

Bonding

What are ionic bonds, and how are they formed?

Computer Lab: Ionic Bonds

- Go to http://www.pbslearningmedia.org/asset/lps07_int_ionicbonding/
- Read each screen and follow the directions where appropriate.
- Answer the questions on the screens in your packet.

What are polar and nonpolar covalent bonds, and how are they formed?

Computer Lab: Covalent Bonds

- Go to http://www.pbslearningmedia.org/asset/lps07_int_covalentbonding/
- Read each screen and follow the directions where appropriate.
- Answer the questions on the screens in your packet.

What are polar and nonpolar covalent bonds, and how are they formed?

**(Packet Pg 4) Compare/Contrast:
Ionic and Covalent Bonds**

- Differences with regard to:
 - How are the bonds formed?
 - What is the charge on the atoms?
 - How many bonds can be formed between the atoms?
 - What types of atoms are involved?

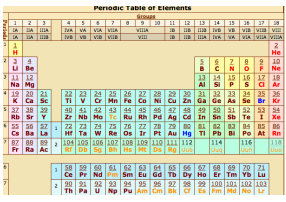
What are polar and nonpolar covalent bonds, and how are they formed?

**Computer Lab:
Compound Treasure Hunt**

- You will receive a set of compounds. For each compound, write the name (from the card), the formula, the common name or purpose, and identify whether or not it contains ionic bonds.

What are polar and nonpolar covalent bonds, and how are they formed?

**Review
Atomic Radius (size)**

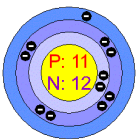


The image shows a periodic table of elements with atomic radii values indicated in small boxes. The values generally decrease from left to right and increase from top to bottom. The table includes elements from Hydrogen (1) to Oganesson (118).

What are polar and nonpolar covalent bonds, and how are they formed?

Review Atomic Radius (size)

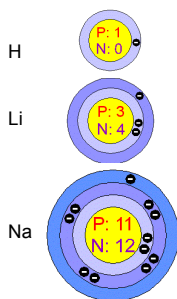
- The atomic radius of an element is half of the distance between the centers of two atoms of that element that are just touching each other.
- Relative size of ions and their parents:
 - Cations are smaller than their parents.
 - Anions are larger than their parents.



What are polar and nonpolar covalent bonds, and how are they formed?

Review Atomic Radius (size)

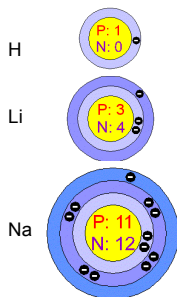
- Down a column?
Atomic size generally **increases** as we move down a group of the periodic table. As we descend, electrons are added to successively higher energy levels.



What are polar and nonpolar covalent bonds, and how are they formed?

Review Atomic Radius (size)

- Down a column? (con't)
The nuclear charge also increases because of additional protons. However, the full nuclear charge is shielded from the outer electrons because of the inner electrons and distance from the nucleus.



What are polar and nonpolar covalent bonds, and how are they formed?

Review

Atomic Radius (size)

- Across a row? Atomic size generally **decreases** as we move from left to right across a period. As we move across a period, electrons are added to the same energy level.

Na

Mg

Al

What are polar and nonpolar covalent bonds, and how are they formed?

Review

Atomic Radius (size)

- Across a row? (con't) Protons are also added to the nucleus. The effect of the increasing nuclear charge on the outermost electrons is to pull them closer to the nucleus. Atomic size therefore decreases.

Na

Mg

Al

What are polar and nonpolar covalent bonds, and how are they formed?

Electronegativity

What are polar and nonpolar covalent bonds, and how are they formed?

Electronegativity

Ability of an atom in a molecule to attract electrons to itself.

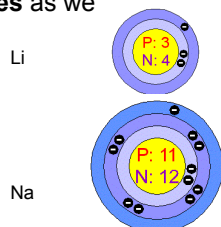
It is a measure of how "greedy" an atom is for electrons.

Exceptions: Noble gases are not included in this general trend.

What are polar and nonpolar covalent bonds, and how are they formed?

Electronegativity

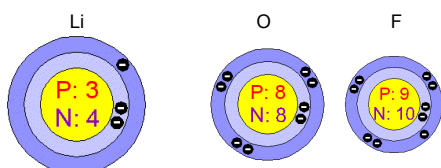
- Down a column? Electronegativity generally **decreases** as we go down a group.

