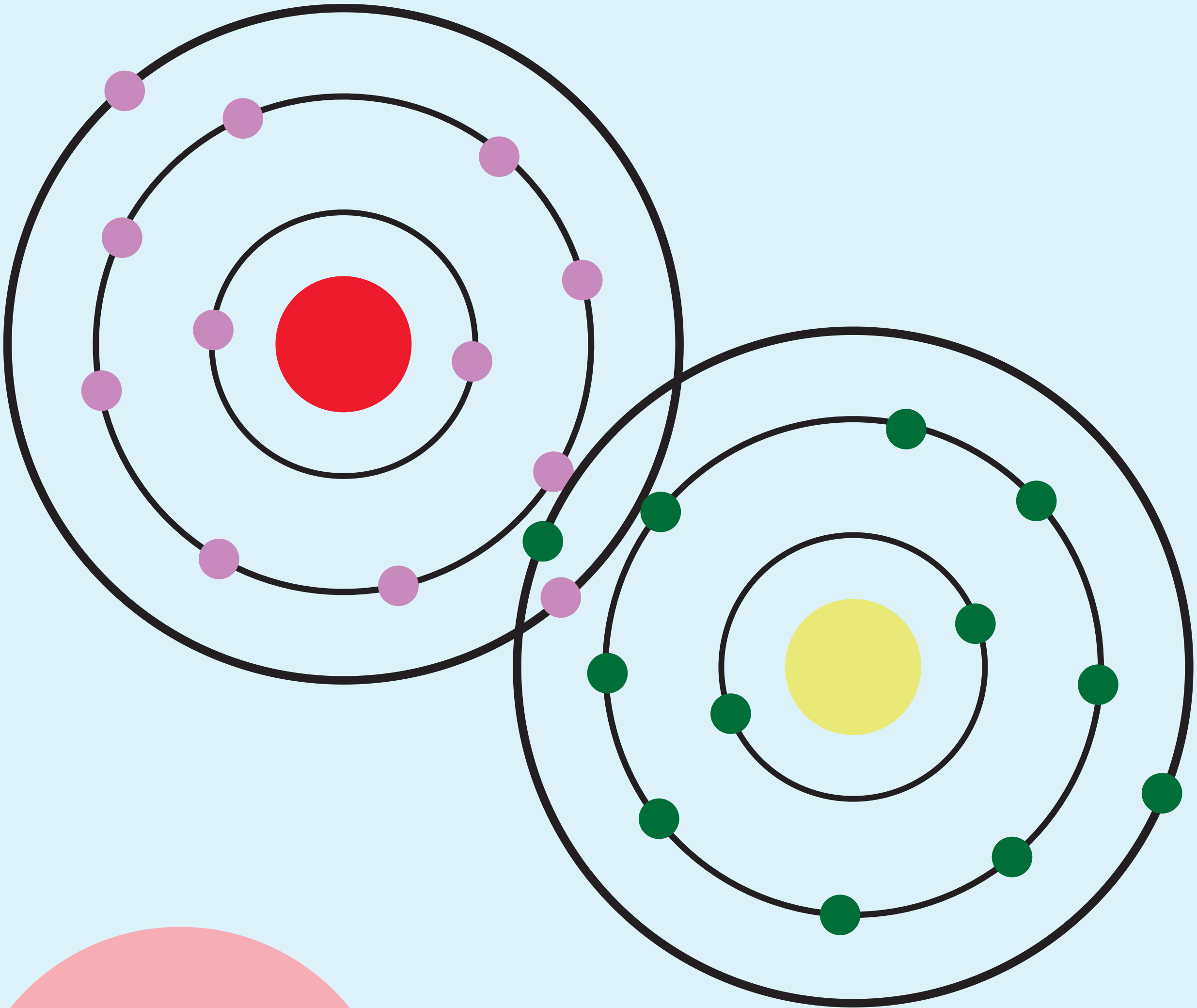
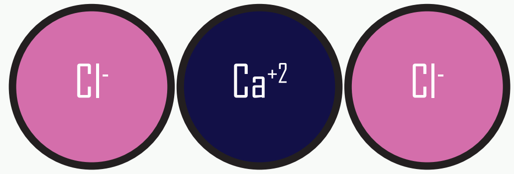


INTRODUCTORY CHEMISTRY

NAMING SYSTEMS

NAMING IONIC COMPOUNDS



It is understood that "calcium chloride" is to mean $CaCl_2$

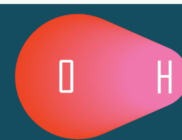
-Naming ionic compounds is rather elementary:

-Name the element on the leftmost side of the periodic table

-Name the other element; add an "-ide" suffix to it

*For the naming of ionic compounds, it is not important to name the number of elements (as in covalent compounds) because that number can often be understood from the name itself

NAMING COVALENT COMPOUNDS



-To begin, the name of the first nonmetal in the molecule (indicated by which element is farthest to the left in the periodic table) will be the first term in the name of the compound.

