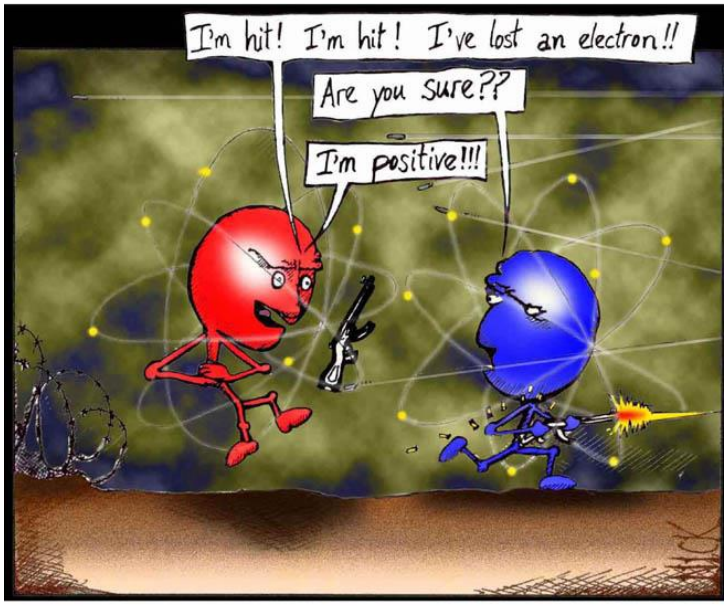
Name:

Regents Chemistry:

NOTES

UNIT 6: Bonding



Another casualty in the War of the Atoms.

Name:

Key Ideas

- Atoms attain a stable valence electron configuration by bonding with other atoms. Noble gases have stable valence configurations and tend not to bond. (5.2b)
- When a bond is broken, energy is absorbed. When a bond is formed, energy is released. (5.2i)
- Chemical bonds are formed when valence electrons are transferred from one atom to another (ionic), shared between atoms (covalent), mobile within a metal (metallic). (5.2a)
- Metals tend to react with nonmetals to form ionic compounds. Nonmetals tend to react with other nonmetals to form molecular (covalent) compounds. Ionic compounds contain polyatomic ions have both ionic and covalent bonding. (5.2h)
- Two major categories of compounds are ionic and molecular (covalent) compounds. (5.2g)
- In a multiple covalent bond, more than one pair of electrons are shared between two atoms. (5.2e)
- The electronegativity difference between two bonded atoms is used to assess the degree of polarity in a (covalent) bond. (5.2k)
- Physical properties of substances can be explained in terms of chemical bonds and intermolecular forces. These properties include conductivity, malleability, solubility, hardness, melting point, and boiling point. (5.2n)
- A chemical compound can be represented by a specific chemical formula and assigned a name based on the IUPAC system. (3.1cc)
- Electron-dot diagrams (Lewis structures) can represent the valence electron arrangement in elements, compounds, and ions. (5.2d)
- Molecular polarity can be determined by the shape of the molecule and the distribution of charge. Symmetrical (nonpolar) molecules include CO_2, CH_4, and diatomic elements. Asymmetrical (polar) molecules include HCl, NH_3, and H_2O. (5.2l)
- Intermolecular forces created by the unequal distribution of charge result in varying degrees of attraction between molecules. Hydrogen bonding is an example of a strong intermolecular force. (5.2m)

Process Skills

- Determine the noble gas configuration an atom will achieve by bonding (5.2iv)
- Distinguish among ionic, molecular, and metallic substances, given their properties. (3.1xix)
- Distinguish between nonpolar covalent bonds (two of the same nonmetals) and polar covalent bonds. (5.2v)
- Compare the physical properties of substances based on chemical bonds and intermolecular forces, e.g., conductivity, malleability, solubility, hardness, melting point, and boiling point (5.2ii)
- Demonstrate bonding concepts, using Lewis dot structures representing valence electrons when transferred (ionic bonding), shared (covalent bonding) or a stable octet. (5.2i)
- Explain vapor pressure, evaporation rate, and phase changes in terms of intermolecular forces (5.2iii)

Name:

	Definition
Anion	A negatively charged ion.
Bond	Forces of attraction that hold atoms together in a molecule or compound.
Brittle	The ability to be crushed into pieces when hammered, a property of nonmetals.
Cation	A positively charged ion.
Compound	A substance composed of two or more atoms from different elements CHEMICALLY bonded together.
Covalent Bond	Chemical bond involving the SHARING of electrons between two nonmetal atoms.
Diatomic molecule	A nonmetal atom that forms one or more nonpolar covalent bonds with another atom of the same element to form a molecule consisting of the two atoms when there is no other element to bond with. Elements that do this are Br, I, N, H, Cl, H, O and F.
Ductile	The ability to be stretched into a wire, a property of metals.
Dull	The lack of ability to reflect light efficiently, a property of nonmetals.
Electrolyte	A substance which when dissolved in water conducts electricity.
Electronegativity	An atom's attraction to electrons in a chemical bond.
Ionic bond	A bond formed when a metal atom loses its valence electrons to a nonmetal atom, forming positive and negatively charged ions that attract to each other. Chemical bond involving the TRANSFER of electrons between a metal and a nonmetal.
Ionic Radius	The size of an ion compared to the original atom. Metal atoms lose electrons and form + charged ions that are smaller than the original atom, nonmetal atoms form – charged ions that are larger than the original atom.
Ionization Energy	Energy required to remove an atom's most loosely held valence electron.

Name:

Luster	The ability to reflect light, a property of metals.
Malleable	The ability to be hammered or rolled into thin sheets, a property of metals.
Metallic bond	A bond formed between metal atoms of the same element resulting from the atoms losing electrons to each other and sharing them loosely as a result.
Nonpolar covalent bond	A bond formed between two nonmetal atoms when unpaired electrons of two atoms are shared equally, with an electronegativity difference of 0 to 0.4.
Nonpolar molecule	A molecule with equal sharing of electrons; a symmetrical covalent molecule.
Oxidation Number	The "charge" an element has within a compound.
Polar Covalent bond	A bond formed between two nonmetal atoms when unpaired electrons of two atoms are shared unequally, with an electronegativity difference of 0.5 to 1.7.
Polar molecule	A covalent molecule with an unequal sharing of electrons; an asymmetrical covalent molecule.
Polyatomic Ion	Atoms of two or more elements chemically bonded together and having a NET CHARGE.
Reactive	Capable of readily undergoing a chemical change.
Stock system	A method for naming ions of elements that can form more than one possible positive charge by using a Roman numeral after the ion name to denote the ion's charge.

Objective:

- *Identify whether a bond is being broken or formed based upon energy being absorbed or released*
- *Distinguish between the three types of bonds and Decide which type of bond is present based upon the atoms involved*
- *Classify a substance as Ionic, Covalent or Metallic based upon its properties*

What is a BOND?

CHEMICAL BOND:

- *INTRA*MOLECULAR _____ that holds one atom to another WITHIN a compound
- The energy stored in a bond is **potential energy** (also known as _____ energy)

Why do atoms BOND?

- Atoms bond together to get 8 valence electrons to become **STABLE** (Stable _____)
- Exception: Hydrogen can only have 2 (stable _____)

FORMING A BOND

- Energy is **RELEASED** (an _____ process)
- Forms a STABLE compound

BREAKING A BOND

- Energy is **ABSORBED** (an _____ process)
- Stability decreases
- Ex: Ripping two atoms apart requires ENERGY

REMEMBER ***BARF***: Break → Absorb**;** Release → Form.

TYPES OF BONDS

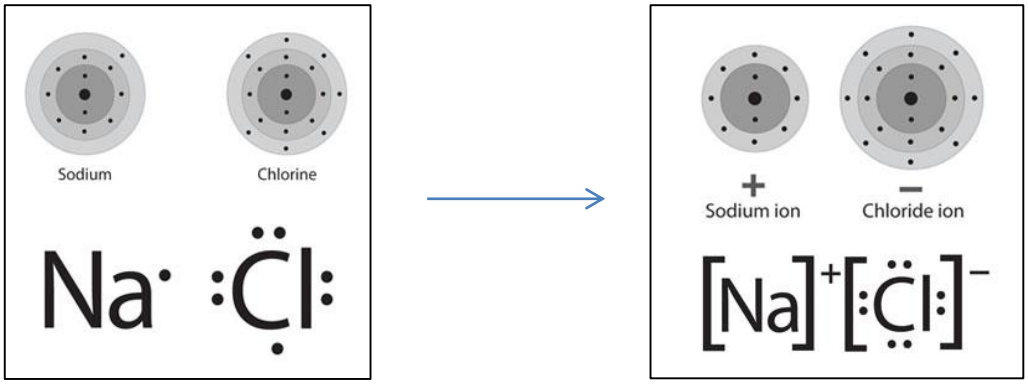
3 TYPES OF BONDS:

1. IONIC
2. COVALENT
3. METALLIC

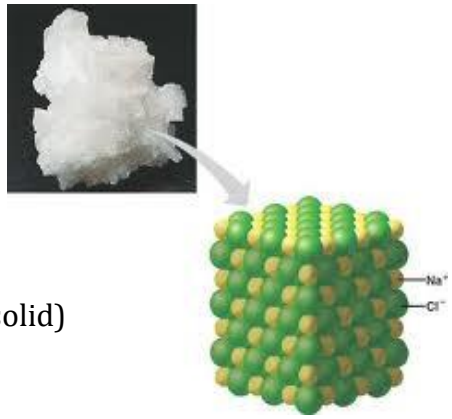
IONIC BONDS:

- Occur between: _____ **&** _____
- Involves the **TRANSFER OF ELECTRONS** from the metal to nonmetal to form a bond.

EXAMPLE:



PROPERTIES OF IONIC COMPOUNDS



- Hard
- **Crystalline** structure
- **HIGH** Melt/Boiling Pt
- **SOLUBLE** in water
- Conduct **ELECTRICITY** in solution (aq) or liquid form (not solid)

ELECTROLYTE

- A compound that separates into ions in solution and is able to _____

<u>COVALENT BONDS</u>: (also known as Molecular Bonding)

- Occur between: _____ **&** _____
- Involves the **SHARING OF ELECTRONS** to obtain a full valence shell (stable)
- Form **MOLECULAR** compounds

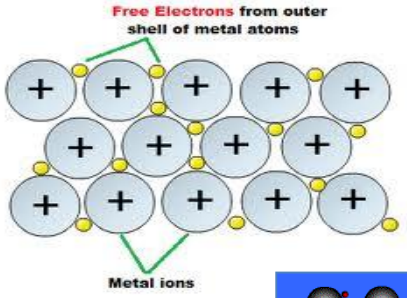
Why do they *SHARE* electrons instead of transfer?

- Each element holds its electrons so that neither is strong enough to remove ("steal") an electron from the other.

PROPERTIES OF COVALENT COMPOUNDS

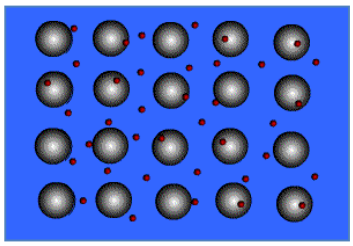
- Soft
- Low melting and boiling pts (due to weak attraction <u>between</u> molecules)
- Do not conduct electricity due to lack of charged particles (no ions are formed)

<u>METALLIC BONDS</u>:



- Between **METAL** atoms of the <u>SAME</u> element
- Ex: Au atoms in a gold ring

SEA OF _____ ELECTRONS!



PROPERTIES OF METALS:

- High _____ point and high _____ point because bonds are strong.
- Always capable of conducting electricity because of mobile electrons (freely flowing delocalized electrons)

<u>EXAMPLE</u>:

What type of bond is created in EACH of the following?

a. KBr : _____

b. HI: _____

c. NO: _____

d. LiCl : _____

IN CLASS FOLLOW UP:

Which noble gas configuration in EACH of the following?

