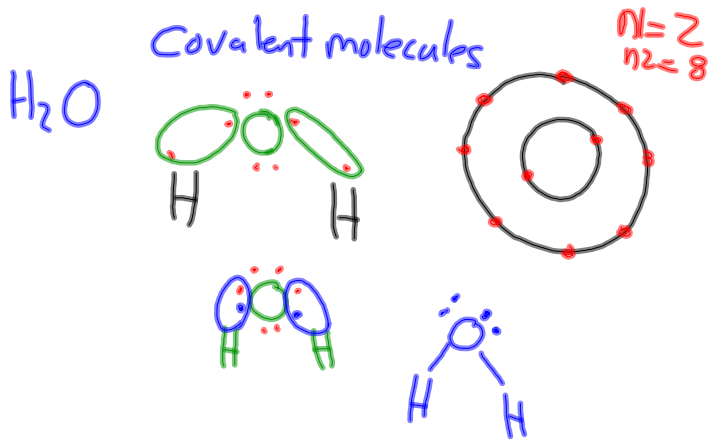
Chapter 8

Ionic bond: Where atom either give up or receive valence electrons

Covalent bonding involves sharing valence electrons



May 5-10:27 AM

8.1 Molecular Compounds

Objectives

8.1.1 **Distinguish** between the melting points and boiling points of molecular compounds and ionic compounds.

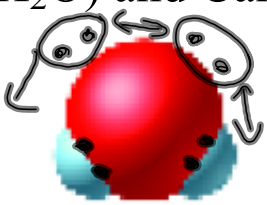
8.1.2 **Describe** the information provided by a molecular formula.

Oct 25-6:41 PM

Molecules are a group of atoms held together by a covalent bond

Some basic molecular compounds are water (H_2O) and Carbon Monoxide (CO).

Diatomic molecule



Water (H_2O)

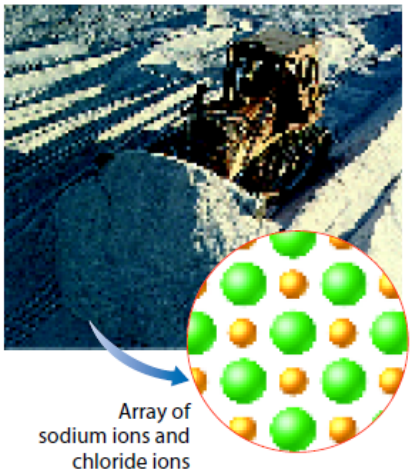
Carbon monoxide (CO)

Molecular compounds are compounds composed of molecules

Oct 25-6:42 PM

Molecular compounds generally have lower melting and boiling points

Ionic compound – Salt

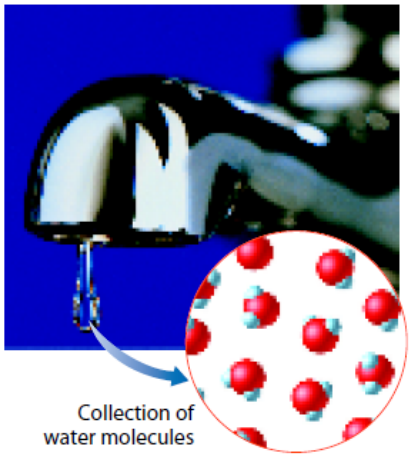


Array of sodium ions and chloride ions

Formula unit of sodium chloride: Na^+ Cl^-

Chemical formula: NaCl

Molecular compound – Water



Collection of water molecules

Molecule of water: O H H

Chemical formula: H_2O

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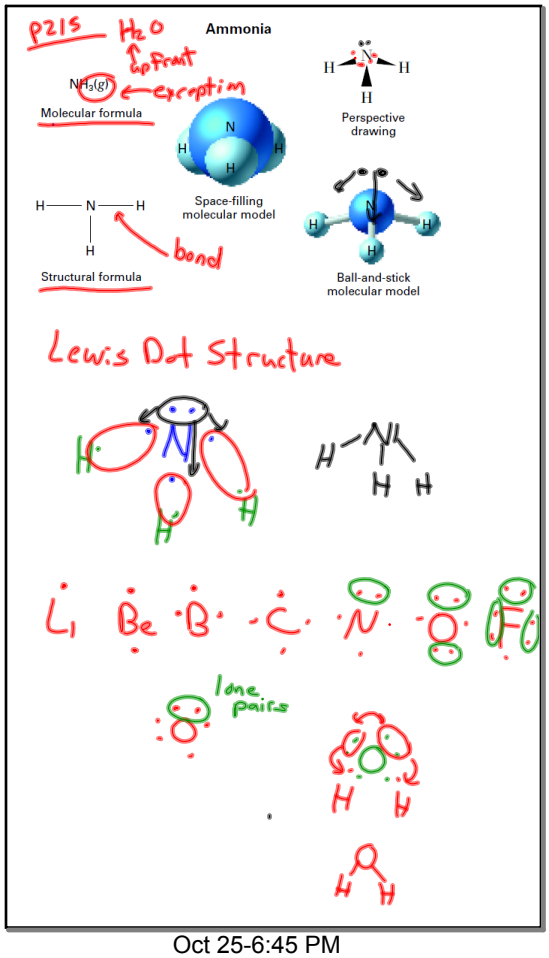

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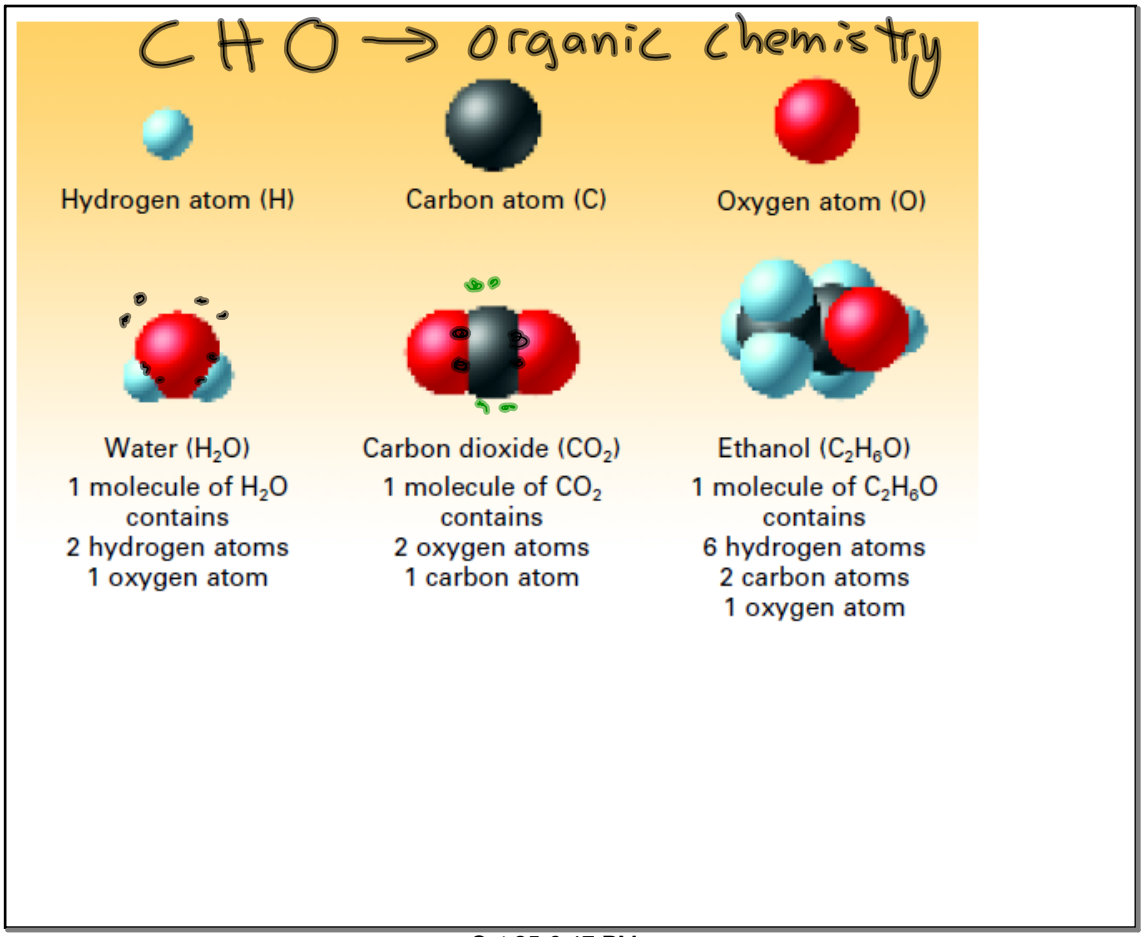

