Covalent Bonding

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Covalent versus Ionic Bonds

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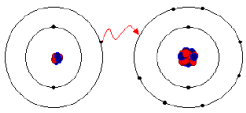
Covalent and Ionic Bonds

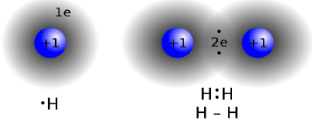
Chemical Bonds

Chemical bonds hold atoms together to create chemical compounds. There are three basic types of bonds:

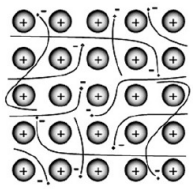
Ionic Bond - The electrostatic attraction between oppositely charged ions



Covalent Bond- The sharing of electrons between atoms



Metallic Bonding - Each metal atom bonds to other metals atoms within a "sea" of delocalized electrons *(covered in a later unit)*



Oct 11-1:24 PM

What kind of Bond am I?

* How ionic or covalent a bond is depends on the difference in electronegativity.
* The smaller the difference, the more likely electrons are "shared" and the bond is considered covalent.
* The greater the difference, the more likely electrons have been transferred, producing ions and resulting in an ionic bond.

	Li	Be	B	C	N	O	F
Electronegativity	1.0	1.6	2.0	2.5	3.0	3.5	4.0
Bond	Li-F	Be-F	B-F	C-F	N-F	O-O	F-F
△ Electronegativity	3	2.4	2.0	1.5	1	0.5	0

Increasing Covalent Character

Dec 1-11:09 AM

Chemical Bonds

We can make a few simplifications...

Ionic Bonding

Ionic bonds occur when the difference in electronegativity between two atoms is greater than or equal to 1.7.

Na ---- F △ electronegativity = 3

Covalent Bonding

If the difference of electronegativity is less than 1.7, neither atom takes electrons from the other; they share electrons. This type of bonding typically takes place between two non-metals.

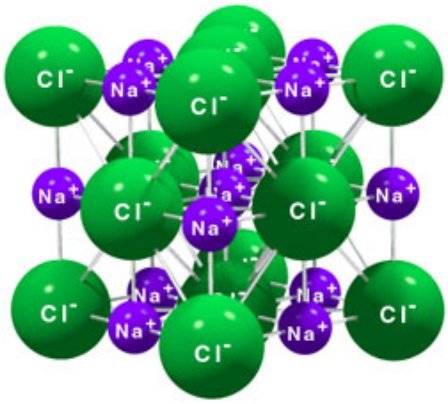
H ---- Cl △ electronegativity = 1.1

Aug 9-10:37 PM

Ionic v. Covalent Bonding

Ionic bonding results in the formation of a lattice. . not individual molecules.

The chemical formula for an ionic compound is just the ratio of each type of ion in the lattice.



Oct 28-8:37 PM

Molecular Compounds

Covalent bonding occurs between non-metals such as C,O,S,H,P,N, etc.

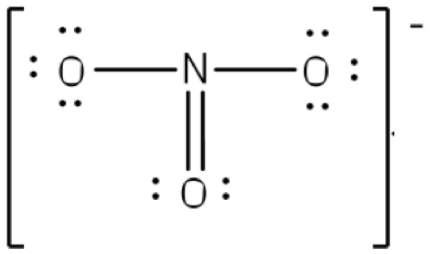
The two atoms involved in the covalent bond share electrons in order to fill their octets.

Unlike the other substances, the covalently bonded atoms **form small individual molecules**. These are called **molecular compounds.**

http://www.teachersdomain.org/asset/lsps07_int_covalentbond/

Oct 10-1:23 PM

Polyatomic ions are held together with covalent bonds

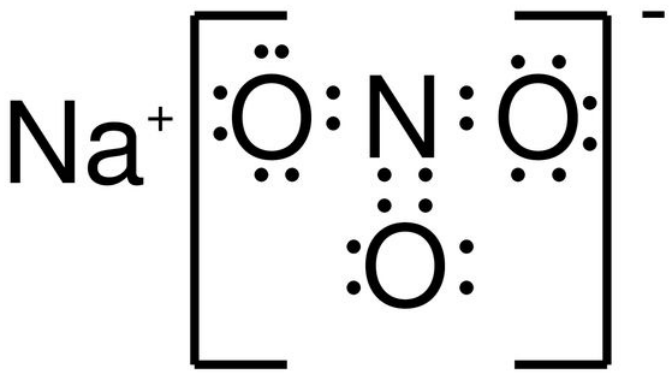


The bonds within this nitrate ion are covalent bonds between the nonmetals N and O.

The nitrate ion can form an ionic bond with any cation.

Polyatomics

- Compounds with polyatomic ions contain **BOTH** ionic and covalent bonds
  - Example: $NaNO_3$



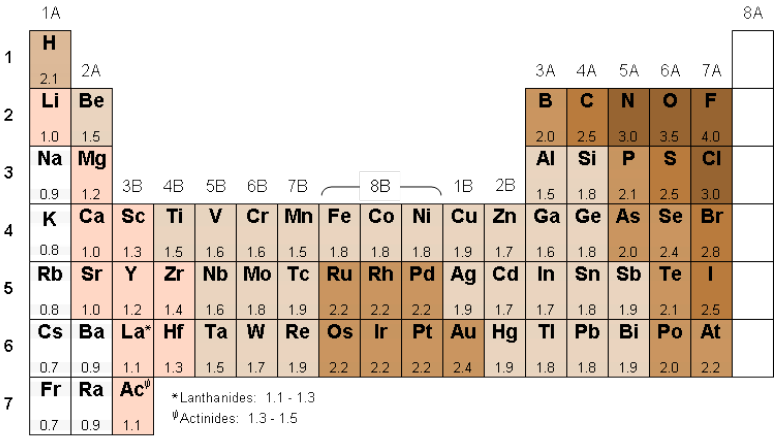
1. Which pair of atoms will form a covalent bond? (hint...look at the differences in electronegativities)

A. Li and Ne

B. K and Br

C. C and O

D. Na and Cl



Apr 12-1:40 PM

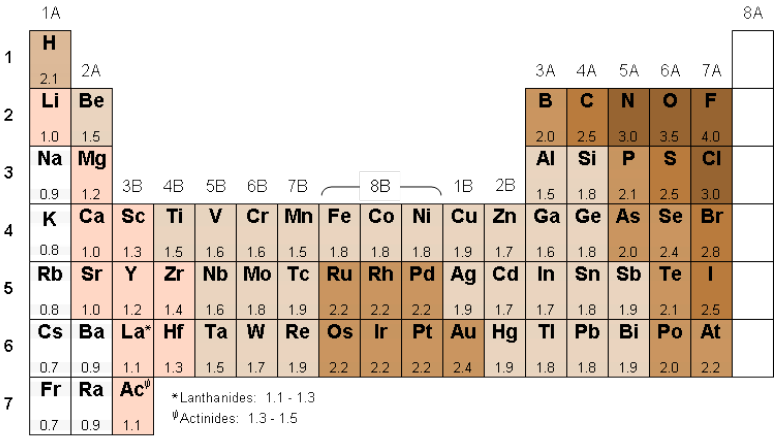
2. Which pair of atoms will form a covalent bond?

