

CHEMISTRY UNIT 3 NOTES

What are Ions?

Ions are atoms that contain an uneven number of protons and electrons which results in an overall positive or negative charge



Cation

Cations are **atoms that contain a positive charge**. The positive charge is a result of the atom containing more protons than electrons



Anion

Anions are **atoms that contain a negative charge**. The negative charge is a result of the atom containing more electrons than protons

For an anion, the ending becomes “-ide”

COMMON CHARGE →	1+	2+	VARIABLE CHARGES										3+	4+	3-	2-	1-	0	
Group # →	1	2	3-12										13	14	15	16	17	18	
	1 H																		2 He
	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo	

VOCABULARY

_____ : the electrostatic force that holds oppositely charged particles together in an ionic compound.

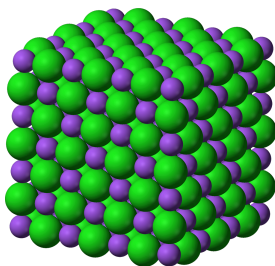
_____ : compounds that contain ionic bonds

_____ : a special ionic bond that occurs between metals and oxygen

_____ : what we call most other ionic compounds

_____ : ionic compounds that contain only two different elements, a metallic cation and a nonmetallic anion

Properties of Ionic Compounds



- Ions are packed in a regular repeating pattern for balancing forces of attraction and repulsion called a _____. Each positive ion is surrounded by negative, and each negative ion is surrounded by positive.

- Ionic solids do not conduct electricity, but melted or in solution they are excellent conductors.
 _____- an ionic compound whose aqueous solution conducts an electric current.
- Melting point, boiling point, and hardness depend on the strength of attraction between particles. Ionic crystals have high melting and boiling points, are _____, _____, and _____.
- Forming ionic bonds is _____, or energy is released, because it is forming something more stable
- _____- the energy required to separate 1 mol of the ions in an ionic compound. The greater the lattice energy, the stronger the forces of attraction

Characteristic	Lattice Energy
Bigger Ion	Lower lattice energy
Bigger Charge	Higher lattice energy

Formulas for Ionic Compounds

-----: the chemical formula for an ionic compound, representing the simplest ratio of the ions involved. Ex: MgCl_2

-----: a one-atom ion such as Mg^{2+}

-----: equal to the charge of a monatomic ion and the number of electrons transferred from the atom to form the ion

1. The symbol of the cation is written first
2. followed by the symbol of the anion.
3. Subscripts represent the number of each ion. If there is no subscript, it is assumed to be one.
4. Ionic compounds must have no charge.

Cross Over Method for Charges

Examples: NaF , KI , MgCl_2 , AlBr_3

Table 9 Common Polyatomic Ions

Ion	Name	Ion	Name
NH_4^+	ammonium	IO_4^-	periodate
NO_2^-	nitrite	$\text{C}_2\text{H}_3\text{O}_2^-$	acetate
NO_3^-	nitrate	H_2PO_4^-	dihydrogen phosphate
OH^-	hydroxide	CO_3^{2-}	carbonate
CN^-	cyanide	SO_3^{2-}	sulfite
MnO_4^-	permanganate	SO_4^{2-}	sulfate
HCO_3^-	hydrogen carbonate	$\text{S}_2\text{O}_3^{2-}$	thiosulfate
ClO^-	hypochlorite	O_2^{2-}	peroxide
ClO_2^-	chlorite	CrO_4^{2-}	chromate
ClO_3^-	chlorate	$\text{Cr}_2\text{O}_7^{2-}$	dichromate
ClO_4^-	perchlorate	HPO_4^{2-}	hydrogen phosphate
BrO_3^-	bromate	PO_4^{3-}	phosphate
IO_3^-	iodate	AsO_4^{3-}	arsenate

Because a polyatomic ion exists as a unit, never change subscripts of the atoms within the ion. If more than one polyatomic ion is needed, place parentheses around the ion and write the subscript outside the parentheses.

OXYANIONS- POLYATOMIC ION COMPOSED OF AN ELEMENT BONDED TO ONE OR MORE OXYGEN ATOM

Oxyanion Nomenclature (Naming)

• Compare the sets of oxyanions below. Notice the pattern in their names.