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8.1 Section Assessment

P216

1. **Key Concept** How are the melting points and boiling points of molecular compounds usually different from ionic compounds?
2. **Key Concept** What information does a molecular formula provide?
3. What are the only elements that exist in nature as uncombined atoms? What term is used to describe such elements?
4. Describe how the molecule whose formula is NO is different from the molecule whose formula is N_2O.
5. Give an example of a diatomic molecule found in Earth's atmosphere.
6. What information does a molecule's molecular structure give?

Oct 25-6:42 PM

Molecular Elements

The following elements must form molecules to remain stable when they are in the "free state". Memorize them.

hydrogen	H_2	chlorine	Cl_2	phosphorus	P_4
nitrogen	N_2	bromine	Br_2	sulphur	S_8
oxygen	O_2	iodine	I_2		
fluorine	F_2	astatine	At_2		

Mar 19-10:15 AM

Nonsystematic Names for Certain Common Compounds (Memorize)					
ozone	O_3	water	H_2O	ammonia	NH_3
methane	CH_4	sucrose	$C_{12}H_{22}O_{11}$	glucose	$C_6H_{12}O_6$
methanol	CH_3OH	ethanol	C_2H_5OH	hydrogen peroxide	H_2O_2
Propane	C_3H_8				

Mar 19-10:15 AM

Prefixes				
mono = 1	di = 2	tri = 3	tetra = 4	penta = 5
hexa = 6	hepta = 7	octa = 8	nona = 9	deca = 10

Mar 19-10:15 AM

Binary Molecular Compounds		
	Molecular Formula	Name
1	CCl_4	Carbon Tetra Chloride
2	CO_2	Carbon Di oxide
3	NO	Nitrogen mono oxide
4	NO_2	Nitrogen dioxide
5	SO_3	Sulfur tri oxide
6	P_4O_{10}	Tetra Phosphorus deca oxide
7	P_4O_6	Tetra Phosphorus hexa oxide
8	CH_4	Methane
9	HCl	hydron chloride → hydrochloric acid
10	H_2O	Water

Mar 19-10:16 AM

11	N_2	nitrogen
12	SO_2	sulphur dioxide
13	CO	carbon monoxide
14	O_3	ozone
15	CH_3CH_2OH (C_2H_5OH)	ethanol
16	$C_{12}H_{22}O_{11}$	sucrose
17	S_8	sulphur
18	ClO_2	chlorine dioxide
19	CH_3OH	methanol
20	P_4	phosphorus
21	NH_3	ammonia
22	N_2O	dinitrogen oxide
23	I_2	iodine
24	$C_6H_{12}O_6$	glucose
25	C_3H_8	propane

Mar 19-10:16 AM

8.2 The Nature of Covalent Bonding

Objectives

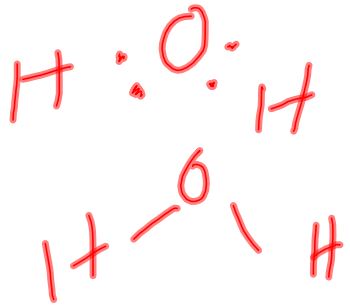
8.2.1 **Describe** how electrons are shared to form covalent bonds and identify exceptions to the octet rule.

8.2.2 **Demonstrate** how electron dot structures represent shared electrons.

8.2.3 **Describe** how atoms form double or triple covalent bonds.

8.2.4 **Distinguish** between a covalent bond and a coordinate covalent bond and describe how the strength of a covalent bond is related to its bond dissociation energy.

8.2.5 **Describe** how oxygen atoms are bonded in ozone.



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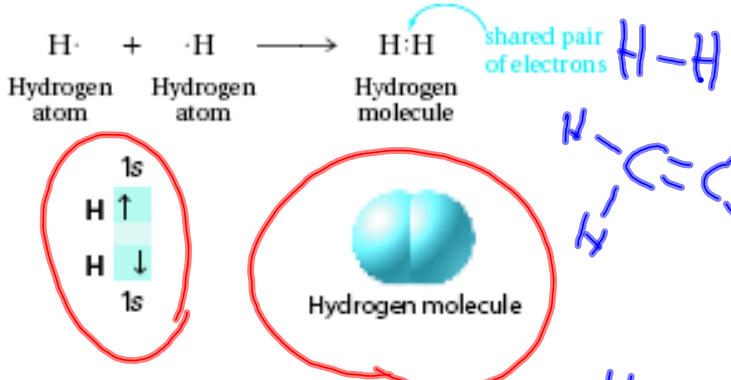
Single Covalent Bonds

The hydrogen atoms in a hydrogen molecule are held together mainly by the attraction of the shared electrons to the positive nuclei. Two atoms held together by sharing a pair of electrons are joined by a **single covalent bond.** Hydrogen gas consists of pairs of diatomic molecules whose atoms share only one pair of electrons, forming a single covalent bond.