A. Li and N

B. Na and Cl

C. K and F

D. H and O



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3. The atoms that would form the MOST covalent bond would be:

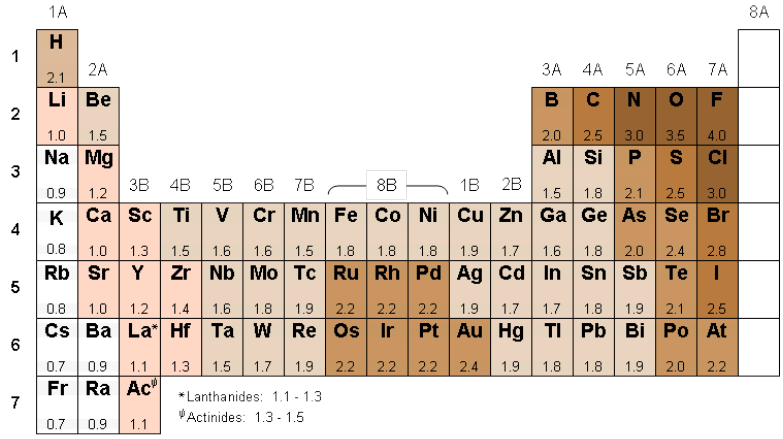
A. C-H

B. O-H

C. Cl-H

D. B-H

E. F-H



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4. The bond with the LEAST ionic character below would be:

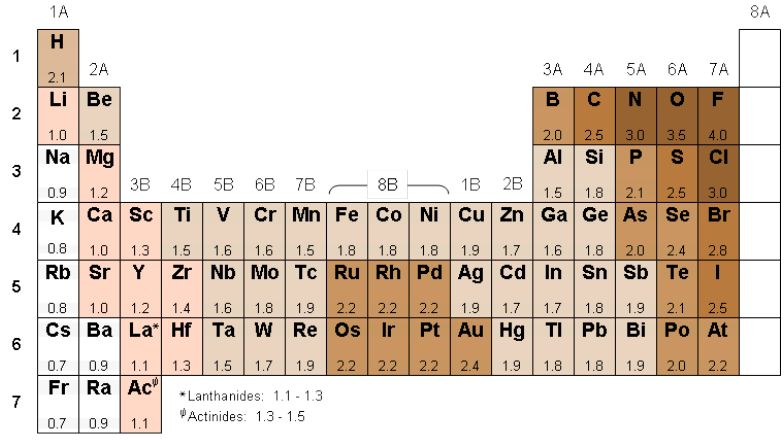
A. Na-F

B. C-F

C. Si-H

D. Al-O

E. Fe-Cl



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Properties of Ionic and Covalent Materials

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Properties of Materials

Substances formed through ionic or covalent bonding

Type of substance	Form of bonds	Identifying trait	Type of substance
Ionic	Ionic bonds	Metal + non-metal and or polyatomic ion	NaCl, $NaNO_3$
Molecule	Covalent bonds	Two or more non-metals	CO_2
Covalent Network	Covalent bonds	Pure Carbon or Si or Ge compound.	diamond, graphite, SiO_2 GeO_2
Metals	Metallic bonding (special type of covalent bond)	Any pure metal or metal mixture.	Ca, Cu, Fe 14K Gold

Dec 3-5:11 PM

Properties of Ionic Compounds

High Boiling and Melting Points

Since the ionic bonds span a short distance between ions, these forces are quite strong resulting in high melting points and boiling points!

Na+ -- Cl-

it takes a lot of energy to break an ionic lattice!

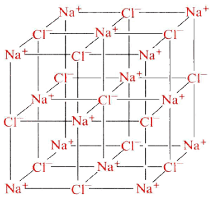
Compound	Melting Point (C)
NaCl	801
MgO	2852

Dec 1-5:23 PM

Properties of Ionic Compounds

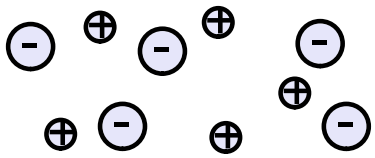
Conductivity

Since ionic compounds consist of ions, when these ions are free to move, the substance can conduct electricity when in solution or liquid (molten) state.



NaCl (s)

Lattice is strong, no conductivity



Molten NaCl(l)

Lattice is broken, ions are free to move and conduct

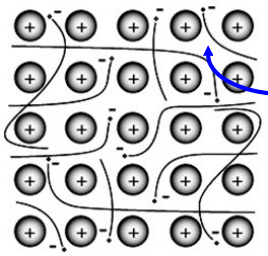
Dec 1-5:33 PM

Properties of Metallic Substances

High Melting and Boiling Points

Metallic compounds are held together by a type of covalent bonds called metallic bonding. In metallic bonding, some electrons are shared but they are loosely held and free to roam.
These covalent bonds between the metal atoms are strong! This gives rise to high melting and boiling points!

Metallic Lattice



strong metallic covalent bonds

Metal	Melting Point
Cu	1085 C
Fe	1585 C

Dec 1-6:06 PM

REAL WORLD APPLICATION

In order to obtain pure metals, the ancients had to melt the metal (metallic substance) out of the rock (an ionic compound).

Why do you think the bronze age (copper mixed with tin) came before the iron age?

Move for answer

Dec 1-6:20 PM

Properties of Metallic Compounds

Good Conductivity

Since the electrons in metals are free to roam somewhat, metals are good conductors of electricity in any state!

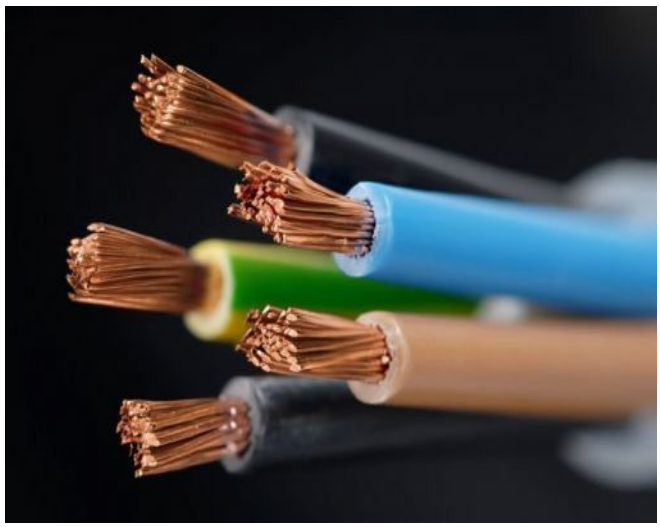
Silver is the most conductive metal and is roughly 5-10 times more conductive than steel (mostly iron).

Dec 1-6:28 PM

REAL WORLD APPLICATION

Copper is often used in electrical cable rather than silver even though it is roughly 10% less conductive than silver.

Why?



Move for answer

Dec 1-6:40 PM

Properties of Covalent Network Substances

High Melting Point and Boiling Point

Like ionic and metallic substances, covalent network solids are giant molecules arranged in 3-D crystalline shapes.

Covalent network solids often form from semi-metals like Silicon or Germanium or elemental carbon.

Since the bonds are covalent, they are quite strong! This gives rise to high melting and boiling points!

Glass (75% SiO_2)

Melts at 1500 C

Diamond (pure C)

Melts at 3500 C

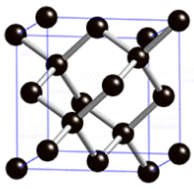
Dec 1-6:59 PM

Properties of Covalent Network Substances

No Conductivity

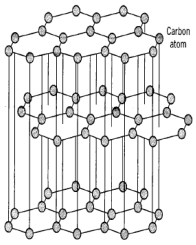
Since these substances have higher electronegativities, they keep good tabs on their electrons thereby preventing the electrons from moving. As a result they are largely non-conductive.

Diamond and graphite are both **allotropes** (different versions) of carbon and are somewhat conductive.