• NO_2^- (nitrite) and NO_3^- (nitrate)

• SO_3^{2-} (sulfite) and SO_4^{2-} (sulfate)

• ClO_2^- (chlorite) and ClO_3^- (chlorate)

- The one with fewer oxygens ends in *-ite*.

- The one with more oxygens ends in *-ate*.

NAMING IONIC COMPOUNDS

1. Name the cation followed by the anion.
2. For monatomic cations, use the element name.
3. For monatomic anions, use the root of the element name plus suffix “-ide”

Ex: CsBr = cesium bromide

4. If something has more than one oxidation number, write the number in roman numeral in parentheses.

Ex: FeO = iron(II) oxide

5. When it contains a polyatomic ion, use the name of the polyatomic ion in place of the cation or anion

Naming Ionic Compounds

Binary ionic compounds are only made up of two elements: a metal and a nonmetal.



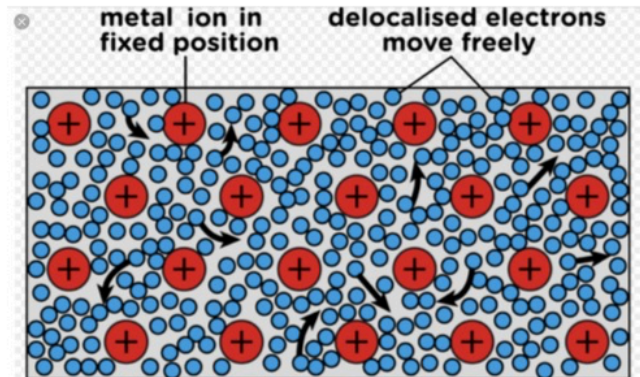
Formula	Name
NaCl	Sodium chloride
Li_2O	Lithium oxide
KI	Potassium iodide

Write the name of the cation, followed by the name of the anion ending in “ide.”

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METALLIC BONDS

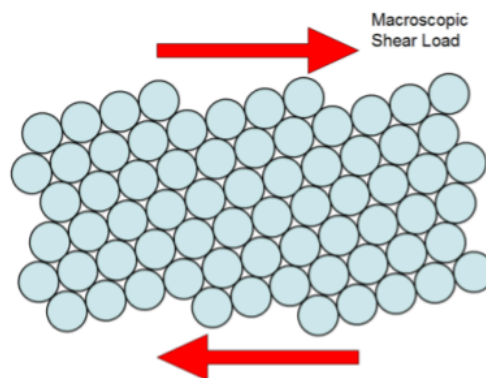
- Metallic bond- the attraction of a metallic cation for delocalized electrons