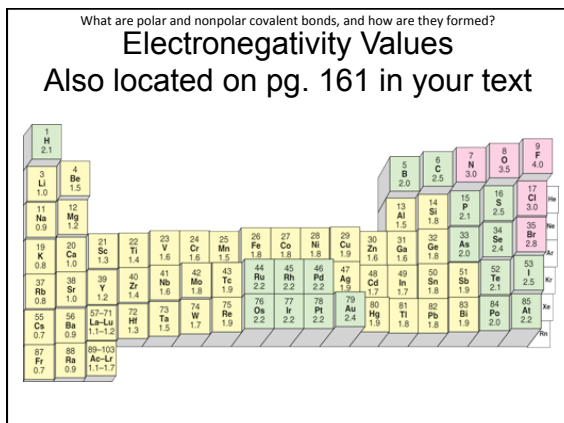


What are polar and nonpolar covalent bonds, and how are they formed?

Electronegativity

- Across a row? Electronegativity generally **increases** as we go across a period.





What are polar and nonpolar covalent bonds, and how are they formed?

Electronegativity Difference

- $\Delta EN = |EN_{\text{Element 1}} - EN_{\text{Element 2}}|$
- Na-Cl: $\Delta EN = |0.9 - 3.0| = 2.1$

IONIC	POLAR COVALENT	NONPOLAR COVALENT
$\Delta EN \geq 1.70$	$\Delta EN: 0.41 - 1.69$	$\Delta EN: 0.00 - 0.40$
Transfer Electrons	Uneven Sharing	Shared Equally

What are polar and nonpolar covalent bonds, and how are they formed?

Electronegativity Difference

Compound	ΔEN Values	Difference	Bond Type
Na - Cl	$ 0.9 - 3.0 $	$= 2.1$	
O - O	$ 3.5 - 3.5 $	$= 0.0$	
O - S	$ 3.5 - 2.5 $	$= 1.0$	
P - H	$ 2.1 - 2.1 $	$= 0.0$	
C - O	$ 2.5 - 3.5 $	$= 1.0$	
K - O	$ 0.8 - 3.5 $	$= 2.7$	
N - H	$ 3.0 - 2.1 $	$= 0.9$	
Mg - F	$ 1.2 - 4.0 $	$= 2.8$	

What are polar and nonpolar covalent bonds, and how are they formed?

Electronegativity Difference

Compound	Δ EN Values	Difference	Bond Type
Na - Cl	0.9 - 3.0	= 2.1	Ionic
O - O	3.5 - 3.5	= 0.0	Nonpolar
O - S	3.5 - 2.5	= 1.0	Polar
P - H	2.1 - 2.1	= 0.0	Nonpolar
C - O	2.5 - 3.5	= 1.0	Polar
K - O	0.8 - 3.5	= 2.7	Ionic
N - H	3.0 - 2.1	= 0.9	Polar
Mg - F	1.2 - 4.0	= 2.8	Ionic

What are polar and nonpolar covalent bonds, and how are they formed?

Dipole Moments

- Represents the atom's polarity magnitude and direction (+ \rightarrow -)

What are polar and nonpolar covalent bonds, and how are they formed?

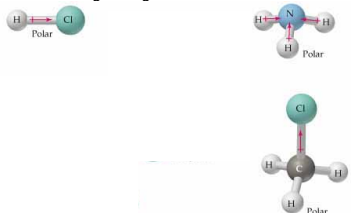
Dipole Moments

- Khan Academy:
- <https://www.khanacademy.org/science/organic-chemistry/gen-chem-review/electronegativity-polarity/v/dipole-moment>

What are polar and nonpolar covalent bonds, and how are they formed?

Dipole Moments

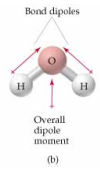
- Represents the atom's polarity magnitude and direction (+ \rightarrow -)
- Examples: H - Cl, NH₃, CH₃Cl, (& -COOH)



What are polar and nonpolar covalent bonds, and how are they formed?

Dipole Moments

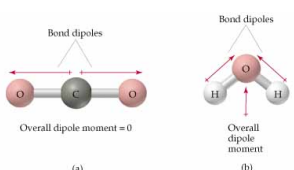
- Represents the atom's polarity magnitude and direction (+ \rightarrow -)
- Examples: H - Cl, NH₃, CH₃Cl, (& -COOH)
- Water:



What are polar and nonpolar covalent bonds, and how are they formed?

