Structure and Bonding; Acids and Bases

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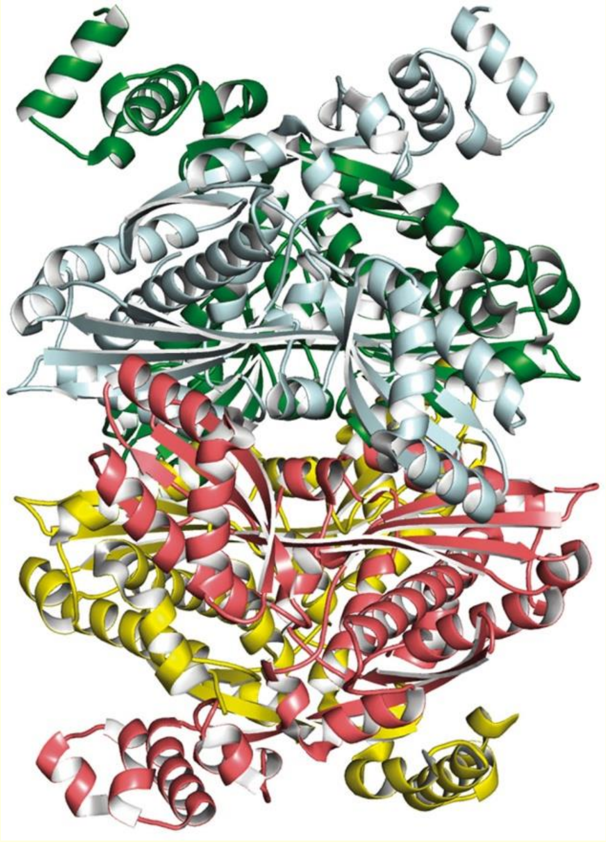
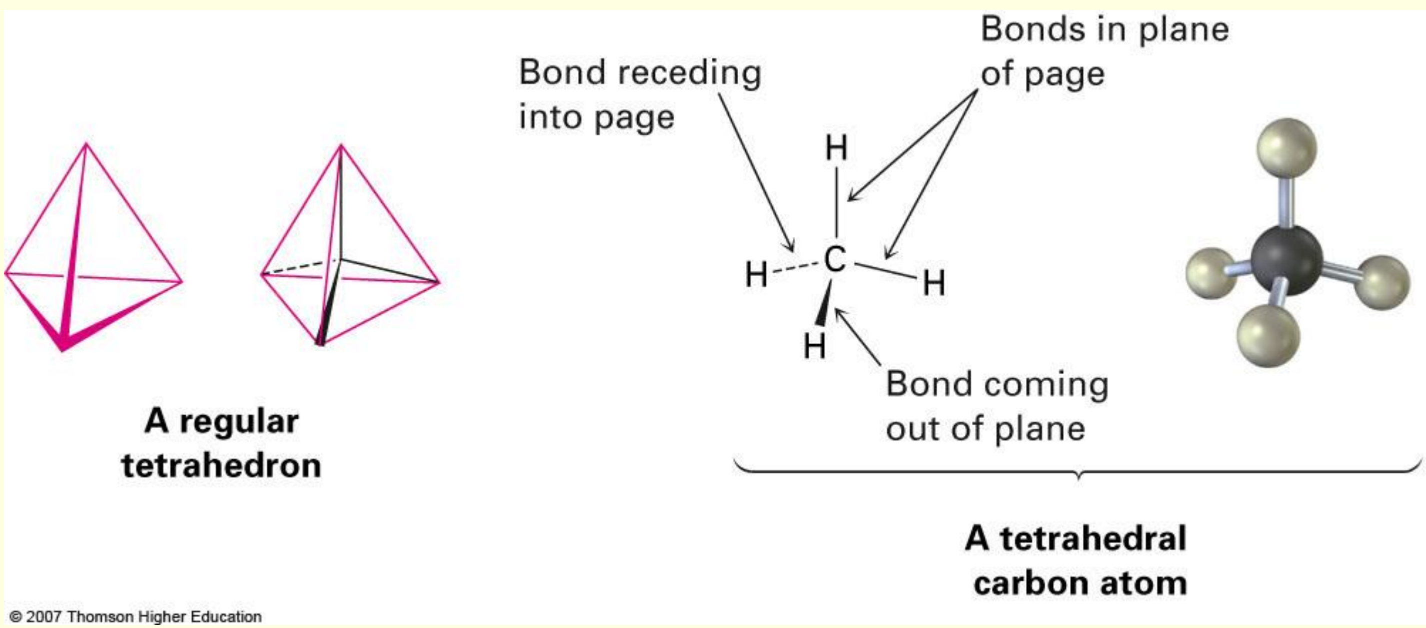
1. Structure and Bonding; Acids and Bases