PROPERTIES OF METALS

Moderately high melting and boiling points

Malleable, ductile, durable, hard, and strong

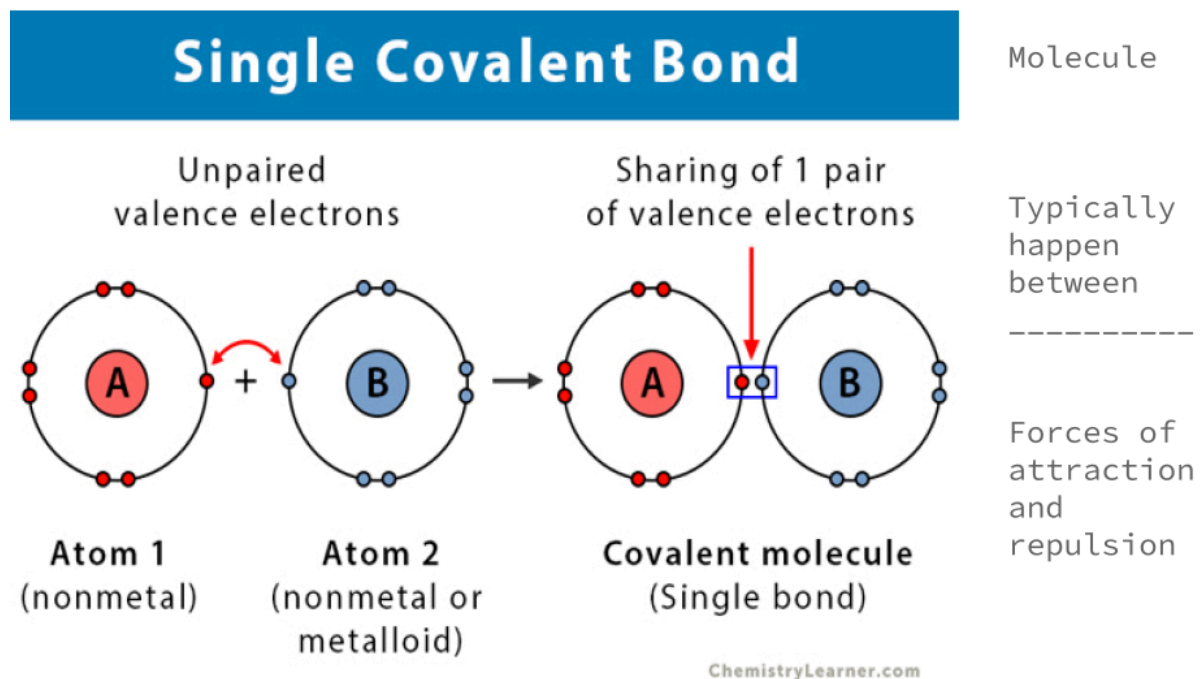


ALLOYS

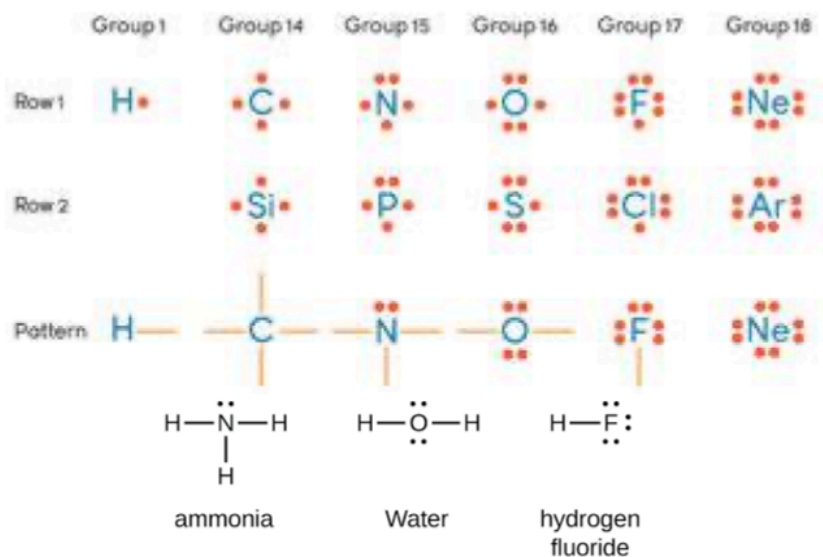
----- - a mixture of elements that has metallic properties like stainless steel, brass, and cast iron

----- - some of the original metallic solid are replaced by other metals of similar size

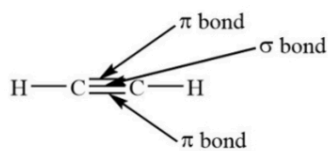
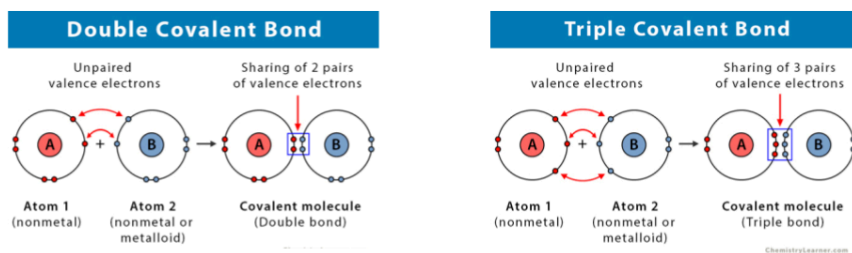
----- - when small holes in metallic crystal are filled with smaller atoms



LEWIS STRUCTURES



MULTIPLE COVALENT BONDS



BOND STRENGTH

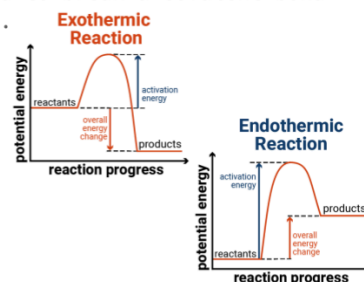
The more bonds there are, the shorter the bond length!

The shorter the bond length, the stronger the bond!



