Physical Science

(GSI 2303)

Course Outline

Course Title: Physical Science (1-17 week/ 2024)

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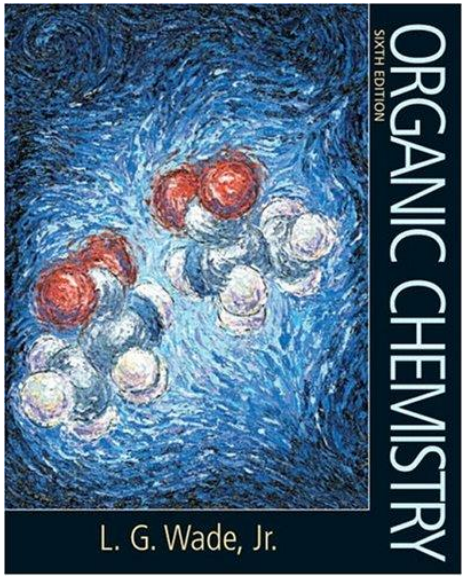
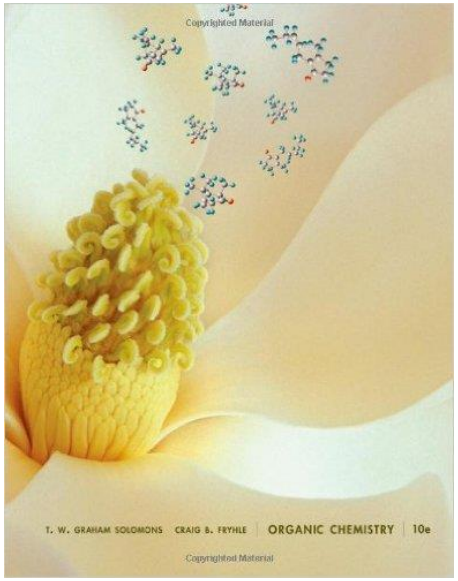
Course description

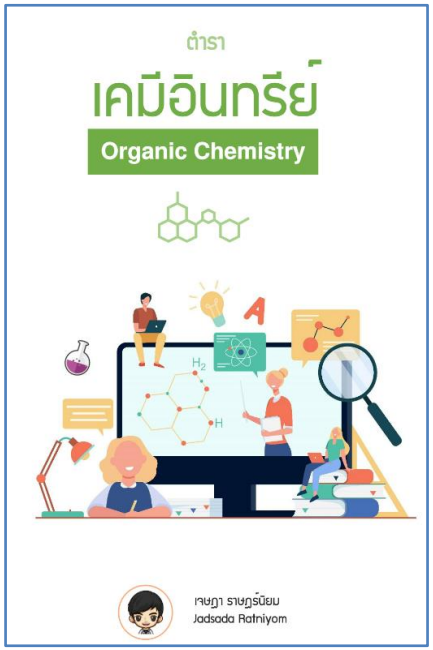
Structures; Functional groups; Naming; Stereochemistry; Chemical reactions and mechanism of chemical reactions of organic compounds such as hydrocarbons, aromatic compounds, and organic compounds with other functional groups such as alkyl, halide, alcohol, ether, aldehyde, ketone, carboxylic acid and derivatives, amine and anide.

Recommended textbooks for organic chemistry

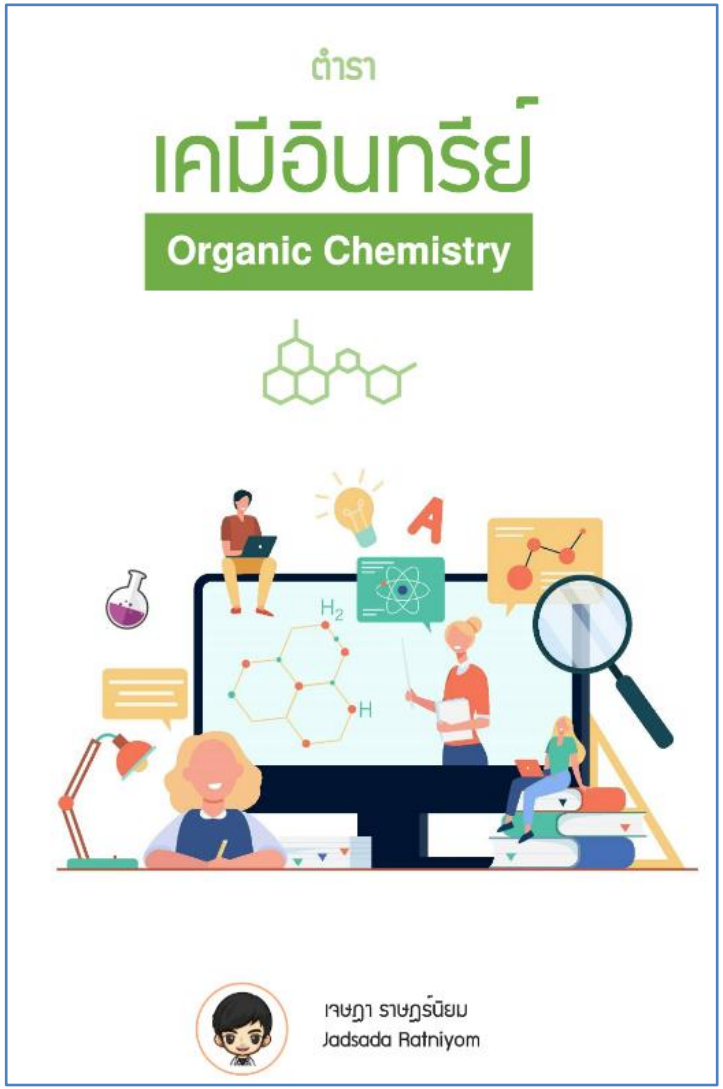
1. Wade, L.G. (2020) *Organic Chemistry.* Pearson.
2. Solomons, T. W. G.; Fryhle, C. (2020) *Organic Chemistry.* John Wiley & Sons.
3. Ratniyom, J. (2023). Organic Chemistry. Anyflip. https://anyflip.com/zoqcv/bnyv/







Recommended textbooks for organic chemistry



CHAPTER

1

Structure and Bonding

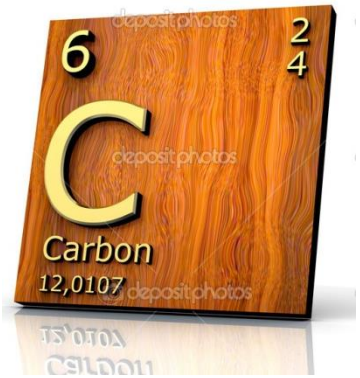
Review

This presentation was modified and used for academic purpose only. Picture and material were taken from references shown in the last page

Outline

- *Review*: Family of carbon compounds
  - + Hydrocarbon and Functional groups
- *Review*: Atomic Orbital
- Modes of Orbital Overlap
- Hybridization & Molecular Orbital
- *Review*: How to Write Structural Formulas
  - + Extended Formulas
  - + Condensed Formulas
  - + Bond line Formulas
  - + Three-Dimensional Formulas

Introduction of organic chemistry



1 1.01 H Hydrogen																	2 4.003 He Helium
3 6.94 Li Lithium	4 9.01 Be Beryllium											5 10.81 B Boron	6 12.01 C Carbon	7 14.01 N Nitrogen	8 15.999 O Oxygen	9 18.998 F Fluorine	10 20.18 Ne Neon
11 22.99 Na Sodium	12 24.31 Mg Magnesium											13 26.98 Al Aluminum	14 28.09 Si Silicon	15 30.97 P Phosphorus	16 32.06 S Sulfur	17 35.45 Cl Chlorine	18 39.95 Ar Argon
19 39.10 K Potassium	20 40.08 Ca Calcium	21 44.96 Sc Scandium	22 47.90 Ti Titanium	23 50.94 V Vanadium	24 51.996 Cr Chromium	25 54.94 Mn Manganese	26 55.85 Fe Iron	27 58.93 Co Cobalt	28 58.70 Ni Nickel	29 63.55 Cu Copper	30 65.37 Zn Zinc	31 69.72 Ga Gallium	32 72.59 Ge Germanium	33 74.92 As Arsenic	34 78.96 Se Selenium	35 79.90 Br Bromine	36 83.80 Kr Krypton
37 85.47 Rb Rubidium	38 87.62 Sr Strontium	39 88.91 Y Yttrium	40 91.22 Zr Zirconium	41 92.91 Nb Niobium	42 95.94 Mo Molybdenum	43 (98) Tc Technetium	44 101.07 Ru Ruthenium	45 102.91 Rh Rhodium	46 106.40 Pd Palladium	47 107.87 Ag Silver	48 112.41 Cd Cadmium	49 114.82 In Indium	50 118.69 Sn Tin	51 121.75 Sb Antimony	52 127.60 Te Tellurium	53 126.90 I Iodine	54 131.30 Xe Xenon
55 132.91 Cs Cesium	56 137.33 Ba Barium	57 138.91 La Lanthanum	72 178.49 Hf Hafnium	73 180.95 Ta Tantalum	74 183.85 W Tungsten	75 186.21 Re Rhenium	76 190.20 Os Osmium	77 192.22 Ir Iridium	78 195.09 Pt Platinum	79 196.97 Au Gold	80 200.59 Hg Mercury	81 204.37 Tl Thallium	82 207.19 Pb Lead	83 208.98 Bi Bismuth	84 (209) Po Polonium	85 (210) At Astatine	86 (222) Rn Radon
87 (223) Fr Francium	88 226.03 Ra Radium	89 227.03 Ac Actinium	104 (261) Rf Rutherfordium	105 (262) Ha Hahnium	106 (266) Sg Seaborgium	107 (262) Bh Bohrium	108 (265) Hs Hassium	109 (266) Mt Meitnerium	110 (271)	111 (272)	112 (277)	(113)	114 (285)	(115)	116 (289)	(117)	118 (293)

Lanthanide series ▸	58 140.12 Ce Cerium	59 140.91 Pr Praseodymium	60 144.24 Nd Neodymium	61 (145) Pm Promethium	62 150.40 Sm Samarium	63 151.96 Eu Europium	64 157.25 Gd Gadolinium	65 158.93 Tb Terbium	66 162.50 Dy Dysprosium	67 164.93 Ho Holmium	68 167.26 Er Erbium	69 168.93 Tm Thulium	70 173.04 Yb Ytterbium	71 174.97 Lu Lutetium
Actinide series ▸	90 232.04 Th Thorium	91 231.04 Pa Protactinium	92 238.03 U Uranium	93 237.05 Np Neptunium	94 (244) Pu Plutonium	95 (243) Am Americium	96 (247) Cm Curium	97 (247) Bk Berkelium	98 (251) Cf Californium	99 (252) Es Einsteinium	100 (257) Fm Fermium	101 (260) Md Mendelevium	102 (259) No Nobelium	103 (262) Lr Lawrencium

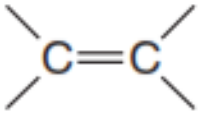
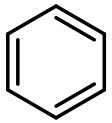
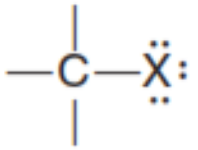
- Organic chemistry is the chemistry of carbon compounds.

Family of carbon compounds

Hydrocarbons are compounds that contain only carbon and hydrogen atoms.

Functional groups are common and specific arrangements of atoms that impart predictable reactivity and properties to a molecule.

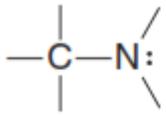
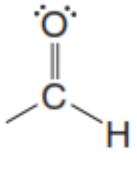
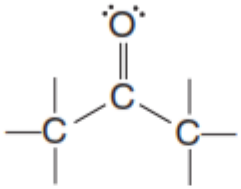
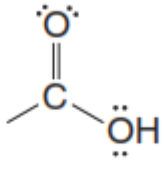
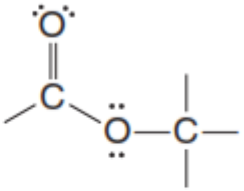
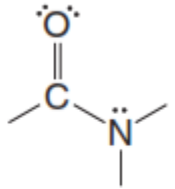
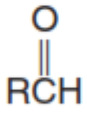
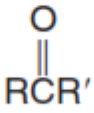
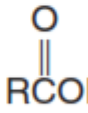
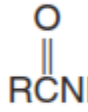
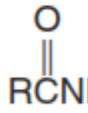
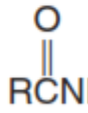
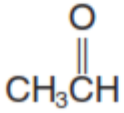
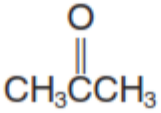
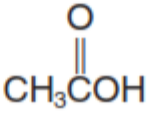
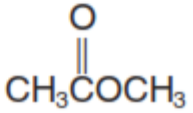
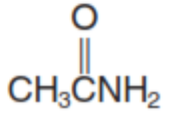
Hydrocarbons

	Family				
	Alkane	**Alkene**	**Alkyne**	**Aromatic**	**Haloalkane**
Functional group	C—H and C—C bonds		—C≡C—	Aromatic ring 	
General formula	RH	$RCH{=}CH_2$ $RCH{=}CHR$ $R_2C{=}CHR$ $R_2C{=}CR_2$	$RC{\equiv}CH$ $RC{\equiv}CR$	ArH	RX
	C_nH_{2n+2}	C_nH_{2n}	C_nH_{2n-2}		

R = alkyl group (C_nH_{2n+1})

