Ms. Martin
Regents Chemistry

Chemical Bonding and Intermolecular Forces Test Review Sheet

Describing a Chemical Bond

- Atoms combine with other atoms to have a more stable electron configuration
- When a bond is formed, energy is released (exothermic)
- A chemical bond is an attractive force between two atoms

Three types of chemical bonds occur between atoms:

1) **ionic bond** (valence electrons are **transferred** between the two atoms)
2) **covalent bond** (valence electrons are **shared** between the two atoms)
3) **metallic bond** ("**A sea of mobile valence electrons**" between all the metal atoms)

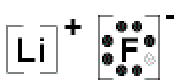
1. Ionic Bonding

- Created by the attraction between positive ion (cations) and negative ions (anions)
- Solid ionic compounds arranged in **crystal lattice structure**
- Generally formed between **metals** (tend to lose electrons) and **nonmetals** (tend to gain electrons)
- Electrons are **transferred** from the metal atom to the nonmetal atom to create opposite charged ions

***Know how to draw Lewis Dot structures of ionic compounds**

In Lewis structures for ionic compounds, metals always have **zero** valence electrons and nonmetals always have **eight.**

Example: Lithium fluoride (LiF) compound can be represented as

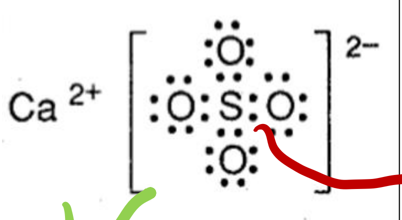


Flourine has 7 from its own valence electrons and 1 from Li (light dot)

Polyatomic Ions

a. **All of the polyatomic ions (and their charges) that you need to know are provided for you in <u>Table E</u> of the NYS Chemistry Reference Tables.**
b. **Compounds containing polyatomic ions are IONIC. But the bonds within the polyatomic ions themselves are covalent. So compounds containing polyatomic ions <u>contain both ionic and covalent bonds.</u>**

Ex.



Covalent Bond

Ionic Bond

c. **By looking at the formula of an ionic compound-you should be able to tell that it contains a polyatomic ion. Traditional "metal and nonmetal" ionic compounds are ALL BINARY. Meaning there are only two types of elements in each of them. NaCl only contains sodium and chlorine-no polyatomic ions are present. However, a formula such as $CaCO_3$ is an ionic compound with more than two types of elements present in the compound. Therefore, it MUST CONTAIN A POLYATOMIC ION.**

2. Metallic Bonding

- Attraction between positive metal ions and mobile electrons between the metal ions **(think of "a sea of electrons" where the positive metal ions floating within the electrons)**
- The mobile electrons explains properties of metals (malleable, ductile, good conductors of electricity and heat)
- Notice the difference between ionic bonding and metallic bonding: ionic bonding results from the attraction between opposite charged ions whereas metallic bonding is the attraction of only positive metal ions and the negatively charged mobile electrons. There is no negative ion in a metallic bond.

3. Covalent Bonding

- Nonmetal atoms tend to gain electrons. What happens if two hydrogen atoms combine? Each hydrogen atom would like to gain one electron to have a stable electron configuration. However, since both hydrogen atoms want to gain electrons, the two hydrogen atoms share electrons so that each hydrogen atom can achieve a **stable electron configuration**. The **sharing of electrons between two atoms** creates a "covalent bond".
- Nonmetal atoms combine with each other by creating a covalent bond between the atoms.
- A molecule is a **group of two or more covalently bonded atoms** that have combined with each other to create a single unit. For example, H_2O is two hydrogens combined with oxygen to form a "molecule" of water. The molecule acts as one item that has two hydrogens bonded with on oxygen.
- **One covalent bond has a total of 2 shared electrons (one pair) between two atoms. A double bond has 4 electrons (two pairs), and a triple bond has 6 (three pairs).**

Rules for Naming Compounds (Nomenclature)

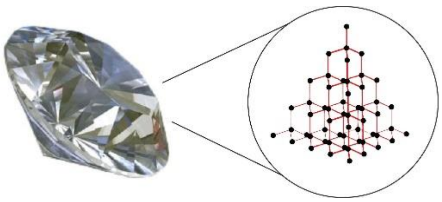
Type of Compound	General Formula	Examples	General Name	Examples
Binary covalent	A_aB_b	N_2O_5 or CO_2	(prefix unless mono)(name of first element in formula) (prefix)(root of second element)ide	dinitrogen pentoxide or carbon dioxide
Binary ionic	M_aA_b	NaCl or $FeCl_3$	(name of metal) (root of nonmetal)ide or (name of metal)(Roman numeral) (root of nonmetal)ide	sodium chloride or iron(III) chloride
Ionic with polyatomic ion(s)	M_aX_b or $(NH_4)_aX_b$ X = formula of polyatomic ion	Li_2HPO_4 or $CuSO_4$ or NH_4Cl or $(NH_4)_2SO_4$	(name of metal) (name of polyatomic ion) or (name of metal)(Roman numeral) (name of polyatomic ion) or ammonium (root of nonmetal)ide or ammonium (name of polyatomic ion)	lithium hydrogen phosphate or copper(II) sulfate or ammonium chloride or ammonium sulfate

M = symbol of metal
X = some element other than H or O
A and B = symbols of nonmetals
The letters a, b, & c represent subscripts.