Diamond (C)

non-conductive



Graphite (C)

a little conductive

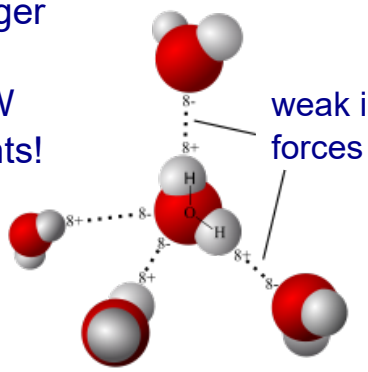
Dec 1-7:10 PM

Properties of Molecular Substances

Low Melting and Boiling Points

Since these substances contain lots of small molecules, the bonds holding these small molecules together are weak intermolecular forces, not the covalent bonds found inside the molecule.

The intermolecular forces extend over a much larger distance and are quite weak giving rise to LOW melting and boiling points!



Dec 1-7:36 PM

Properties of Molecular Substances

No Conductivity

Molecular compounds contain electronegative non-metals which do not lose their electrons easily so they are non-conductive.

As a result they are excellent INSULATORS!

Rubber: $(C_5H_9)_{250}$

Dec 1-7:42 PM

Summary of Substances

Ionic	Metallic	Cov. Network	Molecular
metals and non-metals	metals	semi-metals and pure carbon	non-metals
Na_2O	Fe	C(diamond)	CH_4
High MP	High MP	High MP	Low MP
conduct as liquid	conduct in all states	non-conductive	non-conductive
Brittle	Malleable	Brittle	Brittle

Dec 1-7:48 PM

5. Which of the following would NOT conduct electricity in the solid state?

A. Al

B. Al_2O_3

C. NaCl

D. Both A & B

E. Both B & C

answer

Apr 12-1:51 PM

6. Which of the following would be classified as a covalent network solid?

A. NaCl

B. HF

C. CO_2

D. Ge_2O_3

E. Fe

answer

Apr 12-1:51 PM

7. Which of the following would have the lowest melting point?

A. N_2

B. C (graphite)

C. C (diamond)

D. W

E. LiF

answer

Apr 12-2:16 PM

8. Which of the following will not conduct electricity in any state?

A. Cu

B. NaF

C. Fe

D. CO_2

E. All of these will conduct

answer

Apr 12-2:16 PM

9. Which of the following consists of small individual molecules?

A. C (diamond)

B. SiO_2

C. Cu_2O

D. Na

E. SO_3

answer

Apr 12-2:16 PM

10. Which of the following substances has both ionic and covalent bonding within the crystal?

A. Cu

B. $CuCO_3$

C. LiCl

D. Ba

E. BaF_2

answer

Apr 12-2:16 PM

Naming Binary Molecular Compounds

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Naming Molecular compounds

Naming Binary Molecular Compounds

1. Generally the less electronegative element is written first.

2. The second elements name ends in "ide" .

3. Prefixes are used to indicate how many of each type of atom is in one molecule. However, the prefix "mono" is not used on the first element.

Examples

NO_2 *nitrogen dioxide*

P_2O_5 *diphosphorous pentoxide*
(penta-oxide-->pentoxide)

Oct 10-8:55 PM

Naming Binary Molecular Compounds

Prefixes are used to indicate the number of each type of atom in one molecule.

The first element name only includes a prefix if there is more than one.

The second element name ALWAYS includes a prefix , plus the "ide" ending.

Examples

CO carbon monoxide

CO_2 *carbon dioxide*

Prefix
Mono – 1
Di – 2
Tri – 3
Tetra – 4
Penta – 5
Hexa – 6
Hepta – 7
Octa – 8
Nona – 9
Deca – 10

Oct 19-2:45 PM

Water and Ammonia

Binary compounds of hydogen that are not acids have been given special names.

H_2O is water

NH_3 is ammonia

Nov 4-8:49 PM

Molecular Formulas

Molecular formulas show the actual number of atoms of each element in one molecule.

Ex: C_2H_6

(Not the lowest ratio as in the empirical formula used for Ionic compounds)

Nov 16-2:27 PM

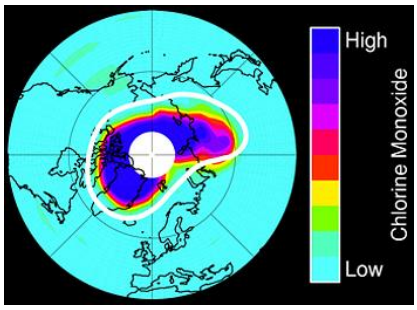
11. Chlorine monoxide is

A. ClO_2

B. ClO

C. OCl

D. O_2Cl



Nov 4-8:44 PM

12. Dinitrogen tetroxide is

A. NO_2

B. N_2O_4

C. NO_3

D. N_4O_2

Nov 4-8:46 PM

13. H_2O is

A. Hydrogen monoxide

B. Dihydrogen monoxide

C. Water

D. Hydrogen dioxide

E. Both B and C

Nov 4-8:47 PM

14. SO_3 is

A. Sulfate

B. Sulfur oxide

C. Sulfur trioxide

D. Sulfite

Nov 4-9:00 PM

15. MgO is

A. Monomagnesium monoxide

B. Magnesium monoxide

C. Monomagnesium oxide

D. Magnesium oxide

Nov 4-9:01 PM

16. P_4O_{10} is

A. Phosphorus pentoxide

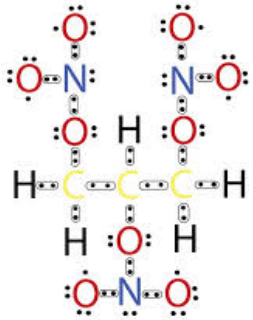
B. Tetraphosphorus decoxide

C. Phosphorus oxide

D. Phosphate

Nov 4-9:02 PM

Lewis Structures



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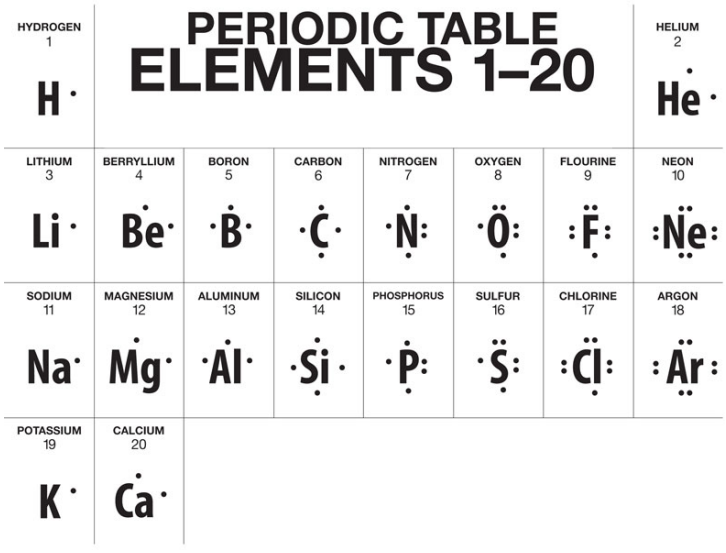
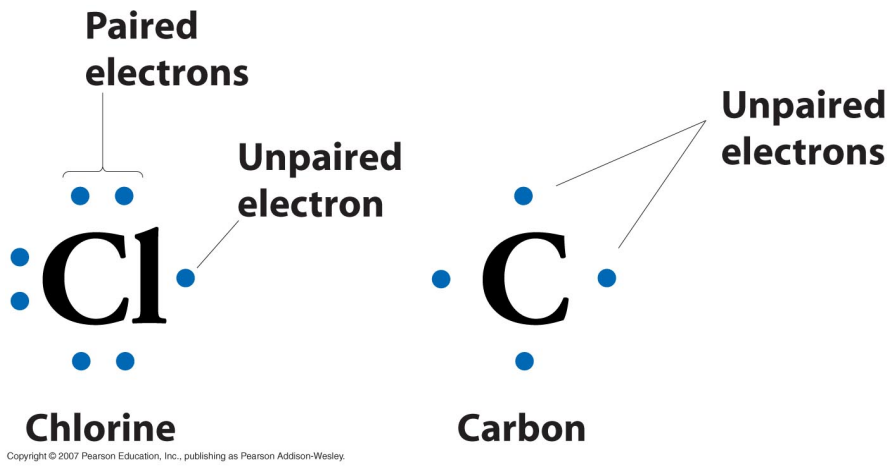
Lewis Structures

Lewis Dot Diagrams

Lewis dot diagrams show valence electrons as dots.
To write Lewis dot diagrams , place one dot on each of the four sides of the symbol, before you pair them.