Dipole Moments

- Represents the atom's polarity magnitude and direction (+ \rightarrow -)
- Bond Polarity and Shape Matters:



What are polar and nonpolar covalent bonds, and how are they formed?

Dipole Moments

- Represents the atom's polarity magnitude and direction (+ \rightarrow -)
- Bond Polarity and Shape Matters:

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What are polar and nonpolar covalent bonds, and how are they formed?

Compare & Contrast: Polar & Nonpolar Covalent

- Differences with regard to:
 - Electronegativity Difference
 - Polar Positive and Polar Negative Side WRT Electronegativity
 - Can it have Permanent Dipole Moment?
 - Effect of Molecule Shape

What are polar and nonpolar covalent bonds, and how are they formed?

REVIEW

- Bonds involve electrons.

What are polar and nonpolar covalent bonds, and how are they formed?

Types of Bonds

	Ionic Ex. NaCl	Polar Covalent Ex. H ₂ O	Nonpolar Covalent Ex. O ₂
Electrons			
Elements			
Structure with Other Compounds			
Electronegativity Differences			
Bond Strength			
Properties of Compounds			

What are polar and nonpolar covalent bonds, and how are they formed?

Types of Bonds

	Ionic Ex. NaCl	Polar Covalent Ex. H ₂ O	Nonpolar Covalent Ex. O ₂
Electrons	Transferred	Shared Unequally	Shared Equally
Elements	Metals & Nonmetals	Nonmetals	Nonmetals
Structure with Other Compounds	Fixed Solid Crystals	Random Close Arrangement	No Structure
Electronegativity Differences	1.70+	0.41-1.65	0.0-0.40
Bond Strength	Strong	Inter: Moderate Intra: Weak	Inter: Weak Intra: Weak
Properties of Compounds	Conducts Electricity High Melting Point	Dissolves Ions; Moderate Melting Point	Does not mix with with polar cmpds; Low Melting Point

How do we diagram molecular structures?

Electron Dot Diagrams (Lewis Dots)

PERIODIC TABLE ELEMENTS 1-20

HYDROGEN 1 H ·							HELIUM 2 · He ·
LITHIUM 3 Li ·	BERYLLIUM 4 Be ·	BORON 5 · B ·	CARBON 6 · C ·	NITROGEN 7 · N ·	OXYGEN 8 · O ·	FLOURINE 9 · F ·	NEON 10 · Ne ·
SODIUM 11 Na ·	MAGNESIUM 12 Mg ·	ALUMINUM 13 · Al ·	SILICON 14 · Si ·	PHOSPHORUS 15 · P ·	SULFUR 16 · S ·	CHLORINE 17 · Cl ·	ARGON 18 · Ar ·
POTASSIUM 19 K ·	CALCIUM 20 Ca ·						

How do we diagram molecular structures?

Steps for Writing Lewis Dots

1. Obtain the sum of the valence electrons from all of the atoms. Do not worry about keeping track of which electrons come from which atoms. It is the total number of valence electrons that is important.

How do we diagram molecular structures?

Steps for Writing Lewis Dots

2. Use one pair of electrons to form a bond between each pair of bound atoms. For convenience, a line (instead of a pair of dots) is often used to indicate each pair of bonding electrons.

How do we diagram molecular structures?

Steps for Writing Lewis Dots

3. Arrange the remaining electrons to satisfy the duet rule for hydrogen and the octet rule for each second-row element. (Ex. SO_4^{2-} ; NH_4^{1+})

How do we diagram molecular structures?

Multiple Bonds

- Lone Pairs: Pair of Electrons that are not involved in bonding
- Single bonds: Involve two atoms sharing one pair of electrons
- Double Bond: Involves two atoms sharing two pairs of electrons (O_2)
- Triple Bond: Involves two atoms sharing three pairs of electrons (CN^-)

How do we diagram molecular structures?

Examples (Single Bonds)

Formula	Atoms	Valence Electrons	Structure w/ Dots	Structure w/ Bonds
CH_4				
NH_3				
H_2O				

How do we diagram molecular structures?

Single vs. Double vs. Triple Bonds

Bond Length

- C-C: 154 pm
- C=C: 133 pm
- C≡C: 120 pm

Bond Energy

- C-C: 376 kJ/mol
- C=C: 611 kJ/mol
- C≡C: 835 kJ/mol

How do we diagram molecular structures?