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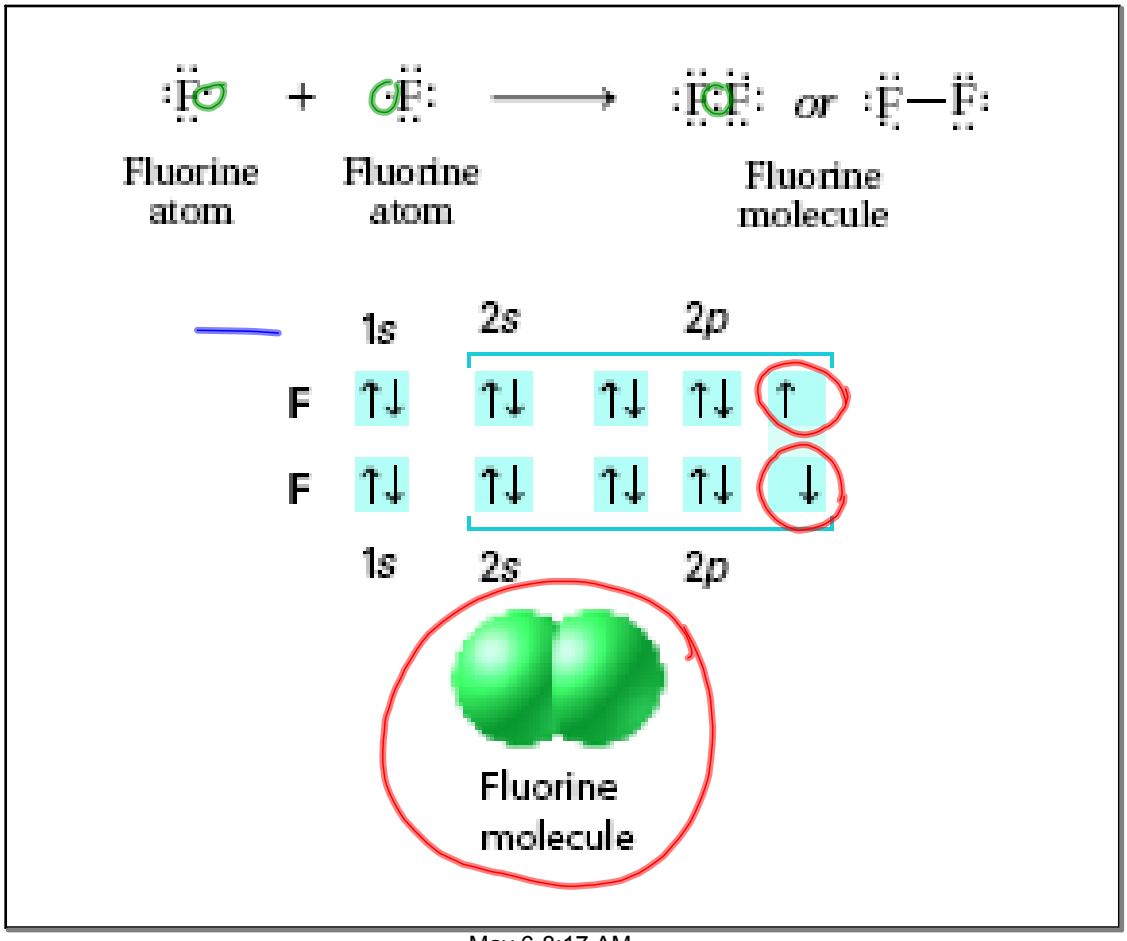

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Practice Problems

P220

NaCl

Chloride Cl^-

Sodiumchloride

7. Draw electron dot structures for each molecule.
   a. chlorine (Cl_2) b. bromine (Br_2) c. iodine (I_2)
8. The following molecules have single covalent bonds. Draw an electron dot structure for each.
   a. H_2O_2 b. PCl_3

Answers

7. a. :Cl:Cl: b. :Br:Br: c. :I:I:
8. a. H:O:O:H b. :Cl:P:Cl: (:Cl:)

Nov 1-6:30 PM

Table 8.1 p 222

The Diatomic Elements

Name	Chemical formula	Electron dot structure	Properties and uses
Fluorine	F_2	:F—F:	Greenish-yellow reactive toxic gas. Compounds of fluorine, a halogen, are added to drinking water and toothpaste to promote healthy teeth.
Chlorine	Cl_2	:Cl—Cl:	Greenish-yellow reactive toxic gas. Chlorine is a halogen used in household bleaching agents.
Bromine	Br_2	:Br—Br:	Dense red-brown liquid with pungent odor. Compounds of bromine, a halogen, are used in the preparation of photographic emulsions.
Iodine	I_2	:I—I:	Dense gray-black solid that produces purple vapors; a halogen. A solution of iodine in alcohol (tincture of iodine) is used as an antiseptic.
Hydrogen	H_2	H — H	Colorless, odorless, tasteless gas. Hydrogen is the lightest known element.
Nitrogen	N_2	:N≡N:	Colorless, odorless, tasteless gas. Air is almost 80% nitrogen by volume.
Oxygen	O_2	Inadequate	Colorless, odorless, tasteless gas that is vital for life. Air is about 20% oxygen by volume.

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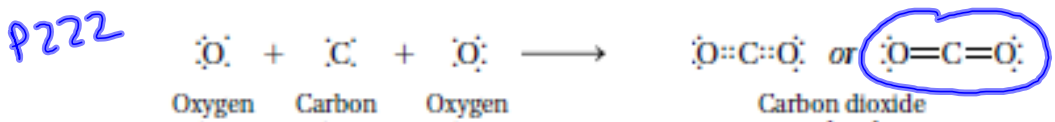
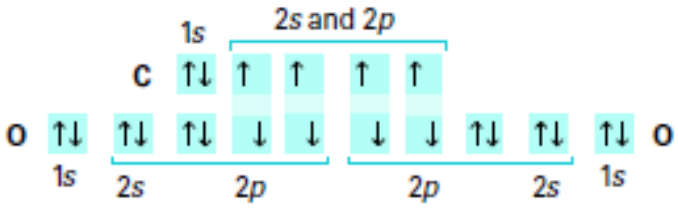
p 222





Carbon dioxide molecule

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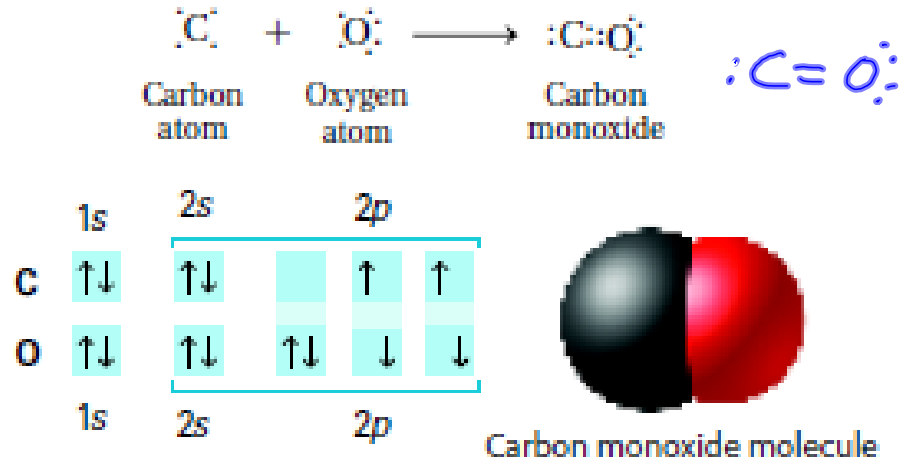

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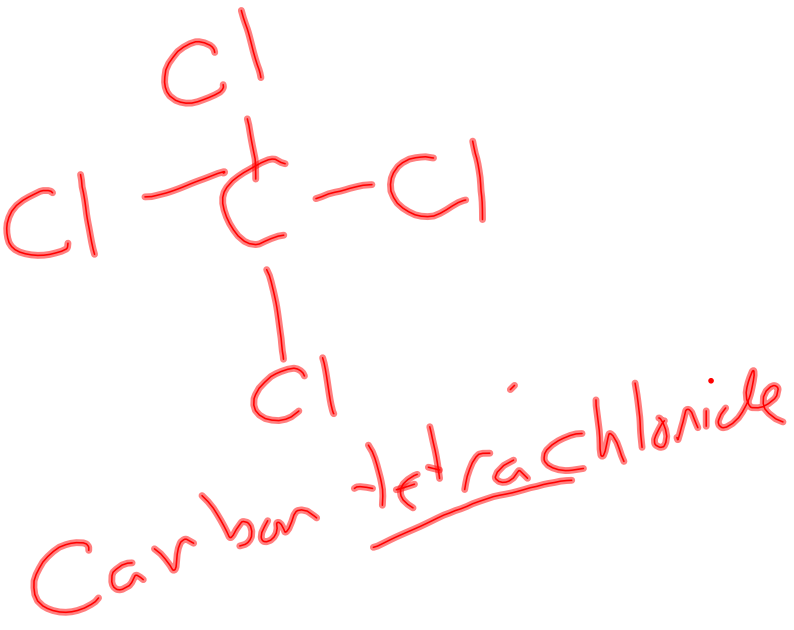