-For the second nonmetal, take the name and add an "-ide" suffix to it

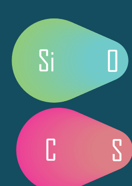
-Add to both prefixes to indicate the number of each respective element in the compound.

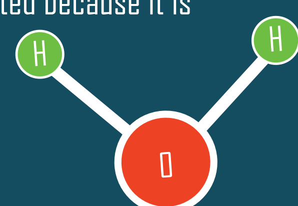
-However, if the first nonmetal has "mono" as a prefix, "mono" is omitted because it is understood

-These rules are easier to see with some examples below

SiO_2 - Silicon Dioxide

CS_2 - Carbon Disulfide





DIHYDROGEN MONOXIDE

(or by its more ubiquitous moniker, water)

Mono - one
Di - two
Tri - three
Tetra - four
Penta - five
Hexa - six
Hepta - seven
Octa - eight
Nona - nine
Deca - ten

MOLE CONVERSIONS

-Mole is an extremely important unit of measurement in chemistry

-A "mole" of something can be thought of like a "dozen"

-As a "dozen" represents 12 of something, a "mole" represents $6.02*10^{23}$ of something, in this case, particles

-Moles are important because they allow chemists to do comparisons between elements; an example of this is given below

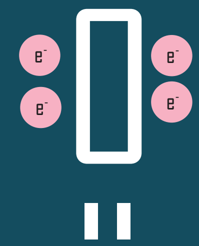
Assume that you have 10.0g of two ionic compounds, lithium fluoride and silver chloride, and dissolve both samples in two beakers with an unspecified amount of water. You want to calculate the number of moles to see in which beaker there are more particles. To do so, you use the molar masses to find:

$$10.0\text{g} \times \frac{1\text{ mole}}{25.94\text{g}} = 0.386 \text{ mol LiF}$$

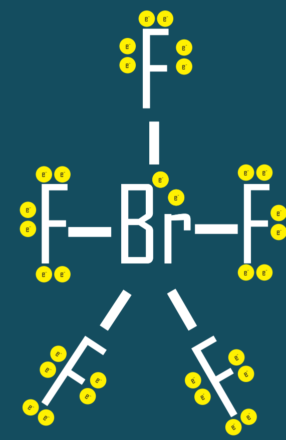
$$10.0\text{g} \times \frac{1\text{ mole}}{143.32\text{g}} = 0.0698 \text{ mol AgCl}$$

LEWIS STRUCTURES

OCTET RULE (OR RULE OF EIGHT)



-The octet rule helps one draw Lewis structures
-It states that around each atom in a covalent molecule, there must be eight electrons around in its valence shell
-A covalent bond occurs when two atoms share two electrons; thus each bond represents two electrons



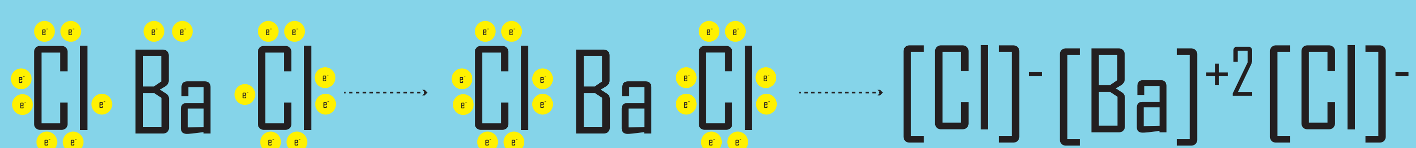
Exceptions to the Octet Rule

-While the Octet Rule is a general rule of thumb, not all elements follow it
-Boron and beryllium do not follow it. Beryllium only allows for four electrons around it while boron only allows six electrons
-Elements in the 3rd period of the periodic table and below may follow the octet rule, or they may have more than eight electrons around their valence shell in what is called an "expanded octet" (see the Lewis Structure of BrF_5 to the right)

DRAWING IONIC STRUCTURES

-The representation of ionic compounds is slightly different from the way covalent compounds are drawn

