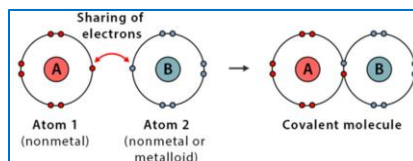


Nomenclature Notes and Practice

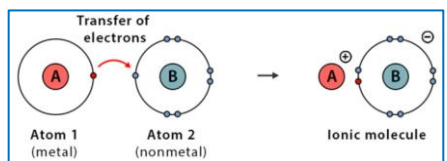
- **Nomenclature** is the collection of rules used to name things. In chemistry, it is useful to have a universal language – agreed upon nomenclature – when naming substances.
- **Purpose:** Understand and use the rules of nomenclature *in English*.

❖ Chemical Bonds:

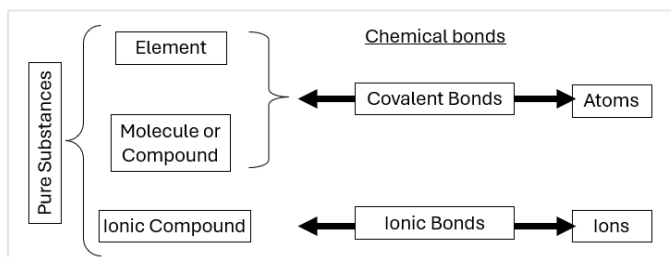
- ❖ Defined as a **force of attraction** (*electrostatic*) between atoms or ions.
- ❖ By forming bonds, atoms or ions attain a more **stable state** with **minimum energy**.
- ❖ This most often happens when the valence shell is complete, and the atom or ion attains a noble gas electron configuration. This is referred to as the **Octet Rule**.
- ❖ **Covalent bonds** form when atoms **share** electrons.



- ❖ **Ionic bonds** form when electrons are **transferred** between atoms.

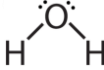



- ❖ When atoms or ions bond, they form **compounds** and/or **molecules**.
 - **Compound:** when two or more **different atoms** or **ions** bond.
 - Examples: H₂O, NaCl, etc.
 - **Molecule:** when atoms **covalently** bond.
 - Examples: H₂O, O₂, and H₂.
 - All covalent compounds are molecules, but not all molecules are compounds.



¹ <https://www.chemistrylearner.com/chemical-bonds/ionic-covalent-metallic-bonds>

❖ Representing chemical bonds:

	Chemical Formula	Structural Formula	Space Filling Model
Covalent Molecule:	H₂O		
Ionic Compound:	NaCl	Na ⁺ Cl ⁻	N.A.

Suggested reading and video (0-5:55): [Chemical Bond \(LibreTexts Chemistry\)](#)

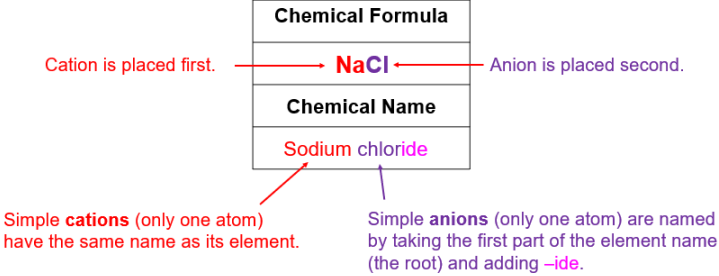
❖ Ionic Compounds

Description	<ul style="list-style-type: none"> Ionic compounds form when there is a transfer of electrons from metals to nonmetals. Metals lose (negative) electron(s) and become positively charged cations. Nonmetals gain electron(s) and become negatively charged anions.
Case #1	<ul style="list-style-type: none"> Ions with fixed charges.
Case #2	<ul style="list-style-type: none"> Transition metals with variable charges
Case #3	<ul style="list-style-type: none"> Compounds with Polyatomic ions.