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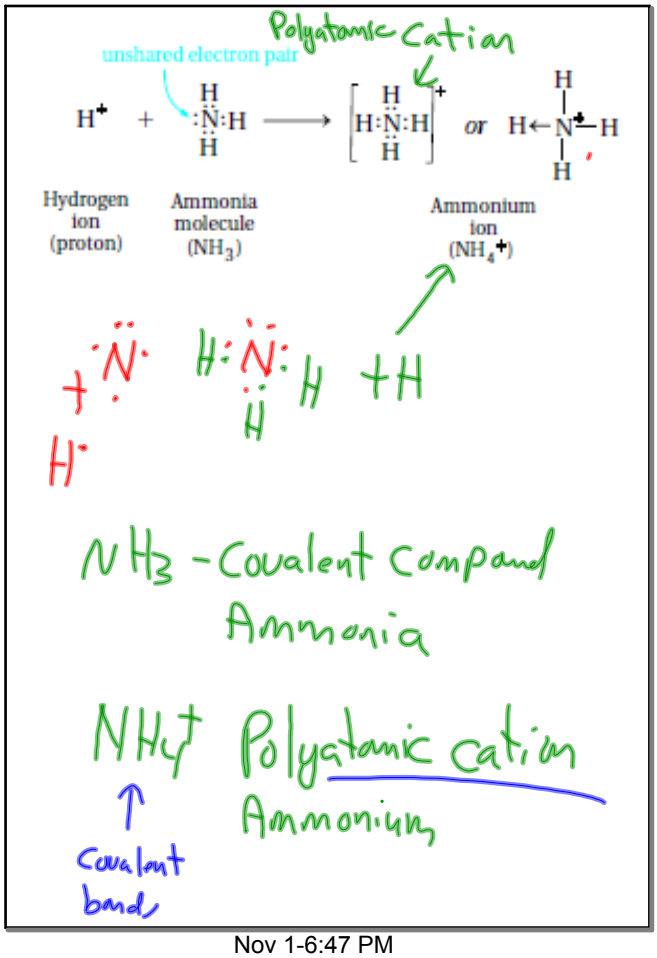

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Then join the remaining oxygen by a coordinate covalent bond, with sulfur donating one of its unshaved pairs to oxygen, and add the two extra electrons. Put brackets about the structure and indicate the 2− charge, giving the result shown.

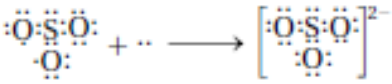

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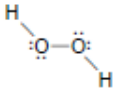
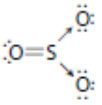
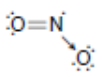
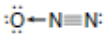
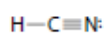
Table 8.2

Some Common Molecular Compounds

Name	Chemical formula	Structure	Properties and uses
Hydrogen peroxide	H_2O_2		Colorless, unstable liquid when pure. It is used as rocket fuel. A 3% solution is used as a bleach and antiseptic.
Sulfur dioxide	SO_2		Oxides of sulfur are produced in combustion of petroleum products and coal. They are major air pollutants in industrial areas. Oxides of sulfur can lead to respiratory problems.
Sulfur trioxide	SO_3		
Nitric oxide	NO		Oxides of nitrogen are major air pollutants produced by the combustion of fossil fuels in automobile engines. They irritate the eyes, throat, and lungs.
Nitrogen dioxide	NO_2		
Nitrous oxide	N_2O		Colorless, sweet-smelling gas. It is used as an anesthetic commonly called laughing gas.
Hydrogen cyanide	HCN		Colorless, toxic gas with the smell of almonds.
Hydrogen fluoride	HF		Two hydrogen halides, all extremely soluble in water. Hydrogen chloride, a colorless gas with pungent odor, readily dissolves in water to give a solution called hydrochloric acid.
Hydrogen chloride	HCl		

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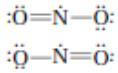
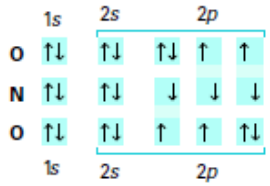
Exceptions to the Octet Rule





Nitrogen dioxide molecule

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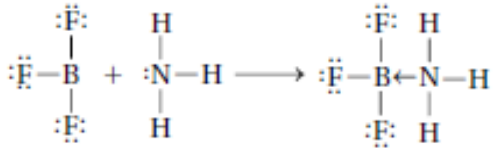

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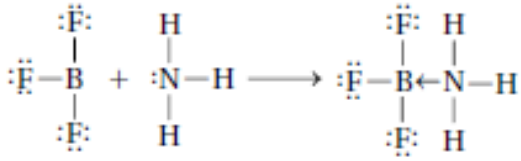


Nov 1-6:53 PM

Practice Problems

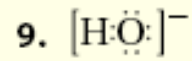
9. Draw the electron dot structure of the hydroxide ion (OH^-).
10. Draw the electron dot structure of the polyatomic boron tetrafluoride anion (BF_4^-).
11. Draw the electron dot structures for sulfate (SO_4^{2-}) and carbonate (CO_3^{2-}). Sulfur and carbon are the central atoms, respectively.
12. Draw the electron dot structure for the hydrogen carbonate ion (HCO_3^-). Carbon is the central atom, and hydrogen is attached to oxygen in this polyatomic anion.

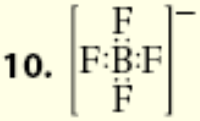
Interactive Textbook

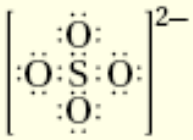
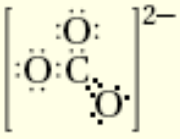
Problem-Solving 8.10 Solve

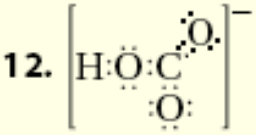
Nov 1-6:51 PM

Answers

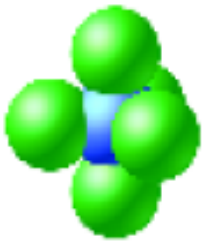
9. 

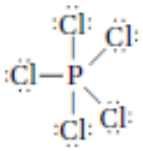
10. 

11. a.  b. 

12. 

May 12-8:53 AM





Phosphorus pentachloride

Sulfur hexafluoride

Nov 1-9:08 PM

8.2 Section Assessment

13. **Key Concept** What electron configurations do atoms usually achieve by sharing electrons to form covalent bonds?
14. **Key Concept** How is an electron dot structure used to represent a covalent bond?
15. **Key Concept** When are two atoms likely to form a double bond between them? A triple bond?
16. **Key Concept** How is a coordinate covalent bond different from other covalent bonds?
17. **Key Concept** How is the strength of a covalent bond related to its bond dissociation energy?
18. **Key Concept** Draw the electron dot resonance structures for ozone and explain how they describe its bonding.
19. **Key Concept** List three ways in which the octet rule can sometimes fail to be obeyed.
20. What kinds of information does a structural formula reveal about the compound it represents?
21. Draw electron dot structures for the following molecules, which have only single covalent bonds.
    a. H_2S **b.** PH_3 **c.** ClF

22. Use the bond dissociation energies of H_2 (435 kJ/mol) and of a typical carbon–carbon bond (347 kJ/mol) to decide which bond is stronger. Explain your reasoning.

Nov 1-6:25 PM

8.3 Bonding Theories

Objectives

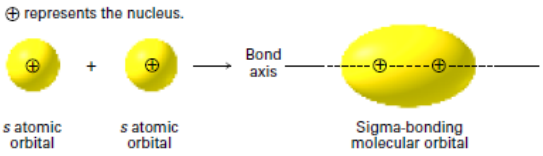
8.3.1 **Describe** the relationship between atomic and molecular orbitals.

8.3.2 **Describe** how VSEPR theory helps predict the shapes of molecules.