1.3 Development of Chemical Bonding Theory

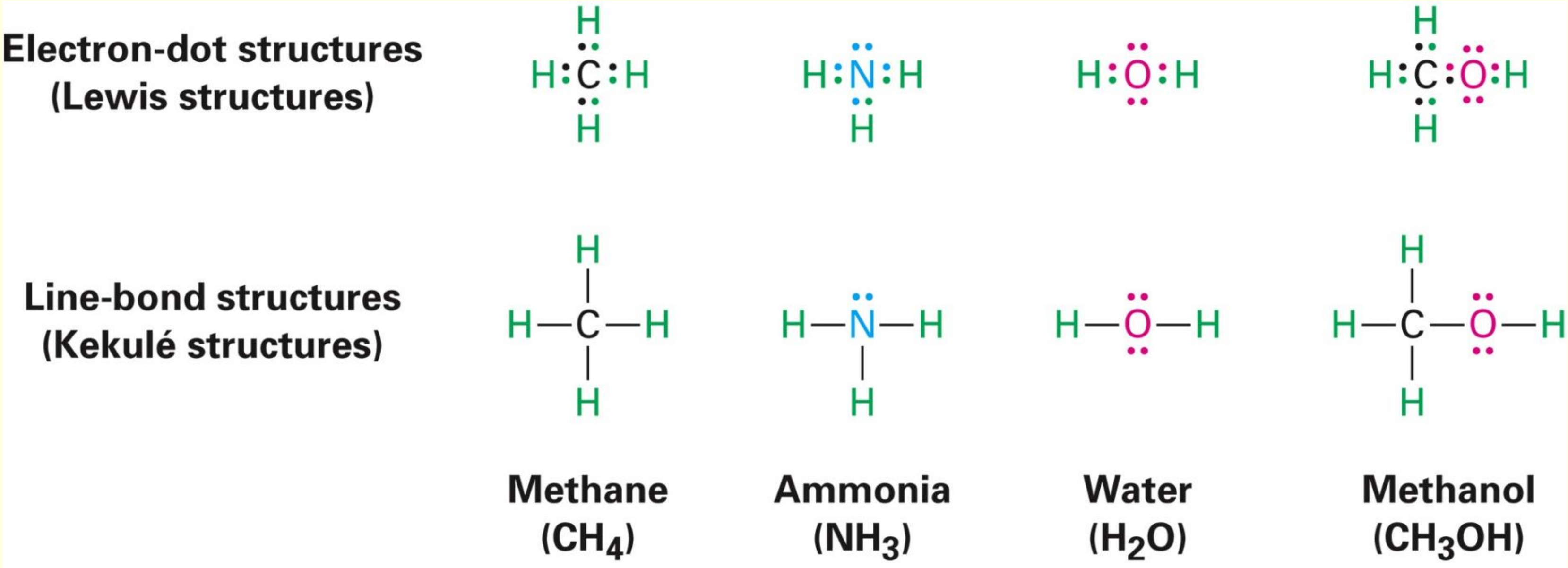
- Kekulé and Couper independently observed that carbon always has four bonds
- van't Hoff and Le Bel proposed that the four bonds of carbon have **specific spatial directions**
- Atoms surround carbon as corners of a **tetrahedron**



1.4 The Nature of Chemical Bonds

- Atoms form bonds because the compound that results is more stable than the separate atoms
- **Ionic bonds** in salts form as a result of **electron transfers**
- **Organic compounds** have covalent bonds from **sharing electrons** (G. N. Lewis, 1916)
- Stable molecule results at completed shell, octet (eight dots) for main-group atoms (two for hydrogen)

- **Lewis structures** (electron dot) show valence electrons of an atom as dots
  - Hydrogen has one dot, representing its 1*s* electron
  - Carbon has four dots ($2s^2\ 2p^2$)
- **Kekule structures** (line-bond structures) have a line drawn between two atoms indicating a 2 electron covalent bond.

