SCH 3U Inorganic Nomenclature

1. All names and formula are **cation/anion**

   - the **cation** is the **positively charged** part of the formula

   - the **anion** is the **negatively charged** part of the formula

   - cation is always before anion

   A line placed between cation and anion may be useful:

   $FeCl_3$ ➜ $Fe|Cl_3$ $Mg_3(PO_4)_2$ ➜ $Mg_3|(PO_4)_2$

   This line will be placed after the first element in all cases (with the one exception of the NH_4^{1+} cation)

   $(NH_4)_2SO_4$ ➜ $(NH_4)_2|SO_4$

   This division between cation and anion must never be overlooked!!

2. **Monovalent Cations: cations with only one possible positive oxidation state.**

   When naming a compound with monovalent cations, the name of the cation is simply the name of the element:

i.e. **Na**Cl ➜ **sodium** chloride

Al_2 $(SO_4)_3$ ➜ **aluminum** sulphate

3. **Elemental Anions: anions that are composed of only one type of element.**

When naming a compound with an elemental anion, the anion name ends in an "ide" suffix. The following table shows the names of different possible elemental anions:

C^{4-}	➜	carbide	
N^{3-}	➜	nitride	
O^{2-}	➜	oxide	
F^{1-}	➜	fluoride	
P^{3-}	➜	phosphide	always follow the
S^{2-}	➜	sulphide	octet rule for
Cl^{1-}	➜	chloride	elemental anions
As^{3-}	➜	arsenide	(only one possible
Se^{2-}	➜	selenide	anionic state)
Br^{1-}	➜	bromide	
Sb^{3-}	➜	antimonide	
Te^{2-}	➜	telluride	
I^{1-}	➜	iodide	

i.e K_3**N** ➜ potassium **nitride**

Please note that the anionic charge in all cases will follow the octet rule!! For example Cl can be Cl^{1+}, Cl^{3+}, C^{5+}, Cl^{7+}, or Cl^{1-}. For anionic charge there is only one possibility, Cl^{1-}, which can be arrived at from the octet rule.

DO SHEET #1 QUESTIONS #1 TO 20

4. **Balance the Charge:**

When writing formula from names, the cation and anion charges must be balanced. This means that the charges must add to zero. Simply stated, the anion charge times the number of anions must equal the cation charge times the number of cations. If a balance is not easily achieved, it is better to increase the number of anions first (the reason for this is more apparent later when dealing with polyvalent cations)

eg sodium chloride

Na^{1+}	Cl^{1-}
1+	1−

therefore NaCl

eg magnesium nitride

${Mg^{2+}}_3$	${N^{3-}}_2$
6+	6−

therefore Mg_3N_2

DO SHEET #1 QUESTIONS #21 TO 40

5. **Polyvalent Cations: cations that may have more than one possible oxidation state.**

Many cations are capable of more than one possible oxidation state. For example, if you look up the oxidation state of nickel (element #28) you will see a 2,3 above the element symbol indicating that nickel can be Ni^{2+} or Ni^{3+}. Manganese can be Mn^{2+}, Mn^{3+}, Mn^{4+}, Mn^{6+} or Mn^{7+}!! **The charge on the cation must be stated.** This can be accomplished two different ways.

a) **I.U.P.A.C. Method:** I.U.P.A.C. stands for International Union of Pure and Applied Chemists – a group of chemists that make decisions for chemists around the world.

The cation charge must be determined and is stated as a roman numeral in brackets after the element name of the cation. Roman Numerals are as follows:

1 ➜ I
2 ➜ II
3 ➜ III
4 ➜ IV
5 ➜ V
6 ➜ VI
7 ➜ VII
8 ➜ VIII
9 ➜ IX
10 ➜ X

To determine the cation charge, start with the charge on the anion. The anion charge is reliable in all cases. **Every elemental anion has only one possible negative oxidation state and this oxidation state always follows the octet rule.** Work clockwise around the compound to determine the total anion charge, the total cation charge (always the opposite of the anion charge) and finally the cation charge.

eg Fe_2S_3

$Fe^{3+}{}_2$	$S^{2-}{}_3$
6+	6−

therefore the iron must be a Fe^{3+}

therefore the name is iron(III) sulphide

eg PbO_2

Pb^{4+}	$O^{2-}{}_2$
4+	4−

∴ lead(IV) oxide

This roman numeral must **not be used** with monovalent cations such as sodium or calcium (look this up). The roman numeral is **only used** if it must be used to distinguish between polyvalent oxidation states.

b) **OUS/IC Method:** This is an older system in which selected cations with particular charges have a special name. This list must be memorized. It is useful to note that this method is usually reserved for divalent cations and that the lower oxidation state has an OUS suffix while the upper oxidation state has a IC suffix (hence the OUS/IC method)