8.3.3 **Identify** ways in which orbital hybridization is useful in describing molecules.

Nov 1-6:24 PM

Figure 8.13 Two *s* atomic orbitals can combine to form a molecular orbital, as in the case of hydrogen (H_2). In a bonding molecular orbital, the electron density between the nuclei is high.



Nov 1-9:14 PM

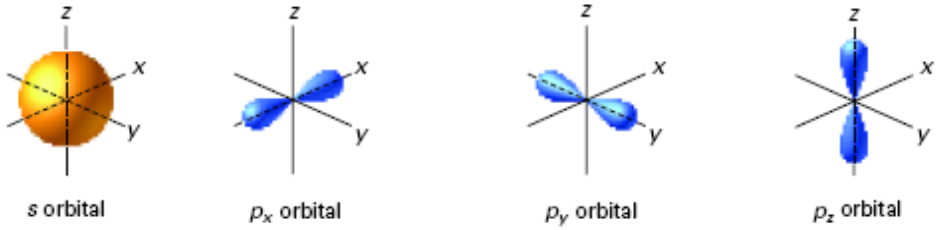
Assignment

Ozone Read the feature on ozone on page R31 of the Elements Handbook. Describe the effect of CFCs on the ozone layer. Explain why the United States has banned the use of CFCs in aerosols.

May 12-8:55 AM

8.3 - Bonding Theories

Earlier this year we talked about atomic orbitals (S, P, D, F)
We are going to expand this idea to talk about molecular orbitals. A molecular orbital that can be occupied by two electrons in a covalent bond is called a bonding orbital



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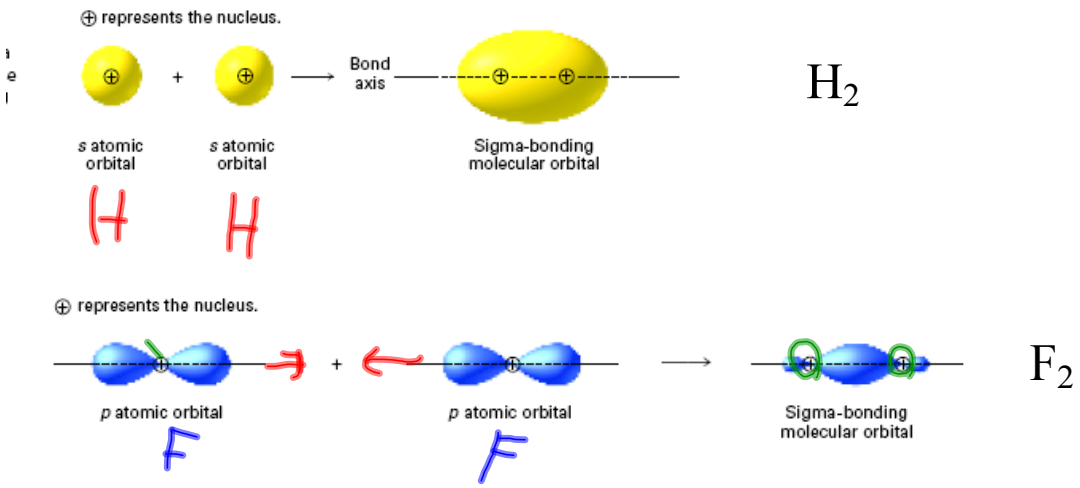
Sigma Bond (σ)



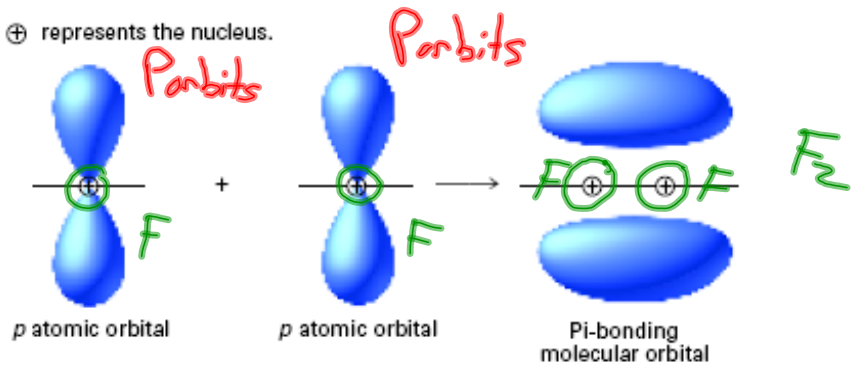
H_2

F_2

p orbitals are overlapping end to end

May 13-7:30 AM

Pi Bonding (π)



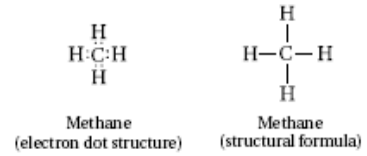
p orbitals are overlapping side to side
Pi bonding is weaker then sigma bonding

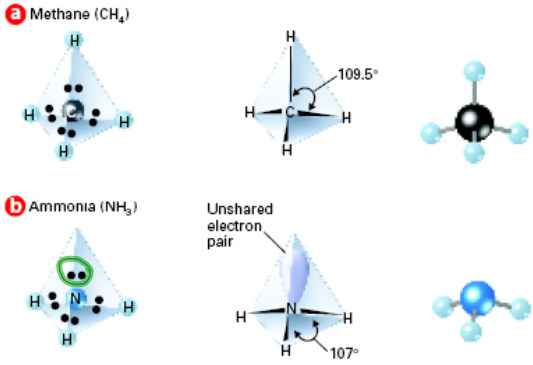
May 13-7:34 AM

VSEPR Theory

Valence Shell Electron Pair Repulsion Theory

VSEPR explains the molecular shape of molecules





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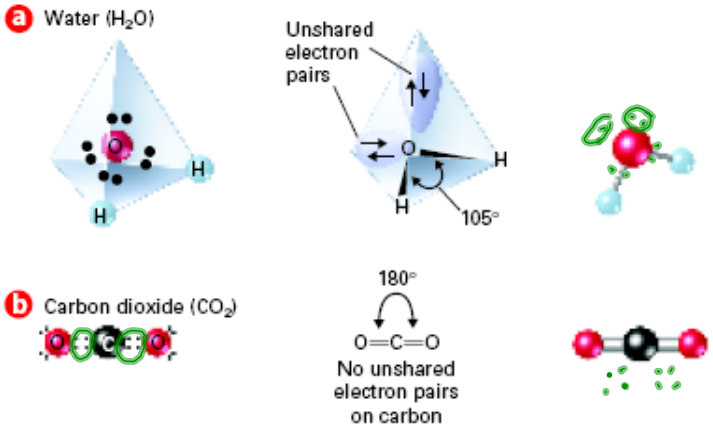
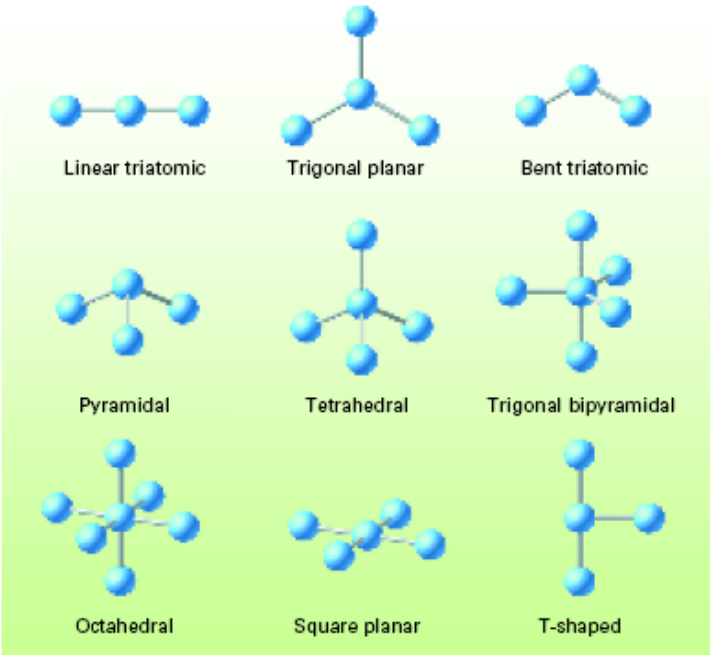