1A	2A											3A	4A	5A	6A	7A	8A
Li ⁺	Be ²⁺													N ³⁻	O ²⁻	F ⁻	
Na ⁺	Mg ²⁺											Al ³⁺		P ³⁺	S ²⁻	Cl ⁻	
K ⁺	Ca ²⁺	Sc ³⁺	Ti ³⁺	V ²⁺ V ³⁺	Cr ²⁺ Cr ³⁺	Mn ²⁺ Mn ³⁺	Fe ²⁺ Fe ³⁺	Co ²⁺ Co ³⁺	Ni ²⁺	Cu ⁺ Cu ²⁺	Zn ²⁺	Ga ³⁺		As ³⁺	Se ²⁺	Br ⁻	
Rb ⁺	Sr ²⁺	Y ³⁺							Pd ²⁺	Ag ⁺	Cd ²⁺		Sn ²⁺ Sn ⁴⁺			I ⁻	
Cs ⁺	Ba ²⁺										Hg ₂ ²⁺ Hg ²⁺		Pb ²⁺ Pb ⁴⁺				

Common Type I cations
 Common Type II cations
 Common monatomic anions

Figure 2: This table shows some common ions. Notice that some Transition Metals have multiple charges. These need to be **memorised**.

<p>Case #1 Binary Ionic Compounds</p>	<ul style="list-style-type: none"> Ions with fixed charges. Groups 1A to 7A. Recall: Group number and the Octet Rule. <ul style="list-style-type: none"> Group 1A = lose one electron and gain a positive charge = +1. Ex: Na^{1+} Group 2A = lose two electrons = +2. Ex. Mg^{2+} Group 3A = lose three electrons = +3. Ex. Al^{3+} <ul style="list-style-type: none"> Group 5A = 5 (group # = valence electrons) + 3 (gain three electrons) = 8 (octet) = -3. Ex. N^{3-} Group 6A = gain two electrons = 8 (octet) – 6 (group #) = -2. Ex. O^{2-} Group 7A = gain one electron = 8 (octet) – 7 (group #) = -1. Ex. F^{1-} 																																																				
<p>Nomenclature</p>	<ul style="list-style-type: none"> Cation: Written first and name is not changed. Anion: Name the nonmetal by taking the first part of its name (the root), dropping the ending, and adding “-ide”. 																																																				
<p>Names and Charges of Common Ions:</p> <table border="1"> <thead> <tr> <th>Cation</th> <th>Name</th> <th>Anion</th> <th>Name*</th> </tr> </thead> <tbody> <tr> <td>H^+</td> <td>hydrogen</td> <td>H^-</td> <td>hydride</td> </tr> <tr> <td>Li^+</td> <td>lithium</td> <td>F^-</td> <td>fluoride</td> </tr> <tr> <td>Na^+</td> <td>sodium</td> <td>Cl^-</td> <td>chloride</td> </tr> <tr> <td>K^+</td> <td>potassium</td> <td>Br^-</td> <td>bromide</td> </tr> <tr> <td>Cs^+</td> <td>cesium</td> <td>I^-</td> <td>iodide</td> </tr> <tr> <td>Be^{2+}</td> <td>beryllium</td> <td>O^{2-}</td> <td>oxide</td> </tr> <tr> <td>Mg^{2+}</td> <td>magnesium</td> <td>S^{2-}</td> <td>sulfide</td> </tr> <tr> <td>Ca^{2+}</td> <td>calcium</td> <td></td> <td></td> </tr> <tr> <td>Ba^{2+}</td> <td>barium</td> <td></td> <td></td> </tr> <tr> <td>Al^{3+}</td> <td>aluminum</td> <td></td> <td></td> </tr> <tr> <td>Ag^+</td> <td>silver</td> <td></td> <td></td> </tr> <tr> <td>Zn^{2+}</td> <td>zinc</td> <td></td> <td></td> </tr> </tbody> </table> <p>*The root is given in color.</p>	Cation	Name	Anion	Name*	H^+	hydrogen	H^-	hydride	Li^+	lithium	F^-	fluoride	Na^+	sodium	Cl^-	chloride	K^+	potassium	Br^-	bromide	Cs^+	cesium	I^-	iodide	Be^{2+}	beryllium	O^{2-}	oxide	Mg^{2+}	magnesium	S^{2-}	sulfide	Ca^{2+}	calcium			Ba^{2+}	barium			Al^{3+}	aluminum			Ag^+	silver			Zn^{2+}	zinc			
Cation	Name	Anion	Name*																																																		
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Zn^{2+}	zinc																																																				
<ul style="list-style-type: none"> Net charge of an ionic compound is always zero; meaning, charges must equal 0 Examples: <ul style="list-style-type: none"> NaCl $1(1+) + 1(1-) = 0$ One sodium ion, Na^+, is needed to balance the charge of one chloride ion, Cl^-. Na_2O $2(1+) + 1(2-) = 0$ Two sodium ions are needed to balance the charge of oxygen, O^{2-}. 																																																					
<p>Examples</p>	<ul style="list-style-type: none"> MgO = magnesium oxide Al_2S_3 = aluminium sulfide 																																																				
<p>Professor Dave: Naming Ionic Compounds (video 5:43)</p>																																																					

- Complete the following table on binary ionic compounds. The first is done for you.