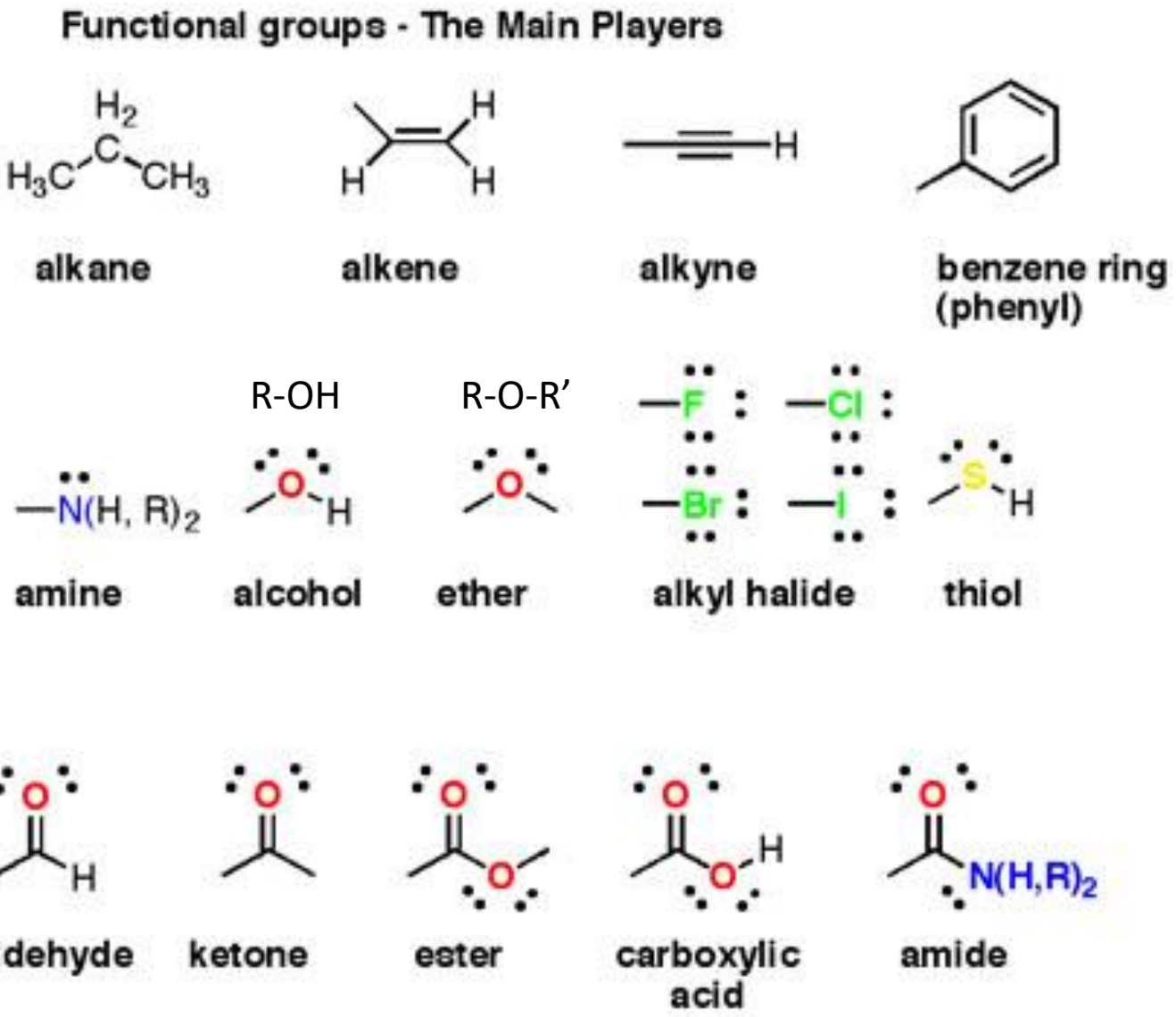
Solomons, T. W. G.; Fryhle, C. (2014) *Organic Chemistry.* John Wiley & Sons.

Functional groups

	Family					
	Amine	Aldehyde	Ketone	Carboxylic Acid	Ester	Amide
Functional group						
General formula	RNH_2 R_2NH R_3N					  
Specific example	CH_3NH_2					

Solomons, T. W. G.; Fryhle, C. (2014) *Organic Chemistry.* John Wiley & Sons.

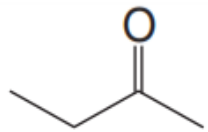
SUMMARY | organic molecules



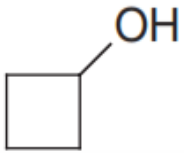
Sample Problem

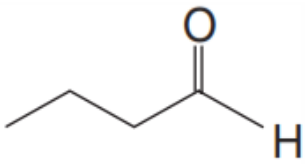
Problem

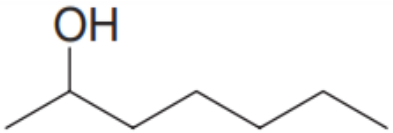
จงระบุว่าสารต่อไปนี้เป็นสารประเภทใด alkane, alkene, alkyne, aromatic , alcohol, ฯลฯ

(a) 

(b) $CH_3—C{\equiv}CH$

(c) 

(d) 

(e) 

Obtained from oil of cloves

(f) 

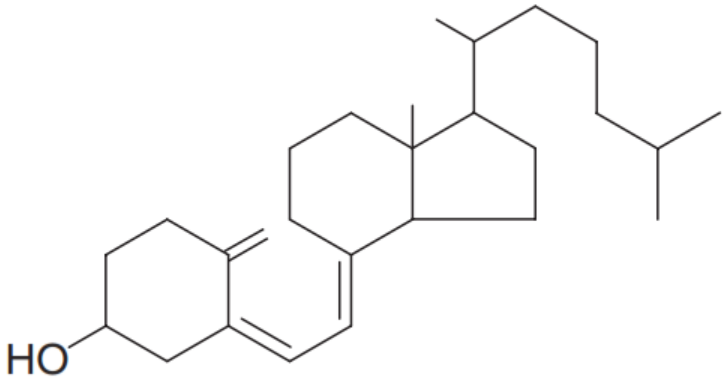
Sex attractant of the common housefly

Solomons, T. W. G., & Fryhle, C. (2014). *Organic Chemistry*: John Wiley & Sons.

Sample Problem

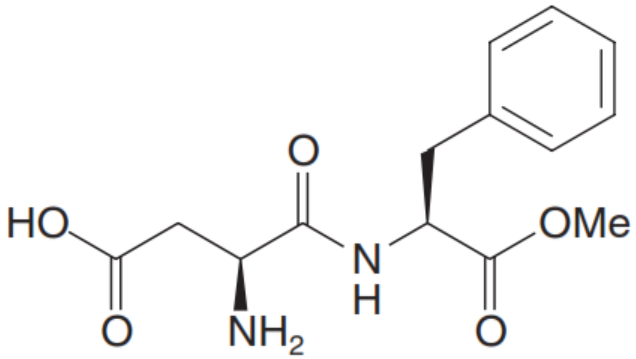
Problem จงวงกลมล้อมรอบหมู่ฟังก์ชันพร้อมระบุชื่อหมู่ฟังก์ชันให้ได้มากที่สุด

(a)



Vitamin D_3

(b)

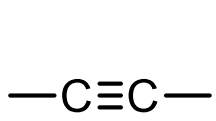


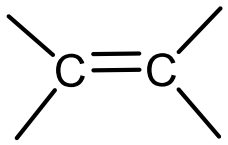
Aspartame

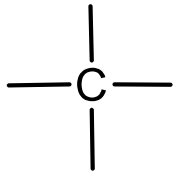
Solomons, T. W. G., & Fryhle, C. (2014). *Organic Chemistry*: John Wiley & Sons.

Hybridized

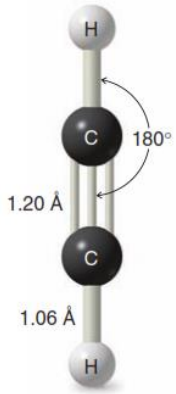
Carbon atom

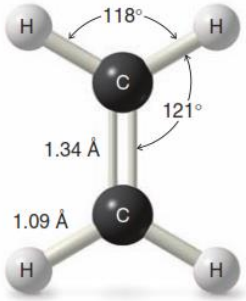


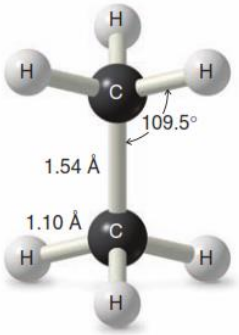




sp ***sp²*** ***sp³***







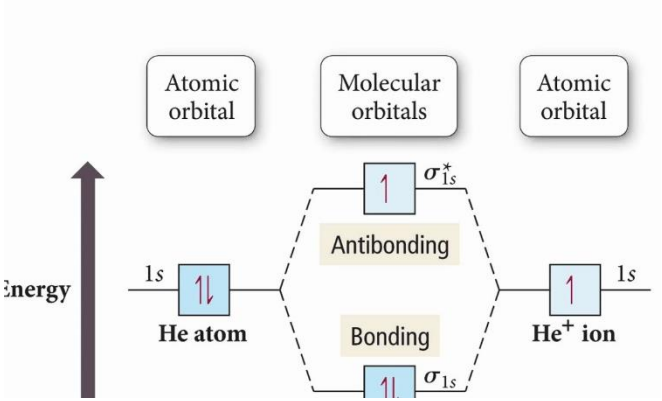
VALENCE BOND (VB) THEORY

1) Hybridization

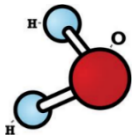
- ❑ The Central Themes of VB Theory
- ❑ Types of Hybrid Orbitals

sp sp^2 sp^3 sp^3d sp^3d^2

2) Molecular orbital theory



Silberberg, M.; Amateis, P. *Chemistry The Molecular Nature of Matter and Change 7th edition*; McGraw-Hill Science, 2014.



Hybrid Orbitals

Key Points (form during bonding)

- The number of hybrid orbitals obtained equals the number of atomic orbitals mixed.
- The type of hybrid orbitals obtained varies with the types of atomic orbitals mixed.
- The *shape* and *orientation* of a hybrid orbital *maximizes* its overlap with the other atom in the bond.

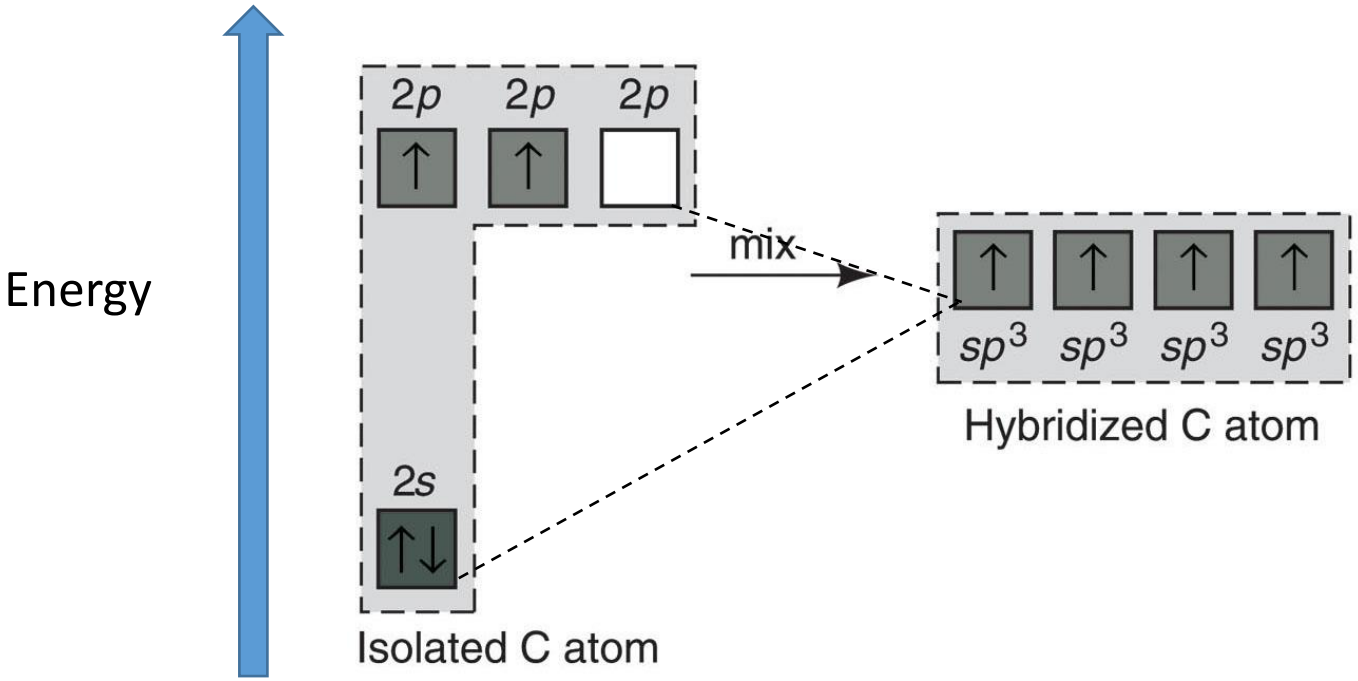
Types of Hybrid Orbitals

sp sp^2 sp^3 sp^3d sp^3d^2

Silberberg, M.; Amateis, P. *Chemistry The Molecular Nature of Matter and Change 7th edition*; McGraw-Hill Science, 2014.

sp^3 Hybridization (sp^3 Carbon)