Oct 17-2:25 PM



Nov 16-10:32 AM

17. How many valence electrons does Oxygen have?

A. 2

B. 3

C. 4

D. 5

E. 6

Nov 4-9:04 PM

18 **The Lewis structure for nitrogen is** 

True

False

Nov 4-9:05 PM

The Octet Rule

Recall that atoms will lose, gain, or share electrons in order to attain a stable, Noble gas configuration. This is usually 8 electrons in an s^2p^6 configuration.

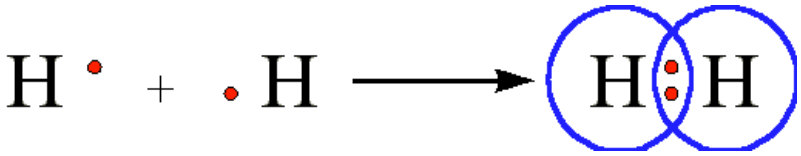
In **covalent bonding, an atom will share electrons** in an effort to obtain eight electrons around it (except hydrogen which is stable with 2 valence electrons).

Exceptions to the Octet Rule	
H	**needs 2e-**
Be	**needs 4e-**
B	**needs 6e-**

Oct 17-2:29 PM

How do electron dot structures represent shared electrons?

An electron dot structure such as H:H represents the shared pair of electrons of the covalent bond by two dots.



Oct 10-8:25 PM

Structural Formulas

A **structural formula** represents the covalent bonds by dashes and shows the arrangement of covalently bonded atoms. As in the example below, one shared pair of electrons is represented by one dash.

Shared pair of electrons

H : H

Hydrogen molecule

H — H

Oct 10-8:25 PM

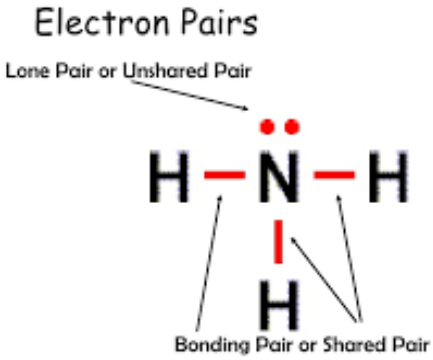
19. How many electrons are shared by two atoms to create a single covalent bond?

A. 2

B. 1

Nov 4-9:07 PM

Single Covalent Bonds

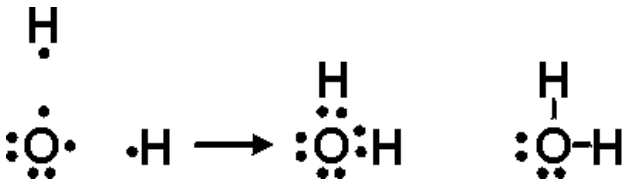


A pair of valence electrons that is not shared between atoms is called an unshared pair, also known as a **lone pair** or a **nonbonding pair.**

Oct 10-8:47 PM

Lewis Structure of H_2O

In a water molecule, each hydrogen and oxygen atom attains a noble-gas configuration by sharing electrons.



The water molecule has two unshared, or lone, pairs of electrons on the central Oxygen atom.

Oct 10-8:48 PM

Drawing Lewis Structures

1. Find the total number of valence electrons in the polyatomic ion or molecule.

PCl_3

Atom	valence electrons	
P	5	
Cl	7	
Cl	7	
Cl	7	= 26 valence electrons

Oct 10-9:17 PM

Drawing Lewis Structures PCl_3

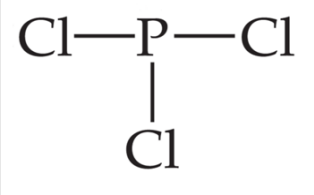
2. **The central atom is usually the atom that needs the most electrons to fill its octet.** (The atom that needs to make the most bonds).

P has 5 valence electrons and needs 3 electrons to fill its octet.
Cl only needs 1 electron to fill its octet.

P will be the central atom.

Place the other atoms around the central atom(s)

The Cl atoms will surround the P atom.



3. Connect atoms with a single line (a single bond = 2 shared electrons).

Oct 10-9:21 PM

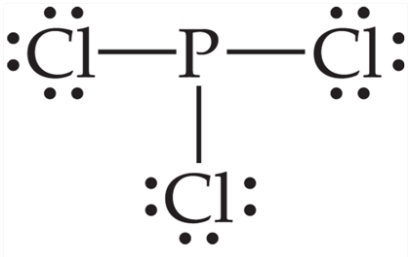
Drawing Lewis Structures

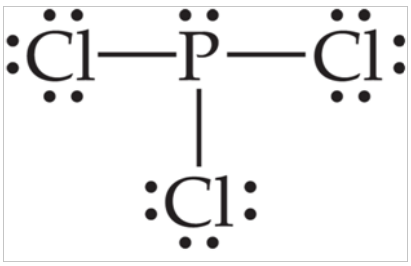
4. Count each single bond as a pair (two) of electrons.

5. Add electons to the outer atoms to give each one 8 (a full shell), **or just 2 electrons for hydrogen.**

6. Place any left over electrons on the central atom.

7. *Check: Does each atom have a full outer shell (8 except, 2 for hydrogen)?*





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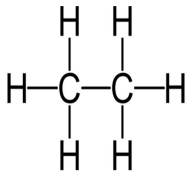
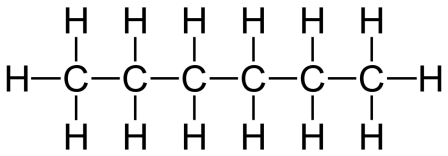
Carbon Backbones

Hydrocarbons are molecules made up of hydrogen can carbon. Multiple carbon atoms will bond to each other forming a "backbone" of these organic molecules.





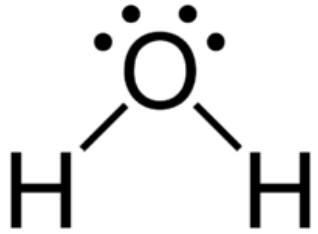
Nov 4-9:22 PM

Drawing Lewis Dot Structures : Summary of Steps

1. Find the total number of valence electrons.
2. The central atom will be the one that needs the most electrons to fill its octet. C is always in the middle.
3. Connect atoms to each other with a single bond.
4. Count each single bond as 2 electrons, then continue adding electrons to the OUTER atoms in order to give each one an octet.
5. Place any left over electrons on the central atom.
6. Check to make sure that you have used all valence electrons.

Nov 4-9:16 PM

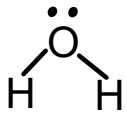
Remember H is an exception and is stable with a duet, only 2 electrons.

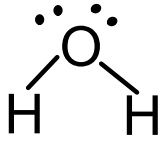


20. Which of the following is the correct Lewis structure for H_2O?

A. H–O–H

C. H–H–O

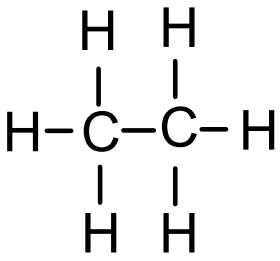
B. 