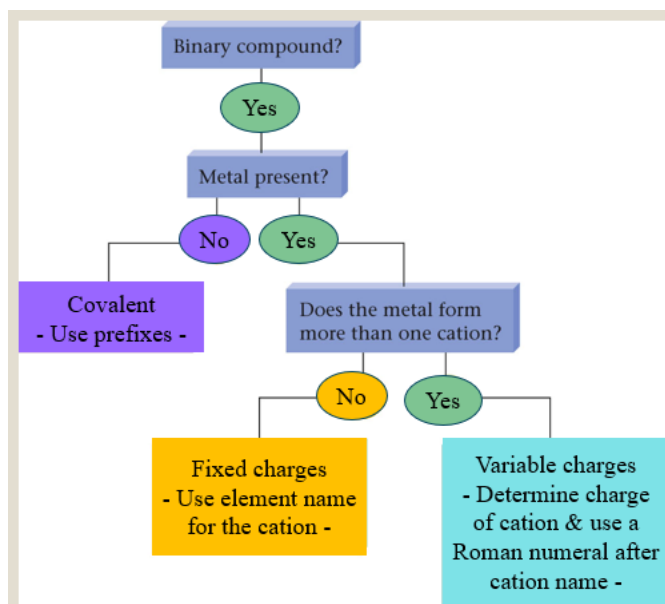
	Formula	Cation	Anion	Name
	$CaCl_2$	Ca^{2+}	Cl^-	<i>Calcium chloride</i>
1)	Al_2O_3	Al^{3+}	O^{2-}	Aluminum oxide
2)	LiH	Li^+	H^-	Lithium hydride
3)	K_3P	K^+	P^{3-}	Potassium phosphide
4)	AlN	Al^{3+}	N^{3-}	Aluminum nitride
5)	NaI	Na^+	I^-	Sodium iodide
6)	MgS	Mg^{2+}	S^{2-}	Magnesium sulfide
7)	Na_2O	Na^+	O^{2-}	Sodium oxide
8)	$SrBr_2$	Sr^{2+}	Br^-	Strontium bromide