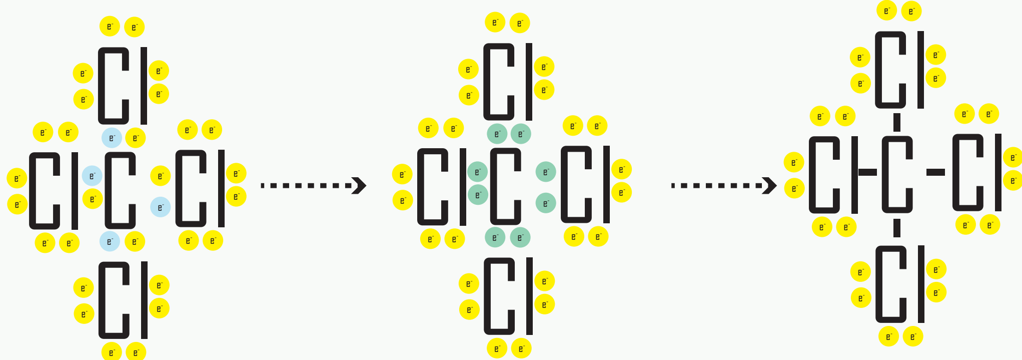
-The Lewis structure needs to show transfer of electrons and the charge on each ion
An example of this representation of this is shown below:



Showing the valence electrons

LEWIS STRUCTURES

HOW TO DRAW LEWIS STRUCTURES

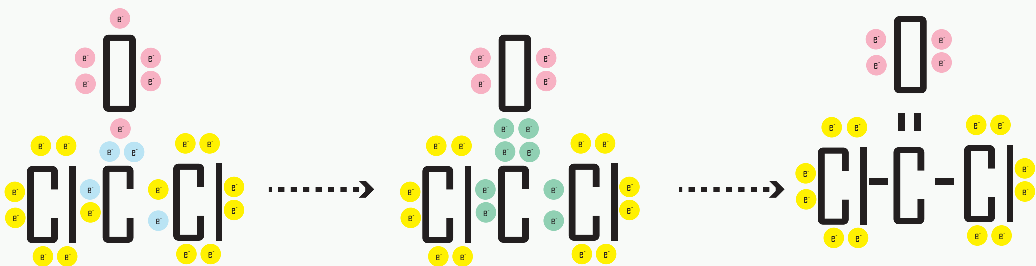


The blue dots represent carbon's valence electrons

The green dots represent the "shared" electrons

The shared electrons can then be represented by a solid line denoting a covalent bond

CARBON TETRACHLORIDE



The blue dots represent carbon's valence electrons
The pink dots represent oxygen's valence electrons

The green dots represent the "shared" electrons

The shared electrons can then be represented by a covalent bond

CARBONYL DICHLORIDE

1) Find the number of valence electrons in each atom of the molecule and add them up

In the case of carbon tetrachloride, each of the chlorines has 7 valence electrons and carbon has 4, meaning that, in total, there are 32 valence electrons

2) Begin Drawing

Write out the atoms as well as the number of valence electrons that each one has. In the case of carbonyl dichloride, six electrons have been drawn around the oxygen for its six valence electrons. Valence electrons are first put around each side of the atom and then paired

Tip: Try starting to draw out your structure by having the atom with the smallest number of valence electrons be the center atom. While this may not always be the case, the atom with the smallest number of valence electrons will need to have the most bonds to achieve the octet rule, thereby increasing the probability that it is the center atom

3) Make Connections

Connections need to be made to satisfy the octet rule. In the case of carbonyl dichloride. It can be seen that when originally drawn the octets of the chlorines are fulfilled with a single connection between each of them and the carbon. However, carbon still only has six electrons around it; so does oxygen. To resolve this, a double connection should be made between the carbon and oxygen.