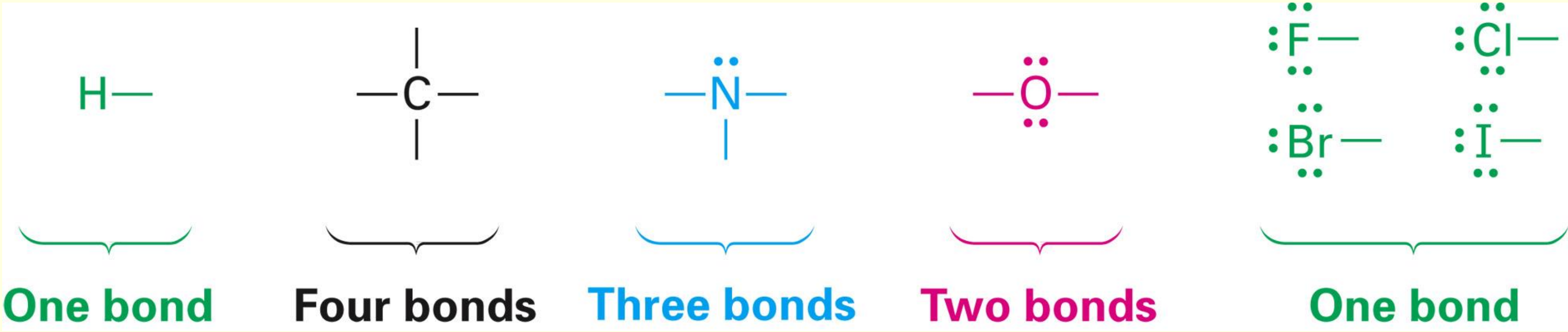


- Atoms with one, two, or three valence electrons form one, two, or three bonds.

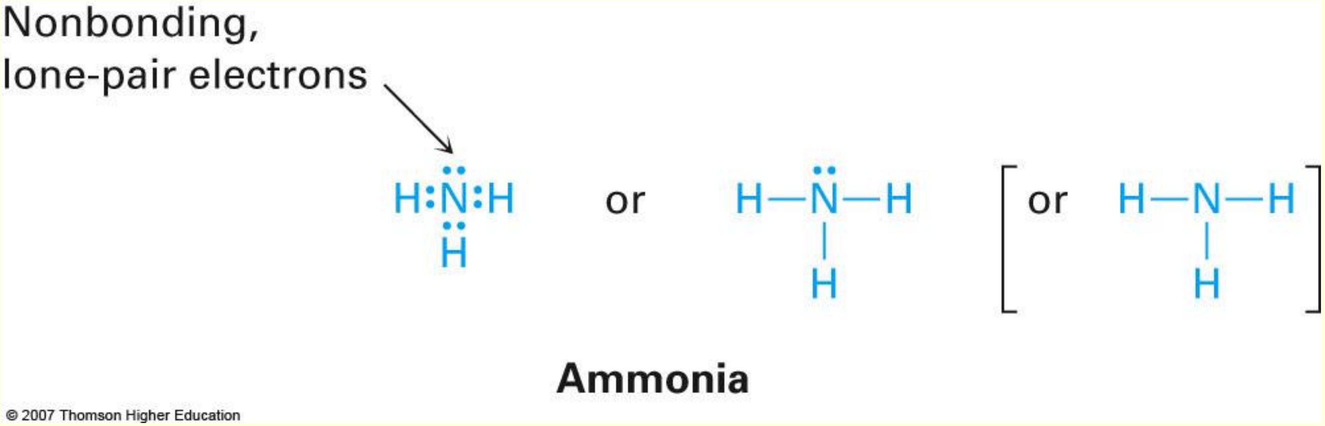
- Atoms with four or more valence electrons form as many bonds as they need electrons **to fill the *s* and *p* levels of their valence shells to reach a stable octet**.

- Carbon has four valence electrons ($2s^2\ 2p^2$), forming four bonds (CH_4).
- Nitrogen has five valence electrons ($2s^2\ 2p^3$) and forms three bonds (NH_3).

- Oxygen has six valence electrons ($2s^2\ 2p^4$) and forms two bonds (H_2O)



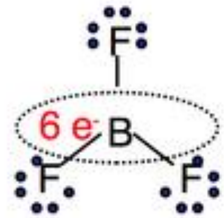
- Valence electrons not used in bonding are called **nonbonding electrons**, or **lone-pair electrons**
  - Nitrogen atom in ammonia (NH_3)



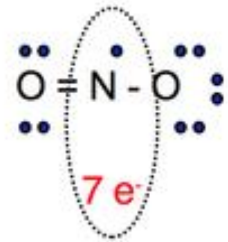
Exceptions To The Octet Rule

Not all molecules conform to octet rule:

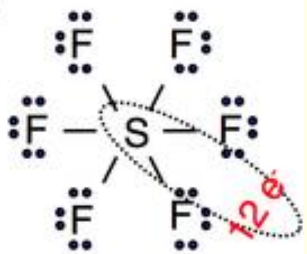
- ***Incomplete Octets*** do not have enough e^- to satisfy all atoms
  Give octet to outside atoms



- ***Odd electron molecules*** (radicals or free radicals) have an odd number of electrons so cannot satisfy every atom
  1 unpaired electron

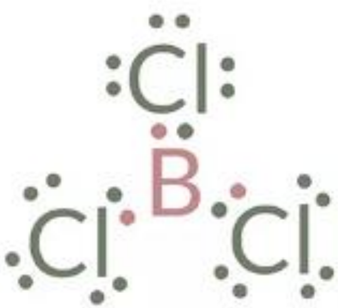


- ***Expanded valence shells*** occur when the center atom has more than 8 valence electrons
  d orbitals close in energy to s & p orbitals
  ONLY occurs in n >= period 3

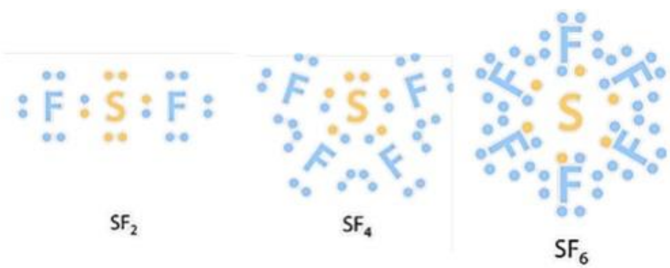


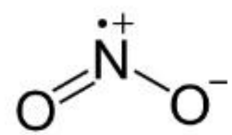
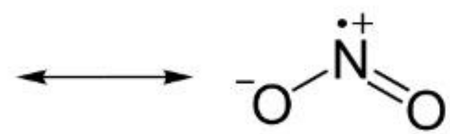
1. 8개 미만의 전자를 가지는 분자
2. 8개 이상의 전자를 가지는 분자
3. 홀수개의 전자를 가지는 분자

$BeCl_2$



BCl_3



Worked Example 1.2

Predicting the Number of Bonds Formed by an Atom

How many hydrogen atoms does phosphorus bond to in forming phosphine, $PH_?$?

Worked Example 1.2 Predicting the Number of Bonds Formed by an Atom

How many hydrogen atoms does phosphorus bond to in forming phosphine, $PH_?$?

Strategy Identify the periodic group of phosphorus, and tell from that how many electrons (bonds) are needed to make an octet.

Solution Phosphorus is in group 5A of the periodic table and has five valence electrons. It thus needs to share three more electrons to make an octet and therefore bonds to three hydrogen atoms, giving PH_3.

Group 1A																	8A
H	2A											3A	4A	5A	6A	7A	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac															

Worked Example 1.3

Drawing Electron-Dot and Line-Bond Structures

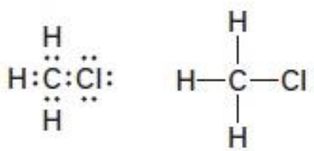
Draw both electron-dot and line-bond structures for chloromethane, CH_3Cl.