BONDS AND ENERGY

Energy is released when a bond forms, but is required for a bond to break. The energy required to break a covalent bond is called bond-dissociation energy.



NAMING BINARY MOLECULAR COMPOUNDS

1. The first element in the formula is always named first.
2. The second element is named using its root and adding the suffix -ide.
3. Prefixes indicate number of atoms.

Ex. N_2O is dinitrogen monoxide

Prefixes - Number of Atoms	
mono-	1
di-	2
tri-	3
tetra-	4
penta-	5
hexa-	6
hepta-	7
octa-	8
nona-	9
deca-	10

NAMING BINARY ACIDS (WHICH CONTAIN HYDROGEN AND ONE OTHER ELEMENT)

1. The first word has the prefix hydro-. The rest of the first word is the form of the root of the second element with the suffix -ic
2. The second word is always acid.

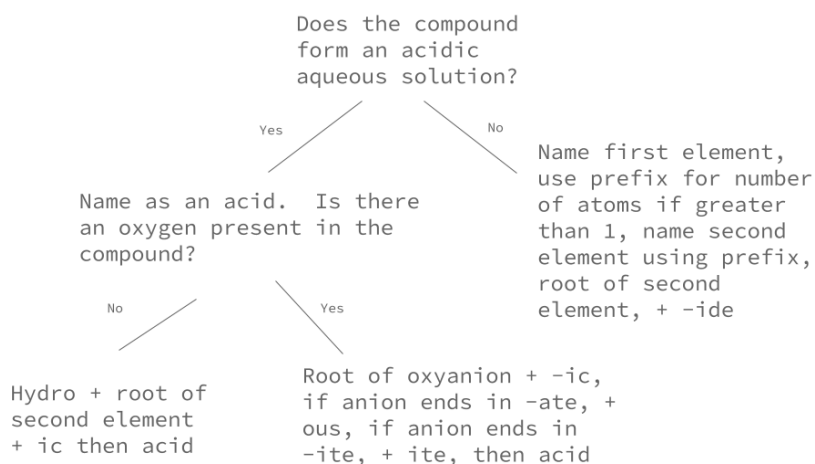
Ex. HCl is hydrochloric acid

NAMING OXYACIDS (AN ACID THAT WITH HYDROGEN AND OXYANION)

Oxyanion is a polyatomic ion that contains oxygen.

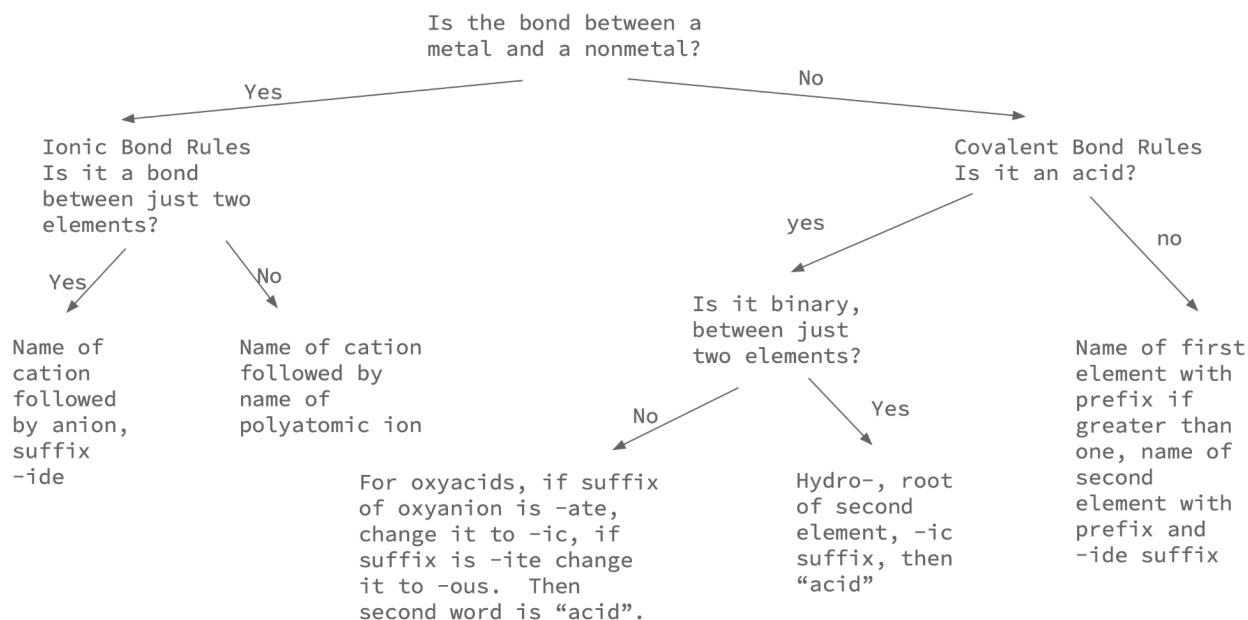
1. The first word is the root of the oxyanion. If there is a prefix, use the prefix. If it has the suffix -ate you replace it with -ic. If it ends with -ite, replace it with -ous.
2. The second word is acid.