4) Check

Count the number of electrons around each atom again. If there was only a single bond between the carbon and the oxygen, not only would the octet rule still not be fulfilled, but there would also be a single unpaired electron, which would still be incorrect. From this we see that there is a double bond between the carbon and oxygen

5) Recheck

Recounting ensures that all electrons have been used and paired and that the octet rule is satisfied for each atom in the Lewis structural formula

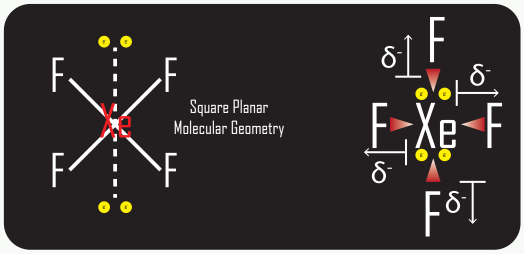
INTERMOLECULAR FORCES

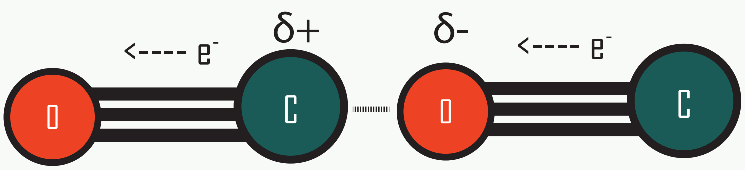
DIPOLE-DIPOLE FORCES

-Dipole-dipole forces are a type of intermolecular attraction created by the electronegativity difference between two covalently bonded atoms of a given compound

-This creates partial charges that allow for attraction

-It is important to note that while individual bonds may be polar, geometries may make the molecule as a whole nonpolar (as seen with XeF_4)





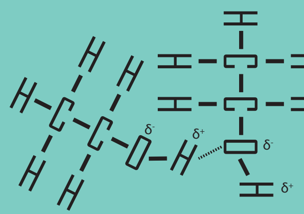
HYDROGEN BONDING

-Hydrogen bonding can be thought of as a special, much stronger type of dipole-dipole attraction

-A hydrogen bond occurs when a hydrogen is covalently bonded to a highly electronegative atom such as nitrogen, oxygen, or fluorine

-This in turn results in an extremely polar covalent bond due to the vast electronegativity differences between the hydrogen and either fluorine, nitrogen, or oxygen.

-This allows the molecule to form strong intermolecular attractions



Hydrogen bonding between two ethanol molecules

ION-ION ATTRACTIONS

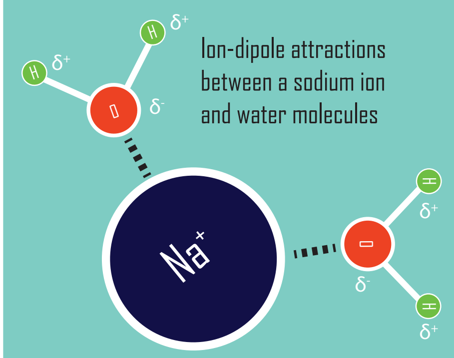
-Ion-ion attractions happen when the attraction is to each to such a degree that an electron gets kicked out of the atom with the lower electronegativity

-As a result, the charges on the atoms are permanent, making Ion-ion attractions the strongest type of intermolecular attractions

-The strength of an ion-ion attraction is related to the strength of the difference of the charges between the ions

-The larger the difference the stronger the attraction

ION-DIPOLE ATTRACTIONS



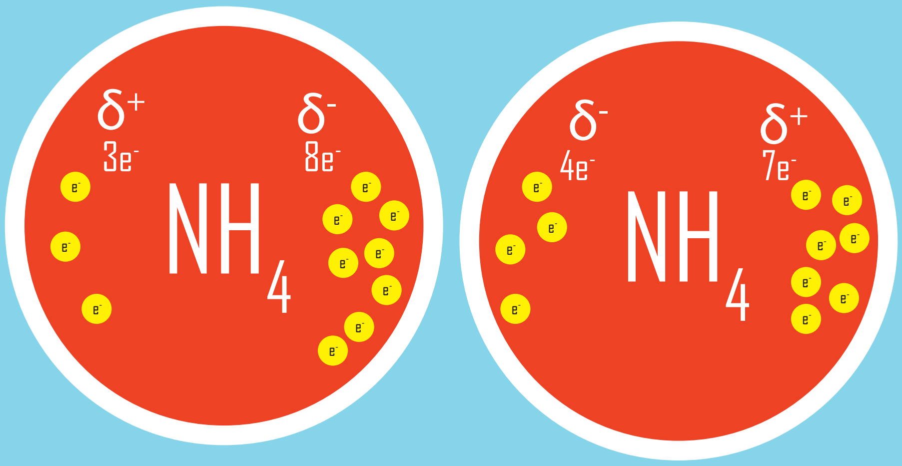
Ion-dipole attractions between a sodium ion and water molecules