*The four common names that you will be responsible for memorizing are: ammonia (NH_3), water (H_2O), ozone (O_3), and methane (CH_4)

- **Network Solids**
  - **Network solids are macromolecules (large molecules) being held together by networks of covalent bonds.**

Ex:



  - **Because network solids have so many bonds within them, they have HIGH MELTING AND BOILING POINTS, and they are INSOLUBLE.**
  - **Additionally, it is important to know that they DO NOT CONDUCT ELECTRICITY IN EITHER THE SOLID OR LIQUID FORM**
  - **The examples you must know of network solids are: Diamonds, Graphite, and SiO_2 (Quartz).**

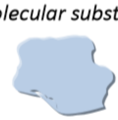
Relate physical properties (melting point, boiling point, conductivity) to type of bonding.

Types of Substance and their Properties: **Summary Table**

Type of Substance	Phase at Room Temp.	Physical Properties (Characteristics)		
		Melting Point	Conductivity	Solubility (in water)
Metallic	solid *(except Hg - liquid)*	Very High	Good (High) *as solids and liquids*	No (insoluble)
Ionic	solid only	High	Good (High) *as liquid and aqueous*	Yes (soluble)
Molecular	solid, liquid, gas	Low	Poor (low) *in all phases*	Yes (slightly soluble)
Network solid	Solid only	Extremely high	Very poor *in all phases*	No (Insoluble)

Four Types of Substances and their Melting Points

Solid forms of the four types of substances mentioned above are given below. Note the big difference in the temperature at which each solid will melt at STP.

Type of substance	*Molecular substance*	*Ionic substance*	*Metallic substance*	*Network solid*
				
Example solid	Ice (H_2O)	Salt (NaCl)	Gold (Au)	Diamond (C)
Melting point	**0°C**	**801°C**	**1065°C**	**3550°C**

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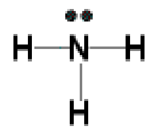
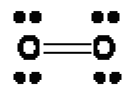
Know how to draw the Lewis structures of covalent compounds!

Ex.

Lewis dot structure for hydrogen fluoride (HF)



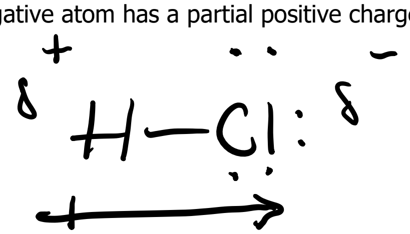
Lewis dot structure for ammonia (NH_3)



Lewis dot structure for the oxygen molecule

The double lines represent two pairs of shared electrons (double bond)

Polarity of Covalent Bonds-Electrons are **shared equally** in a nonpolar covalent bond. Electronegativity difference of **ZERO** between two atoms in a covalent bond indicates a **nonpolar covalent bond**.

- Electron **shared unequally** in a **polar covalent bond**. Electronegativity difference is NOT ZERO.
- Example of nonpolar covalent bond: F-F in F_2
- Example of polar covalent bond: H-Cl in HCl
- **Electrons in a polar covalent bond are closer to the atom with the higher electronegativity**
- Remember that electronegativity is the "ability to attract or gain electrons"
- Comparing the polarity of polar covalent bonds: For example
- Which bond is more polar, H-Cl or H-O? To answer this question, you must determine which bond has the greater electronegativity difference. The H-O bond has a greater electronegativity difference and is more polar than the H-Cl polar covalent bond.
- The more electronegative atom in a bond has a partial negative charge (**δ^-**) and the less electronegative atom has a partial positive charge **(δ^+)**
- **Ex.** 

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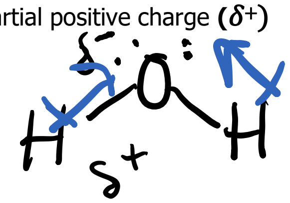
Molecular Shapes & Molecular Polarity

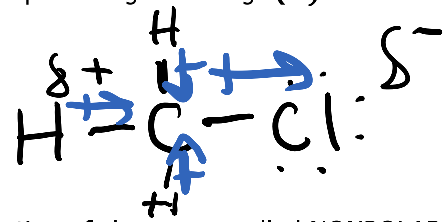
- **Key shapes: linear, bent, tetrahedral, trigonal pyramidal *Know how to determine the shapes of molecules from the Lewis Structure (You do NOT need to know bond angles)**

Determining Molecular Polarity

- Draw the dipole arrows of each bond in the molecule to determine the distribution of charge
- Molecules that have an asymmetric distribution of charge are called POLAR molecules (H_2O, NH_3, HCl, CH_3Cl)
- The more negative end of the molecule has a partial negative charge **(δ^-)** and the more positive end has a partial positive charge **(δ^+)**

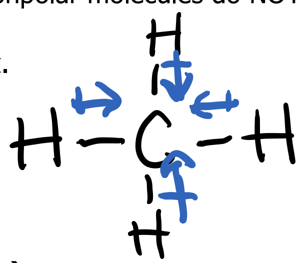
Ex.