Ex. HNO₃ is nitric acid

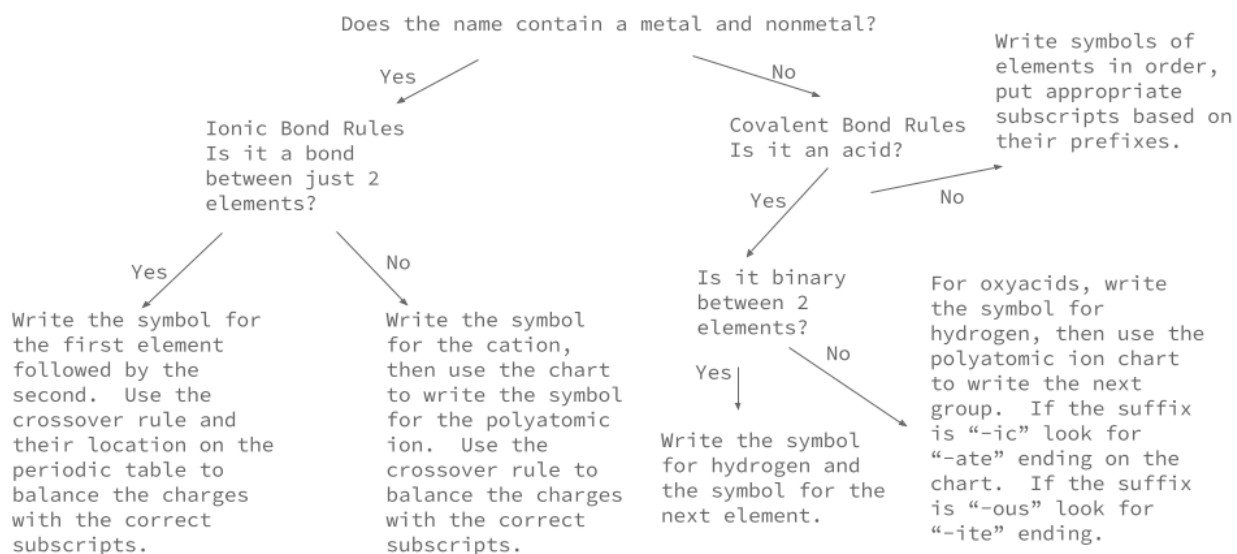


FLOWCHARTS FOR ALL COMPOUNDS

NAMING COMPOUNDS FLOWCHART



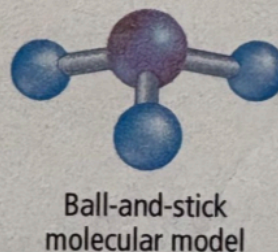
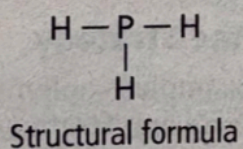
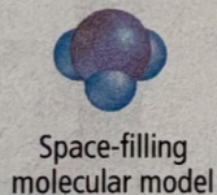
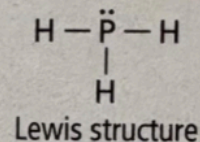
NAME TO COMPOUND FLOWCHART



■ **Figure 13** All of these models can be used to show the relative locations of atoms and electrons in the phosphorus trihydride (phosphine) molecule.

Compare and contrast the types of information contained in each model.