<p>Case #2 Transition Metals</p>	<ul style="list-style-type: none"> Some Transition metals can form 2 or more cations and have variable charges. 																																											
<p>Nomenclature</p>	<ul style="list-style-type: none"> Cation: <ul style="list-style-type: none"> Written first and name doesn't change (as for all cations). MUST include a Roman numeral to indicate charge. Anion: <ul style="list-style-type: none"> Name the nonmetal by taking the first part of its name (the root), drop the ending, and add "-ide" (as for all compounds). 																																											
<p>Names and Charges of Some Transition Metals:</p> <table border="1"> <thead> <tr> <th>Ion</th> <th>Systematic Name</th> <th>Older Name</th> </tr> </thead> <tbody> <tr> <td>Fe³⁺</td> <td>iron(III)</td> <td>ferric</td> </tr> <tr> <td>Fe²⁺</td> <td>iron(II)</td> <td>ferrous</td> </tr> <tr> <td>Cu²⁺</td> <td>copper(II)</td> <td>cupric</td> </tr> <tr> <td>Cu⁺</td> <td>copper(I)</td> <td>cuprous</td> </tr> <tr> <td>Co³⁺</td> <td>cobalt(III)</td> <td>cobaltic</td> </tr> <tr> <td>Co²⁺</td> <td>cobalt(II)</td> <td>cobaltous</td> </tr> <tr> <td>Sn⁴⁺</td> <td>tin(IV)</td> <td>stannic</td> </tr> <tr> <td>Sn²⁺</td> <td>tin(II)</td> <td>stannous</td> </tr> <tr> <td>Pb⁴⁺</td> <td>lead(IV)</td> <td>plumbic</td> </tr> <tr> <td>Pb²⁺</td> <td>lead(II)</td> <td>plumbous</td> </tr> <tr> <td>Hg²⁺</td> <td>mercury(II)</td> <td>mercuric</td> </tr> <tr> <td>Hg₂²⁺*</td> <td>mercury(I)</td> <td>mercurous</td> </tr> </tbody> </table> <p><small>*Mercury(I) ions always occur bound together in pairs to form Hg₂²⁺.</small></p>	Ion	Systematic Name	Older Name	Fe ³⁺	iron(III)	ferric	Fe ²⁺	iron(II)	ferrous	Cu ²⁺	copper(II)	cupric	Cu ⁺	copper(I)	cuprous	Co ³⁺	cobalt(III)	cobaltic	Co ²⁺	cobalt(II)	cobaltous	Sn ⁴⁺	tin(IV)	stannic	Sn ²⁺	tin(II)	stannous	Pb ⁴⁺	lead(IV)	plumbic	Pb ²⁺	lead(II)	plumbous	Hg ²⁺	mercury(II)	mercuric	Hg ₂ ²⁺ *	mercury(I)	mercurous	<table border="1"> <tr> <td>Chemical Formula</td> </tr> <tr> <td>Fe₂O₃</td> </tr> <tr> <td>Chemical Name</td> </tr> <tr> <td>Iron (III) oxide</td> </tr> </table> <p>Roman numeral indicates the charge of the cation.</p>	Chemical Formula	Fe₂O₃	Chemical Name	Iron (III) oxide
Ion	Systematic Name	Older Name																																										
Fe ³⁺	iron(III)	ferric																																										
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	<ul style="list-style-type: none"> Net charge of an ionic compound is always zero. Example: <ul style="list-style-type: none"> Fe₂O₃ 2(3+) + 3(2-) = 0 Two iron ions, each with a charge of +3, are needed to balance three oxygen ions, each with a change of -2. 																																											
<p>Examples</p>	<ul style="list-style-type: none"> CuO = copper (II) oxide FeCl₂ = iron (II) chloride 																																											
<p>Naming Ionic Compounds with Transition Metals (10:09)</p>																																												

- Complete the following table on ionic compounds with transition metals. The first is done for you.

	Name	Formula
	<i>Copper (I) chloride</i>	<i>CuCl</i>
1)	Copper (II) chloride	CuCl ₂
2)	Lead (IV) sulfide	PbS ₂
3)	Lead (II) sulfide	PbCl ₂
4)	Chromium (III) phosphide	CrP
5)	Cobalt (III) oxide	Co ₂ O ₃
6)	Tin (IV) phosphide	Sn ₃ P ₄
7)	Manganese (IV) oxide	MnO ₂
8)	Iron (II) sulfide	FeS

Flowcharts for Naming Binary Compounds:



❖ Binary Covalent Compounds

Description	When two non-metals share electrons and bond.																											
Nomenclature	<ul style="list-style-type: none"> • Prefix System: Prefixes are needed to indicate # of atoms in a compound because nonmetals bond in varying proportions. • The first element in the formula is written <i>first</i> and its name is not changed. NOTE: The prefix <i>mono-</i> is NEVER used if there is only one atom of the first element. • The second element is named by taking the first part of its name (the root), dropping the ending, and adding “-ide”. Other than the use of prefixes, this is the same for Ionic compounds. • When a prefix ends in “a” or “o”, <i>and</i> the element begins with a vowel, the a or o is dropped in the prefix (ex. monooxide = monoxide), which makes it easier to pronounce. 																											
	<table border="1"> <thead> <tr> <th>Prefix</th> <th>Meaning</th> </tr> </thead> <tbody> <tr><td>Mono -</td><td>1</td></tr> <tr><td>Di -</td><td>2</td></tr> <tr><td>Tri -</td><td>3</td></tr> <tr><td>Tetra -</td><td>4</td></tr> <tr><td>Penta -</td><td>5</td></tr> <tr><td>Hexa -</td><td>6</td></tr> <tr><td>Hepta -</td><td>7</td></tr> <tr><td>Octa -</td><td>8</td></tr> <tr><td>Nona -</td><td>9</td></tr> <tr><td>Deca -</td><td>10</td></tr> </tbody> </table>	Prefix	Meaning	Mono -	1	Di -	2	Tri -	3	Tetra -	4	Penta -	5	Hexa -	6	Hepta -	7	Octa -	8	Nona -	9	Deca -	10	<table border="1"> <thead> <tr> <th>Chemical Formula</th> <th>Chemical Name</th> </tr> </thead> <tbody> <tr> <td>N_2O_3</td> <td>Dinitrogen trioxide</td> </tr> </tbody> </table> <p>Element typically on the left or towards the bottom of the Periodic Table. → N_2O_3 ← Element typically on the right or towards the top of the Periodic Table (more electronegative).</p> <p>Full name of the first element. → Dinitrogen</p> <p>Second element named by taking the first part of its name (<i>the root</i>) and adding -ide. → trioxide</p> <p>Prefixes indicate number of atoms.</p>	Chemical Formula	Chemical Name	N_2O_3	Dinitrogen trioxide
Prefix	Meaning																											
Mono -	1																											
Di -	2																											
Tri -	3																											
Tetra -	4																											
Penta -	5																											
Hexa -	6																											
Hepta -	7																											
Octa -	8																											
Nona -	9																											
Deca -	10																											
Chemical Formula	Chemical Name																											
N_2O_3	Dinitrogen trioxide																											
Examples	<ul style="list-style-type: none"> • CO, carbon monoxide • N_2O_5, dinitrogen pentoxide 																											

