

INTRODUCTION TO CHEMICAL BONDING

I. Types of Chemical Bonding

- A. _____: mutual electrical attraction between the nuclei and valence e- of different atoms that binds the atoms together
- B. Why do atoms bond together?
- Atoms by themselves have _____ potential energy
 - Want to have _____ P.E. (this is what happens in nature)
 - In other words, atoms are **LESS** stable alone than combined with other atoms
- C. Electrons are _____ during bonding
- D. Types of chemical bonding
- _____: results from attraction between large numbers of cations and anions; involves the **transfer** of electrons (one atom loses e-, the other atom gains e-)
 - _____: positive ion; atom that has lost e-
 - _____: negative ion; atom that has gained e-
 - _____: results from **sharing of e- pairs** between two atoms
 - _____: type of bond resulting from the unequal sharing of electron pairs
 - _____: type of bond resulting from the equal sharing of electron pairs
- E. Determining Ionic or Covalent Bond (Official Way)
- Remember electronegativity? (how much an atom wants to gain an e-)
 - Difference in EN tells whether bond is ionic or covalent
 - EN difference less than _____ = COVALENT
 - _____ COVALENT: EN difference _____ to _____
 - _____ COVALENT: EN difference _____ to _____
 - EN difference greater than _____ = IONIC
- F. Determining Ionic or Covalent Bond (Easy Way)
- _____: metal & nonmetal in formula
 - _____: 2 or more nonmetals
 - _____: 2 different nonmetals
 - _____: 2 of the same nonmetal

IONIC BONDING & IONIC COMPOUNDS

- A. _____: composed of + and - ions whose charges cancel each other out
- Most exist as _____
 - _____ network of + and - ions; not composed of individual units
- B. Formation of Ionic Compounds
- Na · + ··Cl : -->
 - Ionic compounds minimize P.E. by organizing into _____

COVALENT BONDING AND MOLECULAR COMPOUNDS

I. Molecules & Molecular Formulas

- A. _____: neutral group of atoms held together by covalent bonds

B. _____ Molecule: molecule that contains only two atoms (of the same element)

--> there are only 7 of them; they are

IONIC VS. COVALENT (MOLECULAR) COMPOUNDS

| <u>Ionic Compounds</u> | <u>Covalent/Molecular Compounds</u> |
|--|---|
| Formed by transfer of electrons | Formed by sharing of electrons |
| Occurs between metal & nonmetal | Occurs between nonmetals |
| Smallest unit = "formula unit" | Smallest unit = "molecule" |
| Most exist as solids, usually with crystal structure | Exist as liquids, gases, non-crystal solids |
| Have high melting points | Have low melting points |
| Most dissolve in water | Few dissolve in water |
| Conduct electricity when melted (molten) or dissolved in water | Do not conduct electricity when melted or dissolved in water |
| Fixed + and - parts; anions & cations | May be neutral or have slightly + and - parts |
| Examples = KCl, NaF | Examples: NH ₃ , CO ₂ , CH ₄ |

METALLIC BONDING

*Metal atoms have _____ valence e-

*Results in empty or almost empty _____ orbitals in HOEL

*Also, many metals have empty or partially occupied _____ orbitals just below their HOEL

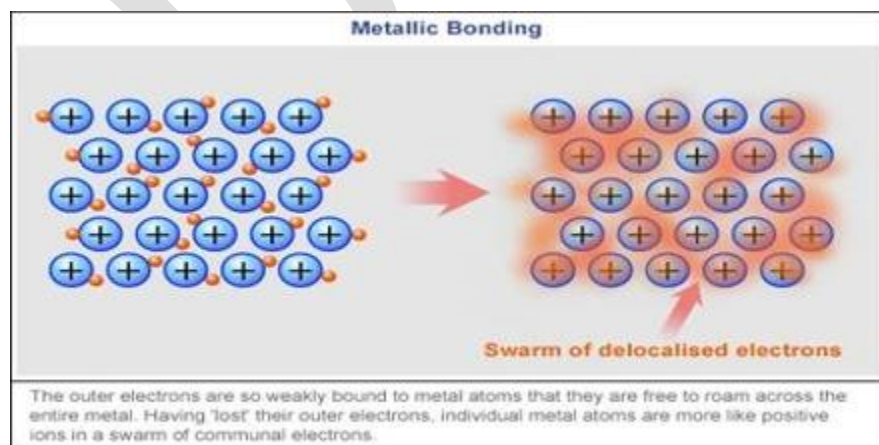
*Vacant orbitals _____

*Allows outer e- to roam freely throughout the entire metal

*Electrons are _____

*Metallic bonding: results from the attraction b/n _____ atoms & surrounding _____ of electrons

*Explains unique properties of metals: _____



LEWIS STRUCTURES: formulas which symbols represent nucleus & inner shell electrons; dot pairs or dashes represent electron pairs in covalent bonds