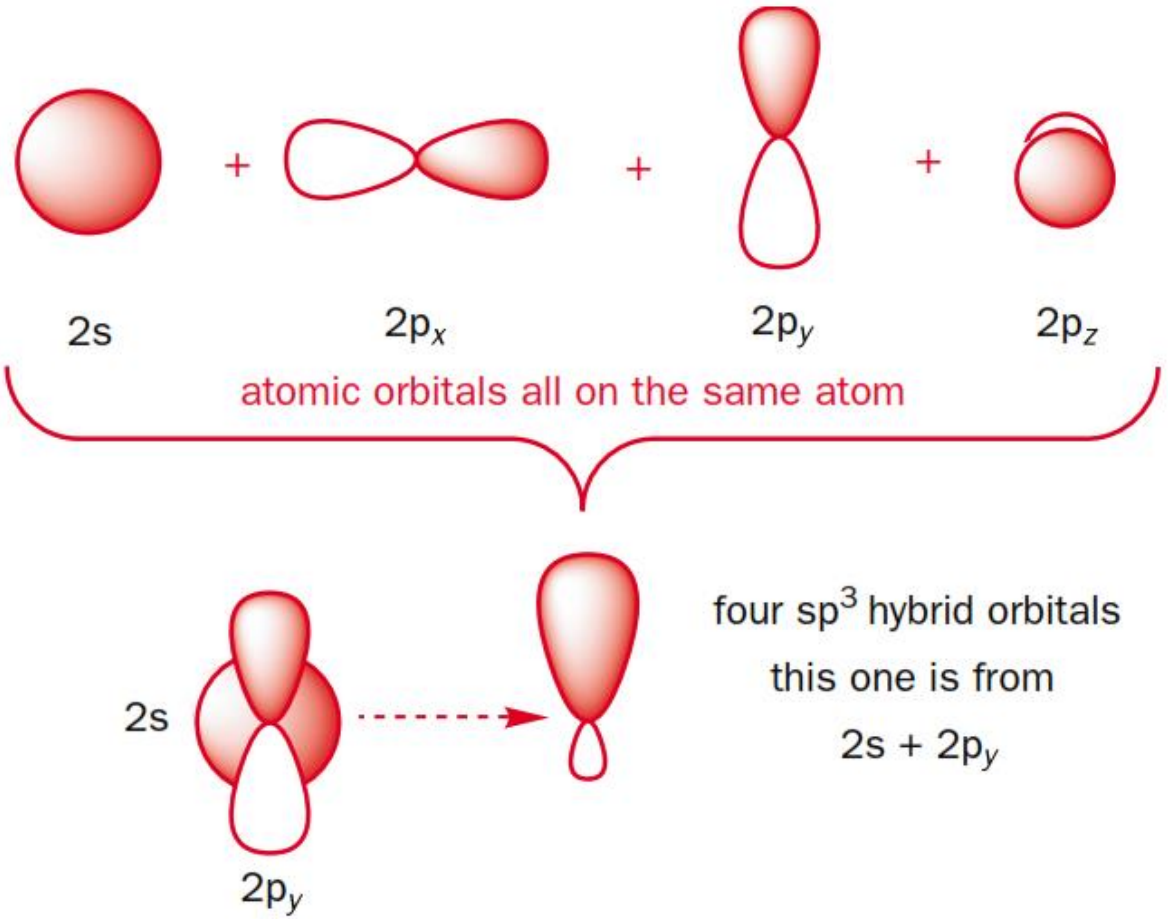
Mixing one s and three p orbitals gives four sp^3 hybrid orbitals that point to the corners of a tetrahedron (109.5 °).

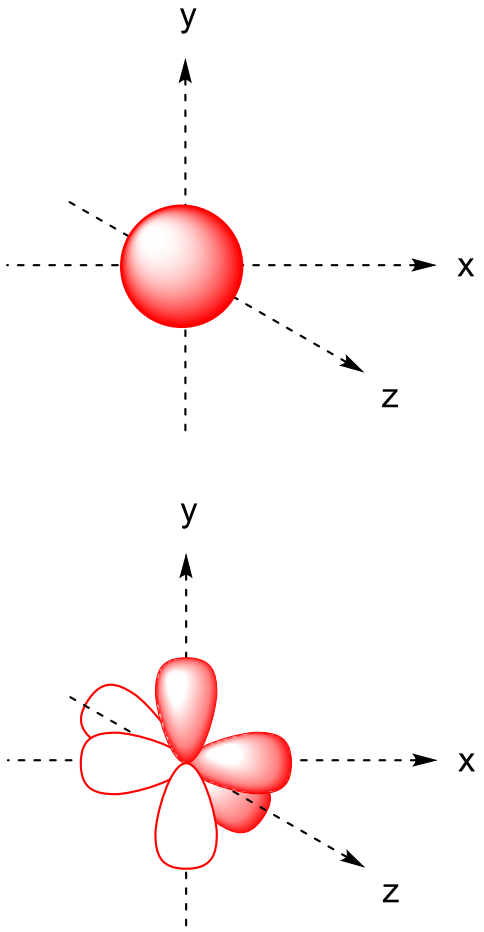


orbital energy-level diagram for the formation of sp^3 *hybrid* orbitals

Silberberg, M.; Amateis, P. *Chemistry The Molecular Nature of Matter and Change 7th edition*; McGraw-Hill Science, 2014.

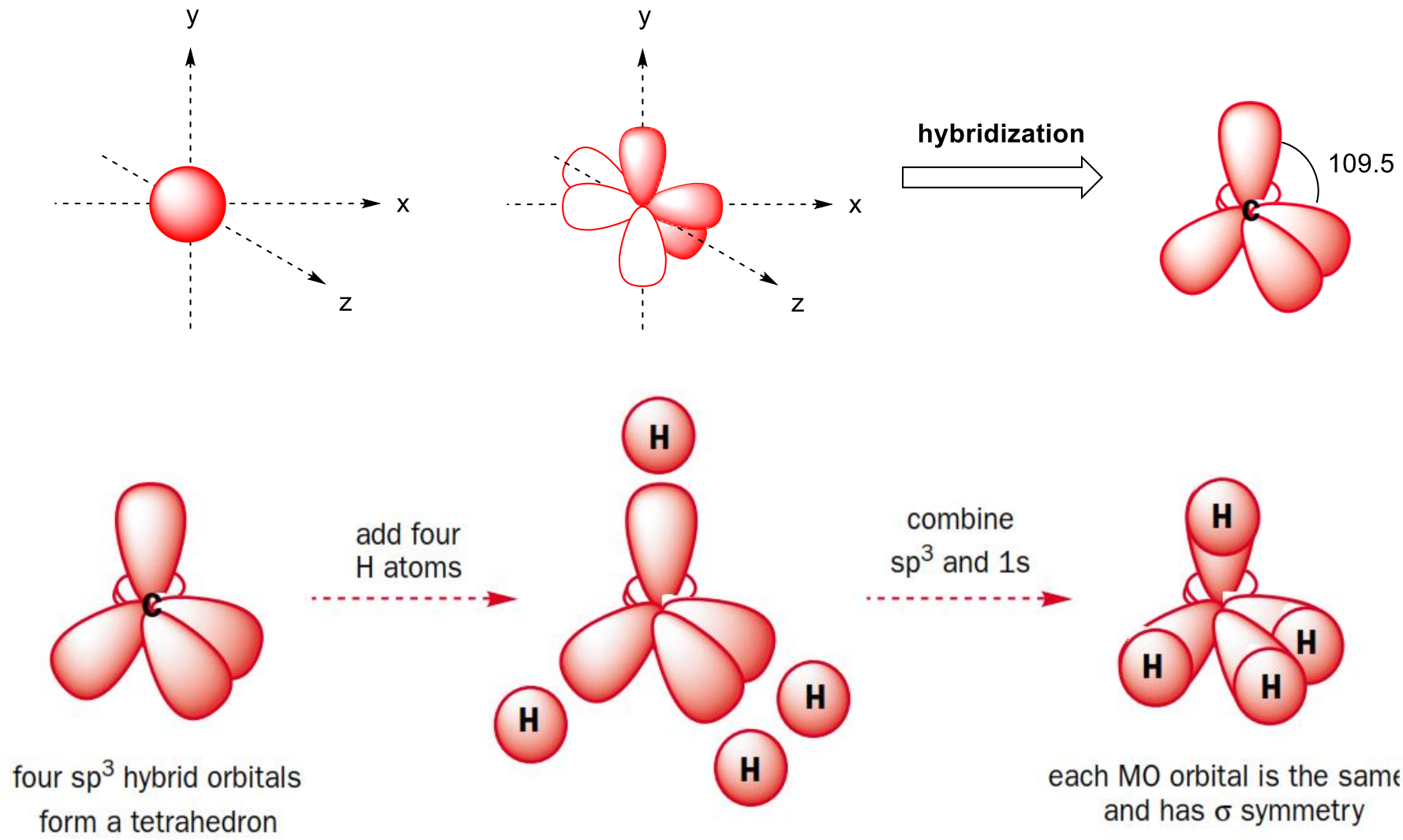
sp^3 Hybridization





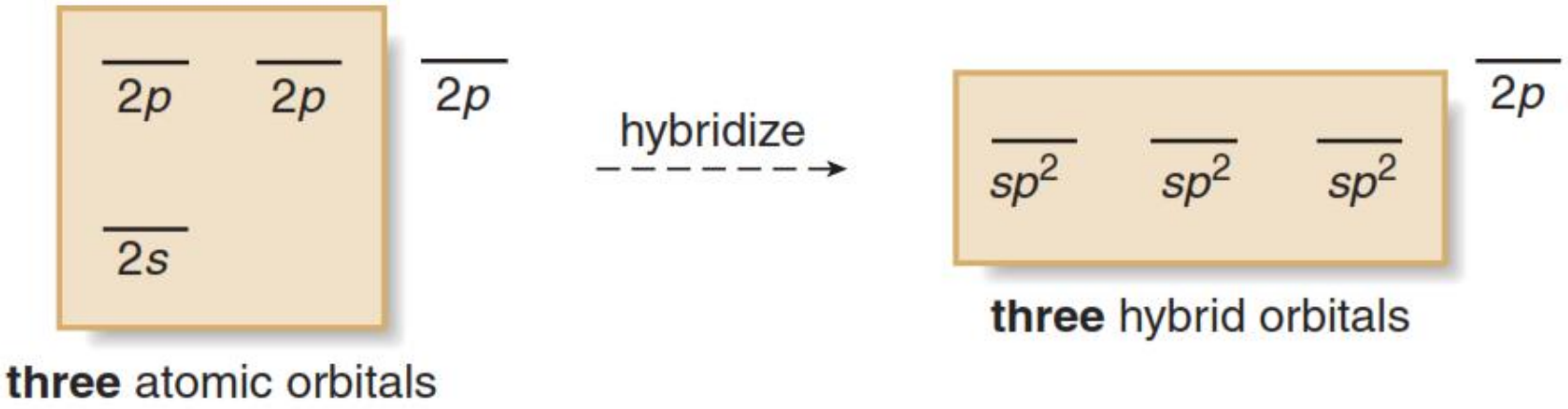
Clayden, J.; Greeves, N.; Warren, S. *Organic Chemistry*; OUP Oxford, 2012.

sp^3 Hybridization



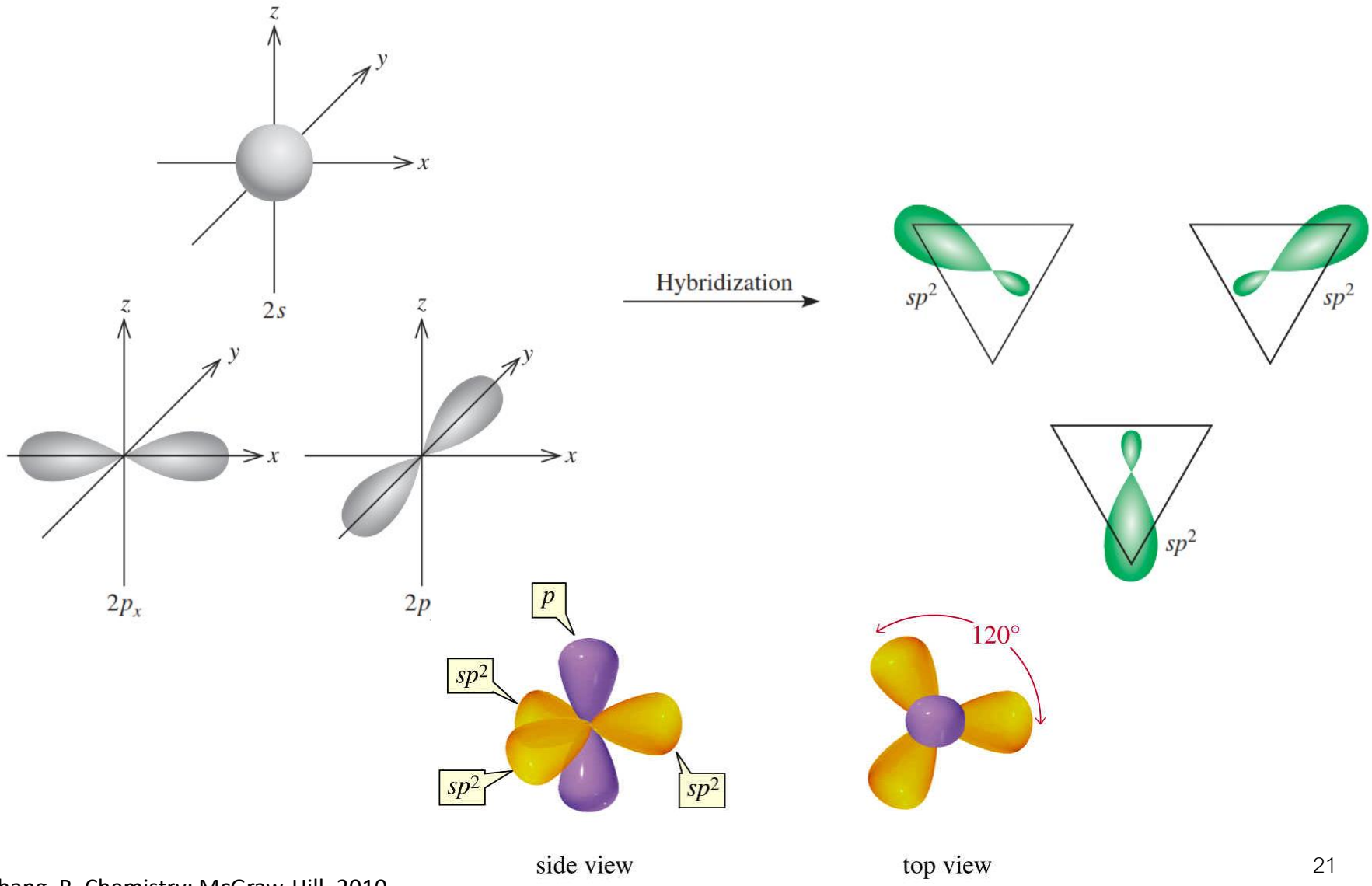
Clayden, J.; Greeves, N.; Warren, S. *Organic Chemistry*; OUP Oxford, 2012.

sp^2 Hybridization



- Forming three sp^2 hybrid orbitals uses one 2s and two 2p orbitals, leaving one 2p orbital unhybridized.