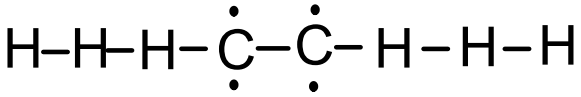
D. 

Nov 4-9:30 PM

21. Which of the following is the correct Lewis Structure for C_2H_6 ?

H–H–H–H–H–H–C–C





Nov 4-9:35 PM

Lewis Structures for Polyatomic ions

The central atom for polyatomic ion structures is usually the first element in the formula.

A **negative ion** has **extra electrons**, add the charge of the ion to your valence electron count.

ClO_2^- has 1(7) + 2(6) **+ 1** = 20 electrons

Place [ ] around the polyatomic structure and add charge to upper right.

Oct 10-9:35 PM

A **positive ion** is **missing electrons**, subtract the charge of the ion from your valence electron count.

NH_4^+ has 1(5) + 4(1) **-1** = 8 electrons

22. How many valence electrons does CO_3^{2-} have?

A. 12

B. 18

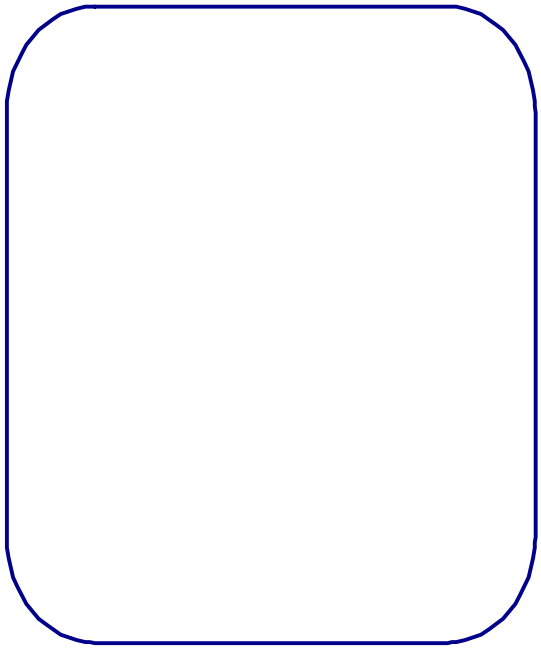
C. 24

D. 26

Nov 5-7:34 PM

Lewis Structures

Draw the Lewis dot structure for the hydronium ion, H_3O^+



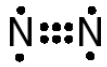
Aug 18-11:07 AM

Double and Triple Covalent Bonds

Atoms will share additional pairs of electrons if it will help them attain an octet.

A double covalent bond is formed by two atoms sharing 4 electrons.

A triple covalent bond is formed by two atoms sharing 6 electrons.

Single bond	Double bond	Triple bond
H–H	O=O	N≡N
H:H		

Oct 10-8:50 PM

Double and Triple Covalent Bonds

Carbon Dioxide, CO_2

1. Determine the # of valence electrons.

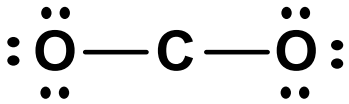
   1 (4) + 2 (6) = 16 e-

2. Form Single Bonds

   O—C—O

This leaves 12 electrons, 6 pairs that have not been placed.

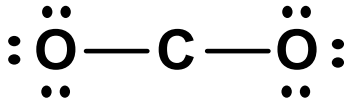
3. Place lone pairs on oxygen atoms to give each 8.



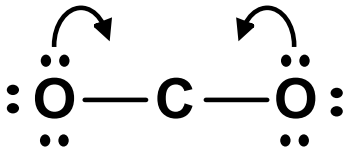
Oct 11-5:15 PM

Carbon Dioxide, CO_2

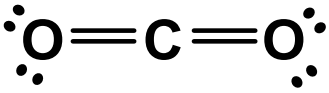
4. Check: We had 16 electrons to work with; how many have we used?



5. We have used 16 electrons, but Carbon still does not have an octet. We must form DOUBLE BONDS between C and O.



Instead of sharing only 1 pair, a double bond shares 2 pairs. So one pair is taken away from each atom and replaced with another bond.



Oct 11-5:15 PM

Writing Lewis Structures

If you run out of electrons before the central atom has an octet……form multiple bonds until it does.

Oct 10-9:25 PM

Bonding of O_2

Oxygen molecule

Oxygen atom

Oxygen atom

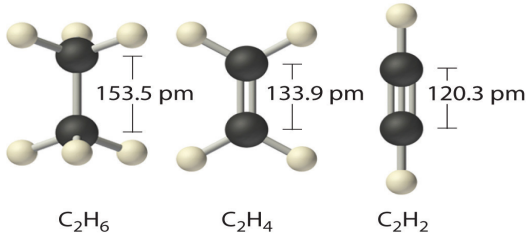
Oxygen molecule

Oct 10-8:51 PM

Draw the Lewis structure for N_2

Draw the Lewis structure for CO

Covalent Bond Length



Bond length is affected by the number of electrons being shared between the two nuclei, and the attraction between the negative electrons and the positive nuclei

Single bonds are the longest.

Double bonds are mid-length

Triple bonds are the shortest.

Oct 25-7:05 PM

Covalent Bond Energy

Bond Type	Bond Energy
C — C	348 kJ
C = C	614 kJ
C ≡ C	839 kJ

Bond strength also varies.

Single bonds are the weakest.

Double bonds are mid-strength.

Triple bonds are the strongest of the three.

Oct 25-6:07 PM

Covalent Bonds Comparison

Type of Bond	Electrons shared	Bond Strength	Bond Length
—	2	weak	long
=	4	intermediate	intermediate
≡	6	strong	short

Oct 25-6:10 PM

24. As the number of bonds between atoms increases, the distance between atoms ....

A. increases

B. decreases

C. remains unchanged

D. varies, depending on the atoms

Nov 5-7:40 PM

25. As the number of bonds between two atoms increases, the strength of the bond ...

A. increases

B. decreases

C. remains unchanged

D. varies, depending on the atoms

Nov 5-7:42 PM

26. As the number of bonds between two atoms increases, the energy of the bond ...

A. increases

B. decreases

C. remains unchanged

D. varies, depending on the atoms

Nov 5-7:42 PM

27. How many electrons are shared by two atoms to create a single bond? _____

28. How many electrons are shared by two atoms to create a double bond? _____

29. How many electrons are shared by two atoms to create a triple bond? _____

Nov 5-7:44 PM

30. Using Lewis structure drawings, determine which molecule below would have the shortest bond length between atoms.

A. O_2

B. F_2

C. Cl_2

D. CO

E. I_2

Nov 5-7:46 PM

31. Which of the following molecules would have the longest C-O bond length? Draw Lewis structures.

A. CO

B. CO_2

C. H_2CO

D. CH_3OH

E. The lengths are all the same.

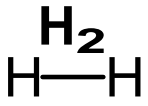
Nov 5-7:48 PM

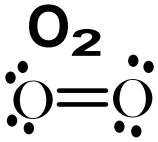
Diatomic Molecules

A diatomic molecule is a molecule consisting of two neutral atoms. Certain elements do not exist as single atoms when in the **pure** state; they always appear as pairs.