INTERMOLECULAR FORCES

LONDON DISPERSION FORCES

-The London Dispersion Force (or LDF) is the weakest force of attraction
-This is because LDF forces do not involve a permanent charge nor a partial charge, but a temporary partial charge
-How can a charge be temporary?
-When electrons swirl around in the molecule, inevitably due to the random whizzing of electrons in an atom, there will be a temporary imbalance of electrons creating a weak and TEMPORARY dipole moment in the molecule
-This dipole moment allows the molecule to become attracted to similarly nonpolar molecules
-An important thing to note is that, unlike with ionic and dipole forces where we focused on the valence shell of the molecule, LDF takes into consideration ALL the electrons in a molecule

-This means larger molecules will have stronger dispersion forces than smaller ones



A visualization of the London Dispersion Force

BALANCED EQUATIONS

HOW TO BALANCE A CHEMICAL EQUATION

$\_\_\_Fe + \_\_\_H_2SO_4 \rightarrow \_\_\_Fe_2(SO_4)_3 + \_\_\_H_2$

$\_2\_Fe + \_\_\_H_2SO_4 \rightarrow \_\_\_Fe_2(SO_4)_3 + \_\_\_H_2$

$\_2\_Fe + \_\_3\_H_2SO_4 \rightarrow \_\_\_Fe_2(SO_4)_3 + \_3\_\_H_2$

$2Fe + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 3H_2$

1) Begin by balancing the easier term in the equation

First look at the iron and realize that while there are two irons in the products. There is only one in the reactants. Fix this by adding a 2 in front of the iron on the reactants side

2) Move on to the harder compounds

Now look at the sulfate. There are 3 of them in the products. To balance this add a 3 to the sulfuric acid in the reactants. As a result, there are now 6 hydrogens in the reactants but only 2 in the products. To balance the hydrogens, add a 3 in front of H_2 in the products.

3) Check

If all the terms of the equation are balanced, then the equation as a whole is balanced

CONVERTING WORD EQUATIONS INTO FORMULA EQUATIONS

Let us assume you were given the following reaction:
Calcium carbonate + hydrochloric acid -> carbon dioxide + calcium chloride + water
How would you go about writing the actual formula equation for the reaction? Some helpful hints for breaking it down are listed below
Calcium carbonate -> seeing the word "carbonate" makes one remember that carbonate is a polyatomic ion with a charge of -2 and that this is an ionic compound. As a result, you know that as calcium is in its ionic form it will have subsequently lost two electrons. As the charges balance, the formula is $Ca(CO_3)$
Hydrochloric acid -> This is an ionic compound and the lack of a numerical prefix (as well as the vast electronegativity difference between hydrogen and chlorine) gives that away. Chlorine's ionic charge is -1 and hydrogen's is +1, leading you to see the compound's formula is HCL
Carbon Dioxide -> the "di" prefix makes one remember that this compound is covalent. From here one can see that this compound will simply be single carbon with two oxygens, CO_2.
Calcium Chloride -> seeing the lack of a numerical prefix leads one to believe that this an ionic compound. Remembering from above you know that calcium in its ionic form will have a charge of +2 and chlorine will have a -1 charge. In order for these to balance to achieve a net charge of zero on the compound, there will have to be two chlorines. This leads one to conclude the compound's formula is $CaCl_2$
Water -> a ubiquitous moniker for H_2O
Combining everything from above results in the following formula equation: $CaCO_3 + HCl \rightarrow CO_2 + CaCl_2 + H_2O$

FINDING THE LIMITING REACTANT IN A REACTION

Oftentimes when a chemical reaction occurs, while all of one reactant may get used up, there may still be some of the other reactant left over. The reactant that gets all used up is known as the "limiting reactant" (it limits how far the reaction can proceed), while the reactant that is leftover is known as the "excess reactant". Instead of experimentally finding the limiting reactant, we can identify it by using dimensional analysis. Let us assume you were given the following reaction:

$$2Al + 3Cl_2 \rightarrow 2AlCl_3$$

You want to find the limiting reactant when 40 grams of aluminum and 50 grams of chlorine are used. To find this you do:

$$40.0\text{g} \times \frac{1 \text{ mole Al}}{26.98\text{g}} \times \frac{2 \text{ mole } AlCl_3}{2 \text{ mole Al}} = 1.48 \text{ mol } AlCl_3$$

$$50.0\text{g} \times \frac{1 \text{ mole } Cl_2}{70.91\text{g}} \times \frac{2 \text{ mole } AlCl_3}{3 \text{ mole } Cl_2} = \boxed{0.470 \text{ mol } AlCl_3}$$