C^{2+} ➜ carbonous
C^{4+} ➜ carbonic

N^{3+} ➜ nitrous
N^{5+} ➜ nitric

P^{3+} ➜ phosphorous
P^{5+} ➜ phosphoric

S^{4+} ➜ sulphurous
S^{6+} ➜ sulphuric

Fe^{2+} ➜ ferrous
Fe^{3+} ➜ ferric

Co^{2+} ➜ cobaltous
Co^{3+} ➜ cobaltic

Ni^{2+} ➜ nickelous
Ni^{3+} ➜ nickelic

Cu^{1+} ➜ cuprous
Cu^{2+} ➜ cupric

As^{3+} ➜ arsenous
As^{5+} ➜ arsenic

Sn^{2+} ➜ stannous
Sn^{4+} ➜ stannic

Sb^{3+} ➜ antimonous (stibous)
Sb^{5+} ➜ antimonic (stibic)

Au^{1+} ➜ aurous
Au^{3+} ➜ auric

Hg^{1+} ➜ mercurous
Hg^{2+} ➜ mercuric

Pb^{2+} ➜ plumbous
Pb^{4+} ➜ plumbic

Many of these names are based on the latin word used to first describe the element. For example lead was called plumbum (which the root of the word plumber - ever wonder why plumber has a silent b?)

Once the charge of the cation is determined, the OUS/IC name can be used.

$AuCl_3$ has a Au^{3+} and is called auric chloride

Au_2O has a Au^{1+} and is called aurous oxide

Since the above formula could also be called gold(III) chloride and gold(I) oxide respectively, these formula have two valid names. **If two names are possible (i.e. there is an OUS/IC name, both are expected).**

DO SHEET #2 QUESTIONS #1 TO 30

DO SHEET #3 QUESTIONS #1 TO 40

6. **Polyatomic Anions: anions that are formed from more than one type of element.**

Many non-metals are able to combine into polyatomic ions. This is similar to a small discrete covalent molecule except that the resulting combination has a net ionic charge. Many ions can be grouped for convenience and some level of systematic naming is evident. The following table helps organize common oxy-anions. The second row shows the most common form for each element. These anions have names that end in “ate”. One less oxygen and the “ate” name ends in “ite”. Two less oxygen add a “hypo” prefix. One more oxygen and the “ate” name becomes a “per__ate”. These ions must be memorized.

Table of Oxy-anions – “THE BIG SEVEN” plus derivatives						
				ClO_4^{1-} perchlorate		IO_4^{1-} periodate
CO_3^{2-} carbonate	NO_3^{1-} nitrate	PO_4^{3-} phosphate	SO_4^{2-} sulphate	ClO_3^{1-} chlorate	BrO_3^{1-} bromate	IO_3^{1-} iodate
	NO_2^{1-} nitrite	PO_3^{3-} phosphite	SO_3^{2-} sulphite	ClO_2^{1-} chlorite		
				ClO^{1-} hypochlorite		
OH^{1-} hydroxide	CN^{1-} cyanide	NH_4^{1+} ammonium				

Nick the Camel had Clam for Supper in Pheonix

Please note that the charge is distributed over the entire ion (it is not the charge on the oxygen which in all cases has a oxidation state of 2-). For an example: the sulphur in SO_4^{2-} has a (6+) oxidation state and each oxygen has an oxidation state of (2-). Adding these charges up gives:

$$\begin{aligned} \text{charge} &= 1(6+) + 4(2-) \\ &= (6+) + (8-) \\ &= (2-) \end{aligned}$$

which gives the overall ionic charge on the sulphate.

Three more ions we will use are:

OH^{1-} ➜ hydroxide
CN^{1-} ➜ cyanide
NH_4^{1+} ➜ ammonium

When using polyatomic ions, the entire group behaves **as if it were a single element:**

Mg^{2+}	$(ClO_3)^{1-}{}_2$
2+	2−

$Fe^{3+}{}_2$	$(CO_3)^{2-}{}_3$
6+	6−

∴ $Fe_2(CO_3)_3$

It is important to note that the charge on these ions is independent of the number of oxygen atoms in the polyatomic ion. Ignore the oxygens!!!

DO SHEET #4 QUESTIONS #1 – 40 (look carefully at answers)

7. **Acid Nomenclature:** For the purposes of this unit an acid will be defined as a substance that **when dissolve in water** produces a hydrogen cation (H^{1+}).