Remember: HONClBrIF

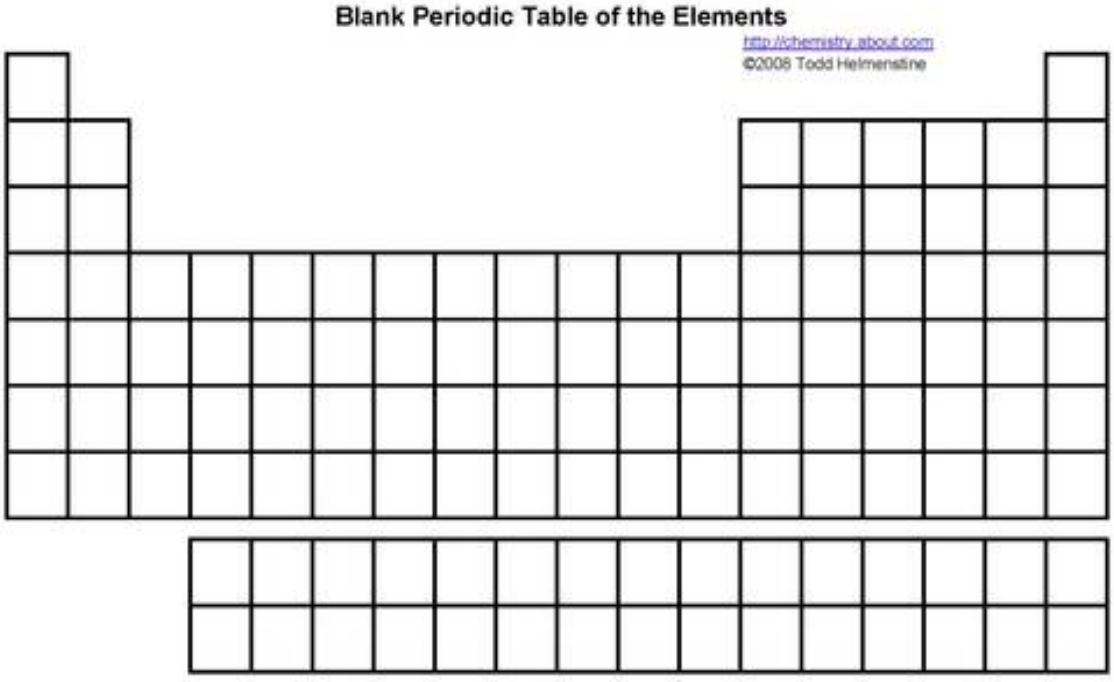
Hydrogen
Nitrogen
Oxygen
Fluorine
Chlorine
Bromine
Iodine





Oct 10-1:28 PM

32. Mark which elements exist as diatomic elements on the periodic table below:



Nov 5-7:50 PM

Exceptions to the Octet Rule

There are three types of ions or molecules that do not follow the octet rule:

#1 Ions or molecules with an **odd number of electrons**

#2 Ions or molecules with **less than an octet**

#3 Ions or molecules with **more than eight valence electrons** (an expanded octet)

Oct 10-9:28 PM

Exception 1: Odd Number of Electrons

Though relatively rare and usually quite unstable and reactive, there are ions and molecules with an odd number of electrons.

NO is an example:

Aug 17-4:55 PM

Exception 2: Fewer Than Eight Electrons

Beryllium (Be) - this metal is shown to form molecular compounds, rather than ionic compounds as expected; only needs 4 electrons to be stable

Boron (B) - only needs 6 electrons to be stable

Memorize these exceptions

Aug 17-5:07 PM

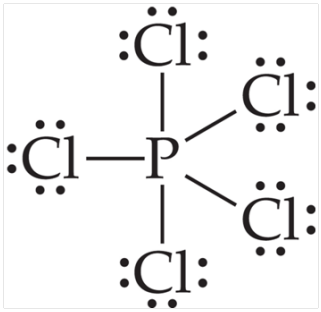
Exception 3: Expanded Octet

The only way PCl_5 exists is if phosphorus has 10 electrons around it.

This is called an **expanded octet**.

Atoms on the third energy level or higher are able to expand their octet to 10 or 12 electrons.

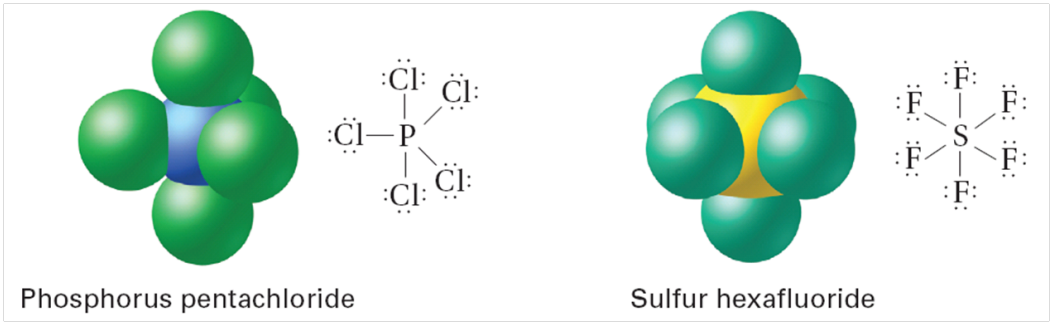
These atoms are larger and can accommodate more electrons.



Oct 10-9:28 PM

Exception 3: Expanded Octet

How many electrons do these central atoms have around them?



Phosphorus pentachloride

Sulfur hexafluoride

Oct 19-3:47 PM

Exceptions to the Octet Rule

Draw the Lewis dot structure for sulfur hexaflouride, SF_6:

Move for answer

Aug 17-9:43 AM

Exceptions to the Octet Rule

Draw the Lewis dot structure for the xenon tetrafluoride, XeF_4.

Move for answer

Oct 10-9:36 PM

Exceptions to the Octet Rule

Draw the Lewis dot structure for boron trifluoride, BF_3:

Move for answer

Aug 17-5:11 PM

Exceptions to the Octet Rule

Draw the Lewis dot structure for the iodine tricholoride, ICl_3.

Move for answer

Aug 17-10:22 AM

33. Which of the following need fewer than 8 valence electrons to be stable?

A. Boron and Beryllium

B. Boron and Helium

C. Boron, Beryllium, and Hydrogen

D. Boron, Beryllium, Hydrogen, and Helium

E. Boron, Beryllium, Hyrogen, Helium, and Oxygen

Nov 5-7:53 PM

34 The correct lewis structure for $BeCl_2$ is

True or False?

Nov 5-7:55 PM

35. Elements in the first two rows of the periodic table cannot have expanded octets because their atoms do not have enough space to accomodate the extra electrons.

True or False

Nov 5-7:56 PM

Resonance Structures

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Resonance Structures

Resonance

Resonance structures are structures of a molecule that differ only in the placement of electrons.

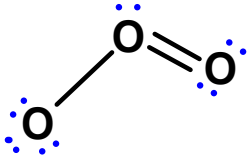
One Lewis structure cannot accurately depict a molecule like ozone: we can place a double bond on the left or the right.
Therefore, we use multiple structures, called resonance structures, to describe the molecule.

Ozone has two resonance structures.

Oct 24-4:50 PM

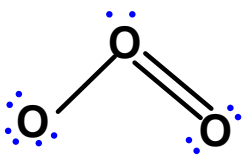
Resonance

Consider the Lewis structure we would draw for ozone, O_3:



We would expect the double bond to have a shorter bond length than the single bond.

However, the true, observed structure of ozone shows that both O-O bonds are the same length. How can this be?



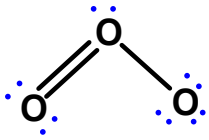
Oct 24-4:49 PM

Resonance

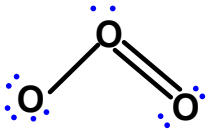
The actual ozone molecule is a synthesis or blend of these two resonance structures.

The bond length for both outer oxygen atoms falls somewhere between the single and double bond length.
The bonds blend to be identical.

