Nomenclature of chemical compounds

Oxidation state - an alternate term that can be used when referring to the charge on an atom.
The oxidation number is assigned according to a standard set of rules. They are as follows:

1. An atom of a pure element has an oxidation number of zero.
2. For single atoms in an ion, their oxidation number is equal to their charge.
3. Fluorine is always -1 in compounds.
4. Cl, Br, and I are alway -1 in compounds except when the are combined with O or F.
5. H is normally +1 and O is normally -2.
6. The oxidation number of a compound is equal to the sum of the oxidation numbers for each atom in the compound.

The sum of all oxidation state of atoms in the chemical formula MUST equal zero.

chemical compounds

Organic compounds	inorganic compounds
Contain carbon, usually in combination with elements such as hydrogen, oxygen, etc.	other compounds (complexes, etc.)

inorganic compounds

oxides	hydrides	hydroxides (bases)	acids	salts

OXIDES

Metal oxides

The metal is written first (using the roman numeral to indicate which valence is present) next “oxide” word is used.

Nonmetal oxides

The nonmetal is written first, next “oxide” word is used. Each prefix indicates the number of each atom present in the compound.

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

oxides

metals

K_2O potassium oxide

Al_2O_3 aluminum oxide

FeO Iron **(II)** oxide, ferrous oxide (wustite)

Fe_2O_3 Iron **(III)** oxide, ferric oxide (hematite)

Hg_2O mercury **(I)** oxide, mercuric oxide

HgO mercury **(II)** oxide

Cr_2O_3 chromium **(III)** oxide

nonmetals

CO carbon **mono**xide

CO_2 carbon **di**oxide

P_2O_5 **di**phosphorus **pent**oxide

NO nitrogen oxide

NO_2 nitrogen **di**oxide

N_2O **di**nitrogen oxide

N_2O_3 **di**nitrogen **tri**oxide

N_2O_5 **di**nitrogen **pent**oxide

SO_2 sulfur **di**oxide

SO_3 sulfur **tri**oxide

The prefix mono- at beginning is dropped.
However if there is more than one atom of the first element present in the compound the appropriate prefix must be used. Where the prefix ends in an “a” or “o” and the element name begins with an “a” or “o”, the final vowel of the prefix is often dropped for ease of pronunciation.
In some cases, compounds of oxygen exist which do not conform to normal rules of combining capacity (or valence). They possess one more atom of oxygen per molecule than the normal oxide. Such oxides are designated by the prefix "**per** -".

Na_2O_2 is Sodium **per**oxide and H_2O_2 is Hydrogen **per**oxide

hydrides

metals

CaH_2 calcium hydride

SbH_3 antimony hydride

GeH_4 germanium (IV) hydride

LiH lithium hydride

nonmetals

$HCl_{(g)}$ hydrogen chloride

$HF_{(g)}$ hydrogen fluoride

H_2S hydrogen sulfide

NH_3 nitrogen **tri**hydride (ammonia)

BASES

The molecule of a base consists of a metal or metallic ion and the hydroxide ion (OH^-). Bases are named as **hydroxides**.

NaOH - sodium hydroxide

LiOH - lithium hydroxide

$Ca(OH)_2$ calcium hydroxide

$Ba(OH)_2$ barium hydroxide

NH_4OH ammonium hydroxide

$Fe(OH)_2$ iron (II) hydroxide

$Ni(OH)_2$ nickel (II) hydroxide

ACIDS

binary acids - hydro acids

$HCl_{(aq)}$ **hydro**chlor**ic** acid

$HF_{(aq)}$ **hydro**fluor**ic** acid

$H_2S_{(aq)}$ **hydro** sulfur**ic** acid

$HI_{(aq)}$ **hydro**iod**ic** acid

HBr **hydro**brom**ic** acid

ternary acids – oxyacids

H_2SO_3 sulphur**ous** acid

H_2SO_4 sulphur**ic** acid

HNO_2 nitr**ous** acid

HNO_3 nitr**ic** acid

HClO h**ypo**chlor**ous** acid

$HClO_2$ chlor**ous** acid

$HClO_3$ chlor**ic** acid

$HClO_4$ p**er**chlor**ic** acid

H_3PO_4 phosphor**ic** acid

H_2CO_3 carbon**ic** acid

Hydro Acids: *Hydro* + halogen name + *ic*

OxoAcids: polyatomic ion + acid.

a. Recognize as polyatomic ions with a hydrogen at the beginning of the formula.
b. Name with *-ous* and *-ic* suffix. (Works just like *-ite* and *-ate* suffix)
c. Name with *-ic* suffix is for acid with more oxygen atoms.

Binary acids (H plus a nonmetal element) are acids which dissociate into hydrogen atoms and anions in water. Acids which only release one hydrogren atom are known as *monoprotic.* Those acids which release more than one hydrogen atom are called *polyprotic*acids. When naming these binary acids, you merely add "hydro-" (denoting the presence of a hydrogen atom) to the beginning and "-ic acid" to the end of the anion name.