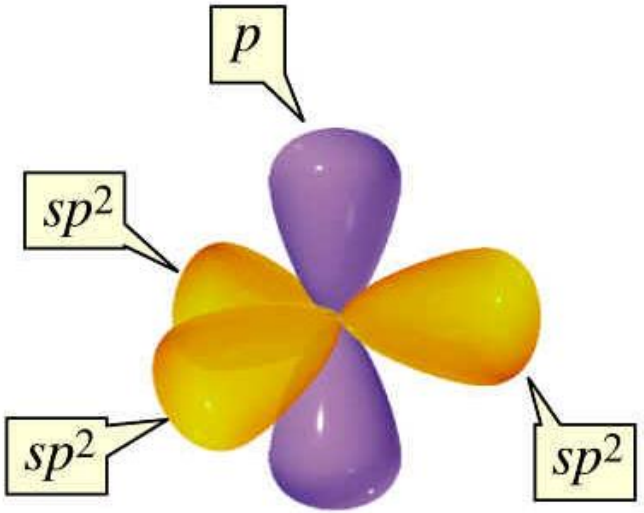
The sp^2 hybrid orbitals



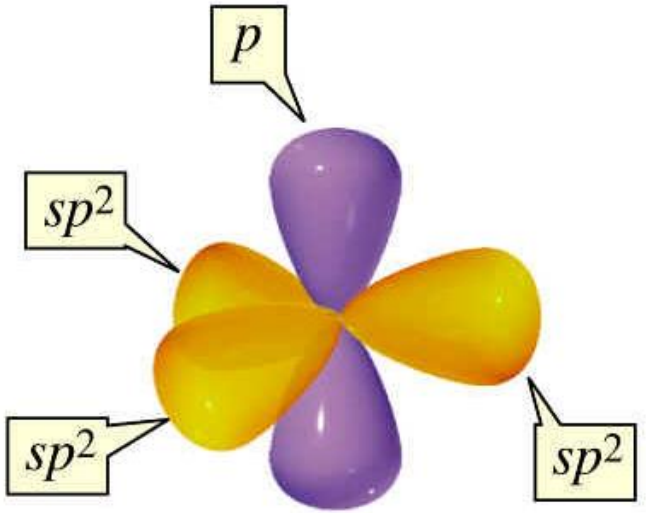
Chang, R. Chemistry; McGraw-Hill, 2010.

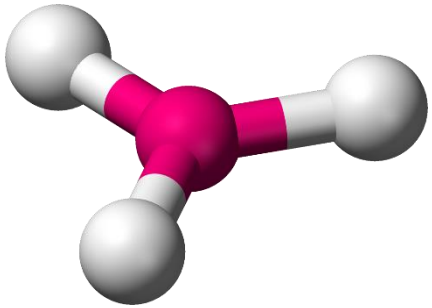
The sp^2 hybrid orbitals

Trigonal planar

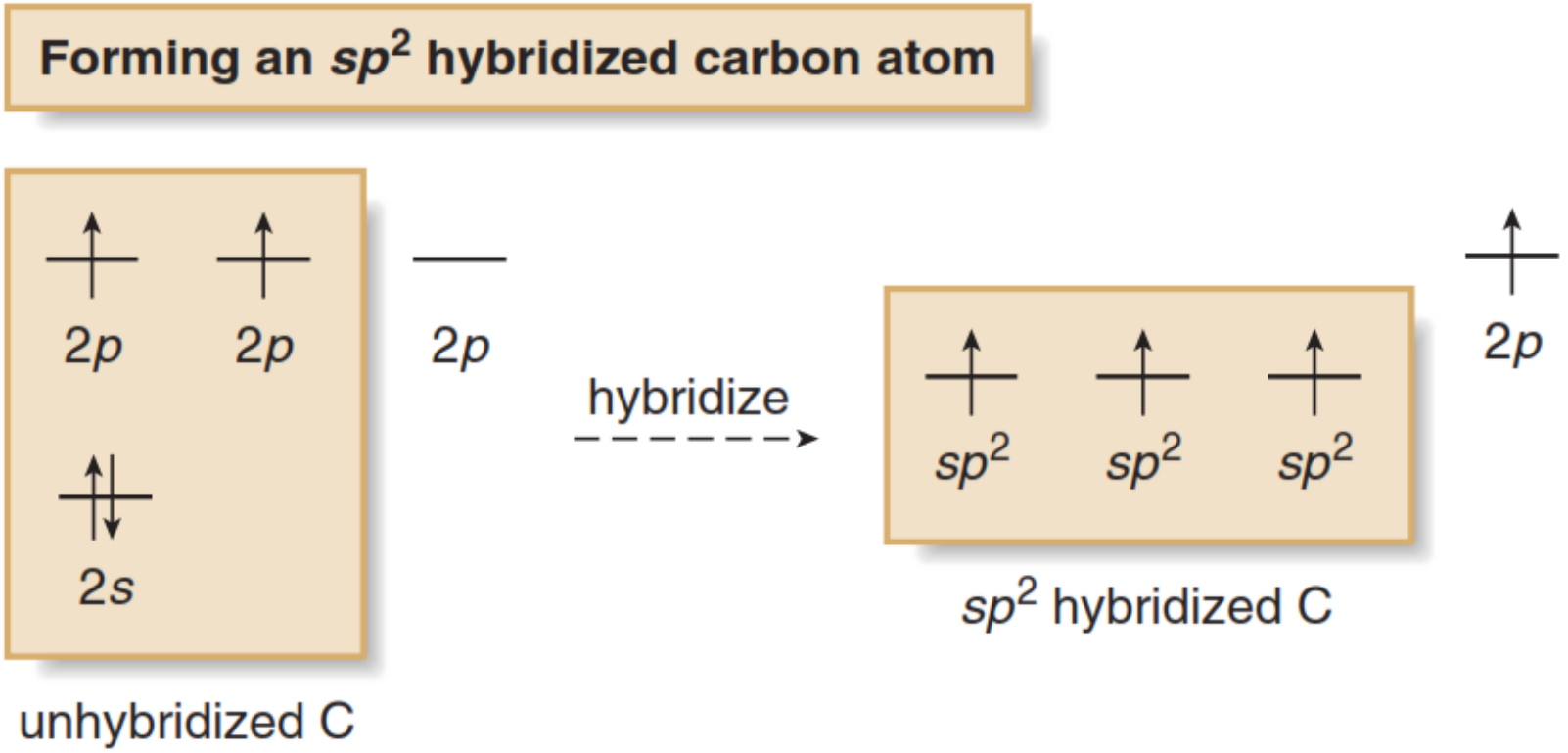


Bent (120)



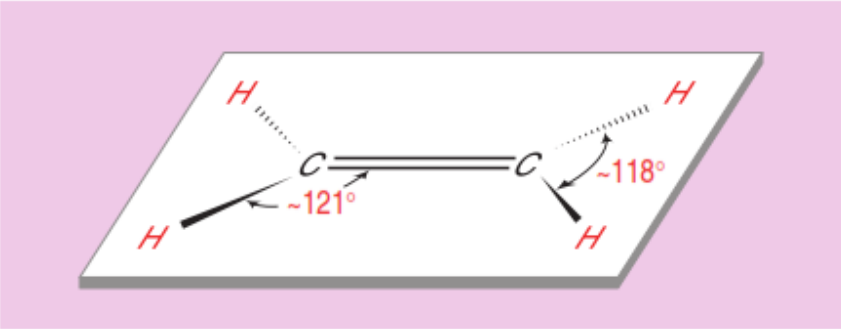


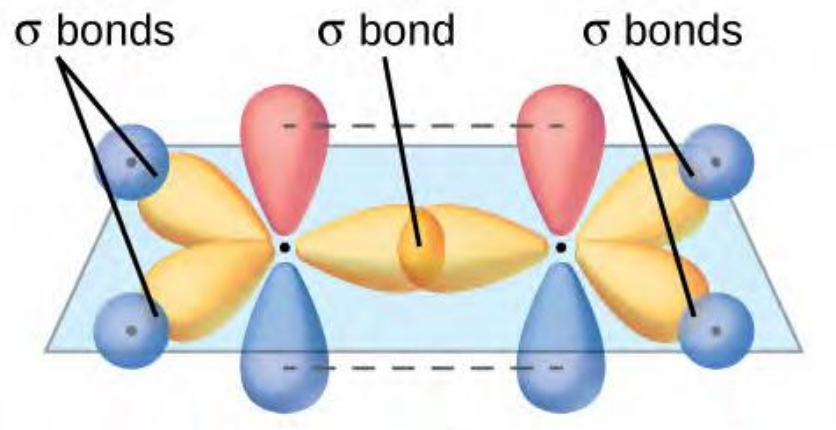
sp^2 Hybridized carbon atom



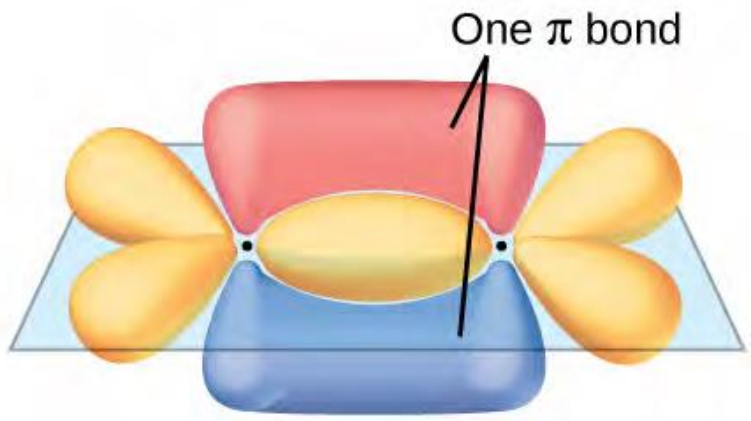
- Forming three sp^2 hybrid orbitals uses one 2s and two 2p orbitals, leaving one 2p orbital unhybridized.

sp^2-hybridized carbon atom in Ethylene

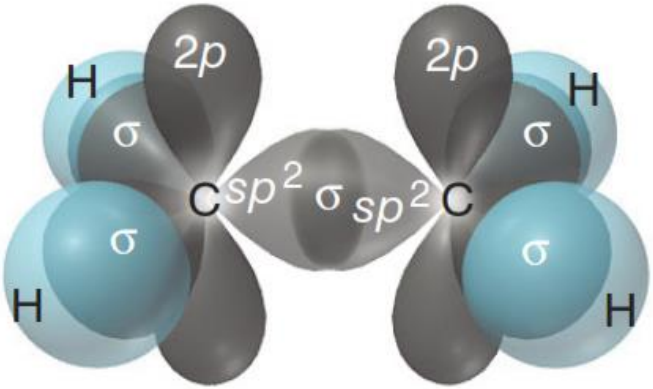




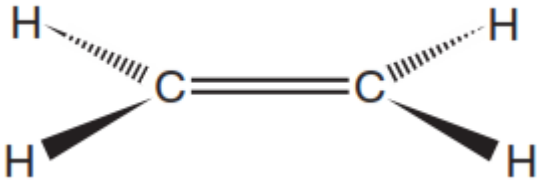
- Two sp^2-hybridized carbon atoms form a **sigma(σ) bond** between them by overlap of one sp^2 orbital from each carbon.
- The remaining carbon sp^2 orbitals form *sigma* bonds to four hydrogens through overlap with the hydrogen 1s orbitals.