Resonance structure



Resonance structure

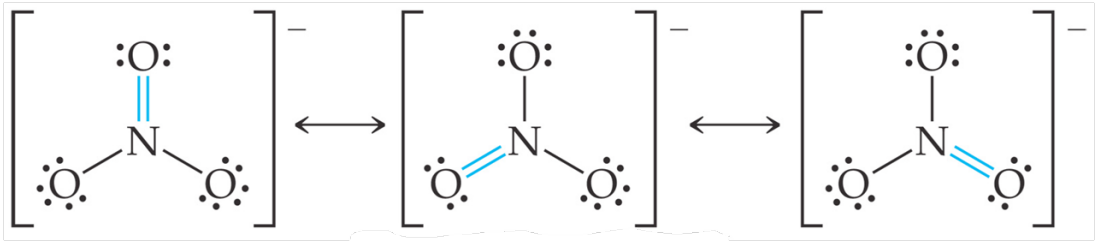


Aug 17-3:06 PM

Resonance

The nitrate ion, NO_3^{1-} also requires resonance structures to explain its covalent bonding.

There are three resonance structures for the nitrate ion:



Oct 23-8:26 PM

Resonance Structures

Draw the Lewis dot structure for SO_3:

move for answer

Oct 17-2:49 PM

36. How many resonance structures can be drawn for the carbonate ion, CO_3^{2-}?

A. 1

B. 2

C. 3

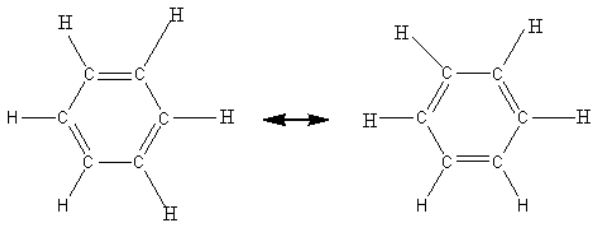
D. 4

E. 5

Nov 5-7:58 PM

Benzene

The benzene molecule is a regular hexagon of carbon atoms with a hydrogen atom bonded to each one. There are two resonance structures for benzene.



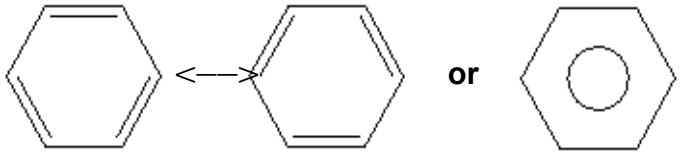
Benzene, C_6H_6, is obtained from the distillation of fossil fuels. More than 4 billion pounds of benzene is produced annually in the United States. Because benzene is a carcinogen, its use is closely regulated.

Oct 24-3:56 PM

Localized v. Delocalized electrons

In truth, the shared pairs of electrons do not always remain between adjacent C atoms. They are not *localized*.

Instead, the electrons are said to be *delocalized*, meaning that they they can move around the 6-carbon ring.

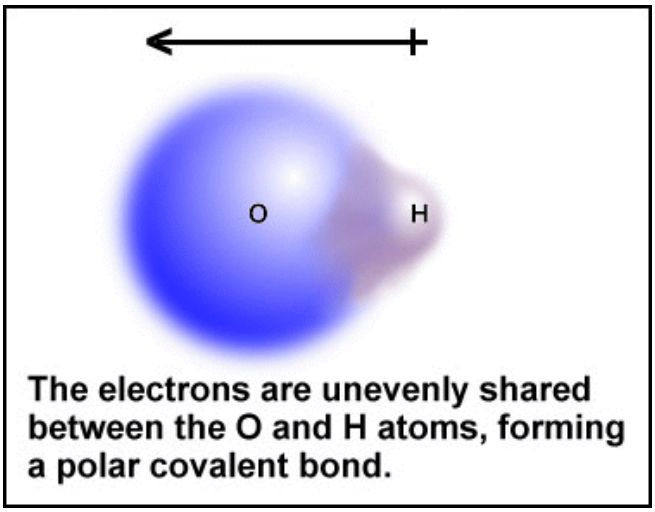


Benzene is commonly depicted as a hexagon with a circle inside to signify the delocalized electrons in the ring.

Oct 24-3:56 PM

Polarity of Bonds

Though atoms often form compounds by sharing electrons, the electrons are not always shared equally. In a covalent bond, one atom may have a greater ability to pull the shared pair toward it.



The electrons are unevenly shared between the O and H atoms, forming a polar covalent bond.

Oct 24-3:50 PM

Bond Dipoles and Electronegativity

When two atoms share electrons unequally, a bond dipole results.

	1A	2A	3B	4B	5B	6B	7B	8B			1B	2B	3A	4A	5A	6A	7A	8A
1	H 2.1																	
2	Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	
3	Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	
4	K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.7	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	
5	Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	
6	Cs 0.7	Ba 0.9	La* 1.1	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	
7	Fr 0.7	Ra 0.9	Ac# 1.1															

*Lanthanides: 1.1 - 1.3
#Actinides: 1.3 - 1.5

Below 1.0
1.0 - 1.4
1.5 - 1.9
2.0 - 2.4
2.5 - 2.9
3.0 - 4.0

Oct 24-4:44 PM

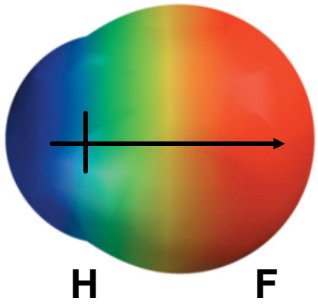
Bonds and Electronegativity

Bond Type	Electronegativity Difference
Non-Polar Covalent	very small or zero
Polar Covalent	about 0.2 to 1.6
Ionic	above 1.7 (between metal & non-metal)

Oct 24-6:05 PM

Polarity of Bonds

In the HF molecule, the fluorine is more electronegative than hydrogen, so the F pulls the electrons closer to its nucleus and results in one end of the molecule being slightly negative, while the other side is slightly positive.



We use the  symbol to designate a dipole (2 poles). The "+" end is on the more positive end of the molecule and the arrow points towards the more negative end.

Oct 24-5:54 PM

Polarity of Bonds

Identical atoms will have an electronegativity difference of ZERO. As a result, the bond is NONPOLAR, and the electrons are shared and distributed equally.

F_2

Oct 24-3:50 PM

Polar Molecules

The effects of shifted electrons due to polar bonds can extend over a molecule - causing the entire molecule to have a more negative end and a more positive end.

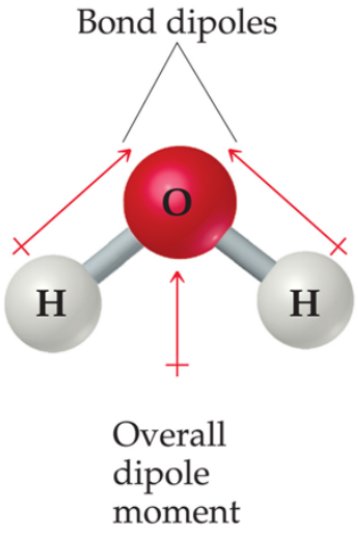
These are called **Polar molecules.**

Dec 3-6:12 PM

Determining Polarity of Molecules

1. Draw the structure

2. Look up electronegativity of atoms. By drawing arrows to indicate individual bond dipoles, you can determine if there is an overall shift in charge for the molecule.



Oct 23-10:11 PM

How to Identify a Polar Molecule

For a molecule to be polar, it must
a) have one or more asymmetrical polar bonds

OR

b) or have unshared electrons on the central atom.

Dec 3-6:19 PM

Non-Polar Molecules

Molecules with non-polar bonds are non-polar (unless they have an unshared pair of electrons on the central atom).