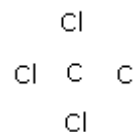
1. _____: (lone pair) pair of electrons that is not involved in bonding & belongs to only one atom
2. _____: produced when one pair of e- is shared between two atoms
3. **MULTIPLE BONDS:** stronger & shorter than single bonds
 - a. **Double Bond:** produced when _____ pairs of e- are shared between two atoms
 - ~ shown by 2 side-by-side pairs of dots
 - ~ stronger and shorter than a single covalent bond
 - b. _____ **Bond:** produced when 3 pairs of e- are shared between two atoms
 - ~ shown by 3 side-by-side pairs of dots
 - ~ stronger and shorter than single and double covalent bonds

STEPS FOR DRAWING LEWIS STRUCTURES

1. Count the total number of valence electrons in the compound.

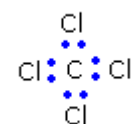
EXAMPLE: CCl₄
 C: 1 x 4 e- = 4
 Cl: 4 x 7 e- = 28
 32

2. Draw the symbols for the elements with the central atom in the middle.
(The central atom is the one that is written first, except hydrogen will never be central.)
3. Connect the surrounding atoms to the central atom with a pair of electrons.



Had 32 e- to start (step 1)

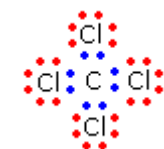
Used 8 e- to connect



Have 24 e- left

4. Put electrons around surrounding atoms until all have 8 electrons around them.
(Exception: Hydrogen will only have 2 e- around it.)

Have 24 e- left
 Used 24 e- to complete surrounding
 Have 0 e- left to use



5. If there are any electrons left over, put them on the central atom.
6. Check to make sure that all atoms have 8 electrons around them.
7. If there are not enough electrons to give all atoms 8 electrons around them, try multiple bonds.

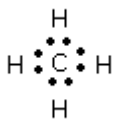
=====

VSEPR (Valence Shell Electron Pair Repulsion) THEORY

valence electrons in an atom will orient themselves to be as far apart as possible

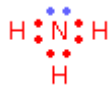
*** CLASSES OF MOLECULES**

- A = central atom
- B = surrounding atoms
- E = unshared electron pairs on central atom
- *** subscript tells how many of each you have ***



EXAMPLE 1: CH₄

1 central atom, 4 surrounding atoms, no unshared e- prs. on central atom CLASS = AB₄



EXAMPLE 2: NH₃

1 central atom, 3 surrounding atoms, 1 unshared e- pr. on central atom

CLASS = AB₃E

* SHAPES OF MOLECULES

| <u>CLASS</u> | <u>SHAPE</u> |
|--------------------------------|------------------|
| AB ₂ | linear |
| AB ₂ E | bent |
| AB ₂ E ₂ | bent |
| AB ₃ | trigonal planar |
| AB ₃ E | trigonal pyramid |
| AB ₄ | tetrahedral |

MOLECULAR POLARITY vs. BOND POLARITY

BOND POLARITY

~ refers to the equal (_____) or unequal (_____) sharing of electrons

~ What makes a bond polar (covalent)?

* If the bond occurs between two _____ nonmetals

MOLECULAR POLARITY

~ refers to the symmetry (_____) or asymmetry (_____) of a molecule

~ What makes a molecule asymmetrical?

* If there are _____ around the central atom.

and/or

* If the surrounding atoms are different _____

Special Cases Regarding Molecular Polarity:

~ When there are only 2 atoms in the compound or ion...

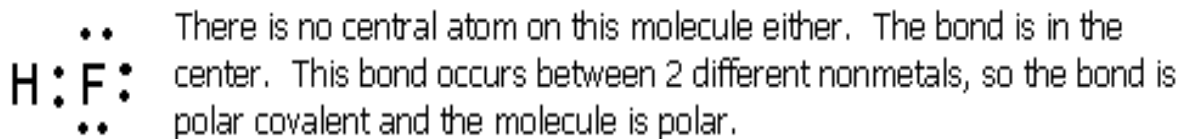
* examples: F₂ or HF



There is no central atom; the bond is in the middle of this molecule. Therefore, when there are only 2 atoms in a molecule, the bond polarity will be the same as the molecular polarity.

Therefore, this is a nonpolar molecule because the bond between the two atoms is nonpolar covalent because the bond is between 2 atoms of the same element.

Molecular polarity will be determined by (and the same as) bond polarity ONLY WHEN THERE ARE ONLY 2 ATOMS IN THE MOLECULE.