PH_3
Molecular formula



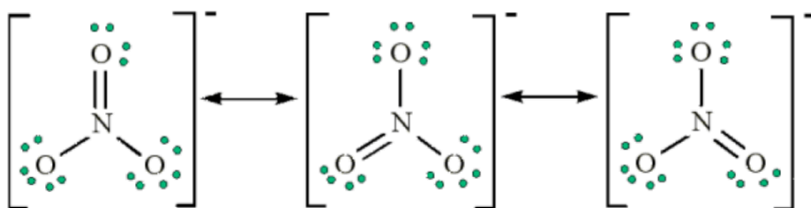
STEPS FOR DRAWING LEWIS STRUCTURES

1. Atom farthest away from fluorine is center (hydrogen is never in center).
2. Total number of valence electrons.
3. Divide by 2 to find number of pairs.
4. Place bonds between atoms.
5. Place remaining pairs around atoms.
6. Is octet rule satisfied? May need to adjust for double and triple bonds.

* If it is a polyatomic ion, make sure to consider the charge when totaling the electrons.

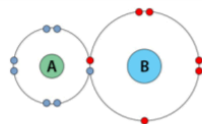
RESONANCE STRUCTURES

When more than one valid Lewis structure can be written.

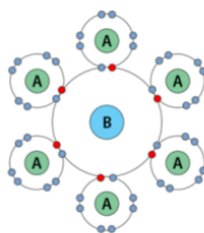


Exceptions to the Octet Rule

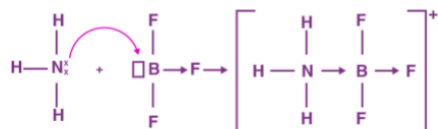
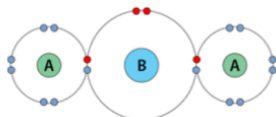
1. Odd Number of Electrons



2. Expanded Octet



3. Incomplete Octet



Ammonia Boron Trifluoride

Explore molecular shapes with interactive table. Concepts In Motion

Molecule	Total Pairs	Shared Pairs	Lone Pairs	Hybrid Orbitals	Molecular Shape*
BeCl ₂	2	2	0	sp	Linear 180°
AlCl ₃	3	3	0	sp ²	Trigonal planar 120°
CH ₄	4	4	0	sp ³	Tetrahedral 109.5°
NH ₃	4	3	1	sp ³	Trigonal pyramidal 107.3°
H ₂ O	4	2	2	sp ³	Bent 104.5°
NbBr ₅	5	5	0	sp ³ d	Trigonal bipyramidal 90°, 120°
SF ₆	6	6	0	sp ³ d ²	Octahedral 90°

The BeCl₂ molecule contains only two pairs of electrons shared with the central Be atom. These bonding electrons have the maximum separation, a bond angle of 180°, and the molecular shape is linear.

The three bonding electron pairs in AlCl₃ have maximum separation in a trigonal planar shape with 120° bond angles.

When the central atom in a molecule has four pairs of bonding electrons, as CH₄ does, the shape is tetrahedral. The bond angles are 109.5°.

NH₃ has three single covalent bonds and one lone pair. The lone pair takes up a greater amount of space than the shared pairs. There is stronger repulsion between the lone pair and the bonding pairs than between two bonding pairs. The resulting geometry is trigonal pyramidal, with 107.3° bond angles.

Water has two covalent bonds and two lone pairs. Repulsion between the lone pairs causes the angle to be 104.5°, less than both tetrahedral and trigonal pyramidal. As a result, water molecules have a bent shape.

The NbBr₅ molecule has five pairs of bonding electrons. The trigonal bipyramidal shape minimizes the repulsion of these shared electron pairs.

As with NbBr₅, SF₆ has no unshared electron pairs on the central atom. However, six shared pairs arranged about the central atom result in an octahedral shape.

Electronegativity
difference between
bonding atoms

Bond type

Zero

Pure covalent

Intermediate

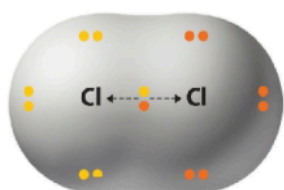
Polar covalent

Large

Ionic

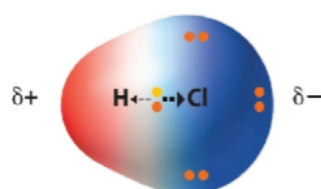
Covalent
character
decreases;
ionic character
increases.