Examples (Double & Triple Bonds)

Formula	Atoms	Valence Electrons	Structure w/ Dots	Structure w/ Bonds
O ₂				
CO ₂				
N ₂				

How do we diagram molecular structures?

Bond Summary
(add to page 9)

Type of Bond	Number of electrons	Number of lines
Single	2	1
Double	4	2
Triple	6	3

How do we diagram molecular structures?

Polyatomic Ions

How do we diagram molecular structures?

Rules for Polyatomic Ion Structures

1. Sum valence electrons.
[Subtract +, Add -]
2. Create single bonds between the atoms.
3. Arrange the remaining electrons to satisfy octet/
duet rules and valence electrons.
4. Double Check
5. Bracket the structure and list the charge.

How do we diagram molecular structures?

Delocalization of Electrons

- Electrons are not associated with 1 atom or bond.

How do we diagram molecular structures?

Polyatomic Ions

A group of covalently bonded atoms with an overall charge.

How do we diagram molecular structures?

Resonance

- Resonance: Having more than one Lewis structure that can be drawn for the molecule.
- Examples: CO_2
- Resonance structures
 - The individual resonance forms.
 - Separated by a double headed arrow

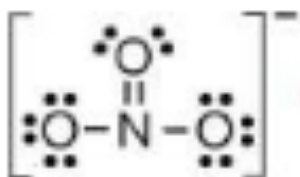
How do we diagram molecular structures?

Examples

- Hydroxide
- Ammonium
- Carbonate
- Nitrate

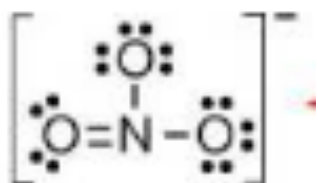
How do we diagram molecular structures?

Nitrate Anion



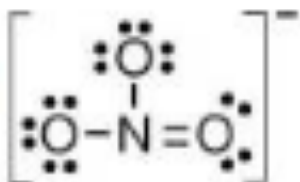
How do we diagram molecular structures?

Nitrate Anion



How do we diagram molecular structures?

Nitrate Anion



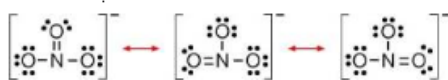
How do we diagram molecular structures?

Resonance

Bonding that cannot be
represented by a single
Lewis Structure

How do we diagram molecular structures?

Representation



How do we diagram molecular structures?

Other Resonance Examples

Some regular molecules (without a charge) also exhibit resonance because they resist their normal Lewis Structure.

O₃ (cannot form regular structure due to angles)

SO₂ (same as above)

How do we diagram molecular structures?

Practice Lewis Structures

Polyatomic:

Regular:

- | | |
|----------------|----------------------------------|
| 1. Cyanide | 4. F ₂ |
| 2. Phosphate | 5. HCN |
| 3. Nitrite (2) | 6. C ₂ H ₄ |

How do I determine the geometry of a molecule using VSEPR theory?

VSEPR

- Valence Shell Electron Pair Repulsion
- Used to predict the shapes and polarities of molecules
- Molecular shapes are predicted based on the fact that electron pairs (bonding and nonbonding) arrange themselves to be as far apart as possible in order to minimize repulsions.

How do I determine the geometry of a molecule using VSEPR theory?

VSEPR

Name	Shape	Atoms Bonded to Central Atom	Lone Pairs of e- on Central Atom	Example
H ₂	Linear Diatomic	N/A	N/A	H-H
Cl ₂	Linear Diatomic	N/A	N/A :Cl - Cl:

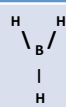
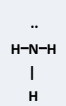
How do I determine the geometry of a molecule using VSEPR theory?

VSEPR

Name	Shape	Atoms Bonded to Central Atom	Lone Pairs of e- on Central Atom	Example
BeF ₂ *does not follow the octet rule	Linear Triatomic	2	0 :F-Be-F:
H ₂ O	Angular or Bent	2	2	.. H-O: H

How do I determine the geometry of a molecule using VSEPR theory?

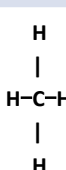
VSEPR

Name	Shape	Atoms Bonded to Central Atom	Lone Pairs of e- on Central Atom	Example
BH ₃ *does not follow the octet rule	Trigonal Planar	3	0	
NH ₃	Trigonal Pyramidal	3	1	

How do I determine the geometry of a molecule using VSEPR theory?