K: Br:

H: I:

N: O:

Li: Cl:

EXAMPLE QUESTIONS:

Which type of bonding is indicated in each of these substances:

- High melting and boiling points; does not conduct in solid phase but conducts in aqueous solution: _____
- Soft, non-conductive, low melting point: _____
- Conducts electricity in solid phase: _____

IN CLASS NOTES:

POLYATOMIC IONS:

- Located on **Table E**
- Atoms of two or more elements chemically bonded together and having a NET CHARGE.
- The atoms in polyatomic ions are held together by COVALENT bonds

Formula	Name
H_3O^+	hydronium
Hg_2^{2+}	mercury(I)
NH_4^+	ammonium
$C_2H_3O_2^-$ } CH_3COO^- }	acetate
CN^-	cyanide
CO_3^{2-}	carbonate
HCO_3^-	hydrogen carbonate
$C_2O_4^{2-}$	oxalate
ClO^-	hypochlorite
ClO_2^-	chlorite
ClO_3^-	chlorate
ClO_4^-	perchlorate

Formula	Name
CrO_4^{2-}	chromate
$Cr_2O_7^{2-}$	dichromate
MnO_4^-	permanganate
NO_2^-	nitrite
NO_3^-	nitrate
O_2^{2-}	peroxide
OH^-	hydroxide
PO_4^{3-}	phosphate
SCN^-	thiocyanate
SO_3^{2-}	sulfite
SO_4^{2-}	sulfate
HSO_4^-	hydrogen sulfate
$S_2O_3^{2-}$	thiosulfate

- Form **IONIC COMPOUNDS** with other substances due to presence of **ions**

- SO, the IONIC COMPOUNDS of POLYATOMIC IONS, have both IONIC & COVALENT bonding!

Example: NH_4Cl

Example: $MgSO_4$

Objective:

- ***Determine how strongly an atom of an element attracts electrons in a chemical bond using electronegativity values from Table S.***
- ***Determine the degree of polarity in a bond based upon the electronegativity difference between two bonded atoms.***

ELECTRONEGATIVITY: _____

Metals have _____ electronegativity values (tend to _____ electrons)

Nonmetals have _____ electronegativity values (tend to _____ electrons)

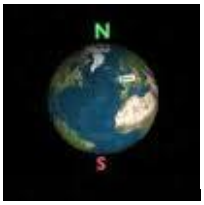
Ionic bonding results from higher electronegativity difference (electrons transferred).

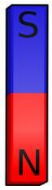
COVALENT BONDS

- Bonds between a _____ & _____
- Involve the _____ of electrons
  - But all sharing is NOT always equal
  - The difference in sharing is caused by the different electronegativities

BOND POLARITY

- Earth has 2 poles (north & south)
- Magnets also have 2 poles
- Bonds may also have 2 poles (called a _____) depending upon their electronegativity differences

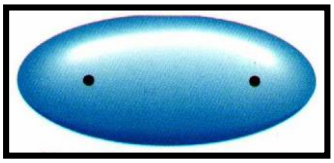


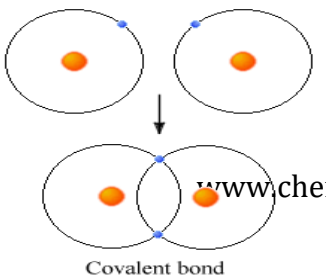


TYPES OF COVALENT BONDS

NON POLAR COVALENT BOND:

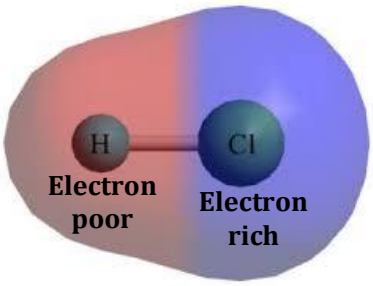
- _____ sharing of electrons
- Electronegativity difference (E.N.D.) between atoms 0 - 0.4
- Usually between identical atoms
- Ex. H_2

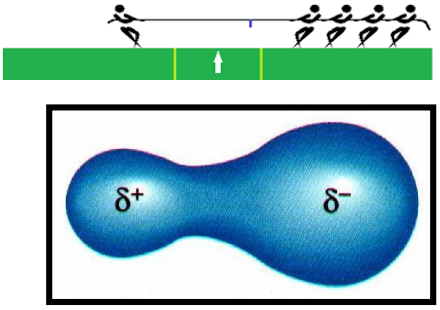




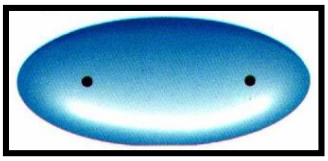
POLAR COVALENT BOND:

- Unequal sharing of electrons
- E.N.D. between atoms 0.5 – 1.7
- One atom is slightly _____ and one atom is slightly _____.
- This is known as a _____.
- Ex: HCl