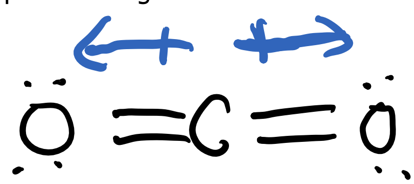




- Molecules that have a symmetric distribution of charge are called NONPOLAR molecules (CH_4, CO_2, H_2)
- Nonpolar molecules do NOT have partial charges!

Ex.





Intermolecular Forces (IMF's)

- **Attraction between molecules** (not chemical bond between atoms)
- Intermolecular forces determine physical properties of a covalent compound.
- **The stronger the intermolecular forces between the molecules of a substance, the higher the melting point and boiling point of a substance.** For example: H_2O has a higher boiling point than CH_4 because the intermolecular forces between water molecules (H-Bonding) is stronger than the intermolecular forces between the molecules of methane (Dipole-Dipole).
- Three types of intermolecular forces described below: dipole forces , hydrogen bonding (strongest) and dispersion forces (weakest)

<u>Dispersion Forces (also called van der Waals forces)</u>

- Weakest of the intermolecular forces
- Exists between all atoms and molecules!
- The only intermolecular force of attraction between nonpolar molecules
- Explains the attractive forces that causes nonpolar points to exist in solid and liquid phases
- Dispersion forces is the attractive force between positive and negative charges that results from temporary dipoles. (Buildup of sheep)
- **Dispersion forces increase as molecular size increases**

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Dipole Forces

- Intermolecular attraction that results from **all polar molecules** (an unequal distribution of electrons around these polar molecules results in a "dipole', positive and negative sides that attract similar molecules)
- Nature of attraction is positive side of a molecule with the negative side of another molecule

Hydrogen Bonding

- Hydrogen bonding (strongest of intermolecular forces) occurs when an H in a molecule is covalently bonded to the elements (O, N, or F)
- Hydrogen bonding is a type of dipole-dipole intermolecular force
- **Hydrogen bonding is not a chemical bond between atoms forming a compound, but an intermolecular force**
- Water is the best example of hydrogen bonding between water molecules that explains the properties of water such as high boiling point
- Other molecules where hydrogen bonding is the intermolecular force include: NH_3 and HF

Need to know how to use Table H to determine vapor pressure of substances at different temperatures or vapor pressures at the same temperature.

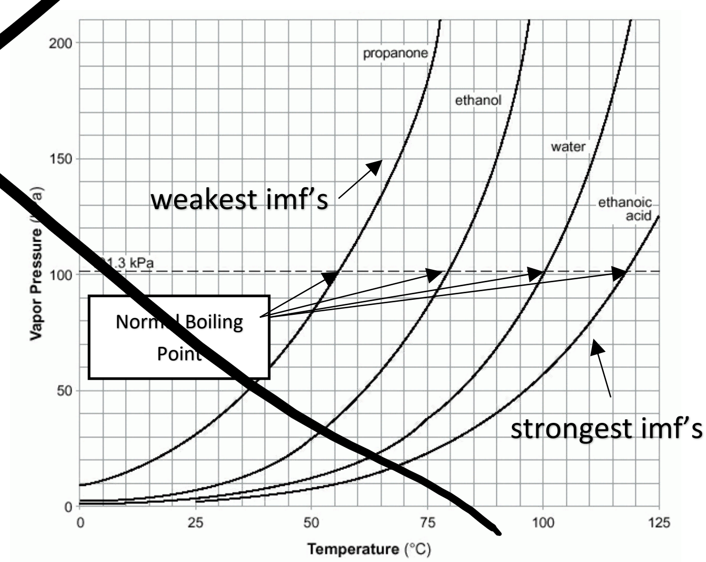
Vapor pressure increases as the strength of intermolecular forces decrease and boiling point decreases

Propanone has a higher vapor pressure than the other substances because the intermolecular forces between particles of propanone are the weakest.

Ethanoic acid has the strongest imf's and the lowest vapor pressure.

<u>Boiling Point</u> of any substance is the temperature where the vapor pressure of a substance equals the "external pressure" on the liquid.

<u>Normal Boiling Point</u> of a substance is the temperature where the vapor pressure of a substance equals the Standard Pressure (1 atm or 101.3 kPa)



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