- therefore the formula must have a H^{1+} cation
- the compound must be in aqueous phase (aq)

HCl **is not** an acid

HCl(aq) **is** an acid

NaCl(aq) is not an acid, but it is an aqueous solution

Acid nomenclature is divided into two different types

- **simple elemental anion**
- **polyatomic oxy-anion**

Simple Elemental Anion Acids include the following:

HF(aq)	hydrofluoric acid
HCl(aq)	hydrochloric acid
HBr(aq)	hydrobromic acid
HI(aq)	hydroiodic acid
H_2S(aq)	hydrosulphuric acid

In each case the form "hydro______ic" indicates that the anion is a simple element and the word acid is a reminder that the cation is an H^{1+}

Polyatomic Oxy-anion Acids include the following (based on the big seven):

$H_2CO_3(aq)$	carbonic acid
$HNO_3(aq)$	nitric acid
$HNO_2(aq)$	nitrous acid
$H_3PO_4(aq)$	phosphoric acid
$H_3PO_3(aq)$	phosphorous acid
$H_2SO_4(aq)$	sulphuric acid
$H_2SO_3(aq)$	sulphurous acid
$HClO_4(aq)$	perchloric acid
$HClO_3(aq)$	chloric acid
$HClO_2(aq)$	chlorous acid
$HClO(aq)$	hypochlorous acid
$HBrO_3(aq)$	bromic acid
$HIO_4(aq)$	periodic acid
$HIO_3(aq)$	iodic acid

The following relationship can be seen from these names by using the chlorine oxy-anions as examples:

ClO_4^{1-} – perchlor**ate** becomes perchlor**ic**

ClO_3^{1-} – chlor**ate** becomes chlor**ic**

ClO_2^{1-} – chlor**ite** becomes chlor**ous**

ClO^{1-} – hypochlor**ite** becomes hypochlor**ous**

ate becomes ic and **ite becomes ous**

This word acid in the name is a reminder of the hydrogen cation and aqueous state.

DO SHEET #5 QUESTIONS #1 – 40 (look carefully at answers)

8. **Prefix Method:**

- most difficult method to fully comprehend

- usually restricted to discrete covalent molecules (CO_2 - carbon dioxide, SO_3 - sulphur trioxide)

- used only with polyvalent cations and is a third way to address the polyvalent oxidation states

- difficulty is that only one prefix may be used unless absolutely necessary (frequently misused)

- prefix must be used on either the cation or the anion in such a way as to **differentiate between the compound in the question and other compounds that would result if the cation had a different oxidation state**

- difficult to master

- if in doubt the prefix will be on the anion about 90% of the time

The prefixes are:

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

- only way to be sure that the name is correct is to write other possible formula that result from a difference in oxidation state

- the prefix can then by used to **differentiate**

CO_2 vs CO carbon dioxide vs carbon

monoxide

Au_2O vs Au_2O_3	gold monoxide vs gold trioxide
Cu_2O vs CuO	dicopper oxide vs monocopper oxide
P_2O_3 vs P_2O_5	phosphorus trioxide vs phosphorus pentoxide (note spelling of pentoxide)

- going from name to formula, oxidation states must be determined

eg arsenic pentoxide – must have a formula with five oxygens

As_2^{5+}	O_5^{2-}
10+	10–

- try different oxidation states on the cation until you get the one that works

DO SHEET #6 QUESTIONS #1 – 20

9. **Peroxides:**

- Peroxides are special arrangements of oxygen in which:

  - the oxygen **must be** in groups of two (i.e. O_2)

  - oxidation state of oxygen 1– (a rare oxidation state of oxygen that should have been included on the periodic table)

  - a peroxide, there is **one more oxygen than is expected.** Comparison with oxygen in a normal oxidation state may be helpful:

H_2O_2 vs H_2O	hydrogen peroxide vs hydrogen oxide
Au_2O_2 vs Au_2O	gold(I) peroxide vs gold(I) oxide

10. **Amphiprotic Anions:**

- contain a hydrogen cation as a part of their structure

- related to oxy-anions:

HCO_3^{1-}	bicarbonate (hydrogen carbonate)	(CO_3^{2-}	carbonate)
HSO_3^{1-}	bisulphite (hydrogen sulphite)	(SO_3^{2-}	sulphite)
HSO_4^{1-}	bisulphate (hydrogen sulphate)	(SO_4^{2-}	sulphate)

- the extra hydrogen with 1+ oxidation state reduces the oxy-anions normal charge from 2– to 1–

- the "bi" prefix denotes the extra hydrogen

- rules for using these amphiprotic anions are the same as for any other polyatomic anion

eg aluminum bicarbonate

Al^{3+}	$(HCO_3^{1-})_3$
3+	3−

DO SHEET #7 QUESTIONS #1 - 20