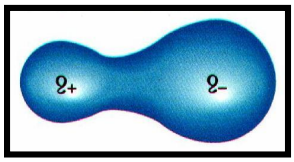




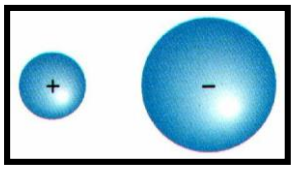
COMPARING IONIC AND COVALENT BONDS



Non Polar Covalent



Polar Covalent



Ionic

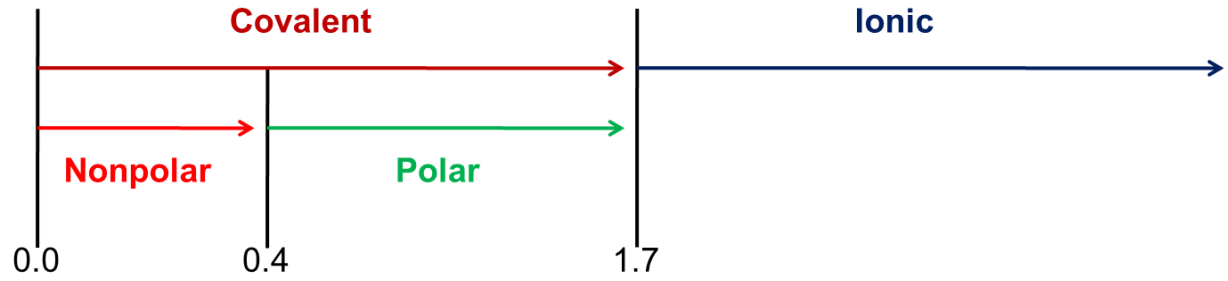
HOW TO DETERMINE TYPE OF BOND:

1. Determine if the bond is ionic or covalent.
2. If it is covalent (NM & NM), look at the elements:
    a. If they are different, the bond is _____.
    b. If they are not different, the bond is _____.
3. The <u>greater the END</u>, the <u>greater the degree of polarity</u>.

SUMMARY OF BOND TYPES

NM & NM **M & NM**

Identical
NM atoms



EXAMPLES:

Na-S:

C-Cl:

C-C:

H-O:

F-F:

K-O:

Additional space for notes:

Objective:

- ***Construct Lewis dot diagrams for ionic compounds.***

RECALL drawing dot diagrams for ions:

Positive ions have _____ electrons.

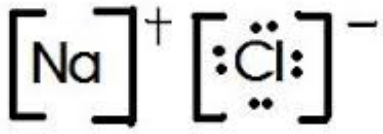
Negative ions have _____ electrons (except for H^- with only two).

STEPS FOR CONSTRUCTING DOT DIAGRAMS FOR IONIC COMPOUNDS

Draw ion dot diagrams next to each other making sure that:

1. The ion charges cancel out (add up to _____)
2. The opposite charged ions are next to each other, and the like charged ions are as far away from each other as they can be.

EXAMPLE: Draw dot diagram of NaCl



EXAMPLE: $CaCl_2$ (Calcium Chloride)

EXAMPLE: Barium Sulfide

Formula:_____

EXAMPLE: Aluminum Oxide

Formula:_____

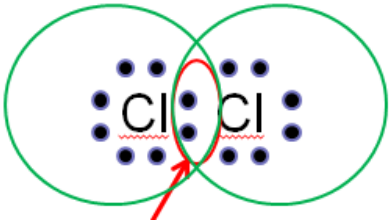
Objective:

- ***Construct Lewis dot diagrams for covalent compounds***
- ***Determine the number of electrons shared in a covalent bond.***

RULES FOR DRAWING DOT DIAGRAMS FOR COVALENT COMPOUNDS

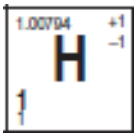
1. Write the element symbols next to each other (if more than two symbols write the UNIQUE symbol in the center)
2. Count up the total number of valence electrons for all the elements
3. Put 8 electrons around the central atom (if only two atoms pick one to place them around)
4. Distribute the remaining valence electrons to the other atoms equally until you run out
5. Check to see if each atom has a complete valence shell (8 electrons except Hydrogen which has 2)