Worked Example 1.3 Drawing Electron-Dot and Line-Bond Structures

Draw both electron-dot and line-bond structures for chloromethane, CH_3Cl.

Strategy Remember that a bond—that is, a pair of shared electrons—is represented as a line between atoms.

Solution Hydrogen has one valence electron, carbon has four valence electrons, and chlorine has seven valence electrons. Thus, chloromethane is represented as



Chloromethane

Group 1A	2A											3A	4A	5A	6A	7A	8A
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac															

염화 메틸(Chloromethane, methyl chloride)

염화메틸은 어디에 사용될까요?

주로 **실리콘 수지의 원료로 사용**되며 유화제에도 사용됩니다.
이외에도 계면활성제 및 농약의 원료, 발포스티롤 등의 발포제, 열에 약한 천연 약품의 추출 등에 사용됩니다
담배나 목재를 태울 때도 일부 배출된다.

주로 공기를 통해 흡수되며, 오염된 음식이나 물을 섭취할 때도 흡수될 수 있다.
우리 몸속에 들어온 **염화메틸은 대부분 소변을 볼 때나 숨을 내쉴 때 배출되기 때문에 몸속에 축적되지는 않는다.**

하지만 **짧은 기간 동안 높은 농도에 노출**되면 휘청거림, 어지러움 등을 유발할 수 있다. 낮은 농도에서도 오랫동안 지속적으로 노출되면 위와 같은 증상이 나타날 수 있으며 특히 **간, 신장, 고환 및 폐 등에도 악영향이** 미칠 수 있다.

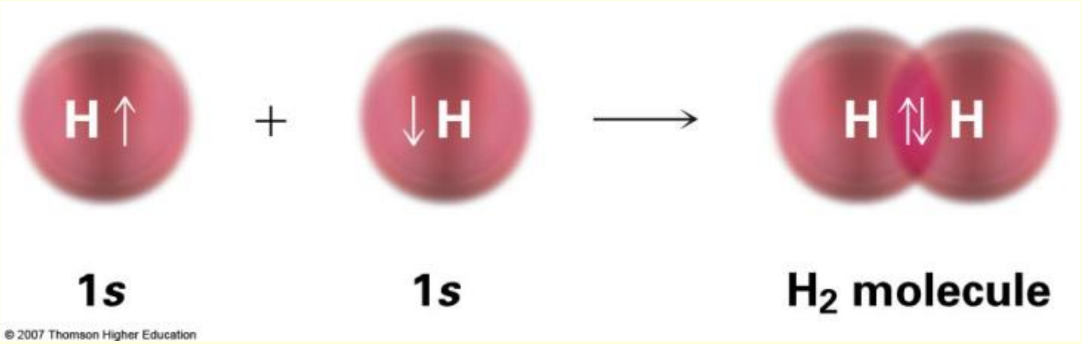
이런 위험성을 감안, 유엔 산하 국제암연구소(IARC)는 염화메틸을 '발암성 등급 3군'으로 분류하고 있으며, 미국 환경보호청(EPA)은 **'발암성 등급 D군'**으로 분류하고 있다.