As only 0.47 mol of $AlCl_3$ can be produced with 50 grams of chlorine, **chlorine would be considered the limiting reactan**t in this scenario

SOLUTIONS AND CONCENTRATIONS

CALCULATING MOLARITY AND MOLALITY

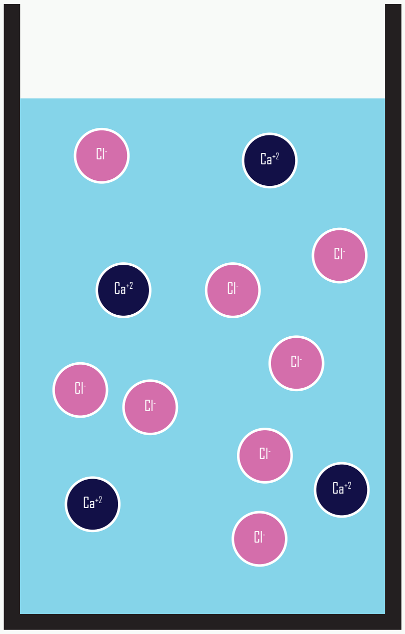
(UNITS OF CONCENTRATION)

-The formula for molarity is:

$$M = \frac{mol}{L}$$

-The formula for molality is:

$$m = \frac{mol}{kg}$$



Example

Assume you just put in 55.49 grams of calcium chloride in 2 liters of water. Using dimensional analysis, you find that you put in 0.5 moles of calcium chloride in the water. Thus, you find that the molarity is 0.25 mol/L. Then by using water's density of 1 kg/L, you find that 2 liters of water weigh 2 kg meaning the molality is 0.25 mol/kg

FINDING NET IONIC EQUATIONS

For our purposes, let us assume that you were given the following equation

$$AgNO_3(aq) + KCl(aq) \text{ -> } AgCl(s) + KNO_3(aq)$$

1) Disassociate the soluble compounds in the equation

$$Ag^+ + (NO_3)^- + K^+ + Cl^- \text{ -> } AgCl + K^+ + (NO_3)^-$$

2) Balance

$$Ag^+ + \cancel{(NO_3)^-} + \cancel{K^+} + Cl^- \text{ -> } AgCl + \cancel{K^+} + \cancel{(NO_3)^-}$$

3) Remove Spectator Ions

$$Ag^+ + Cl^- \text{ -> } AgCl$$

SPECTATOR IONS

-Spectator ions are ions that are present both at the beginning of a reaction and remain unaffected by the end of it

-As a result, when writing out reactions, they are unimportant (as nothing occurred to them, they were just merely "spectators" to the actual reaction) and are thus crossed out

SOLUTIONS AND CONCENTRATIONS

FINDING IF A COMPOUND IS SOLUBLE

(For example in water)

-The solubility of a molecule is directly related to its polarity
-In order for a compound to be soluble, its intermolecular forces need to be stronger than the solvent's
-For our purposes we will focus on water; water uses hydrogen bonding for its intermolecular forces
-For a compound to be soluble, water needs to disassociate from itself and re-associate with the compound to be dissolved (the solute)

-Ionic compounds are soluble in water

-Why? This is because (remember earlier) ionic compounds have permanent charges on the atoms that make them up. Permanent charges are very strong and this makes it favorable for them to separate the water molecules from each other

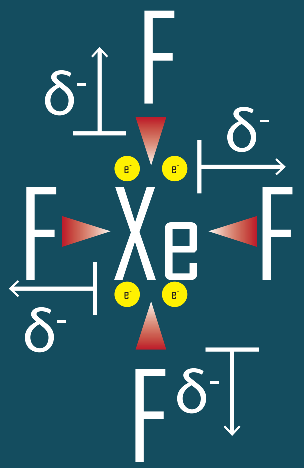
-Compounds that use dipole-dipole attractions are soluble in water

-Why? This is because while dipole-dipole attractions are slightly less strong than hydrogen bonding, the partial charges are still strong. This makes it attractive for water to disassociate and re associate to the compound and allows for the compound to dissolve

-Compounds that use London Dispersion forces as their intermolecular force of attraction are insoluble

-Why? This is because LDF transposes a temporary charge. The strength of and the charge itself of the molecule will come and go depending on the electron distribution within the molecule. As a result, it is unfavorable for water to disassociate from itself and form attractions with these compounds. That makes these compounds insoluble in water

-A rule of thumb for predicting solubility is **"like dissolves like"**



XeF_4 is a nonpolar molecule, and as a result, it is **NOT** soluble in water