Total # of valence electrons for 2 Chlorine atom = 7 x 2 = 14

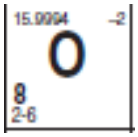


***A shared pair of electrons counts for both atoms*

***Each atom of Chlorine now has 8 electrons*.



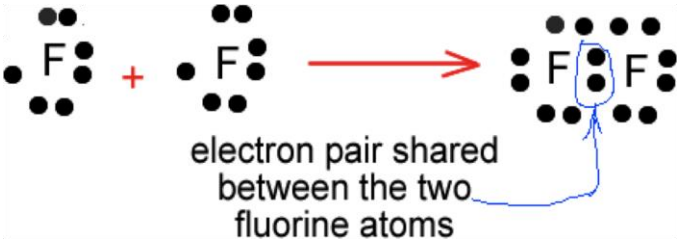
EXAMPLE: H_2O

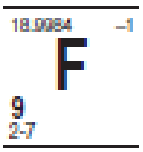


Total # of valence electrons for H_2O = 2(1) + 6 = 8

Water molecules are always drawn _____!!!

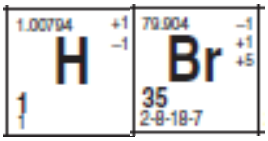
EXAMPLE: F_2 (total # of valence electrons = 14)





Draw F_2 with a line representing the bonded electrons:

Example: HBr



IF ALL ATOMS DO NOT HAVE A FULL VALENCE SHELL

YOU MUST ADD MULTIPLE BONDS (sharing of 2 or more PAIRS of electrons)

EXAMPLE: CO_2

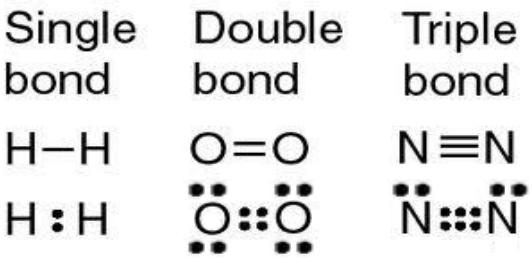
(total valence electrons = 16)

HOW MANY ELECTRONS CAN BE SHARED:

Single bond = sharing a pair (2) electrons

Double bond = sharing 2 pair (4) electrons

Triple bond = sharing 3 pair (6) electrons



EXAMPLE: Draw the dot diagram for O_2

(total valence electrons = 12)

Additional Notes on this Lesson:

Objective:

- Determine the polarity of a molecule based on its shape and distribution of charge

Recall: Bond Polarity depended on E.N.D. between atoms

A polar bond resulted from an *unequal distribution* of charge between the two atoms.

MOLECULAR POLARITY: is a result of the distribution of charge within a molecule (can be two *or more* atoms!)

Molecular Polarity Depends Upon:

1. **Bond Polarity**
2. **Shape of molecule**

POLAR VS. NON POLAR MOLECULES

A molecule is **NONPOLAR** if it:

- Is **SYMMETRICAL**

A molecule is **POLAR** if it:

- Is ASYMMETRICAL **(NOT symmetrical)**

Way to remember:

Examples:

CO_2 HF

Symmetrical asymmetrical

Non-polar Polar

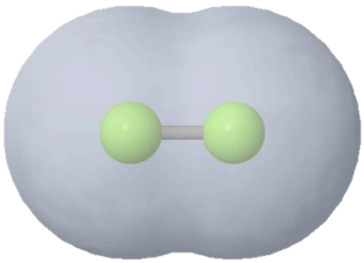
DETERMINING SYMMETRY:

TWO-ATOM MOLECULES (linear):

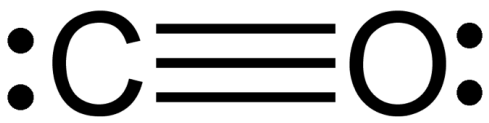
Symmetric (and non-polar) if bond is Non-polar;
Asymmetric (and polar) if bond is polar

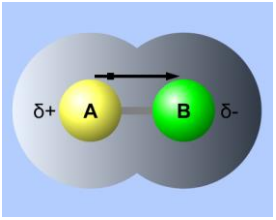
Examples:

Symmetric: Any diatomic element: Br_2, I_2, N_2, Cl_2, H_2, O_2, F_2
NON-POLAR



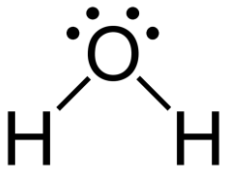
Asymmetric: Carbon Monoxide, CO
POLAR





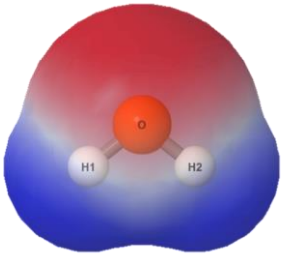
IF MORE THAN TWO ATOMS, DRAW THE DOT DIAGRAM

WATER, H_2O

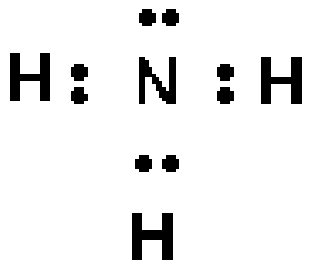


WATER IS A BENT MOLECULE!!

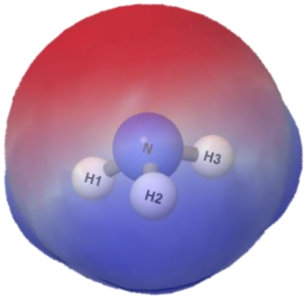
SNAP:
ASYMMETRIC
POLAR



AMMONIA, NH_3



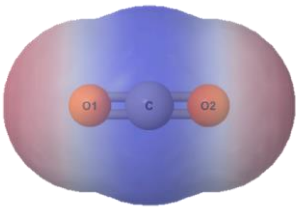
SNAP:
_____
_____



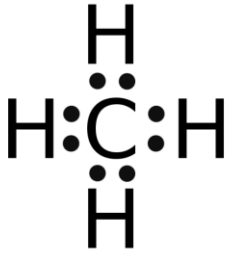
CARBON DIOXIDE, CO_2

CO_2 IS A LINEAR MOLECULE!!

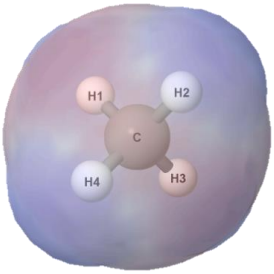
SNAP:
_____
_____



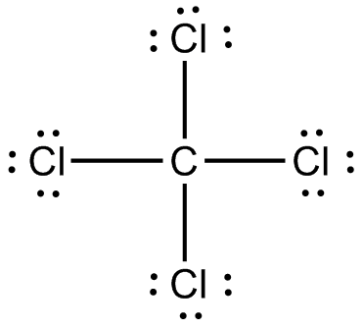
METHANE, CH4



SNAP:
_____
_____



EXAMPLE: Determine the molecular polarity and shape of CCl_4



SNAP:

_____

_____

EXAMPLE: Determine the molecular polarity and shape of H_2S

Dot Diagram:

SNAP:

_____

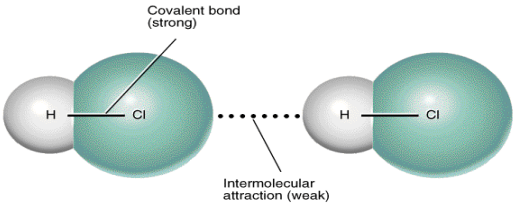
_____

Objective:

- ***Determine the type of intermolecular force that exists between covalent compounds***
- ***Determine the effect of intermolecular forces on melting and boiling point***

INTERMOLECULAR FORCE (IMF):

- Weak forces of attraction **BETWEEN** molecules (covalent compounds)



TYPES OF INTERMOLECULAR FORCES

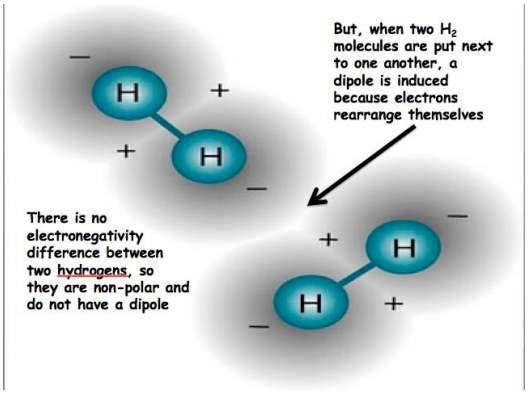
1. Dispersion Forces
2. Dipole-Dipole
3. Hydrogen Bonding