1.5 Forming Covalent Bonds: Valence Bond Theory

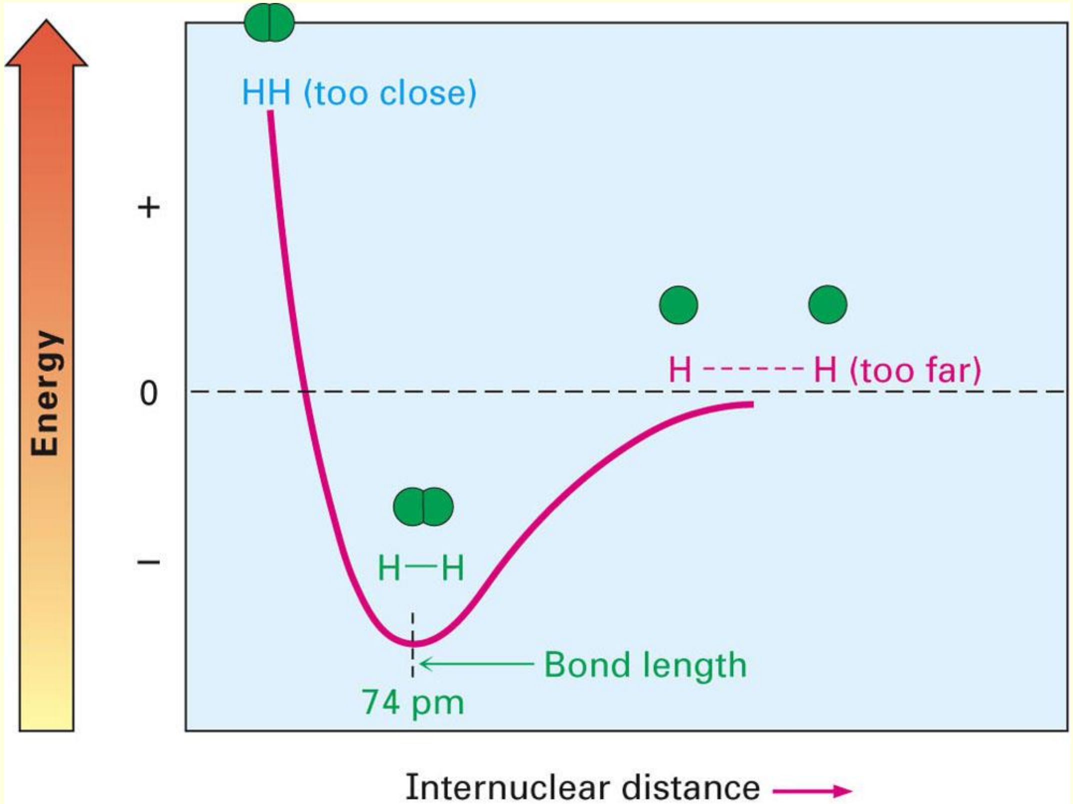
- Covalent bond forms when two atoms approach each other closely so that a singly occupied orbital on one atom *overlaps* a singly occupied orbital on the other atom

Valence Bond Theory:

- Electrons are paired in the overlapping orbitals and are attracted to nuclei of both atoms
  - H–H bond results from the overlap of two singly occupied hydrogen 1*s* orbitals



- Reaction 2 H• $\rightarrow$ H_2 releases 436 kJ/mol
- Product has 436 kJ/mol less energy than two atoms: H–H has **bond strength** of 436 kJ/mol. (1 kJ = 0.2390 kcal; 1 kcal = 4.184 kJ)
- Bond Length: Distance between nuclei that leads to maximum stability (minimum energy point)



Problem 1.5 What are likely formulas for the following molecules?

(a) $CCl_?$ **(b)** $AlH_?$ **(c)** $CH_?Cl_2$ **(d)** $SiF_?$

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(a) $CCl_?$ **(b)** $AlH_?$ **(c)** $CH_?Cl_2$ **(d)** $SiF_?$

1.5 **(a)** CCl_4 **(b)** AlH_3 **(c)** CH_2Cl_2 **(d)** SiF_4

Problem 1.6 Write both electron-dot and line-bond structures for the following molecules, showing all nonbonded electrons:

(a) $CHCl_3$, chloroform

(b) H_2S, hydrogen sulfide

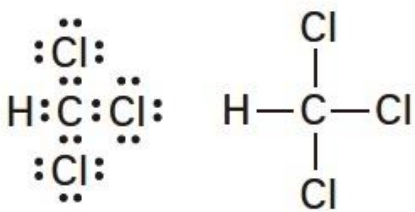
(c) CH_3NH_2, methylamine

Problem 1.6 Write both electron-dot and line-bond structures for the following molecules, showing all nonbonded electrons:

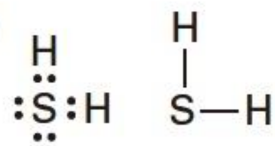
(a) $CHCl_3$, chloroform **(b)** H_2S, hydrogen sulfide

(c) CH_3NH_2, methylamine

1.6 **(a)**



(b)



(c)