	IIIb	IVb	Vb	VIb	VIIb	0
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H 1.008 Wasserstoff																	2 He 4.0003 Helium
2	3 Li 6.94 Lithium	4 Be 9.01 Beryllium				2nd period							5 B 10.81 Bor	6 C 12.011 Kohlenstoff	7 N 14.01 Stickstoff	8 O 16.00 Sauerstoff	9 F 19.00 Fluor	10 Ne 20.18 Neon
3	11 Na 22.99 Natrium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicium	15 P 30.97 Phosphor	16 S 32.06 Schwefel	17 Cl 35.45 Chlor	18 Ar 39.95 Argon
4	19 K 39.10 Kalium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.90 Titan	23 V 50.94 Vanadium	24 Cr 52.00 Chrom	25 Mn 54.94 Mangan	26 Fe 55.85	27 Co 58.93 Cobalt	28 Ni 58.71 Nickel	29 Cu 63.55 Kupfer	30 Zn 65.37 Zink	31 Ga 69.72 Gallium	32 Ge 72.59 Germanium	33 As 74.92 Arsen	34 Se 78.96 Selen	35 Br 79.90 Brom	36 Kr 83.80 Krypton
5	37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niob	42 Mo 95.94 Molybdän	43 Tc 98.91 Technecium	44 Ru 101.07 Ruthenium	45 Rh 102.91 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.87 Silber	48 Cd 112.40 Cadmium	49 In 114.82 Indium	50 Sn 118.69 Zinn	51 Sb 121.75 Antimon	52 Te 127.60 Tellur	53 I 126.90 Iod	54 Xe 131.30 Xenon
6	55 Cs 132.91 Cäsium	56 Ba 137.34 Barium	57 La 138.91 Lanthan	72 Hf 178.49 Hafnium	73 Ta 180.95 Tantal	74 W 183.85 Wolfram	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.22 Iridium	78 Pt 195.09 Platin	79 Au 196.97 Gold	80 Hg 200.59 Quecksilber	81 Tl 204.37 Thallium	82 Pb 207.2 Blei	83 Bi 209.98 Bismut	84 Po 208.98 Polonium	85 At 209.99 Astat	86 Rn 222.02 Radon
7	87 Fr 223.02 Francium	88 Ra 226.03 Radium	89 Ac 227.03 Actinium	104 Rf 261.11 Rutherfordium	105 Db 262.11	106 Sg 263.12	107 Bh 262.12	108 Hs	109 Mt									

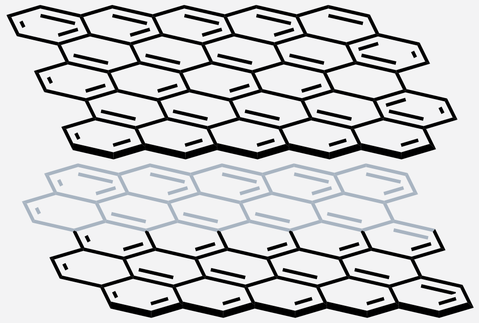
- carbon is in group 4 of the 2nd period of the PSE; 4 valence electrons on 2nd shell for bonding
- carbon is tetravalent, connects with four bonds (electron pairs) to other atoms

Modifications (Allotropes) of Carbon

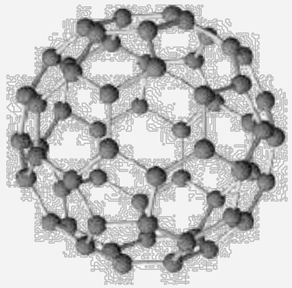
graphite



every carbon has 3 neighbors
every carbon has 4 bonds



fullerenes, nanotubes



every carbon has 3 neighbors
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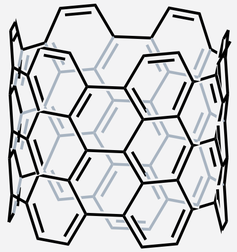
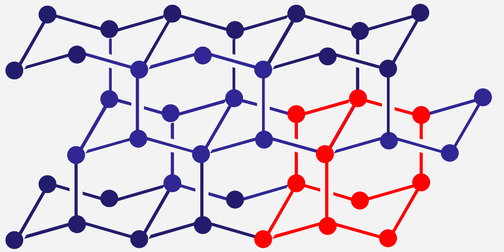
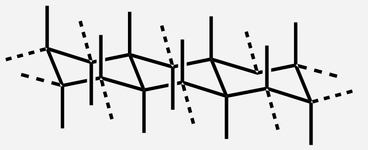


diamond



every carbon has 4 neighbors
every carbon has 4 bonds



- **carbon is always tetravalent (connected with four bonds to other atoms)**
- **coordination geometry: tetrahedral (4 neighbors), trigonal (3 neighbors), linear (2 neighbors)**

Learning Outcomes

- organic chemistry deals with molecular compounds of carbon
- carbon is always tetravalent
- carbon can attain different hybridization states, coordination geometries
- carbon forms covalent single, double, triple bonds to other atoms
- therefore, a vast array of binding options, molecular geometries
- carbon in stable molecules is always tetravalent
- carbon in stable molecules is really always tetravalent!