DISPERSION FORCES:

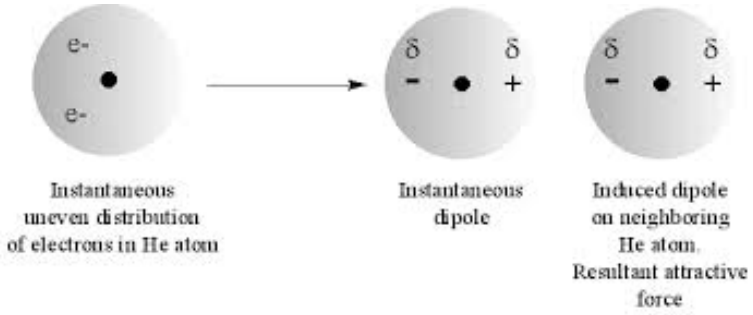
- Weakest IMF
- Occurs between nonpolar molecules – explains how nonpolar molecules can exist in solid and liquid phases
- Temporary dipoles
- MORE ELECTRONS = GREATER FORCE

All else being equal, the _____ the molecule, the _____ the IMF]

EXAMPLE: H_2

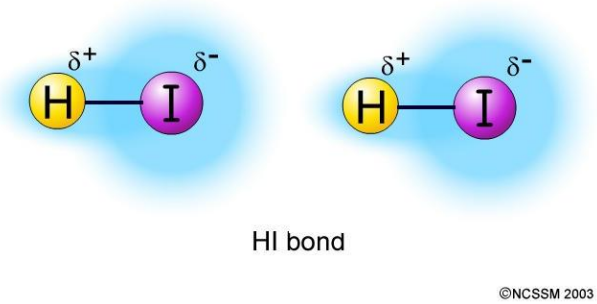


EXAMPLE: He

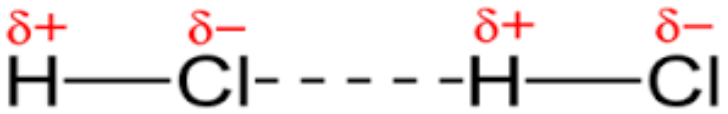


DIPOLE DIPOLE FORCES:

- Between **polar covalent** molecules
- Partial negative end of dipole attracted to partial positive end of another dipole
- The *more polar* the bond the *greater* the IMF between the molecules

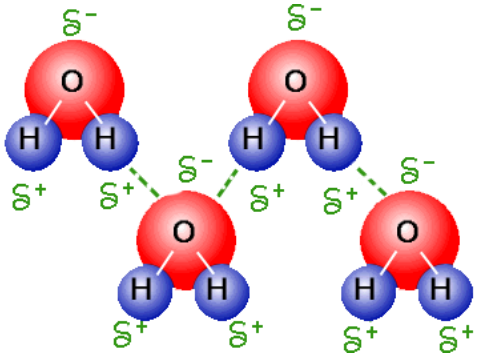


EXAMPLE: HCl

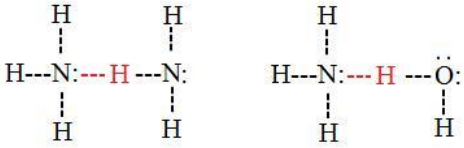


HYDROGEN BONDING:

- Special case of diploe interaction
- ***Strongest IMF***
- Occurs between hydrogen of 1 molecule and F, O or N in another
- Remember
- "H bonding is FON"



EXAMPLE: NH_3



EXAMPLE: What type of IMF occurs between molecules of Cl_2?

Dispersion because Cl_2 is nonpolar

EXAMPLE: What type of IMF occurs between molecules of NH_3?

Hydrogen bonding

(remember H-bonding is FON)

IMFs and Melting and Boiling Points

The STRONGER the IMF, the greater the melting and boiling points of a substance.

EXAMPLE:

at room temperature

H_2 (Dispersion forces, weak IMF)	vs.	H_2O (Hydrogen bonding, strongest IMF)
GAS		LIQUID