**LEWIS STRUCTURES 1 WORKSHEET**

| | | |
|---|---|---|
| 1. SiF_4 | 2. BF_3 | 3. NH_3 |
| Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: |
| 4. H_2O | 5. CHBr_3 | 6. HI |
| Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: |
| 7. SO_3 | 8. AsCl_3 | 9. H_2S |
| Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: |
| 10. SeH_2 | 11. PO_4^{3-} | 12. NO_2^{-1} |
| Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: |

UNIT 6 - CHEMICAL BONDING

| | | |
|---|---|---|
| 13. ClO_3^{-1} | 14. HCN | 15. PI_3 |
| Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: |

LEWIS STRUCTURES 2 WORKSHEET

| | | |
|---|---|---|
| 1. OF_2 | 2. GeI_4 | 3. SCl_2 |
| Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: |
| 4. SeO_2 | 5. PCl_3 | 6. NH_4^{+1} |
| Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: |
| 7. NOCl | 8. CO_2 | 9. SO_4^{-2} |
| Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: | Molecular Polarity: Class: Shape: |

| | | |
|---|--|---|
| 10. ICl Molecular Polarity: Class: Shape: | 11. CH ₂ Cl ₂ Molecular Polarity: Class: Shape: | 12. H ₃ O ⁺¹ Molecular Polarity: Class: Shape: |
| 13. N ₂ Molecular Polarity: Class: Shape: | 14. ClO ⁻¹ Molecular Polarity: Class: Shape: | 15. CH ₂ O Molecular Polarity: Class: Shape: |

POLYATOMIC IONS

- _____ : charged group of covalently bonded atoms
- Combine with ions of _____ charge to form ionic compounds
- Compounds with polyatomic ions have _____ bonding
- Lewis Structures
 - Negatively charged polyatomic ion = _____ e⁻ to total number of valence e⁻ for cmpd
 - Positively charged polyatomic ion = _____ e⁻ from total # of valence e⁻ for cmpd

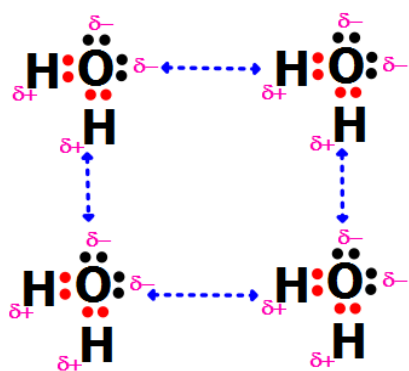
INTERMOLECULAR FORCES (IMFs) NOTES

intermolecular forces: forces of attraction between molecules in a sample of a compound

3 TYPES OF IM FORCES (in order from strongest to weakest)

- HYDROGEN "BONDING"
 - * occurs between molecules with hydrogen & nitrogen, hydrogen & oxygen, and hydrogen & fluorine
 - * accounts for the unusually high boiling point of NH₃, H₂O, and HF
- DIPOLE-DIPOLE FORCES
 - * occurs between polar molecules (dipoles)
 - * the slightly positive end of one polar molecule is attracted to the slightly negative end of another polar molecule
 - * same principle as hydrogen bonding, but not quite as strong of an IMF
- LONDON DISPERSION FORCES
 - * occurs between all molecules
 - * allows for noble gases and nonpolar molecules to be liquefied
 - * moving electrons (in electron cloud of an atom) temporarily attract the electrons from another atom

**** COVALENT BONDING IS STRONGER THAN ANY OF THESE IM FORCES. ****



•• = **covalent bond**
within water
molecule

δ = **"slightly"**

↔ = **attraction**
between
water
molecules -
called an
INTERMOLECULAR
FORCE (IMF)

IMFs are not as strong as covalent bonds!

Unit 6 Review Worksheet

- Individual atoms of elements are (more / less) stable than when they are combined with other elements.
- What is the difference between ionic and covalent bonding?
- What is the cut-off number for the difference in electronegativity to determine whether a bond is ionic or covalent? Polar or nonpolar covalent?
- Between what types of elements does ionic bonding occur?
- Between what types of elements does polar covalent bonding occur? Nonpolar covalent?
- When must you use multiple bonds when drawing a Lewis structure?
- How can you tell which is the central atom by looking at the chemical formula?
- What two (2) requirements must a molecule meet in order to be considered nonpolar?
- What do "A", "B", and "E" stand for when determining the class of a molecule?
- What does the subscript "2" mean in the class AB_2E ?
- Which classes of molecules have a bent shape?
- Which class of molecules has a linear shape?
- Which class has a tetrahedral shape?
- Which class has a trigonal planar shape?
- Which class has a trigonal pyramid shape?
- What is the smallest unit of an ionic compound called? A covalent compound?
- Which type of compound has low melting points?
- Which type of compound dissolves in water?
- Which type of compound conducts electricity when melted?
- Which type of compound occurs as liquids, gases, or non-crystalline solids?
- What are the three types of intermolecular forces?
- Between which types of compounds do these intermolecular forces (#21) occur?

23. Arrange the following in order of increasing strength:

- (A) hydrogen bonding (B) covalent bonding
 (C) dipole-dipole forces (D) London dispersion forces

24. For each of the following compounds, draw the Lewis structure. Then tell the molecular polarity, class, and shape of the molecule. Also tell the type(s) of IM forces that occur within a sample of that compound.

- (A) SiF_4 (B) SBr_2 (C) NH_3
 (D) SO_3 (E) SiO_2 (F) SeS_2

Unit 6 Summary (Graphic Organizer)