Salts

binary salts

$SnCl_2$ tin **(II)** chlor**ide**

$SnCl_4$ tin **(IV)** chlor**ide**

CuBr copper **(I)** brom**ide**

$CuBr_2$ copper **(II)** brom**ide**

ZnI_2 zinc iod**ide**

NH_4Cl ammonium chloride

ternary salts – oxysalts

Na_2CO_3 sodium carbonate

$KMnO_4$ potassium permanganate

$Fe(NO_3)_2$ iron (II) nitrate

$BaSO_4$ barium sulfate

$Ca(NO_3)_2$ calcium nitrate

$Ca(NO_2)_2$ calcium nitrite

$Fe(NO_3)_2$ iron (II) nitrate

Na_3PO_4 sodium phosphate

Acid name	*Anion name*
Hypo _____ous acid	Hypo___ite
___ous acid	___ite
___ic acid	_____ate
per___ic acid	per___ate

ClO_4^- is the **per**chlor**ate** ion (**per** means "above") note the oxidation number of Cl is +7 here
ClO_3^- is the chlor**ate** ion , ox number of Cl is +5
ClO_2^- is the chlor**ite** ion , ox number of Cl is +3
ClO^- is the **hypo**chlor**ite** ion (**hypo** means "below") ox number of Cl is +1

The "old" method.

This method involves using the suffixes -ous and -ic to distinguish between the low and high valence versions of the metal. The suffix -ous is used to denote the presence of ion with the lower combining capacity or valence, and -ic denotes the presence of the metallic ion with the higher combining capacity or valence. For example, Copper forms two ions; Cu^+, and Cu^{2+}. So Copper and bromine could form two compounds; CuBr or $CuBr_2$:

Naming these two compounds then goes as follows:

CuBr Cupr**ous** bromide $CuBr_2$ Cupr**ic** bromide

The problem with this method of distinguishing between the high and low valence versions of the metallic ion is that it is not consistent. Some metals are described using their latin names, while others are written in English. Some metals can have more than two valences. Some metals have latin names and only one valence so "ous" and "ic" are not necessary at all. It can get confusing. Here is a list of the names used for a selection of the "irregular" metallic elements. One of these latin named divalent substances is a non metal (just to confuse things further). If this method is to be used, this chart must be memorized.

Metal name	Symbol	Latin name	Name used in nomenclature
Sodium	Na	Natrium	Sodium (only one valence)
Potassium	K	Kalium	Potassium (only one valence)
Iron	Fe	Ferrum	Ferr - ous or Ferr-ic
Copper	Cu	Cuprum	Cupr - ous or Cupr - ic
Silver	Ag	Argentum	Silver (only one valence)
Tin	Sn	Stannum	Stann - ous or Stann - ic
Antimony (non-metal)	Sb	Stibnium	Antimoni - ous or Antimon - ic or Stibn-ous or Stibn-ic
Tungsten	W	Wolfram (German) or Tungsten (English)	Tungsten
Gold	Au	Aurum	Gold
Mercury	Hg	Hygrargyrum	mercur-ous or mercur-ic
Lead	Pb	Plumbum	plumbic

Chemical equations

Reaction can be represented by the chemical equation

$$C + O_2 \rightarrow CO_2$$

Reactants $\rightarrow$ products

Where the + sign means "react with" and the $\rightarrow$ sign means "to yield". Thus, this symbolic expression can be read: " carbon reacts with molecular oxygen to yield carbon dioxide".

Percent Composition - The percent composition of a component in a compound is the percent of the total mass of the compound that is due to that component.

To calculate the percent composition of a component in a compound:

1. Find the molar mass of the compound by adding up the masses of each atom in the compound using the periodic table
2. Calculate the mass due to the component in the compound you are for which you are solving by adding up the mass of these atoms.
3. Divide the mass due to the component by the total molar mass of the compound and multiply by 100.

Problem 1

What is the percent composition of sodium nitrate $NaNO_3$?

Solution:
In one mole of sodium nitrate we have:
1 mole of sodium atoms
1 "   nitrogen atoms
3 moles of oxygen atoms

calculate the mass of one mole of the compound
total mass of compound (molecular mass) = 23 + 14 + 3*16 = 85 g

how much sodium is in the compound

$$\frac{\text{grams of Na}}{\text{mass of one mol of compound}} \times 100\ \% = \text{percent of Na (27\%)}$$

percent of N = 16.5 %
percent of O = 56.5 %

Problem 2

Calculate the percent by weight of sodium (Na) in sodium chloride (NaCl)

Solution:
Calculate the molecular mass (MM):

MM = 22.99 + 35.45 = 58.44

Calculate the total mass of Na present:
1 Na is present in the formula, mass = 22.99
Calculate the percent by weight of Na in NaCl:
%Na = (mass Na ÷ MM) x 100 = (22.99 ÷ 58.44) x 100 = **39.34%**

Problem 3

Calculate the percent by weight of oxygen in sodium sulfate (Na_2SO_4).