Bond Type	Electronegativity Difference
pure covalent	< 0.4
polar covalent	between 0.4 and 1.8
ionic	> 1.8



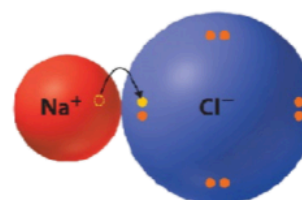
Non-Polar Covalent Bond

Bonding electrons *shared equally* between two atoms.
No charges on atoms.



Polar Covalent Bond

Bonding electrons *shared unequally* between two atoms.
Partial charges on atoms.



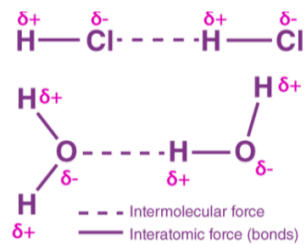
Ionic Bond

Complete *transfer* of one or more valence electrons.
Full charges on resulting ions.

POLARITY AND SOLUBILITY:

"Like dissolves like"

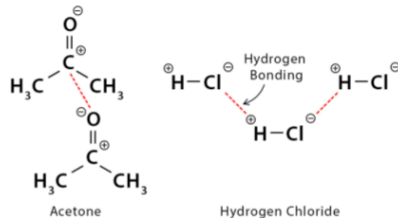
INTERMOLECULAR FORCES OR VAN DER WAALS FORCES



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Intermolecular Forces Types & Examples

1. Dipole-dipole Forces



How strong?

Strongest:

Medium:

Weakest:

2. London Dispersion Forces



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Covalent Network Solids

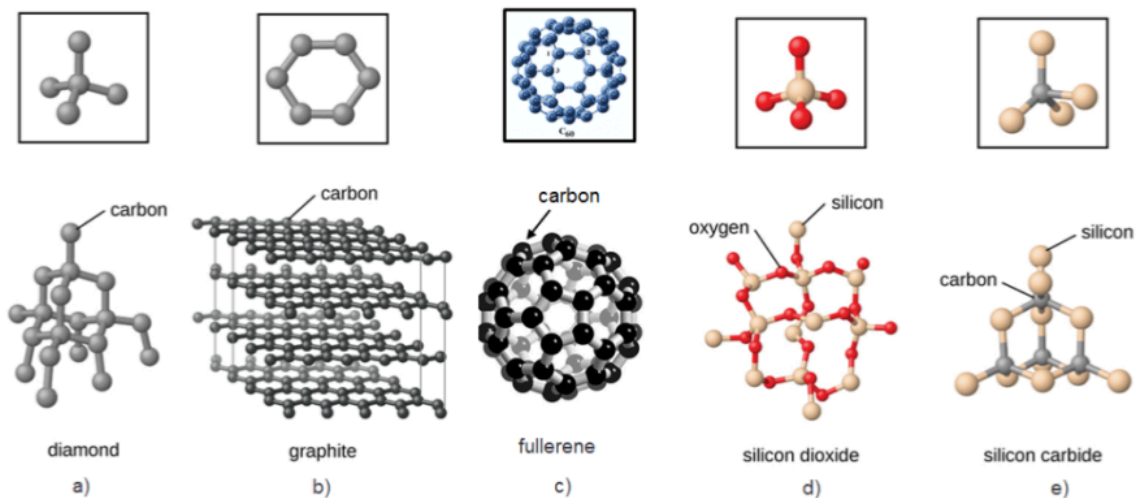


FIGURE 4 : A covalent crystal contains a 3-dimensional network of covalent bonds, as illustrated by the structures of diamond, graphite, fullerene, silicon dioxide and silicon carbide

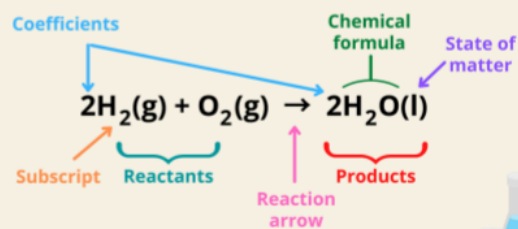
EVIDENCE OF A CHEMICAL CHANGE/REACTION:

- COLOR CHANGES – (COLOR APPEARS OR DISAPPEARS)
- TEMPERATURE CHANGES
- GAS/GAS BUBBLES PRODUCED
- FIRE/EXPLOSION
- **PRECIPTATE** IS FORMED – A SOLID FORMS OUT OF 2 LIQUIDS



What Is a Chemical Equation?