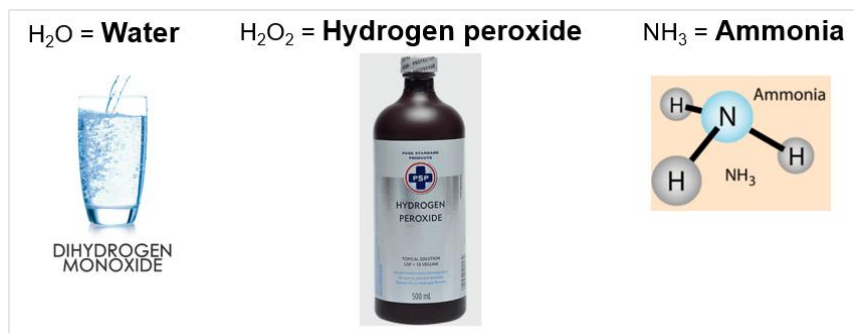


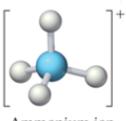
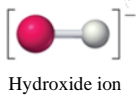
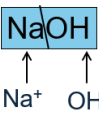
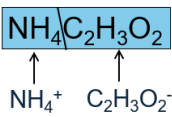
Figure 1: Certain compounds have specific names. The ones shown here must be **memorized**.

- Complete the following table on covalent compounds (The first is done for you):


	Formula	First nonmetal	Second nonmetal	Name
	<i>PCl₅</i>	<i>Phosphorus</i>	<i>pentachloride</i>	<i>Phosphorus pentachloride</i>
1)	CO ₂	Carbon	dioxide	<i>Carbon dioxide</i>
2)	N ₂ F ₂	Dinitrogen	difluoride	<i>Dinitrogen difluoride</i>
3)	C ₃ N ₄	Tricarbon	tetranitride	Tricarbon tetranitride
4)	H ₂ O ₂	Dihydrogen	dioxide	<i>Hydrogen peroxide</i>
5)	SF ₆	Sulfur	hexafluoride	<i>Sulfur hexafluoride</i>
6)	P ₂ O ₃	Diphosphorus	trioxide	Diphosphorus trioxide
7)	N ₂ O ₃	Dinitrogen	trioxide	<i>Dinitrogen trioxide</i>
8)	SiBr ₄	Silicon	tetrabromide	<i>Silicon tetrabromide</i>

Case #3 Polyatomic Ions	<ul style="list-style-type: none"> Polyatomic ions are charged species containing two (or more) atoms covalently bonded.
Nomenclature	<ul style="list-style-type: none"> Naming is the same as for all ionic compounds. Memorize the Polyatomic Table <i>or learn the rules.</i>