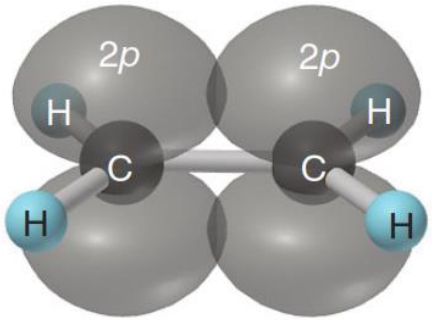


The π and σ bonds in ethylene (C_2H_4).



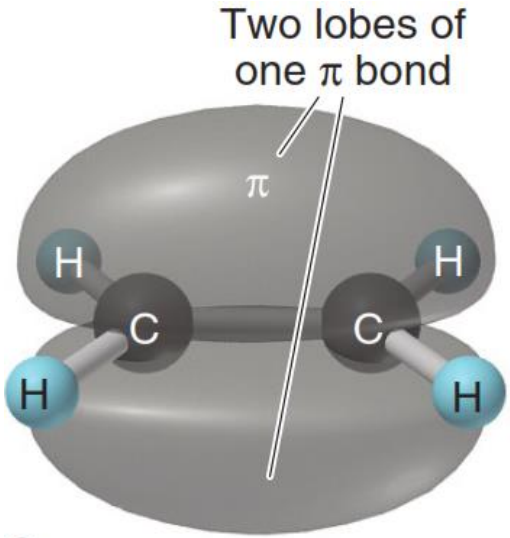
A





B

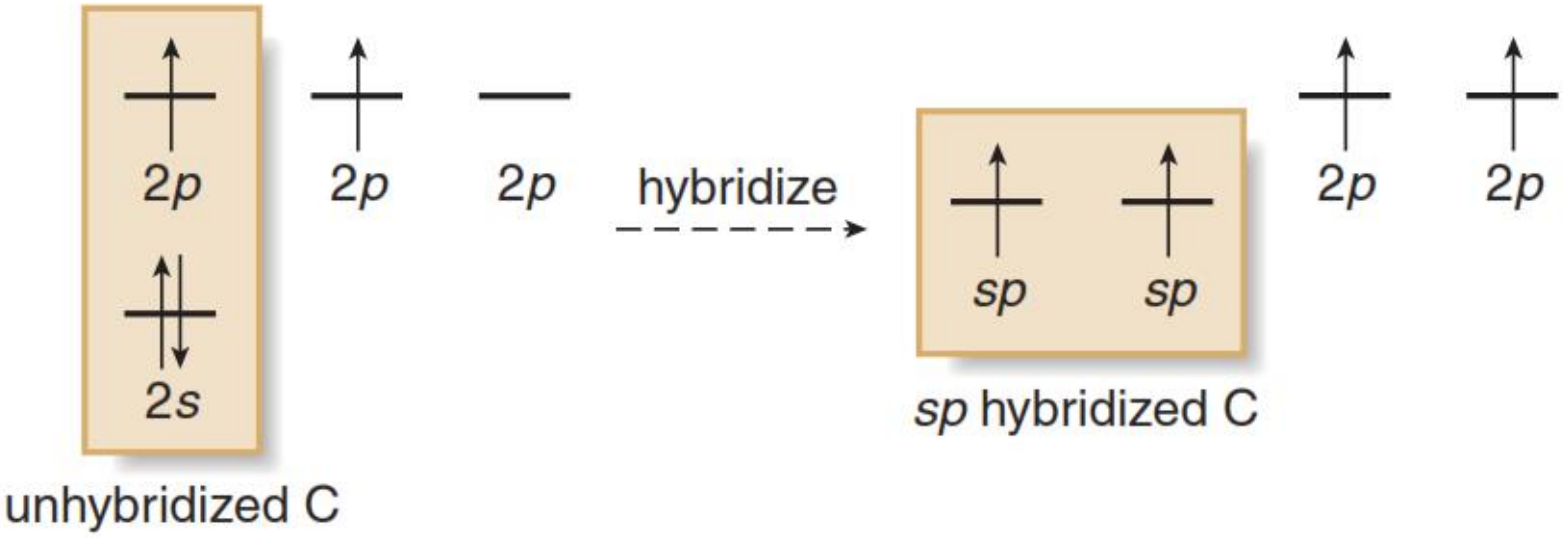
ethylene



C

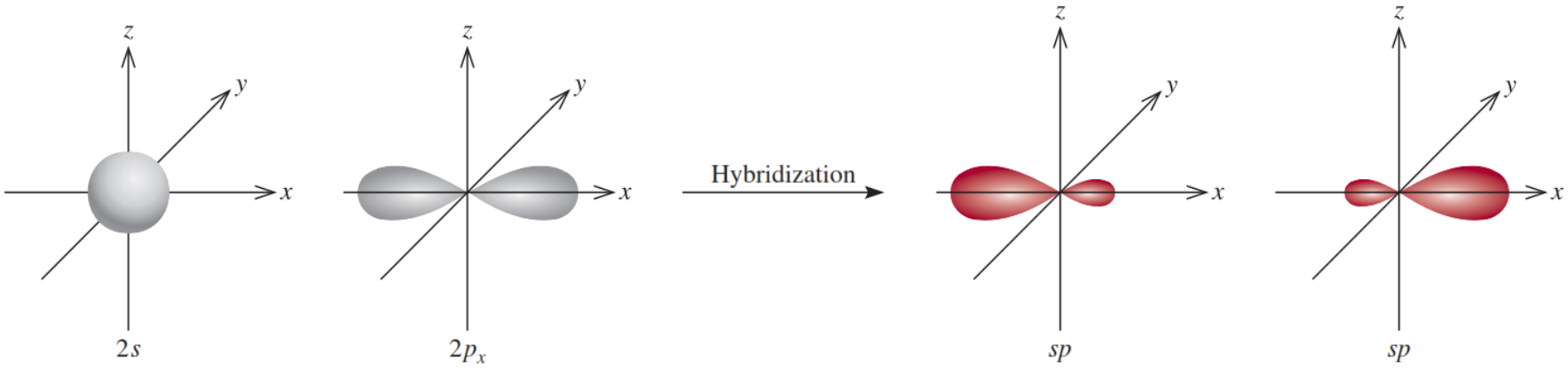
Silberberg, M.; Amateis, P. *Chemistry The Molecular Nature of Matter and Change 7th edition*; McGraw-Hill Science, 2014.

sp Hybridized carbon atom

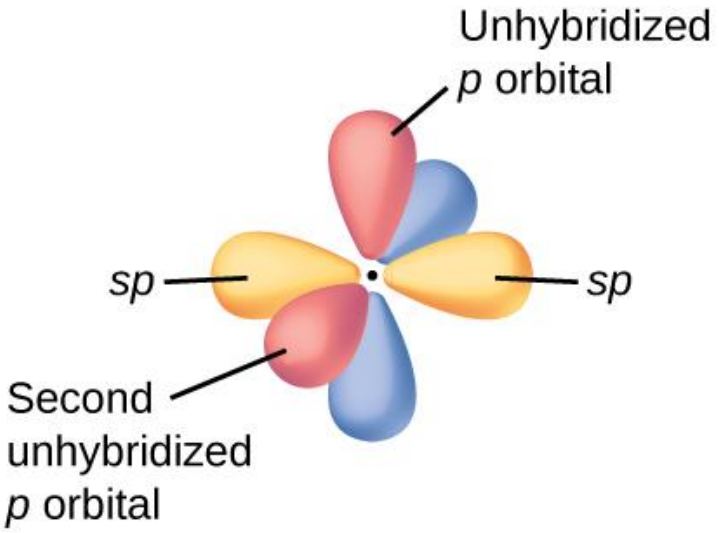


- ***sp hybrid orbitals*** are formed from one 2s and one 2p orbital, leaving two 2p orbitals unhybridized.
- Because carbon has four valence electrons, each of these orbitals has one electron that can be used to form a bond.

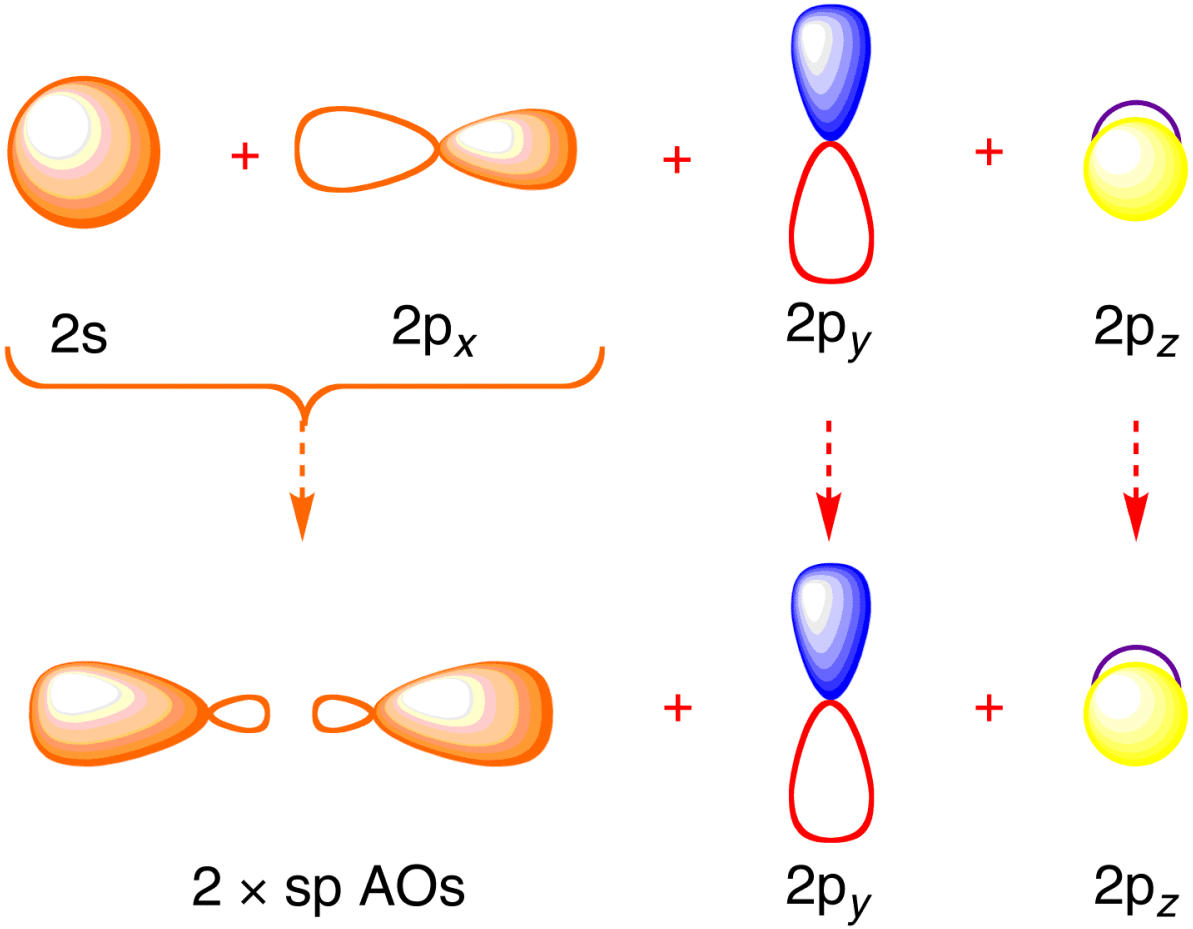
sp Hybridization



Chang, R. Chemistry; McGraw-Hill, 2010.

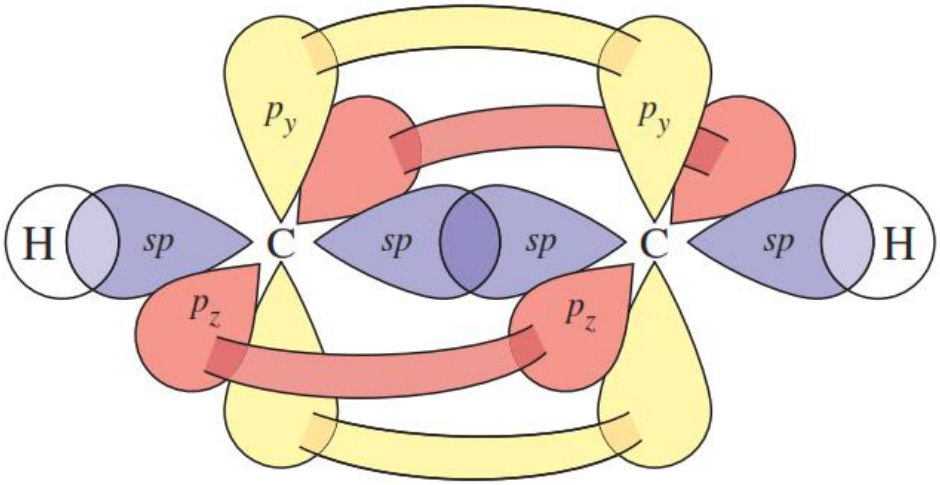


sp Hybridization

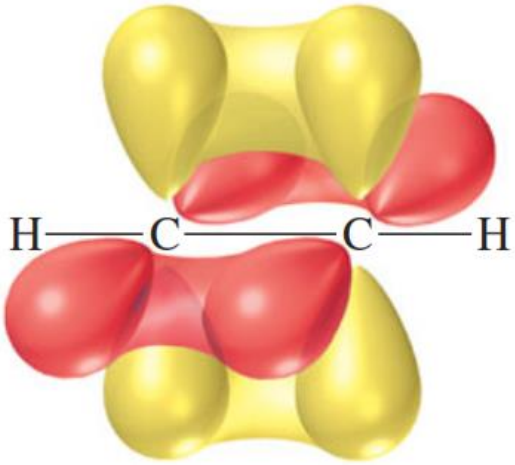


two p orbitals are unchanged

Orbital hybridization (sp-hybridization)



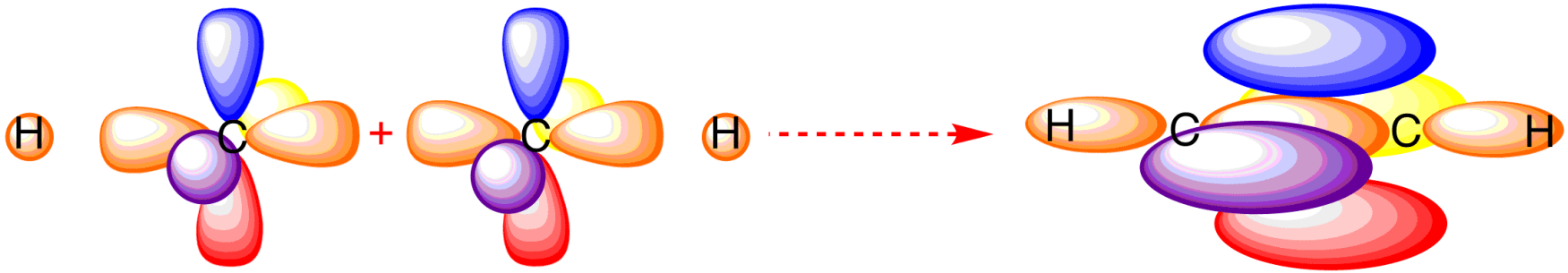
acetylene



acetylene

- Two carbon atoms overlap **sp orbitals** to form a **sigma bond** between them.
- The two p orbitals on each carbon atom also overlap side to side to form two π bonds. These are the other two bonds of the triple bond.