A chemical equation is a written representation of a chemical reaction.



List reactants on the left side of the reaction arrow and products on the right side.



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(g)	gas
(l)	liquid
(s)	solid
(aq)	aqueous

• Word Equation:

• hydrogen + oxygen → water

• Skeleton Equation:

• $\text{H}_{2(\text{g})} + \text{O}_{2(\text{g})} \rightarrow \text{H}_2\text{O}_{(\text{l})}$

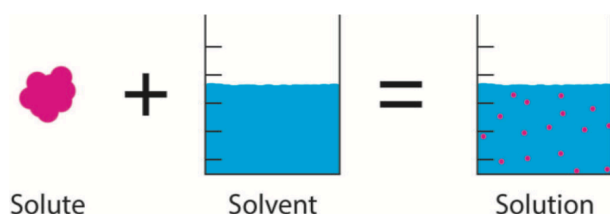
• Balanced Equation:

• $\text{___H}_{2(\text{g})} + \text{___O}_{2(\text{g})} \rightarrow \text{___H}_2\text{O}_{(\text{l})}$

• $2\text{H}_{2(\text{g})} + \text{O}_{2(\text{g})} \rightarrow 2\text{H}_2\text{O}_{(\text{l})}$

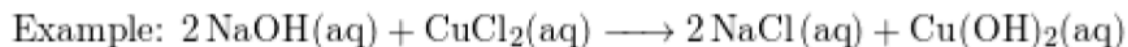
WRITING CHEMICAL EQUATIONS

1. Write the skeleton equation.
2. Count atoms of reactants and products.
3. Add/Adjust coefficients.
4. Reduce coefficients to lowest possible ratio.
5. Check work.

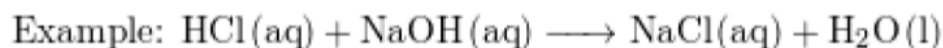


In aqueous solutions, only double replacement reaction occurs. Three types of products that form in aqueous solutions are, a precipitate, water, or a gas.

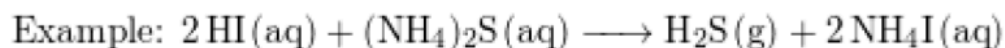
- 1) Reactions that form precipitates:



- 2) Reactions that form water:

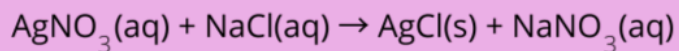


- 3) Reactions that form gases:

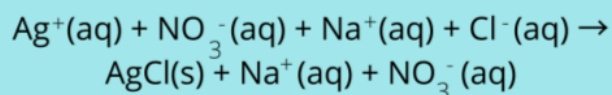


Net Ionic Equation and Complete Ionic Equation

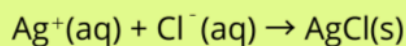
Molecular Equation or Balanced Equation



Complete Ionic Equation



Net Ionic Equation



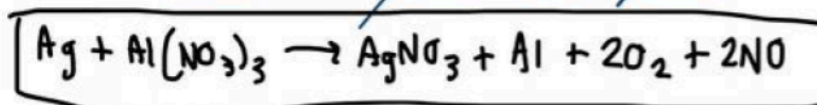
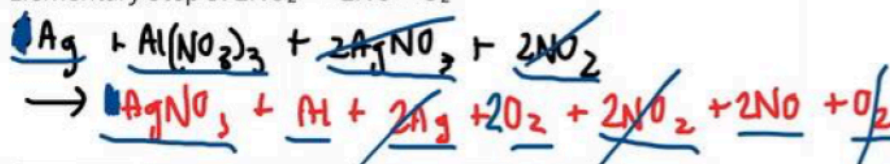
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Example #1: Create an overall balanced equation from the following elementary steps.

Elementary Step 1: $3\text{Ag} + \text{Al}(\text{NO}_3)_3 \rightarrow 3\text{AgNO}_3 + \text{Al}$

Elementary Step 2: $2\text{AgNO}_3 \rightarrow 2\text{Ag} + \text{O}_2 + 2\text{NO}_2$

Elementary Step 3: $2\text{NO}_2 \rightarrow 2\text{NO} + \text{O}_2$



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