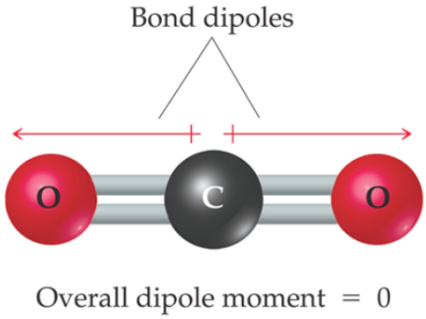
A molecule with polar bonds that are equal and arranged so that they cancel each other out results in a non-polar molecule as well.

Oct 23-10:09 PM

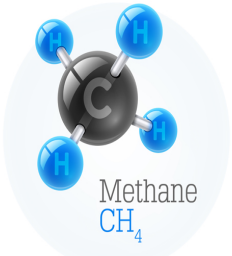
For instance, in the case of CO_2:

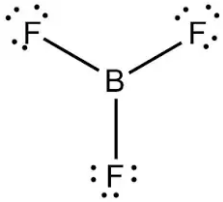
Each O=C bond is polar, but their directions are 180° from each other, and they cancel out.

Polar bonds add like vectors.



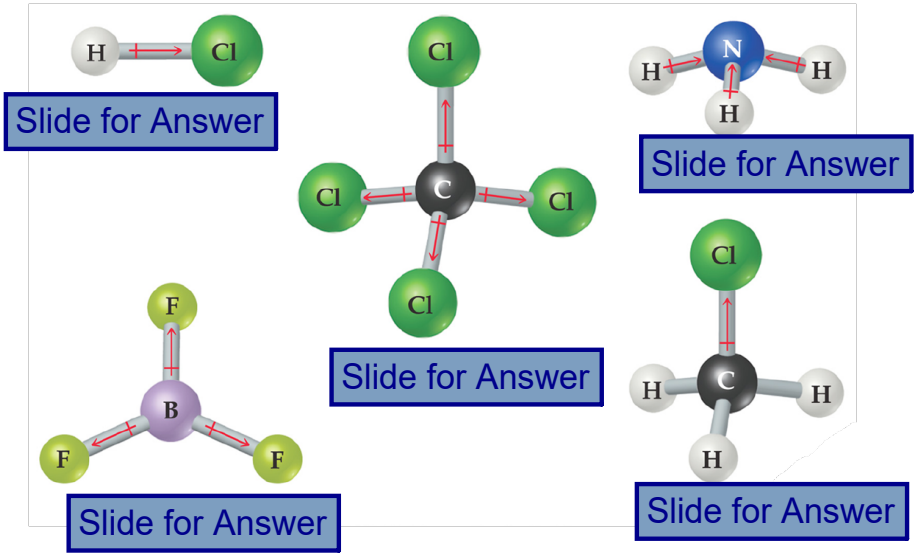
Examples of other symmetrical molecules that are non-polar but have polar bonds:





Polarity of Molecules

These are some examples of polar & nonpolar molecules.



Oct 23-10:14 PM

37. Which of these are polar molecules?

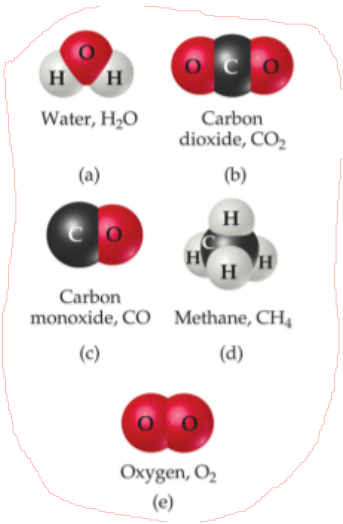
A. a and b

B. a, b, and c

C. a and c

D. a, c, and d

E. c and e



Nov 5-8:00 PM

38. Sulfur trioxide (SO_3). Polar or non-polar?

39. Hydrogen sulfide gas (H_2S). Polar or non-polar?

Nov 5-8:01 PM

40. Which of the following contains polar bonds but is a non-polar molecule?

A. CH_4

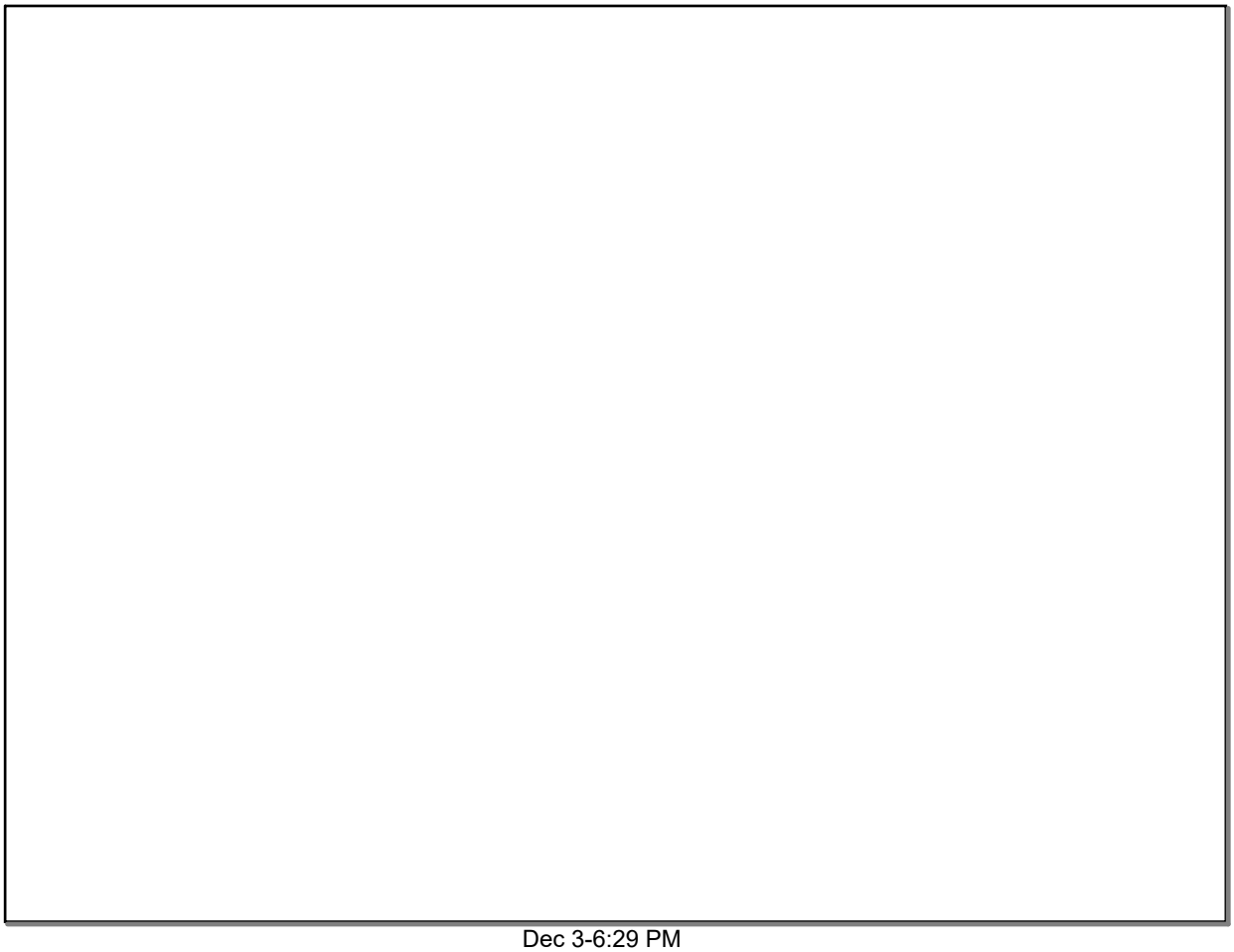
B. CS_2

C. H_2S

D. CF_4

E. All of these are polar.

Mar 25-11:07 PM



Dec 3-6:29 PM