May 13-7:44 AM

Nine possible shapes

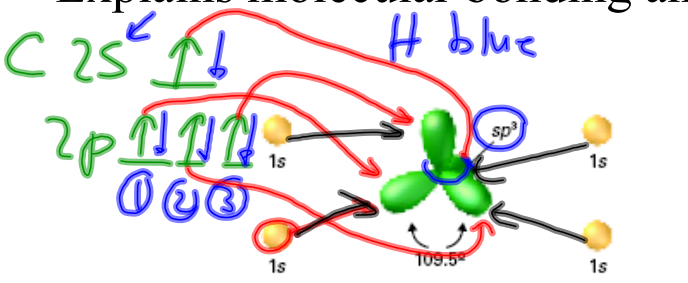


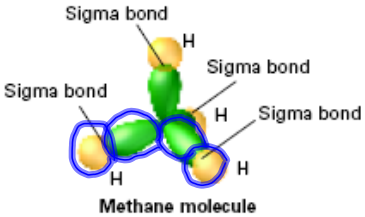
May 13-7:41 AM

Hybrid Orbitals

C $1s^2 2s^2 2p^2$

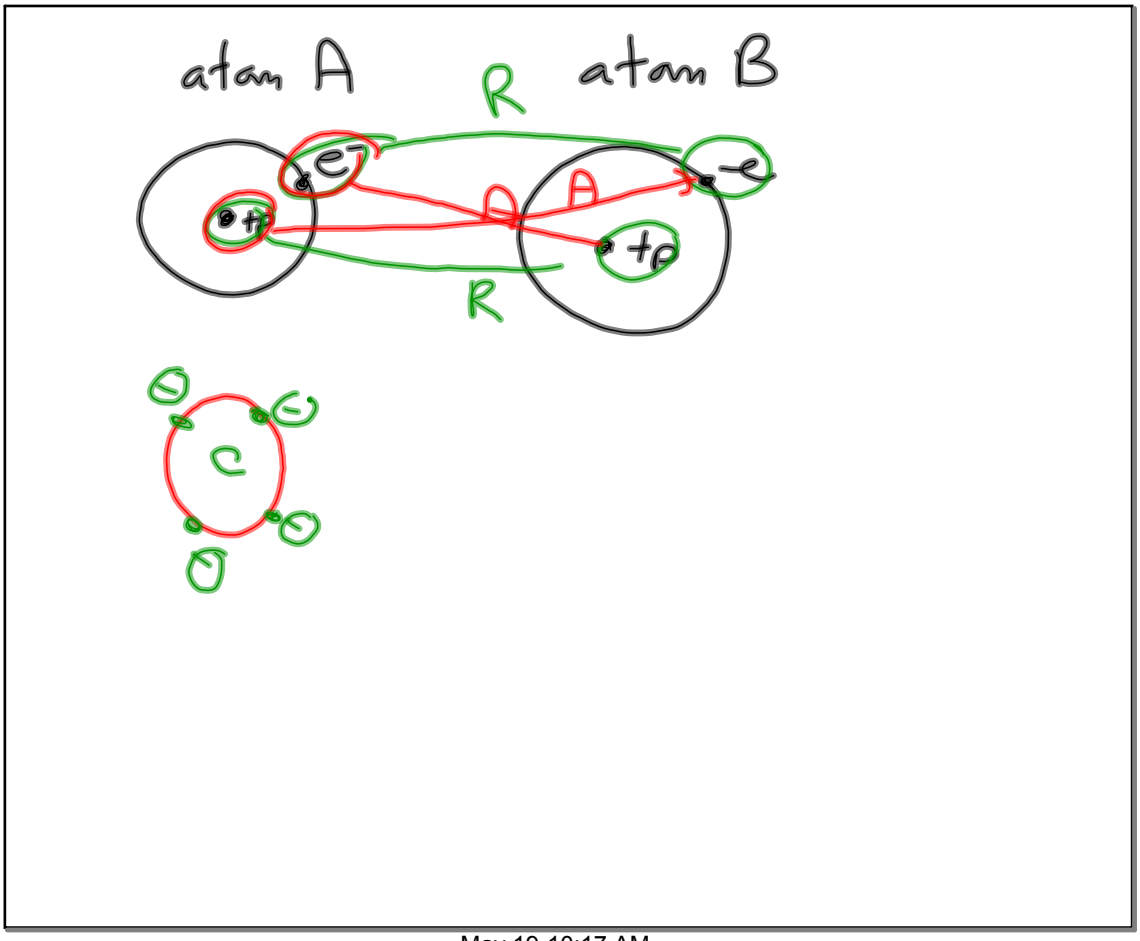
Explains molecular bonding and molecular shape