VSEPR

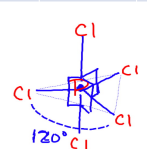
Name	Shape	Atoms Bonded to Central Atom	Lone Pairs of e- on Central Atom	Example
CH ₄	Tetrahedral	4	0	See below



How do I determine the geometry of a molecule using VSEPR theory?

VSEPR

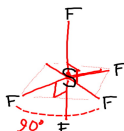
Name	Shape	Atoms Bonded to Central Atom	Lone Pairs of e- on Central Atom	Example
PCl ₅ *does not follow the octet rule	Trigonal Bipyramidal	5	0	See below



How do I determine the geometry of a molecule using VSEPR theory?

VSEPR

Name	Shape	Atoms Bonded to Central Atom	Lone Pairs of e- on Central Atom	Example
SF ₆	Octahedral	6	0	See below



What forces hold molecules together?

Intermolecular Forces

- 3 Types of Intermolecular Forces:
- London Dispersion
- Dipole – Dipole
- Hydrogen Bonding

What forces hold molecules together?

Computer Lab: Intermolecular Forces

- Go to <https://www.wisc-online.com/LearningContent/gch6804/index.html>
Read each screen and follow the directions where appropriate.
- Answer the questions on the screens in your packet.

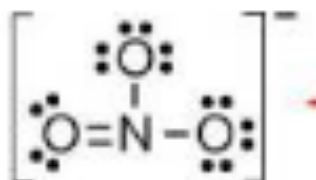
What forces hold molecules together?

Intermolecular Forces

- London Dispersion: Result from the electrons in an atom or molecule being unevenly distributed.
- Dipole-Dipole: Results from molecules that have an uneven distribution of charge when (1) the electronegatives are different and (2) the molecule is unsymmetrical.
- Hydrogen Bonding: Results from molecules that have hydrogen bonded to a more electronegative element (N, O, F)

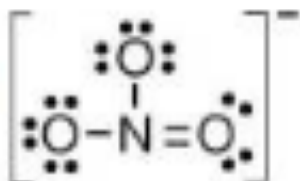
How do we diagram molecular structures?

Nitrate Anion



How do we diagram molecular structures?

Nitrate Anion



VSEPR

Name	Shape	Number of bonds	Atoms Bonded to Central Atom	Lone Pairs on e- on Central Atom	Lewis Structure
H ₂	Linear Diatomic	1	N/A	N/A	H-H
Cl ₂	Linear Diatomic	1	N/A	N/A :Cl-Cl:

VSEPR

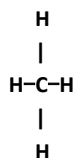
Name	Shape	Number of bonds	Atoms Bonded to Central Atom	Lone Pairs on e- on Central Atom	Lewis Structure
BeF ₂ *does not follow the octet rule	Linear Triatomic	2	2	0 :F-Be-F:
H ₂ O	Angular or Bent	2	2	2	.. H-O: H

VSEPR

Name	Shape	Number of bonds	Atoms Bonded to Central Atom	Lone Pairs on e- on Central Atom	Lewis Structure
BH ₃ *does not follow the octet rule	Trigonal Planar	3	3	0	H \ B / H H
NH ₃	Trigonal Pyramidal	3	3	1	.. H-N-H H

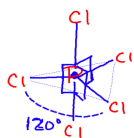
VSEPR

Name	Shape	Number of bonds	Atoms Bonded to Central Atom	Lone Pairs of e- on Central Atom	Lewis Structure
CH ₄	Tetrahedral	4	4	0	See below

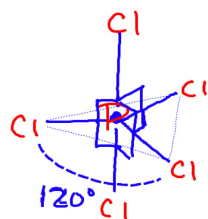


VSEPR

Name	Shape	Number of bonds	Atoms Bonded to Central Atom	Lone Pairs of e- on Central Atom	Lewis Structure
PCl ₅ *does not follow the octet rule	Trigonal Bipyramidal	5	5	0	See the following slide

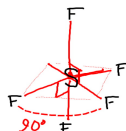


How do I determine the geometry of a molecule using VSEPR theory?



VSEPR

Name	Shape	Number of bonds	Atoms Bonded to Central Atom	Lone Pairs of e- on Central Atom	Lewis Structure/Geometry
SF ₆	Octahedral	6	6	0	See below



How do I determine the geometry of a molecule using VSEPR theory?