Solution:
Calculate the molecular mass (MM):
MM = (2 x 22.99) + 32.06 + (4 x 16.00) = 142.04
Calculate the total mass of O present in Na_2SO_4:
4 O are present in the formula,
mass = 4 x 16.00 = 64.00
Calculate the percent by weight of O in Na_2SO_4
%O = (mass O ÷ MM) x 100 = (64.00 ÷ 142.04) x 100 = **45.06%**

Problem 4

How many moles and grams of water are produced when potassium hydroxide react with sulfuric acid ?

Definition of Mass Percent Concentration

Mass (or weight) percentage (% w/w) is one of the most often used ways of expressing concentrations. It is defined as

$$c_{\%w/w} = \frac{m_{substance}}{m_{solution}} \cdot 100\%$$

Mass of solution (in case of simple solution containing only one solvent and one solute) is

$$m_{solution} = m_{substance} + m_{sovent}$$

so we can formulate the definition in slightly different way:

$$c_{\%w/w} = \frac{m_{substance}}{m_{substance} + m_{solvent}} \cdot 100\%$$

Weight percentage is the only percentage concentration that is always unambiguous. Note that it is expressed in % units (as opposed to % w/v).

Problem 5

How many grams of NaOH would be required to prepare 800 grams of a 40% by mass NaOH solution? How many grams of water is required?

Solution:
1. Apply the definition for mass percent and solve for mass of solute
   mass % = mass of NaOH (100) / mass of solution = 40 = mass of NaOH (100) / 800

mass of NaOH = (40) (800) / 100 = 320 grams NaOH required

2. Determine the mass of water required

Total mass of solution = mass of solute + mass of water

800 = 320 + mass of water

mass of water = 800 - 320 = 480 grams of water

Problem 6

Determine the mass % of a NaCl solution if 58.5 grams of NaCl was dissolved in 50 ml of water (assume the density of water to be 1 g/ml)

Solution:

1. Convert ml of water to grams

   mass = 50 ml X 1 g/ml = 50 grams water

2. Determine total mass of solution

   Mass of solution = mass of solute + mass of solvent = 58.5 + 50 = 108.5 g

3. Apply the definition of mass percent

   mass % = 58.5 (100) / 108.5 = 53.9%NaCl

Problem 7

How would you prepare 500 grams of a 20% by mass NaOH solution. How much NaOH and how much water would be needed?

Solutions:

1. Determine the mass of NaOH needed from the definition of mass percent

   20 = mass of NaOH (100) / 500 grams

   mass of NaOH = (20) (500) / 100 = 100 grams NaOH

2. Determine the mass of water needed

   Total mass of solution = mass of solute + mass of solvent

   500 g = 100 grams solute + mass of water

   mass of water = 500 - 100 = 400 grams water

Problems:

1. Name the following compounds: (a) KI; (b) $CaCl_2$; (c) $Mg(NO_3)_2$; (d) K_2CrO_4; (e) Cr_2O_3; (f) $FeSO_4$; (g) ZnS; (h) K_3PO_4; (i) NH_4I; (j) $Cu(OH)_2$.
2. Write the correct chemical formulae for the folowing: (a) calcium oxide; (b) strontium fluoride; (c) aluminum sulfate; (d) ammonium chromate; (e) magnesium hydroxide; (f) potassium carbonate; (g) mercury (II) nitrate; (h) iron (III) oxide; (i) chromium (II) chloride; (j) lithium sulfide; (k) magnesium perchlorate; (l)
3. Phosphoric acid is used in detergents, fertilizers, toothpastes, and carbonated beverages. Calculate the percent composition by mass of H, P, and O in this compound.
4. Consider the combustion of carbon monoxide in oxygen gas:

   $$2\ CO + O_2 \rightarrow 2\ CO_2$$

   Starting with 3.6 moles of CO, calculate the number of moles of CO_2 produced if there is enough oxygen gas to react with all of the CO.

5. Silicon tetrachloride can be prepared by heating Si in chlorine gas:

$$Si + 2\ Cl_2 \rightarrow SiCl_4$$

In one reaction, 0.507 mole of $SiCl_4$ is produced. How many moles os molecular chlorine were used in the reaction?

6. How many grams of potassium are needed to react completely with 19.2 g of molecular bromine (Br_2) to produce KBr?
7. Nitrous oxide (N_2O) is also called “laughing gas”. It can be prepared by the thermal decomposition of ammonium nitrate. The other product is H_2O. Write a balanced equation for this reaction. How many grams of N_2O are formed if 0.46 mole of $NH_4NO_3$is used in the reaction?
8. How much H_2O, in moles, results from burning an excess of H_2 in 3.3 mol O_2?
9. What mass of H_2 in grams, must react with excess O_2 to produce 5.4 g H_2O?
10. Iron metal reacts with chlorine gas according to the equation

$$2\ Fe + 3\ Cl_2 \rightarrow 2\ FeCl_3$$

How much Cl_2, in moles, is required to convert 4.4 mol Fe to $FeCl_3$?