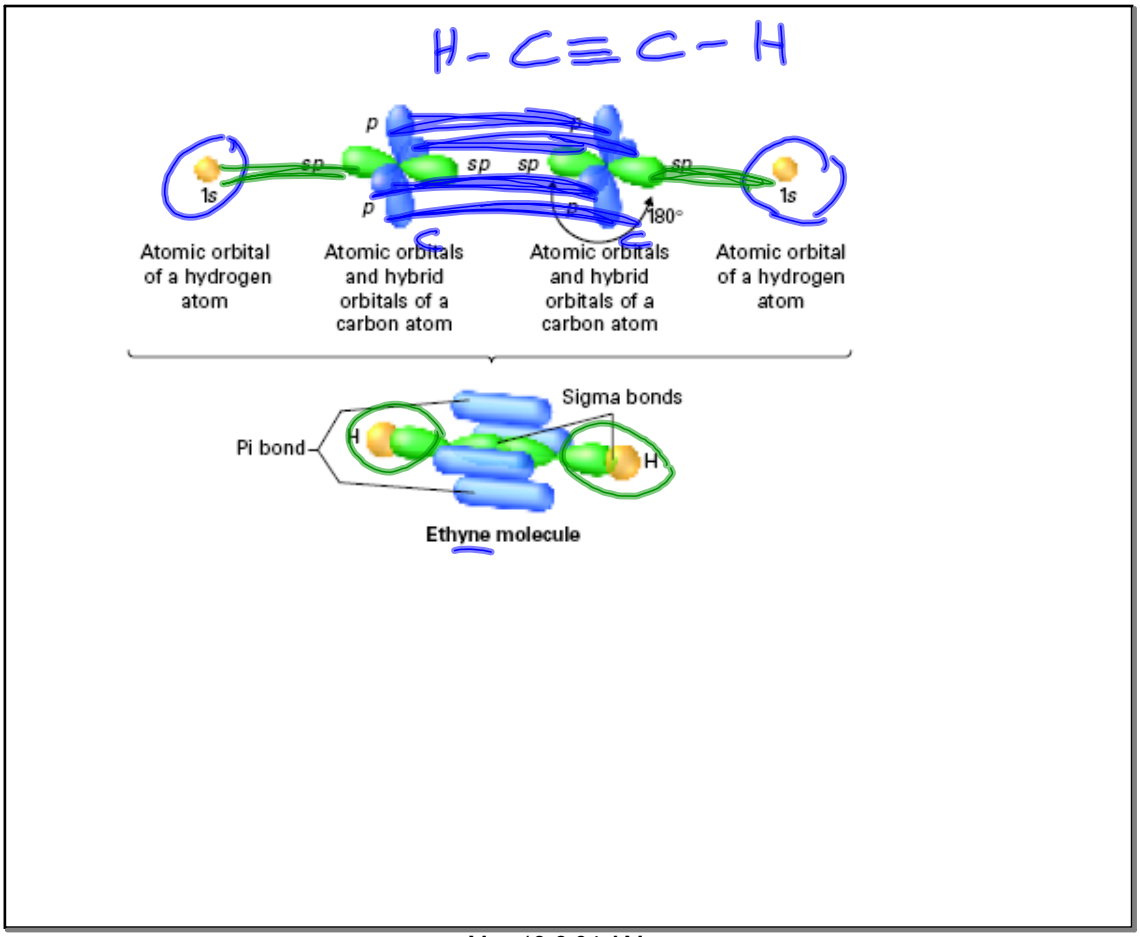


CH_4

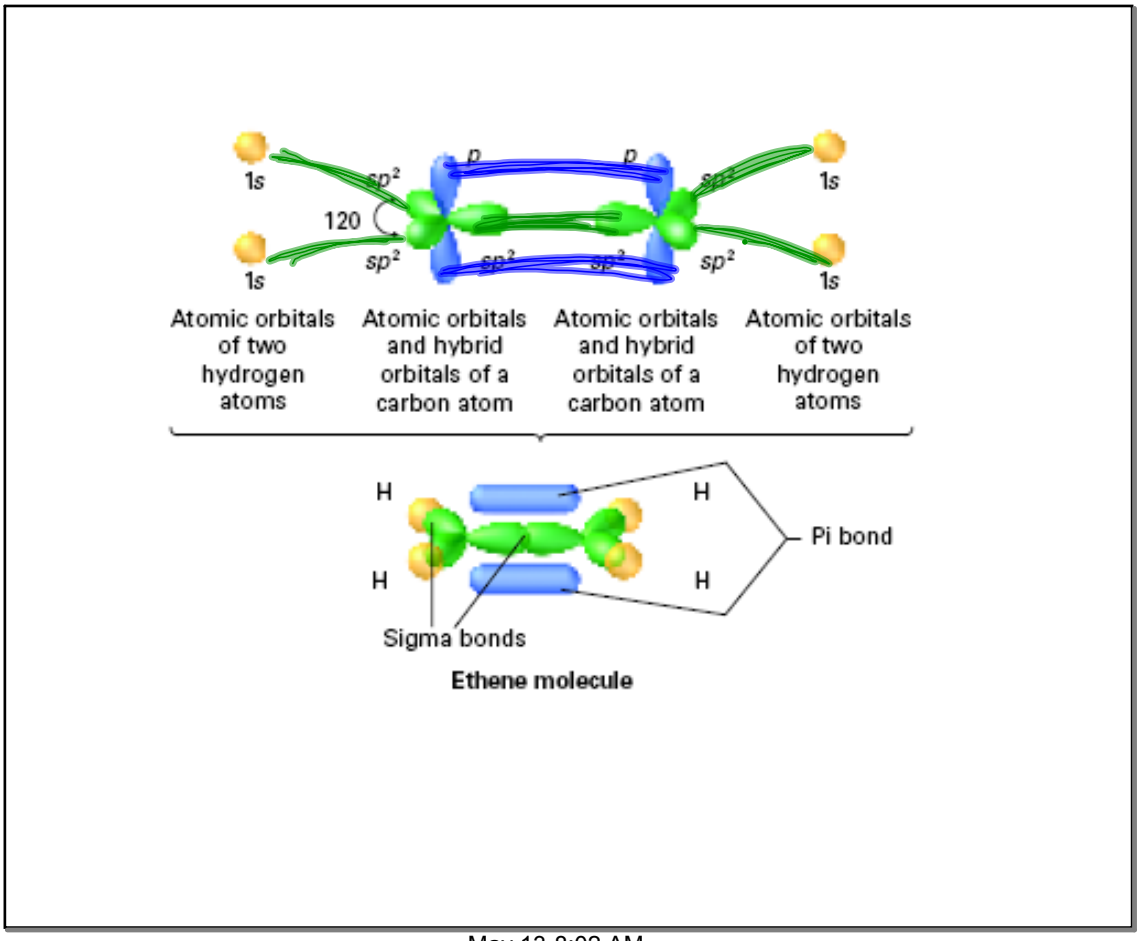
May 13-7:49 AM



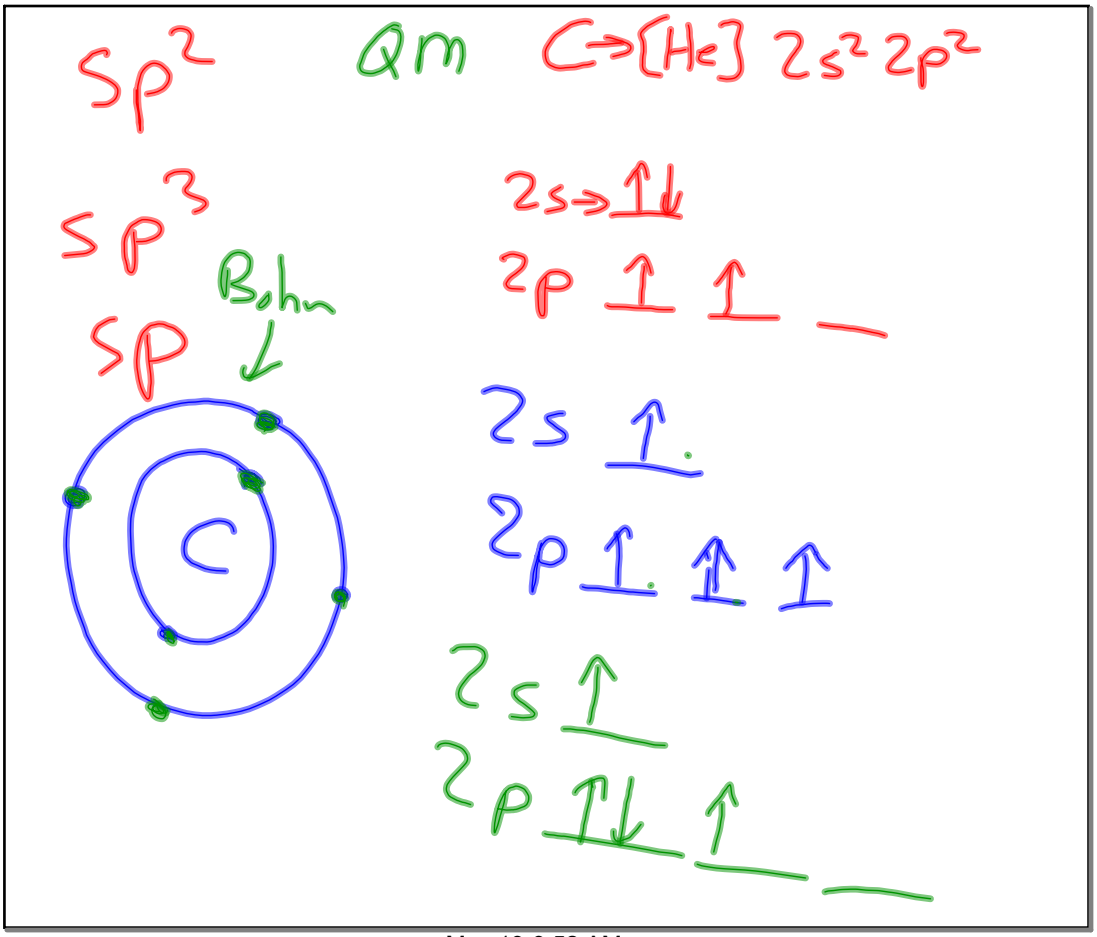
May 19-10:17 AM



May 13-8:04 AM



May 13-8:02 AM



May 19-9:52 AM

8.4 Polar Bonds and Molecules

Objectives

8.4.1 **Describe** how electronegativity values determine the distribution of charge in a polar molecule.

8.4.2 **Describe** what happens to polar molecules when they are placed between oppositely charged metal plates.

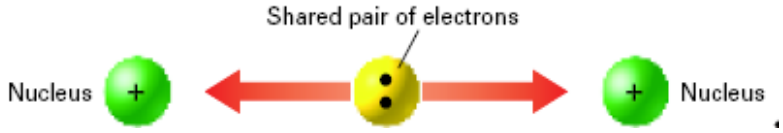
8.4.3 **Evaluate** the strength of intermolecular attractions compared with the strength of ionic and covalent bonds.

8.4.4 **Identify** the reason why network solids have high melting points.

Nov 1-9:38 PM

8.4 - Polar Bonds and Molecules

- Covalent bonds involve sharing electrons
- However, atoms share electons differently in covalent bonds
- When atoms share electons equally, the bond is a covalent bond is considered **nonpolar**



May 13-8:33 AM

Polar covalent bond is when electrons is not shared equally between atoms

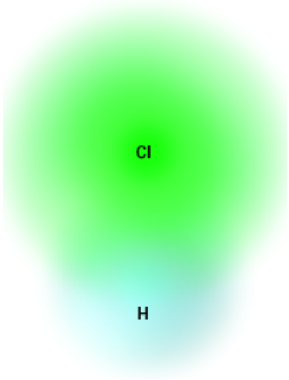


Table 8.3

Electronegativity Differences and Bond Types

Electronegativity difference range	Most probable type of bond	Example
0.0–0.4	Nonpolar covalent	H—H (0.0)
0.4–1.0	Moderately polar covalent	$H-\overset{\delta+}{Cl}$ (0.9)
1.0–2.0	Very polar covalent	$H-\overset{\delta-}{F}$ (1.9)
≥ 2.0	Ionic	Na^+Cl^- (2.1)

May 13-8:59 AM

Electronegativity is the ability of an atom to attract electons p177

Table 6.2

Electronegativity Values for Selected Elements

H 2.1						
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
Rb 0.8	Sr 1.0	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5
Cs 0.7	Ba 0.9	Tl 1.8	Pb 1.9	Bi 1.9		

May 13-9:09 AM

Identifying Bond Type

Which type of bond (nonpolar covalent, moderately-polar covalent, or ionic) will form between each of the following pairs of atoms?

a. N and H **b.** F and F **c.** Ca and Cl **d.** Al and Cl

Nov 1-9:45 PM

30. Identify the bonds between atoms of each pair of elements as nonpolar covalent, moderately polar covalent, very covalent, or ionic.

a. H and Br **b.** K and Cl **c.** C and O
d. Cl and F **e.** Li and O **f.** Br and Br

31. Place the following covalent bonds in order from least to most polar.

a. H—Cl **b.** H—Br
c. H—S **d.** H—C

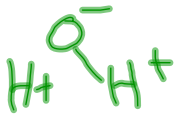
Answers

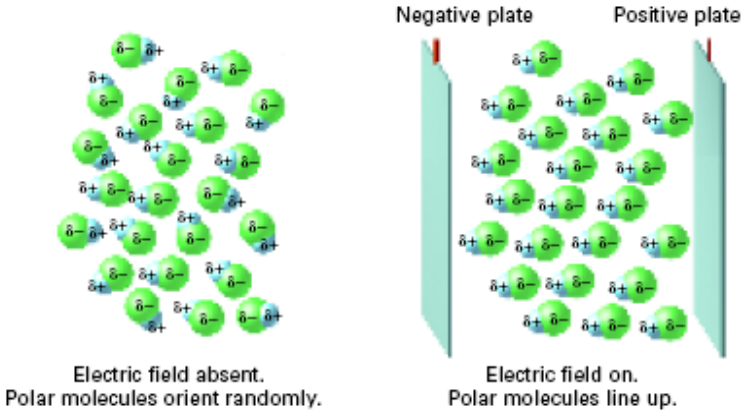
30. a. moderately polar covalent **b.** ionic **c.** moderately to very polar covalent **d.** moderately to very polar covalent **e.** ionic **f.** nonpolar covalent

31. c and d (tie), b, a

Nov 1-9:46 PM

Dipole is a molecule that has two poles (charges)





The video yesterday showed an example of how water would bend when exposed to water

May 13-9:12 AM

Attraction between molecules

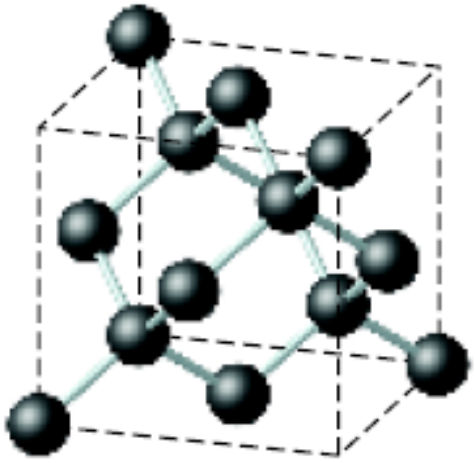
Van der Waals Forces
- a - Dipole Interaction
- b - Dispersion Forces

Hydrogen Bonding

May 13-9:36 AM

Network Solid

Figure 8.28 Diamond is a network-solid form of carbon. Diamond has a three-dimensional structure, with each carbon at the center of a tetrahedron.



May 19-9:19 AM

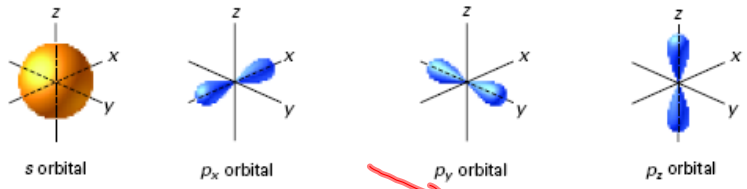
Table 8.4

Characteristics of Ionic and Covalent Compounds

Characteristic	Ionic compound	Covalent compound
Representative unit	Formula unit	Molecule
Bond formation	Transfer of one or more electrons between atoms	Sharing of electron pairs between atoms
Type of elements	Metallic and nonmetallic	Nonmetallic
Physical state	Solid	Solid, liquid, or gas
Melting point	High (usually above 300°C)	Low (usually below 300°C)
Solubility in water	Usually high	High to low
Electrical conductivity of aqueous solution	Good conductor	Poor to nonconducting

May 19-9:20 AM

Review



He $1s^2$ ↑↓

H $1s$ ↑

H· ·H

H:H

F [He] $2s^2 2p^5$

F $1s^2$ ↑↓

$2s^2$ ↑↓

$2p^5$ ↑↓ ↑↓ ↑

May 19-8:43 AM

9. Name the following compounds or write out the molecular formula:

1. CCl_4 _____
2. CO_2 _____
3. NO _____
4. NO_2 _____
5. SO_3 _____
6. Nitrogen _____
7. Ammonia _____
8. Glucose _____
9. Carbon monoxide _____
10. Dinitrogen tetraoxide _____

May 19-9:19 AM