Ion	Name	Ion	Name
Hg ₂ ²⁺	Mercury(I)	CO ₃ ²⁻	Carbonate
NH ₄ ⁺	Ammonium	HCO ₃ ⁻	Hydrogen carbonate (bicarbonate is a widely used common name)
NO ₂ ⁻	Nitrite	ClO ⁻ or OCl ⁻	Hypochlorite
NO ₃ ⁻	Nitrate	ClO ₂ ⁻	Chlorite
SO ₃ ²⁻	Sulfite	ClO ₃ ⁻	Chlorate
SO ₄ ²⁻	Sulfate	ClO ₄ ⁻	Perchlorate
HSO ₄ ⁻	Hydrogen sulfate (bisulfate is a widely used common name)	C ₂ H ₃ O ₂ ⁻	Acetate
OH ⁻	Hydroxide	MnO ₄ ⁻	Permanganate
CN ⁻	Cyanide	Cr ₂ O ₇ ²⁻	Dichromate
PO ₄ ³⁻	Phosphate	CrO ₄ ²⁻	Chromate
HPO ₄ ²⁻	Hydrogen phosphate	O ₂ ²⁻	Peroxide
H ₂ PO ₄ ⁻	Dihydrogen phosphate	C ₂ O ₄ ²⁻	Oxalate
NCS ⁻ or SCN ⁻	Thiocyanate	S ₂ O ₃ ²⁻	Thiosulfate

Examples	 Ammonium ion NH ₄ ⁺	 Hydroxide ion OH ⁻	 Sodium hydroxide	 Ammonium acetate
	Ammonium hydroxide, NH₄OH			

Oxyanion Series: Polyatomic anions that contain atom(s) of nonmetal(s) and varying numbers of oxygen atoms.

Polyatomic anion	Prefix	Suffix	Name	 Increasing number of oxygens.	Example:
- ClO ⁻	<i>Hypo -</i>	<i>- ite</i>	hypochlorite		NaClO Sodium hypochlorite
- ClO ₂ ⁻	<i>None</i>	<i>- ite</i>	chlorite		NaClO ₂ Sodium chlorite
- ClO ₃ ⁻	<i>None</i>	<i>- ate</i>	chlorate		NaClO ₃ Sodium chlorate
- ClO ₄ ⁻	<i>Per -</i>	<i>- ate</i>	perchlorate		NaClO ₄ Sodium perchlorate

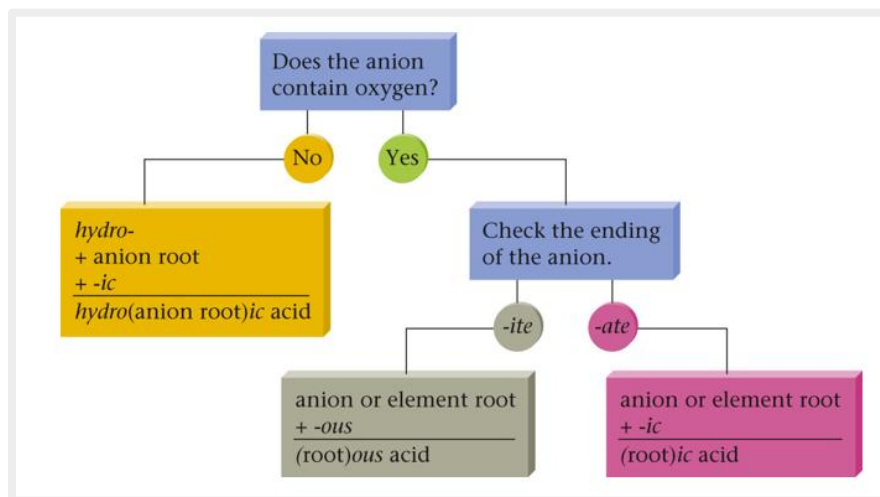
[Writing Formulas with Polyatomic Ions \(11:20\)](#)

- Complete the following table on ionic compounds with polyatomic ions. The first is done for you.

	Formula	Ions	Name
	Na_2SO_4	$Na^+ \quad SO_4^{2-}$	<i>Sodium sulfate</i>
1)	$NaHSO_4$	$Na^+ \quad HSO_4^-$	Sodium hydrogen sulfate or sodium bisulfate
2)	K_3PO_4	$K^+ \quad PO_4^{3-}$	Potassium phosphate
3)	$LiNO_3$	$Li^+ \quad NO_3^-$	Lithium nitrate
4)	$Fe(NO_3)_3$	$Fe^{3+} \quad NO_3^-$	Iron(III) nitrate
5)	Na_2SO_3	$Na^+ \quad SO_3^{2-}$	Sodium sulfite
6)	$Ba(OH)_2$	$Ba^{2+} \quad OH^-$	Barium hydroxide
7)	Na_2CO_3	$Na^+ \quad CO_3^{2-}$	Sodium carbonate
8)	NH_4CN	$NH_4^+ \quad CN^-$	Ammonium cyanide