Orbital hybridization (sp-hybridization)



2sp hybridized carbon atoms

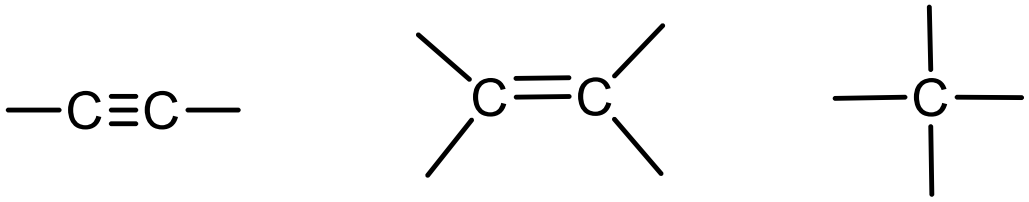
$2p_y$ and $2p_z$ orbitals remain

linear σ bonds form skeleton

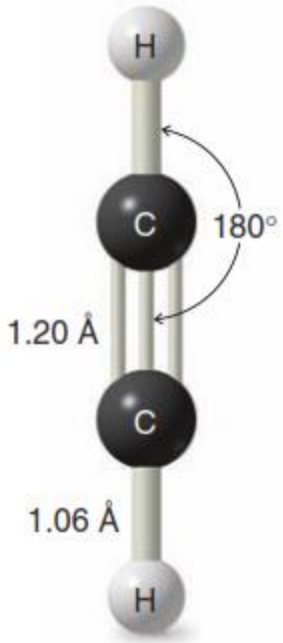
two perpendicular π bonds

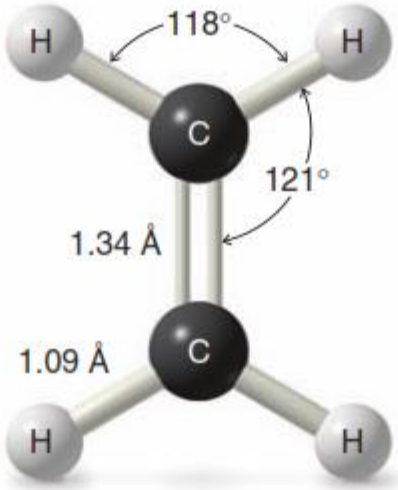
H—C≡C—H

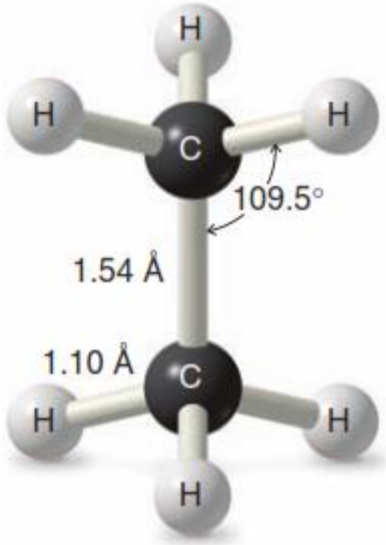
Summary: Hybridized carbon atom



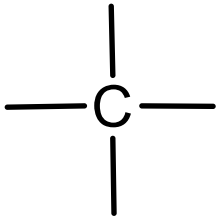
sp ***sp²*** ***sp³***

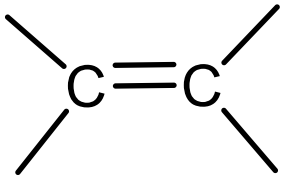


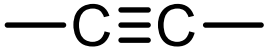




Summary: Hybridized carbon atom





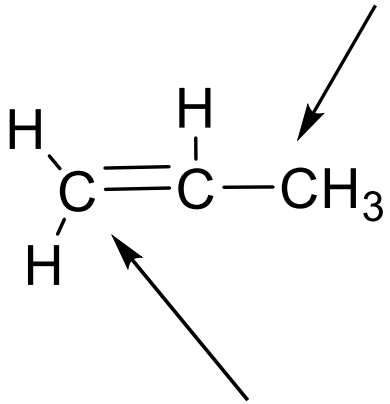


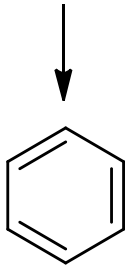
	sp^3	sp^2	sp
Bond length	1	2	3
Bonding energy	3	2	1

Sample Problem

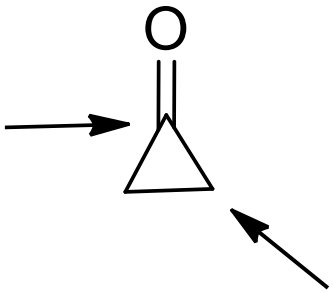
Problem

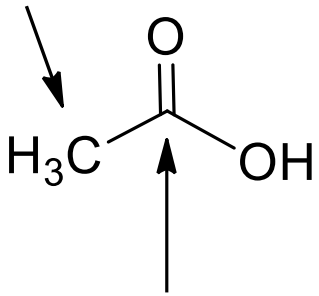
จงระบุไฮบริดออบิทอร์ตรงจุดที่ลูกศรชี้ ของสารต่อไปนี้ พร้อมระบุจำนวนพันธะไพน์และ sigma bond





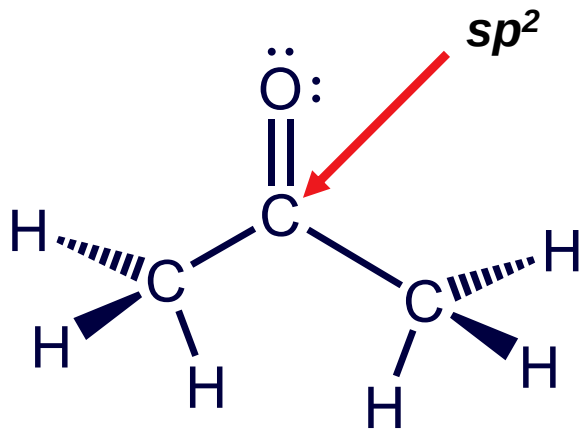
HCN



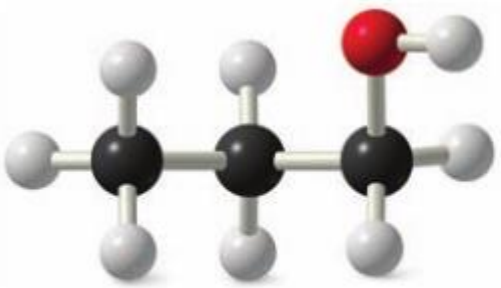


Sample Problem

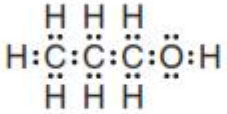
PROBLEM: จงทำนายว่า C ตรงจุดที่ลูกศร ชี้มี hybridization แบบใด และเขียน orbital energy-level diagram อธิบายการเกิด hybridization นั้น



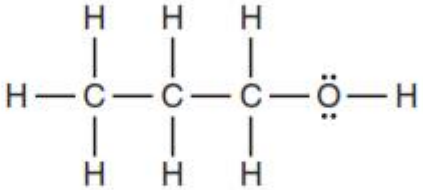
How to write Structural Formulas



Ball-and-stick model
(*a*)



Dot formula
(*b*)



Dash formula
(*c*)

$CH_3CH_2CH_2\ddot{O}H$

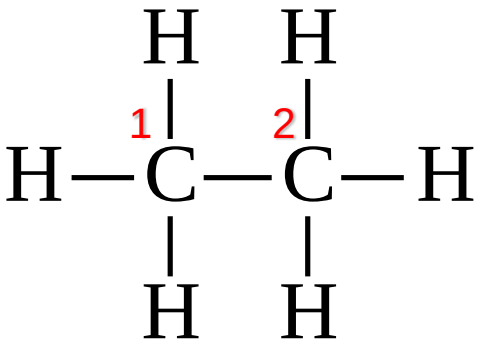
Condensed formula
(*d*)

Bond-line formula
(*e*)

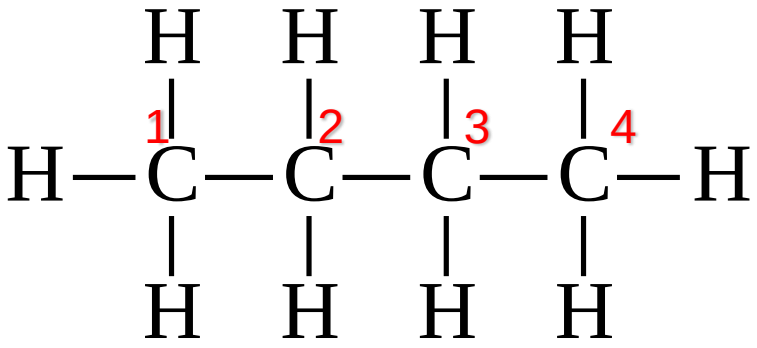
Wade, L.G. (2013) *Organic Chemistry.* Pearson.

Structures and Formulas

Extended **Condensed** (สูตรแบบย่อ)



CH_3CH_3



1 2 3 4

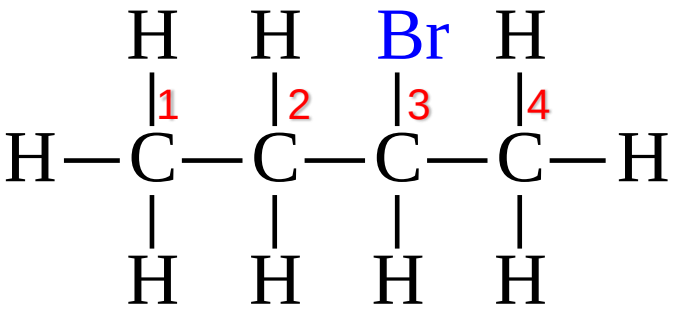
$CH_3CH_2CH_2CH_3$

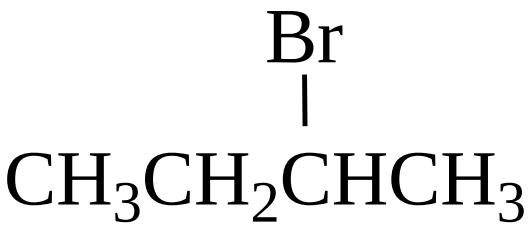
Wade, L.G. (2013) *Organic Chemistry.* Pearson.

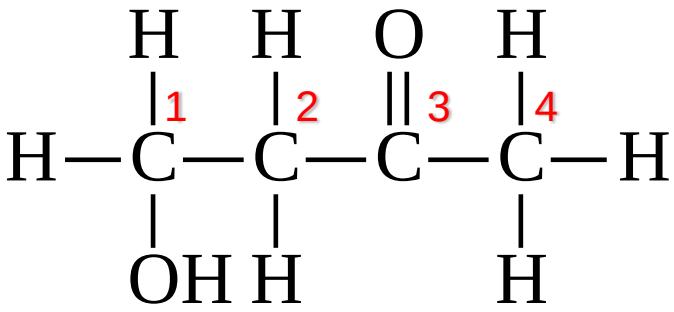
Structures and Formulas

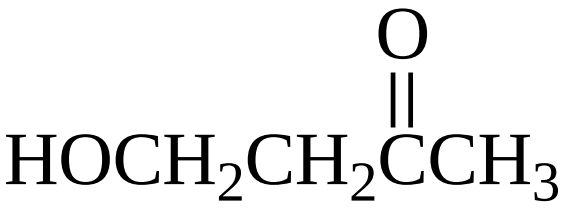
Extended

Condensed (สูตรแบบย่อ)



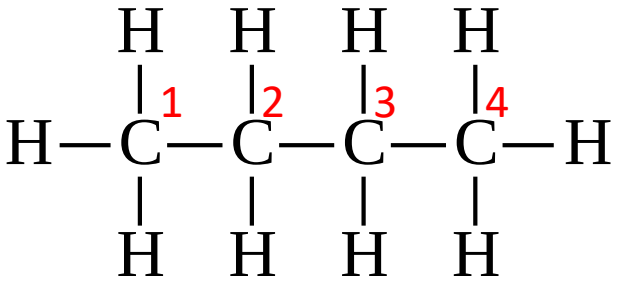


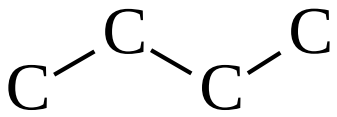


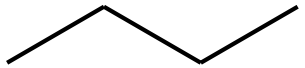


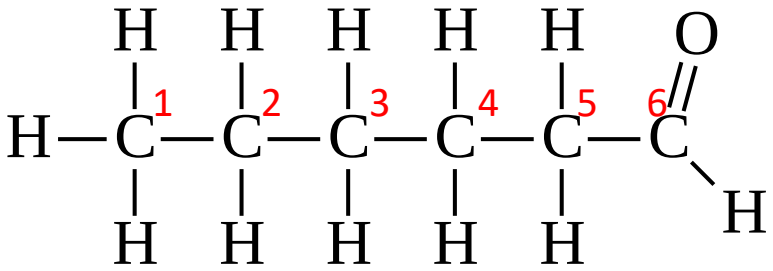
Wade, L.G. (2013) *Organic Chemistry.* Pearson.

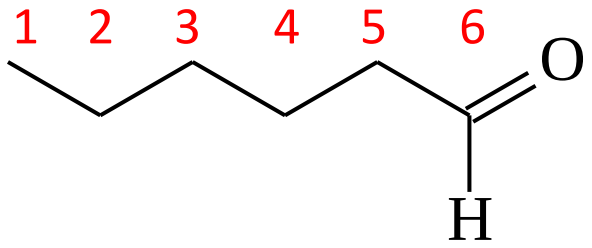
Bond line Formulas (สูตรแบบเส้น)











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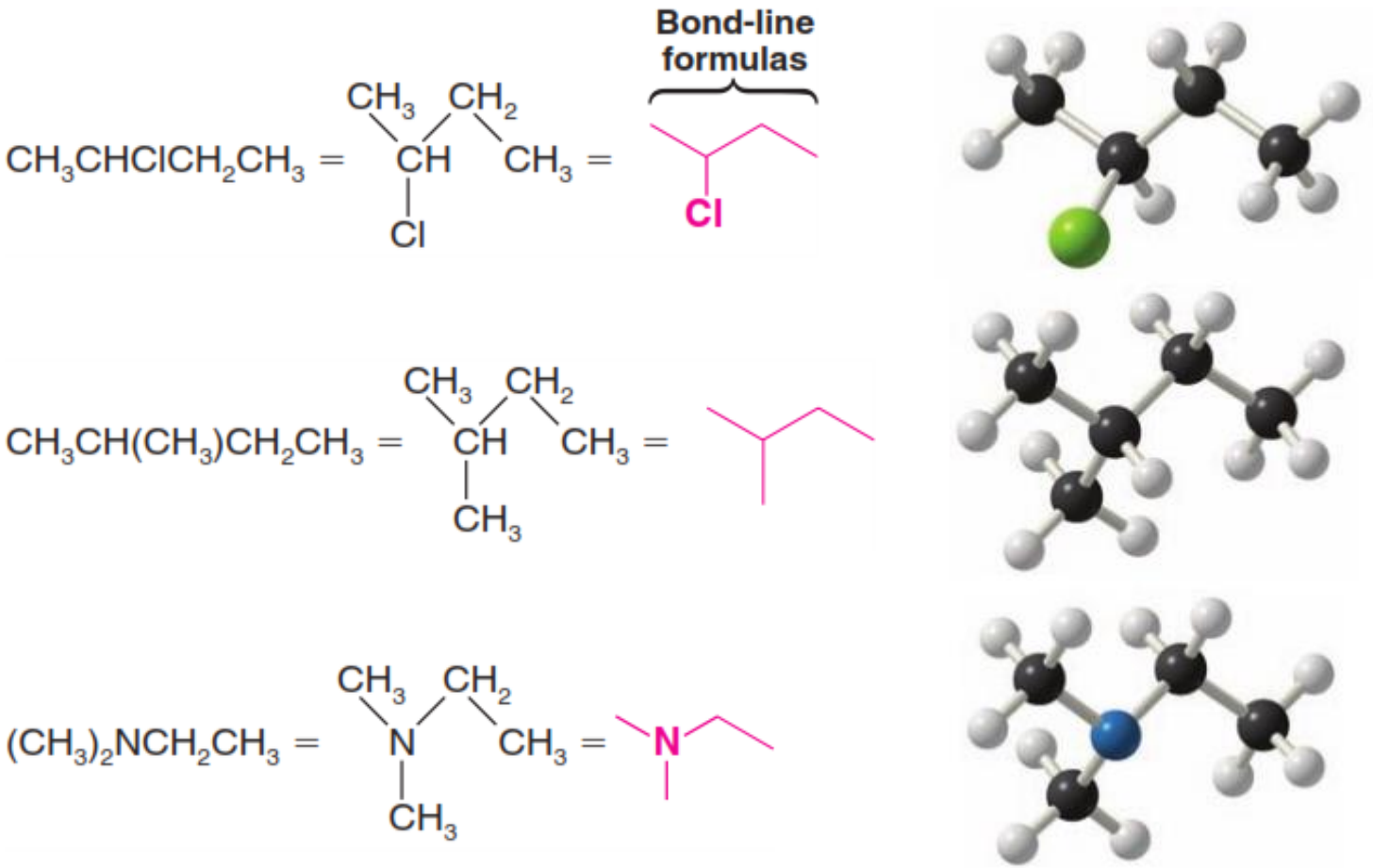
Bond line Formulas (สูตรแบบเส้น)



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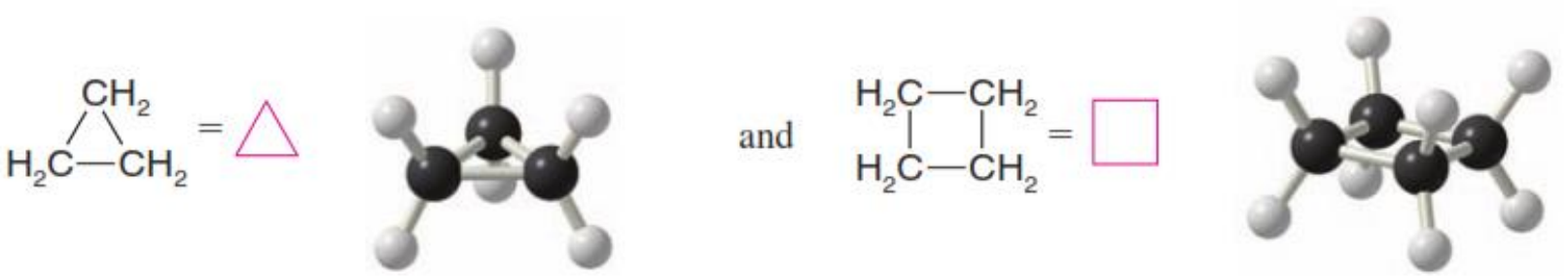
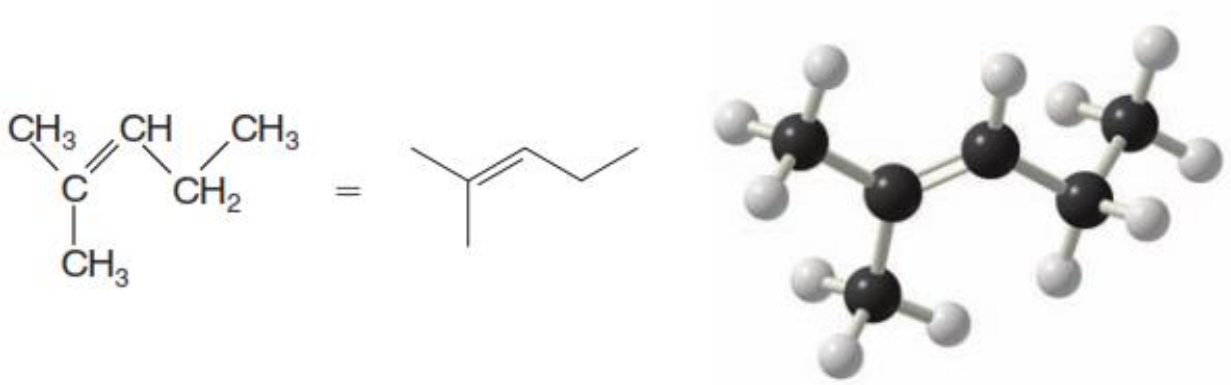
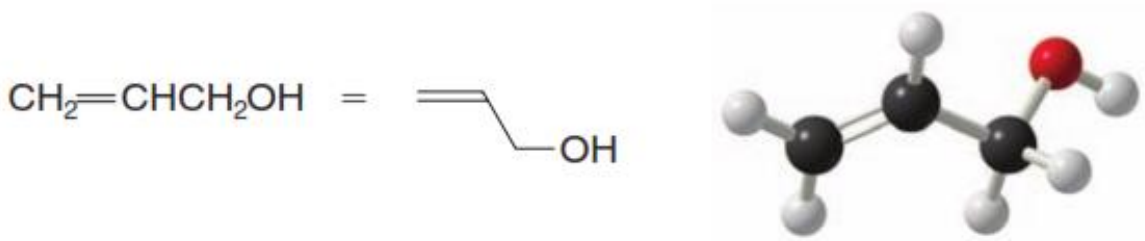
Bond line Formulas (สูตรแบบเส้น)

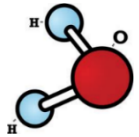






Wade, L.G. (2013) *Organic Chemistry.* Pearson.

Sample Problem



Problem จงเขียนสูตรแบบเส้น (bond-line formula) จากสารต่อไปนี้

(a) $(CH_3)_2CHCH_2CH_3$

(b) $(CH_3)_2CHCH_2CH_2OH$

(c) $(CH_3)_2C{=}CHCH_2CH_3$

(d) $CH_3CH_2CH_2CH_2CH_3$

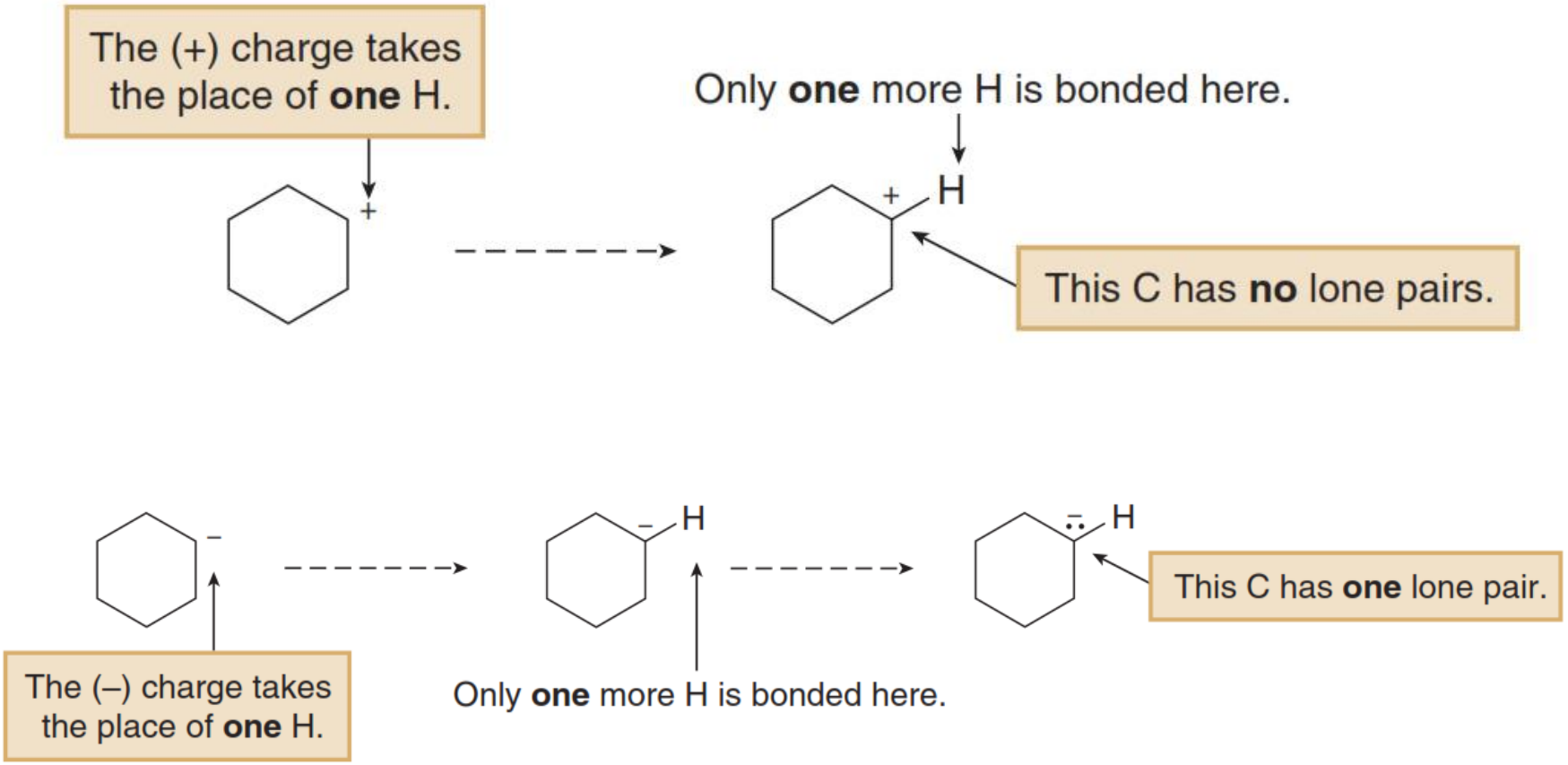
(e) $CH_3CH_2CH(OH)CH_2CH_3$

(f) $CH_2{=}C(CH_2CH_3)_2$

(g) $CH_3\overset{\overset{O}{\|}}{C}CH_2CH_2CH_2CH_3$

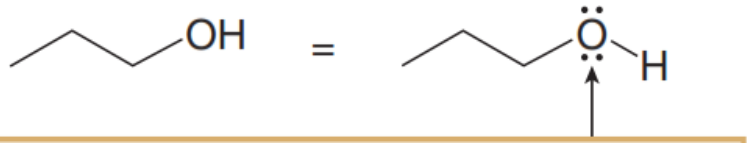
(h) $CH_3CHClCH_2CH(CH_3)_2$

Bond line Formulas with charged C atom

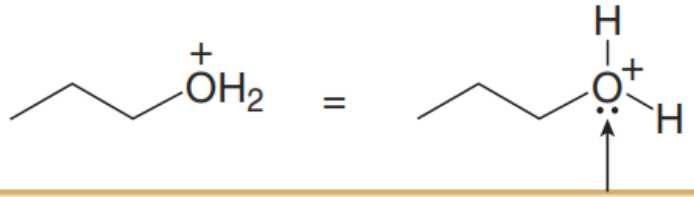


Bond line Formulas with charged C atom

Bond line Formulas often leave out lone pairs on heteroatoms, but don't forget about them



A neutral O atom "owns" six electrons:
- two bonds (four bonding electrons)
- **two** lone pairs (four unshared electrons).

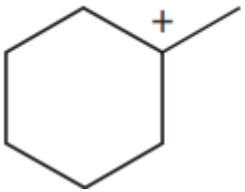


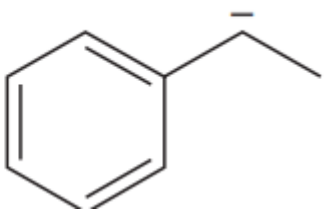
A positively charged O atom "owns" five electrons, one fewer than its group number of six:
- three bonds (six bonding electrons)
- **one** lone pair (two unshared electrons).

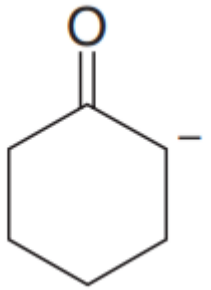
Sample Problem

Problem

Draw in all hydrogens and lone pairs on the charged carbons in each ion.

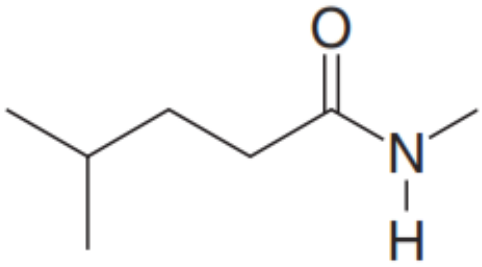
a. 

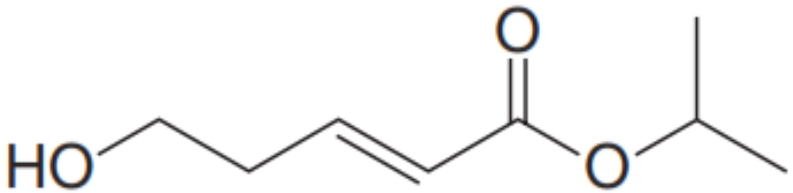
b. 

d. 

Sample Problem

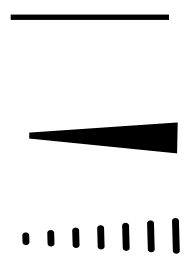
Problem จงเติมอิเล็กตรอนคู่โดดเดี่ยว ตรง heteroatom

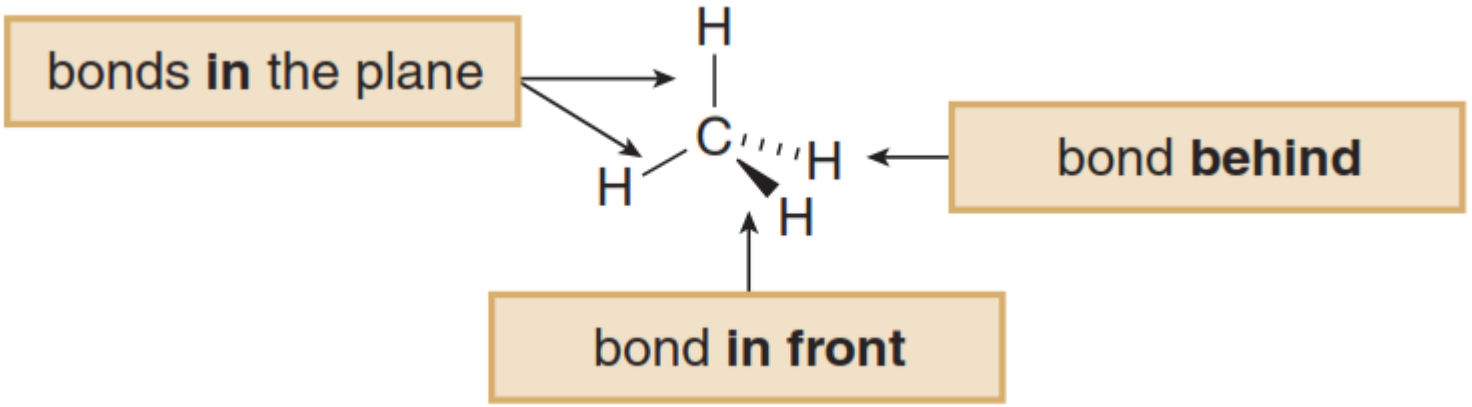


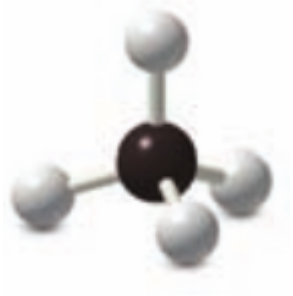


Drawing Three-Dimensional Molecules

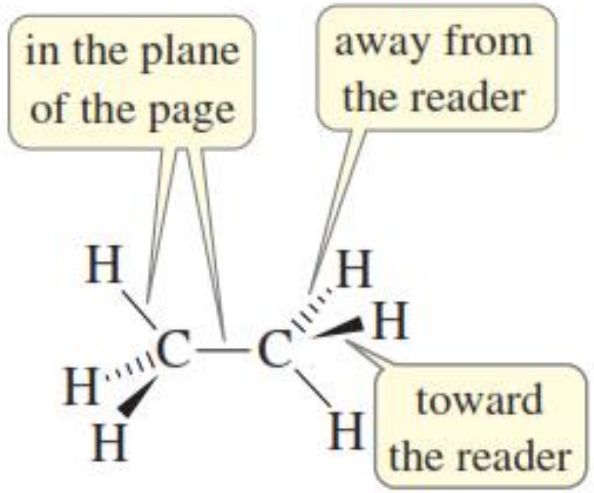
- A *solid line* is used for a bond *in* the plane.
- A *wedge* is used for a bond in *front* of the plane.
- A *dashed line* is used for a bond *behind* the plane.



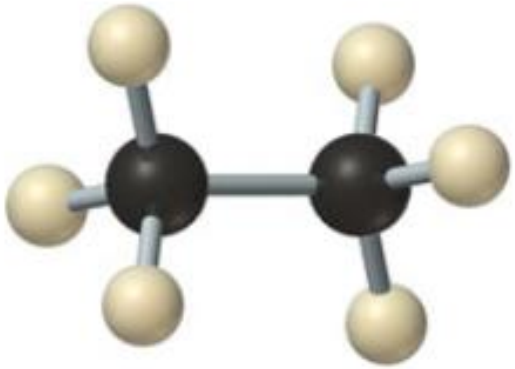




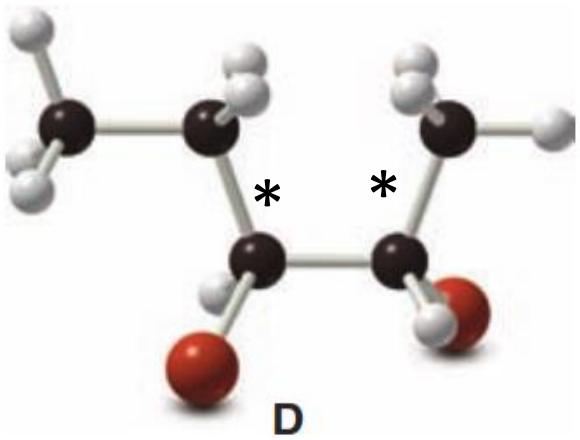
Drawing Three-Dimensional Molecules



ethane



ethane

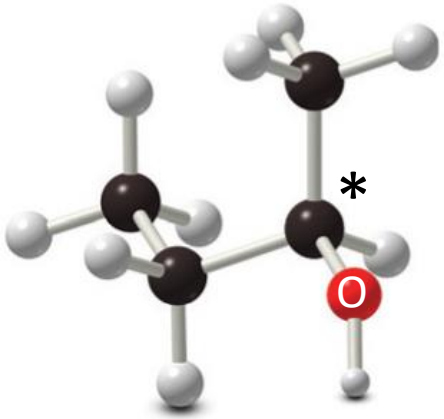


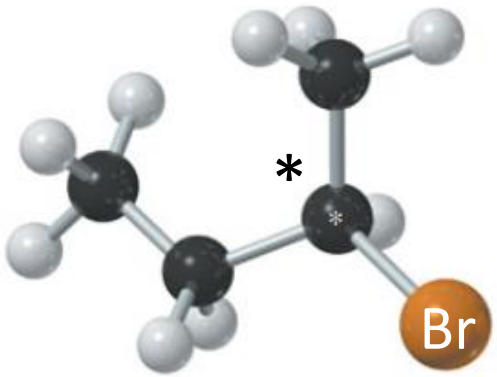
D

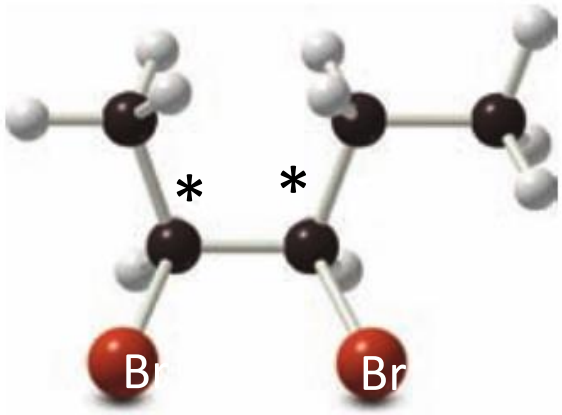
Sample Problem

Problem

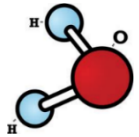
จงใช้ model ต่อไปนี้ เขียนแสดงโครงสร้าง 3 มิติ (ให้ยึดหลักโดยพยายามทำให้ C* เป็น 3 มิติ)





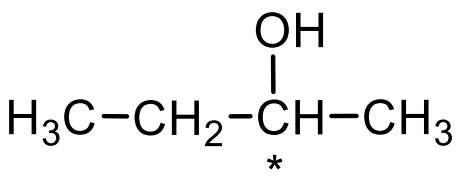


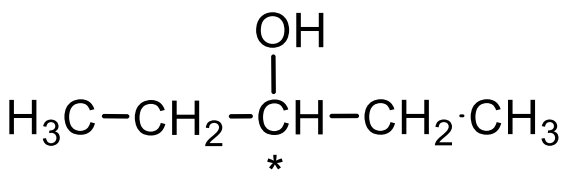
Sample Problem

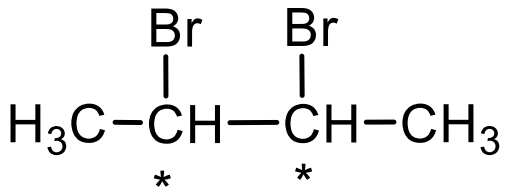


Problem

เปลี่ยนสารต่อไปนี้เป็นสูตรแบบเส้น (bond line structure) แต่เขียนแสดงโครงสร้าง 3 มิติ ตรงจุดที่มี *







References

1) Solomons, T. W. G.; Fryhle, C. *Organic Chemistry; John Wiley & Sons, 2009.*
2) Wade, L. G. *Organic Chemistry; Pearson Prentice Hall, 2010.*
3) Pine, S. H.; Hendrickson, J. B. *Organic chemistry; McGraw-Hill, 1980.*
4) สุนันทา วิบูลย์จันทร์ *เคมีอินทรีย์*. สำนักพิมพ์เอ็นดับเบิลมีเดีย จำกัด, 2548.
5) Clayden, J.; Greeves, N. and Warren, S. *Organic Chemistry. OUP Oxford*, *2012*