❖ Acids

Description	<ul style="list-style-type: none"> Acids contain at least one proton (H^+).
Nomenclature	<ul style="list-style-type: none"> At this point, all acids are covalent and are divided into acids with and acids without oxygen.
Acids – Without oxygen	
<ul style="list-style-type: none"> Named with the prefix <i>hydro-</i>, the <i>root of the element</i>, and the <i>suffix – ic</i>. If nomenclature is needed, the formula will include the state “aqueous” (aq). Examples: <ul style="list-style-type: none"> HCl (aq) = <i>hydrochloric acid</i> (vs HCl with no state = hydrogen monochloride) HCN (aq) = hydrocyanic acid H_2S (aq) = hydrosulfuric acid 	
Acids – With oxygen	
<ul style="list-style-type: none"> Two possibilities: <ol style="list-style-type: none"> Anion ends in <i>-ate</i>: <ul style="list-style-type: none"> Suffix <i>-ic</i> is added to the anion root (<i>higher oxidation state</i>). Example: HNO_3 (hydrogen <i>nitrate</i> is the compound) = Nitric acid Anion ends in <i>-ite</i>: <ul style="list-style-type: none"> Suffix <i>-ous</i> is added to the anion root (<i>lower oxidation state</i>) Example: HNO_2 (hydrogen <i>nitrite</i>) = Nitrous acid 	

Flowcharts for Naming Acids:

- Complete the following table on naming acids. The first is done for you.

	Formula	Name of Compound		
		Hydrogen	Anion	
	<i>HCl (aq)</i>	<i>Hydrogen</i>	<i>chloride</i>	<i>Hydrochloric acid</i>
1)	HBr (aq)	Hydrogen	bromide	Hydrobromic acid
2)	HI (aq)	Hydrogen	iodide	Hydroiodic acid
3)	H₃PO₄ (aq)	Hydrogen	phosphate	Phosphoric acid
4)	H₃PO₃ (aq)	Hydrogen	phosphite	Phosphorous acid
5)	H₂SO₄ (aq)	Hydrogen	sulfate	Sulfuric acid
6)	H₂SO₃ (aq)	Hydrogen	sulfite	Sulfurous acid

❖ Monatomic, Diatomic, or Polyatomic substances

- The Periodic Table depict pure elements at standard conditions of 25°C and 1 atm. They can exist as monatomic, diatomic, or polyatomic substances.
- **Monatomic gases:**
 - Are naturally stable as single atoms.
- **Diatomic elements:**
 - Natural form of the element is as a molecule with two identical atoms.
- **Polyatomic Elements:**
 - Natural form of the element is as a molecule with more than 3 atoms.

Diatomic Elements	Polyatomic Elements	Monatomic Gases and Elements
I Have N o B right Or C lever F riends (mnemonic)	<ul style="list-style-type: none"> • Sulfur, S_8 (s) • Phosphorus, P_4 (s) 	<ul style="list-style-type: none"> • Noble (Inert) Gases (Group VIIIA)
<ol style="list-style-type: none"> 1. Iodine (purple solid), I_2 (s) 2. Hydrogen (colourless gas), H_2 (g) 3. Nitrogen (colourless gas), N_2 (g) 4. Oxygen (colourless gas), O_2 (g) 5. Chlorine (greenish yellow gas), Cl_2 (g) 6. Fluorine (light yellow gas), F_2 (g) 7. Bromine (reddish-brown liquid), Br_2 (l) 		<ul style="list-style-type: none"> • Any element NOT listed on this table (<i>most metals</i>)

Name of the element	Group Name	Formula
<i>Bromine or liquid bromine</i>	<i>Halogen</i>	<i>Br₂</i>
<i>Iron metal</i>	Transition metals	Fe
Sodium or elemental sodium	Alkali metals	Na
<i>Argon gas</i>	Noble gases	Ar
Nitrogen gas	Group VA	N ₂
Oxygen gas	Group VIA	O ₂

Flowchart for Naming Substances:

