## Number of protons, neutrons and electrons

Number of protons = atomic number
Number of neutrons = mass number - atomic number
Number of electrons = atomic number - the charge
Example:
Carbon - 12 has an atomic number of 6 and a mass number of 12
number of protons= 6
number of neutrons= 12-6 = 6
number of electrons = 6 - 0 (neutral atom) = 6
if it is an isotope/has a charge:
Carbon - 13
number of protons = 6
number of neutrons = 13 - 6 = 7
number of electrons = 6 - +1 = 5 (C-13 has a +1 charge, so it loses 1 electron)

## Naming transition metals

For binary compounds (those with only two elements), the naming convention follows a specific set of rules.
However, compounds involving a metal and a non-metal, like iron chloride, the non-metal is typically ended with an 'ide'.
Non-metals typically form a negatively charged ion (anion), which are named with an 'ide'.
This is why both FeCl2 and FeCl3 are referred to as "chloride."
Chlorine forms the chloride ion when it gains an electron, becoming $C^{l}$-.
In the case of iron chloride, the 'ide' ending used in both Fecl2 and Fecl3 doesn't refer to the number of chlorine present, but the nature of the charge formed by the chlorine, which is an anion
The use of 'ate' and 'ite' are typically used when the non-metal in a compound is oxygen
- Chlorate ($ClO^3$-) and chlorite ($ClO^2$-) have suffixes indicating the number of oxygen present/the specific arrangement of atoms around oxygen
This naming convention doesn't directly apply to compounds involving chlorine and other elements like iron.
Instead, they are named according to their oxidation states. When an element can have multiple oxidation states, it's indicated using Roman numerals.
So, to name transition metals, you must first figure out the oxidation state of the compound, and indicate this using roman numerals
Example:
$FeCl^2$
- The iron here has a 2+ oxidation state, meaning it's lost 2 electrons
- Therefore, it's named Iron (ii) Chloride
$FeCl^3$
- In this case, iron has lost 3 electrons making it +3

## Naming transition metals (cont)

- So it's named Iron (iii) chloride

Another example CuS - Copper sulfide

To figure out if it's i-iii, we figure out the charge of copper by first figuring out the charge of sulfur

- Sulfur is a chalogen found in group 6a, and they form $^{2-}$ anions
- Copper can form either +1 or +2 ions, so in this case it would have to be a +2 charge to balance out the charge of sulfur.
- *if the charge of copper was +1, then 2 copper atoms would be needed to balance the compound, but given that there is only 1 in CuS, we can determine that the charge would be +2*

Since Cus is a neutral compound, the total positive charge of copper must balance the total negative charge of sulfur by determining coppers charge, which we already determined was -2. since the compound is neutral, the total sum of charges must = 0

We denote the charge of copper as 'x'

- X+(-2) = 0x

We denote the charge of copper as "x." Since the compound is neutral, the sum of the charges of copper and sulfur must equal zero:

- x + (−2) = 0
- solving for x, we find that x = +2, meaning copper must have a +2 charge

Therefore, in naming CuS, we put the number of the charge in roman numerals

- CuS = Copper(ii) sulfide.

In the case of Cu2S, we'd follow the same steps

- S has a charge of -2, we must balance the copper
- 2x + (-2) = 0
- solving for x, we find x = +1 because 1 x +1 + (-2) = 0

Therefore, copper has a +1 charge

so Cu2S = Copper (i) sulfide

## Average atomic mass of isotopes

Atomic mass x abundance of isotope for each isotope, then add together
Example:
Iron has 4 isotopes.
Fe-54, 56, 57, and 58
To calculate the average atomic mass, first get the abundance % and atomic mass of each isotope.
Fe-54
abundance % = 5.845%
Atomic mass = 53. 9396
Convert abundance to decimal format by dividing by 100
= 0.05845
Now, multiply the atomic mass with the % as a decimal
5.845 x 0.05845 = 0.34164025
Do the same for the remaining isotopes, then add the final numbers together
= 55.845
Highest abundance % is the most commonly found isotope btw

## max obtainable mass

Maximum mass that can be obtained
Laughing gas” or nitrous oxide, N 2O, is prepared by the thermal decomposition of ammonium nitrate: NH4NO3 (s) ☰ N 2O (g) + 2 H2O (l) (a) What is the maximum mass in grams of N2O (g) that can be obtained from 1.53 ☐ 10 2 g of ammonium nitrate?
Calculate moles of ammonium nitrate
- Mass is 153g, molar mass is 80g/mol, divide mass by molar mass
- Moles = 153/80 = 1.91 moles
According to equation, 1 mole of NH4NO3 yields 1 mole of N20
Number of moles of N2O produced will also be 1.91
Convert moles of N2O to grams
Multiply N2O molar mass (44.02) by number of moles
Mass of N2O = 1.91 x 44.02g/mol = 84.1 grams
If the percentage yield was 76%, what mass (grams) of N 2O was actually produced?
Calculate maximum theoretical yield – 84.1 grams
Apply percentage yield to find actual yield

## max obtainable mass (cont)

Given the percentage yield as 76%, we multiply it by the maximum theoretical yied
Actual yield = 84.1 g x 76/100 = 63.9g

## % (w/w)

Percentage by weight, indicating the mass of the solute per 100 grams of total product (solution)
Tells us the proportion of the solute to the entire product
Number of grams of NaOh present in a 375g can of oven cleaner labelled 4.2% (w/w) NaOH
Calculate mass of NaOH per gram
Given percentage of NaOH in oven cleaner Is 4.2% w/w
To convert % to grams/gram, divide it by 100
- 4.2/100 = 0.042g
Determine total mass of NaOH in the can
Total mass is given as 375g
To find mass of NaOH in the can, you multiply the mass of NaOH per gram of product by the total mass of the can
- NaOH mass in can = 0.042 g/g x 375g
- = 15.75g

## Evaporation/ %Mass

Calculate concentration of a solid as a percentage by mass (% mass)
% of mass calculated by dividing the mass of the solute by the total mass of the solution and then multiply by 100
Calculate the concentration of the solid mass per unit volume g/L
This concentration represents the amount of solid material (solute) per unit volume of the solution
A 1.62 kg (1.71 L) sample of creek water was evaporated to dryness, leaving 6.33 g of solid material.
Calculate the concentration of this solid as percentage by mass and calculate the concentration of this solid mass per unit volume g/l
Concentration of the solid as a percentage by mass (% mass)
The mass of the solid material left after evaporating is 6.33g
The total mass of the solution is 1.62kg = 1620g

## Evaporation/ %Mass (cont)

% mass = (6.33g/1620g) x 100% - 0.391%
Calculate the concentration
The volume of creek water is 1.71L
Concentration = mass of solute / volume of solution
= 6.33g/1.71L = 3.70 g/L

## concentration in dissolved solution

Figure out number of moles first
Molarity = moles per litre (mol.$L^{-1}$)
work out number of moles first, then divide by the volume
Molar mass of Na = 22.99
MM of Cl = 35.45
divide by the given volume (6g)
6/(22.99 + 35.35 moles)
=6g/58.44 mol
= 0.103 gmol $^{-1}$
volume in mL, convert to L
750ml/1000 = 0.75L
concentration is the mols/volume
0.103/0.75
= 0.14M

## Moles corresponding to molecules

convert number of molecules to moles by dividing given number of molecules by Avo number
Number of moles = number of molecules/6.022 x $10^{23}$
Moles of $CH_4$ corresponding to 1.56 x $10^{20}$ molecules
N($CH_4$) = 1.56 x $10^{20 \text{ molecules/6.022 x 10}}$ 23^
= 25.9 x $10^{-4}$

## Mass of product

**If 100.0 g of Al is added to 0.11 mol of O2, how many grams of Al 2O3 (s) will be produced?**
Write balanced equation
3Al + 3O2 --> 2Al2O3
- 4 moles of Al react with 3 moles of oxygen to make 2 moles of aluminum oxide
Moles of Al using its molar mass
= moles of Al = mass of Al/Molar mass of Al
= 100g/27 g/mol = 3.70 mol
Mols of oxygen are already given, they are 0.11 mol
Determine limiting reactants
we assume 1 is in excess
- We use stochiometry to determine how much of the O2 would be needed to react completely with the excess reactant. if there is more of the other reactant than the calculated amount, then it is in excess; otherwise it is the limiting reactant.
- to react all alumium, it would require 3/4 x moles of Al
- 3/4 x 3.70 = 2.78 mol of O2
Assuming O2 is in excess, it would require 4/3 x moles of O2
= 4/3 x 0.11 = 15 mol Al
Since theres less than 2.78 mol O2 to react with the Al, and more than 0.15 mol Al to react with the O2, O2 is the limiting reactant
Calculate moles of Al2O3
from the equation, we see that 4 moles of Al react with 3 moles of O to produce 2 moles of Al2O3.
Since O is limtiing reactant, we use its moles to find the moles of Al2O3
moles of Al2O3 = 2/3 moles of O2
= 2/3 x 011 = 0.073
Mass of Al2O3 produces
= Moles of Al2O3 x molar mass of Al2O3
= 0.073 x 102.0 = 7.48 grams

## lewis structure

Count total number of valence electrons and add them together
- for exanmple, NCl3, nitrogen has 5, chlorine has 7. since there are 3 Cl atoms, thats 3x7 = 21 valence electrons.
- 5 + 21 = 26 valence electrons for the entire molecules

Choose the central atom
- the central atom is the less electronegative one, as it can make more bonds
- NCl3, nitrogen is the central atom

Connect the atoms with single bonds
- Connect the central nitrogen atom to each of the 3 chlorine atoms using single bonds
- this uses up 3 pairs of electrons, 26-3 = 23 electrons remaining

distribute the remaining electrons
- place lone pairs on the outer atoms first, and then fill the remaning electrons around the central atoms
- each lone pair is represented by 2 electrons

check for formal charges after
- a formal charge occurs when an atom doesnt have the expected number of valence electrons
- calculate the formal charge for each atom by subtracting the number of lone pair electrons and half the number of bonding electrons from the number of valence electrons the atom brings

If any atoms have formal charges, try to minimize them by moving lone pairs or changing the arrangement of bonds
- the goal is to have the lowest formal charges possible while still satisfying the octet rule

N - 1 lone pair (2 electrons)
Each Cl - 3 lone pairs (6 electrons)

## mass of production in reaction

KCN (aq) + HCl (aq) --> KCl (aq) + HCN (g)

**If 0.250 g KCN reacts with excess acid, calculate the mass (in g) of HCN produced?**

Determine molar masses of the substances involved
- Molar mass of KCN = molar mass of K + molar mass of C + molar mass of N
- Molar mass of HCN = molar mass of H + C + N

conver the mass of KCN to moles
- number of moles = mass/molar mass

## mass of production in reaction (cont)

apply stoichiometry to find the molar ratio of KCN and HCN to find the number of moles of HCN produced when a certain number of moles of KCN reacts

Convert moles of HCN to mass
- mass = number of moles x molar mass

Moles of KCN = 0.250/65
= 0.003846

the ratio is 1:1, so the number of HCN moles is the same as the number of KCN moles

To find the mass of HCN, multiply the number of moles of HCN by it's molar mass

Moles of HCN x Molar mass of HCN
= 0.003846 mol x 27g/mol
= 0.104 g

mass of HCN produced when 0.250 g of KCN reacts with excess acid is 0.104

## concentration of a solution

**"Calculate the concentration (mol/L) of a saline solution of 9 g table salt in 1 L water."**

Determine the molar mass of NaCl
- sum of the atomic mass of Na and Cl
- MM Na + MM Cl
= 22.99 g/mol + 35.45 g/mol
= 58.44 g/mol

Convert the mass to moles
- the given mass of table salt is 9g
- number of moles of Nacl
= Mass of NaCl/ molar mass of NaCl
= 9g/58.44g/mol
= 0/154 mol

Now calculate the morality/concentration of the NaCl in the saline solution

Concentration (mol/L) = number of mols of solute/ volume of solution (L)
= 0/154mol/1L
= 0/154 mol/L

The concentration of the saline solution, 9g of NaCl in 1L of water, is 0.154 mol/L

## concentration of a solution (cont)

**Explain how you would proceed to make 50 ml of 0.030 M solution out of the above stock saline solution.**

Calculate volume of stock solution needed

use the dilution formula to calculate the volume of the stock solution (0.154 M) to prepare the desired result:

C1V1 = C2V2

- C1 = concentration of stock solution (0.514 M)
- V1 = volume of stock needed (?)
- C2 = desired concentration of final solution (0.030 M)
- V2 = Volume of final solution (50mL)

Solve for V1

V1 = C2 X V2 / C1

= (0.030 mol/L) x (0.050L) / 0.514 mol/L

= 0.0015 / 0.154 L

convert to mL

= 0.0097 X 1000 mL/L

= V1 = 9.7mL

You need 9.7 mL of the solution to prepare 50 mL of the desired solution.

## water solubility and ions

Determing which compounds will form ions when dissolved in water.

Identify if compound is ionic, polar covalent or non-polar covalent

- ionic: consist of metal and a nonmetal or a metal and a polyatomic ion
- polar: significant different in electronegativity btwn bonded atoms, resulting in partial pos/neg charges
- non polar: similar electronegativity, resulting in equal sharing of electrons and no signfiicant charge seperations

Solubility rules:

- Most nitrate (NO3-), acetate (C2H3O2-), and chlorate (ClO3-) salts are soluble
- most alkali metal (group 1) and ammonium salts (NH4+) salts are soluble
- most chloride (Cl-), bromide (Br-). and iodide (I-) salts are soluble, except for those of silver, lead(ii) and mercury(i)

## water solubility and ions (cont)

- most sulfate ($SO4^{2-}$) salts are soluble, except for those of calcium, stronium, barium. lead(ii), and some silver salts

**Dissociation in water**

ionic compounds with ions are soluble according to the rules, it will dissociate into ions when dissolved in water

if polar or nonpolar, it wont

Some compounds that fully dissociate into ions in solution are considered strong electrolytes

- these compounds conduct electricity well in solution due to the presence of free ions
- strong acids, bases and soluble ionic compounds

Some dissociation behaviour of a compound can vary, some partially dissociate into ions while others fully dissociate

- weak acids and bases partially dissociate into ions in solution, theyre waek electrolytes
- non-electrolytes dont dissociate into ions when dissolved in water

**Example**

Li2SO4

Lithium sulfate, containing lithium (Li) and sulfate ($SO4^{2-}$) ions.

Li salts, such as lithium sulfate, are generalyl soluble in water as lithium compounds are highly soluble

most sulfate salts are soluble

based on this, lithium sulfate will dissociate into its constituent ions

- Li+ and $SO4^{-2}$

Li2SO4 --> 2Li+ + $SO4^{2-}$

## volume of acid to neutralise

volume 0.355 M perchloric acid to neautralise 15.5mL of a 0.179 calcium hydroxide solution

Write a balanced equation for the reaction

- perchloric acid (HClO4) and calcium hydroxide (Ca(OH)2)
- 2HClO4 + Ca(OH)2 --> Ca(ClO4)2 + Ca(ClO4)2 +2H2O

Determine the stoichiometry

From the equation, you can see that 2 moles of HClO4 react with 1 mole of Ca(OH)2, meaning the stoichiometric ratio is 2:1

Calculate the moles of Ca(OH)2

## volume of acid to neutralise (cont)

Use the given concentration and volume of the calcium hydroxide solution to calculate the number of moles present.
- Moles of $Ca(OH)_2$ = concentration x volume
= 0.179 M x 15.5mL/1000L
= 0.179 M x 0.0155L
= 0.00277 Mol
find the moles of $HClO_4$
since the ratio between them is 2:1, the number of moles of perchloric acid needed is twice the number of calcium hydroxide
- moles of $HClO_4$
= 2 x 0.00277
= 0.00554 Mol
now use the concentration of perchloric acid solution to find the volume of it thats needed
Volume = moles/concentration
= 0.00554mol/0.355M
= 0.00554/0.355 L
= 0.0156 litres
So approx. 0.0156 litres or 15.6 mL of 0.355 M of perchloric acid needed to neutralise 15.5mL of 0.179 M calcium hydroxide solution

## Molecular formula from % composition

Follow previous steps to get the empirical formula, then find the molar mass of it by adding up the atomic masses of all atoms in the formula
Determine the molecular formula mass
You need to know the molecular weight/molar mass of the compound, if not known, you have to determine it experimentally
Calculate the 'multiplier' or 'factor'
Divide the molecular weight of the compound by the empirical formula mass to get the 'multiplier' that represents how many times the empirical formula must be multiplied to get the molecular formula
Multiply the subscripts in the empirical formula by the 'multiplier'
**Example:**

## Molecular formula from % composition (cont)

Compound: 40% carbon, 6,7% hydrogen, and 53.3% oxygen, with a molecular weight of 180 g/mol
the empirical formula is $CH_2O$
to find the mass of it:
Mass of C = 12.01 g/mol
Mass of H = 1.01 g/mol
Mass of O = 16 g/mol
The empirical formula mass:
(12.01 x 1) + (1.01 x 2) + (16.00 x 1)
= 30.03g/mol
Calculate the 'multiplier'.
- Multiplier= Molecular weight/Empirical formula mass=180/30.03
= 6
Multiply the subscripts in the empirical formula by the multiplier
$C_1H_2O_1$ x 6 = $C_6H_{12}O_6$
so the molecular formula is $C_6H_{12}O_6$
By following these steps, you can determine the molecular formula of a compound from its percent composition and molecular weight.

## Excess reactant

Write balanced equation and determine limiting reactant
- calculate moles of each reactant involved and compare these values to determine which is limiting and which is in excess
- the limiting reactant is the one that produces the least amount of product
Calculate theoretical yield
use the stoichiometry of the balanced equation
- multiply the number of moles of the limiting reactant by the stoichiometric coefficient of the product in the balanced equation to get the theoretical yield in moles.
Determine the excess reactant
This is the one that is not limiting
- subtract the amount of excess reactant that reacts from the initial amount of excess reactant given
now calculate the amount left after the reaction

## Excess reactant (cont)

- subtract the amount of excess reactant that reacted from the initial amount of excess reactant given.
Example:
Hydrogen gas and oxygen gas to form water
balance equation:
$2H_2(g)+O_2(g)\rightarrow 2H_2O(g)$
- Suppose we have 10.0 grams of hydrogen gas and 20.0 grams of oxygen gas.
Determine limiting reactant
calculate moles of each reactant
- $H_2$ molar mass = 2.02g/mol
- $O_2$ molar mass = 32 g/mol
divide by the respective grams amount
- $H_2$ - 10.0g / 2.02g/mol = 4.95
- $O_2$ - 20.9g / 32g/mol = 0.625
$O_2$ has fewer moles, so its the limiting reactant, while $H_2$ is the excess
Calculate theoretical yield
Balanced equation shows us that 2 moles of $H_2$ react with 1 mole of $O_2$ to produce 2 moles of $H_2O$.
$O_2$ is limiting, so the amount of $H_2O$ produced is determined by its quantity
- the theoretical yield of $H_2O$ is 2 x 0.625 mol = 1.25 mol
Since all the $O_2$ is consumed, we don't need to calculate the amount of excess reactant ($H_2$) that reacts.
Since all $O_2$ was consumed, and the initial moles of $H_2$ was 4.95, all moles of $H_2$ will react, leaving no excess $H_2$ after reaction.
**7g ammonia reacted with 10 g of oxygen, which reagent is in excess?**
Determine number of moles of each reactant
N = mass (gs)/molar mass
$NH_3$/ammonia
N($NH_3$) = 7g/17.034g/mol
For $O_2$/oxygen
N($O_2$) – 10g/32g/mol
Compare the number of moles to find the limiting reagent

## Excess reactant (cont)

Use the stoichiometric ratio 4:5 moles of $NH_3$ react with 1 mole of $O_2$
N($NH_3$) = 4/5 x n($O_2$)
Calculate the number of moles of $NH_3$ using the same ratio
Identify the limiting reagent by comparing the calculated moles of $NH_3$ and $O_2$
If n($NH_3$) < n($O_2$), $NH_3$ is limiting, and vice versa
$O_2$ is the limiting reagent, bc n($O_2$) = 0.411 moles, which is less than n($NH_3$) = 0.25 moles
Calculate the mass of the product based o the limiting reagent
Use the stochiometry to find the number of moles of the product NO, then use the molar mass of NO to find the mass of the product
Mass(NO) = n(NO) X molar mass (NO)
0.25 moles x 30g/mol
= 7.5g, round to 8g

## Moles of substance A to B

Write balanced equation and identify given and unknown quantities
- Given: number of moles of A you have
- Unknown: The substance B you want to convert to
Use molar ratios
- From the balanced equation, identify the molar ratios between A and B
- these ratios are determined by the coefficients in front of the substances
- if the balanced equation is aA + bB --> cC + dD, then the molar ratio of A to B b/a
Use the molar ratio to calculate the number of moles of substance B that will form or react with the moles of substance A
- Multiply the moles of A by the appropriate molar ratio
Ensure all reactants and products are included in the stoichiometric calculation:
**- Limiting and excess reactants:**
limiting: reactant completely consumed in reaction, limiting amount of product that can be formed
excess: reactant not completely consumed and is left over after limiting reactant is consumed fully
**- Theoretical yield**
Max. amount of product that can be obtained from given amount of reactants assuming all reactants are converted to products according to the stoichiometry of the balanced equation

## Moles of substance A to B (cont)

**-compare actual and theoretical yields**
actual yield: amount of product obtained from reaction in practice
if its less than the theoretical yield, it indicates one or more reactants were limiting and the reaction didnt proceed to completion.
if any reactant is limiting or in excess, adjust the stoichiometric calculations:
limiting: calculate amount of product formed based on its quantity
excess: determine amount left over after reaction is complete
To conclude, indicate the number of B moles formed or reacted based n the given A moles

## grams to atoms

find molar mass and calculate number of moles by dividing number of grams by molar mass
multiply the number of moles by avogrado's number
Example:
10 grams of Na to atoms
molar mass of Na is approx. 22.99 g/mol
divide 10 grams by molar mass
= 10/22.99
= 0.435 moles
Multiply number of moles by Avogrado's number
0.434 x $(6.022x10^{23})$
= 2.6 x $10^{23}$ atoms in 10 grams of Na

## Naming ionic main metal compounds

Some ionic compounds containing a transition metal require Roman numerals while some don't. The way we determine this is whether or not that transition metal can exhibit multiple oxidation states.
Elements in groups 1, 2 and 13 commonly have 1 oxidation state:
- Sodium, Na, is usually $Na^+$ with a +1 charge, calcium, Ca, is usually $Ca^{2+}$
- They don't require the use of roman numerals
For these kinds of ionic compounds, we simply use the same naming system as the other ionic compounds.

## Ionic compounds chemical formula

Determine if the elements in the compound typically form ions and which charge it forms.
Then, balance the charges
- since ionic compounds are electrically negative, the total positive charge from the cations must balance the total negative charge from the anions. To achieve this, you may need to adjust the number of ions present in the compound.
when writing the formula, simplify the subscripts by dividing them by their greatest common number, but don't change the ratio between them.
if there is more than one possible ionization state, use Roman numerals.
Example:
Sodium chloride (NaCl)
- Sodium, Na, has a +1 charge = $Na^+$
- Chlorine, Cl, has a -1 charge = $Cl^-$
- Since they have equal opposite charges, no need for adjustment/b-alancing
Aluminium chloride
- Al has a charge of $^{+3}$, while chlorine has a charge of $^{-1}$
- So, we just need to swap the subscripts with the number of the other element present:
- $Al^{+3}$ + $Cl^{-1}$ --> Al1 Cl3 (we can omit the 1 from Al coz its already a given)
- Now, the total Al charge is +3, and the total Cl charge is -3, making them balanced
Aluminum chloride = AlCl3

## Grams to molecules

Find total molar mass of all elements in substance.
Use the converstion factor Avogadro's number - 6.022 x $10^{23}$ molecules/mol
Calculate number of moles
- divide number of grams by molar mass
Convert moles to molecules by multiplying the number of moles by Avogadro's number
**10 g H2O to molecules**
Molar mass = 18.016g/mol
Divide 10 grams by molar mass
=10 grams/18.016g/mol = 0.555
Convert to molecules
0.555 x (6.022 x $10^{23}$)

## Grams to molecules (cont)

= 3.34 x $10^{23}$ molecules of $H_2O$

## Grams to moles

Find the atomic mass of each element and multiply it by the number of that element in 1 molecule of the substance.
Add the masses of all the atoms to find the molar mass.
Multiply the number of grams by the reciprocal molar mass of the substance.
Example:
50 grams of $H_2O$ to moles
- Molar mass of $H_2O$ is sum of the masses of H and O
- (H) 1.008g/mol x 2 + (O) 16g/mol
= 18.016
Determine the substance: We want to convert grams of water ($H_2O$) to moles.
- The reciprocal of the molar mass of $H_2O$ is 1/18.016g/mol
- multiply 50 grams by 1/18.016g/mol
= 2.78 moles

## Find amount of mols in gs of substance

Find molar mass of substance and divide it by the amount of grams
Example:
Moles in 1 gram $H_2O$
- molar mass = 18.016g.mol
- Divide by 1
- 1/18.016 = 0.0555
Moles in 2 grams $H_2O$
- multiply reciprocal of $H_2O$ by 2
= 2 x (1/18.016)
= 0.1109 moles in 2 grams of $H_2O$

## Naming polyatomc ions

Polyatomic ions are ions that contain more than 1 atom, monatomic ions only contain 1 atom
$NO_3^-$, $NO_4^-$ = polyatomic
$N^{3-}$ = monatomic
Suffixes:
'ate' or 'ite' - typically polyatomic ion that contains 1 oxygen atom
'ide' - typically monoatomic ion that lacks oxygen
so, $N^{3-}$ is Nitr**ide**
and $NO_3^-$ is Nitr**ate**
Example:
$Cl^-$ Chloride (no oxygen - ide)
$ClO^-$ Hypochloride (1 more oxygen - 'hypo' prefix)
$ClO_2^-$ Chlorite (1 more oxygen - ide)
$ClO_3^-$ Chlorate (1 more oxygen - ate)
$ClO_4^-$ Perchlorate (1 more oxygen - 'per' prefix)

## Dilution p2

**Water needed to dilute 100ml of 1.0 M solution of Nacl to a 0.25 solution**
Initial volume and concentration
100ml and 1.0 M respectively
Final concentration = 0.25 M (as desired)
Calculate amount of solute (initial)
Initial volume x initial concentration
= 100ml x 1.0M = 100 moles
Calculate final volume needed
- we want to dilute solution to a final concentration of 0.25 M, so we use this formula
Final concentration = amount of solute (initial)/final volume
rearrange formula
Final volume = amount of solute (initial)/final concentration
= 100 moles/0.25 = 400ml
To get the amount of water needed, we calculate the difference btwn the final volume and the initial volume
Final volume - initial volume

### Dilution p2 (cont)

= 400ml - 100ml = 300ml
So you add 300ml of water

### Covalent/molecular compound chemical formula

**Sulfur Dioxide**
No prefix in front of 'sulfur' means there is only one in the compound
'di' prefix infront of 'oxygen' means there are 2 in the compound
So, the formula would be SO2
**Dinitrogen pentoxide**
'di' in front of nitrogen means there are two in the compound
'penta' in front of oxygen means there are 5 in the compound
So, the formula would be N2O5

### Grams to make solution

Number of moles can be calculated using the formula
n = c x v
c - concentration in mol/L, V - volume in L
mass = n x molar mass
How many grams of solid Mg(NO3)2 are required to make 2.5 L of a 1.5 M Mg(NO3)2 solution?
V = 2.5, the C = 1.5 mol/L, we want to find the mass of solid Mg(NO3)2 needed to make this solution
N = 1.5mol/L x 2.5L
= 3.75 moles
Now calculate the mass
3.75 moles x 148.31 g/mol
= 556.1625 grams, rounded to 556 grams

### Naming: ionic compounds

A compound is a substance with more than 1 element
NaCl is Sodium chloride - two different elements present, making it a compound
An ionic compound is one that is composed of ions
NaCl is composed of Na+ and Cl-, an anion and a cation respectively
When naming an anionic compound, the ending of the last element is changed to 'ide'

### Naming: ionic compounds (cont)

NaCl - Sodium + chlorine = sodium chlor*ide*
Name the first element, and end the second element in 'ide'
Example:
AlP contains Aluminium and phosphorous = Aluminium phosphide
Polyatomic ionic compounds follow the same rules, look at the section for them

### Atoms in grams

Calculate molar mass of compounds then calculate the number of moles
n = mass/molar mass
multiply with avo number
sodium atoms in 1kg of Na2SO4
molar mass Na = 22.99
S = 32.07
O = 16
2 x 22.99 + 32.07 + 4 x 16
= 141.05 g/mol
Moles of Na2SO4
= mass/molar mass = 1000/141.04
= 7.09
since there are 2 moles of Na for every 1 mole of Na2SO4, Na atoms are doubled
2 x 7,09 = 14.18
14.18 x 6.022 x $10^{23}$
Na atoms = 8.53 x $10^{24}$

### Amount of molecules in gs

Divide mass (g) by the molar mass of the molecule, then multiply it by avos number (6.022 x $10^{23}$)
Oxygen molecules in 6 grams of oxygen
n = mass (g)/molar mass (g/mol$^{-1}$)
molar mass of O2 = 16 x 2 = 32
6/32 = 0.187
0.187 x 6.022 x $10^{23}$ molecules/mol

## Product formed in reaction

Balance the equation, and determine the number of moles for each reactant
N = mass of reactant/molar mass
Barium peroxide reacts with hydrochloric acid to form peroxide, $H_2O_2$:
$BaO_2(s) + 2HCl(aq) \rightarrow H_2O_2(aq) + BaCl_2(aq)$.
If 2.01 g of barium peroxide is reacted with 0.75 g of acid (HCl) how much peroxide will be produced?
Determine moles for each reactant
$BaO_2$ barium peroxide
- $N(BaO_2) = 2.01g/169.3$ g/mol
Hydrochloric acid HCL
- $N(HCl) = 0.75g/36.458$ g/mol
Compare the number of moles
From the equation, ½ moles of $BaO_2$ react with 1 mole of Hcl
$N(BaO_2) = ½ \times n(HCl)$
Calculate the number of moles of $BaO_2$ using the same ratio
Compare the moles, whichever is smaller is the limiting reagent
Hcl = 0.0199 moles
$BaO_2$ = 0.0103 moles
- Hcl limiting reagent
Calculate product mass based on limiting reagent/HCl using stoichiometry to find number of moles
In the equation, the stoichiometric coefficients represent the mole ratio btwn reactants and products
Hcl is limiting, and 2 moles of HCl react to produce 1 mole of $H_2O_2$
Therefore, $n(H_2O_2) = ½ n(HCl)$
Molar mass of $H_2O_2$ is 34.014gmol
To convert moles to grams, use its molar mass
- Number of moles x molar mass
- 0.0103 moles x 34.014g/mol

## Naming covalent/molecular prefixes

Mono - 1
Die - 2
Tri - 3
Tetra - 4
Penta - 5
Hexa - 6
Hepta - 7
Octo - 8
Nona - 9
Deca - 10
CO = Carbon monoxide
- 1st element has subscript of 1, but doesn't need prefix 'mono'
- 2nd element has subscript of 1 (1 oxygen atom), so prefix 'mono' is used
$CO_2$ = Carbon dioxide
- 2nd element has subscript of 2 (2 oxygen atoms), so 'di' is used
$NO_2$ = Nitrogen Dioxide
$N_2O_5$ = Dinitrogen pentoxide
- 1st element has subscript of 2, so 'die' is used
- 2nd element has subscript of 5, so 'penta' is used

## molecular shape and molecule polarity

To predict molecular shape and whetehr a molecule is polar;
identify central atom (which can form most bonds/least electronegative)
determine the electron geometry around the central atom by considering both bonding and non-bonding electron pairs
- $NCL_3$, N has 1 lone pair and forms 3 single bonds with the Cl
- this gives it a tetrahedral electron geomotry
Determien the molecular shape by considering only the positions of bonded atoms
- in $NCl_3$, the lone pair of electrons on N repels the bonding pair, causing the molecule to adopt a trigonal pyramidal shape
Determine polarity - consider the electronegativity of the atoms and the molecular shape
- $NCl_3$, N is less electronegative than Cl, meaning the bonds btwn N and Cl are polar

## molecular shape and molecule polarity (cont)

- the chlorine atom carries a partial neg charge, and the N carries a partial pos charge

While the arrangment of atoms in Ncl3 is symmetrical, symmetry alone doesnt determine polarity

the distribution of electron density due to the lone pair of N still results in a net dipole moment (overall polarity of the molecule), making the molecule polar

## Moles produced and molecules to react

2CO + O2 --> 2CO2

**If 5.23 moles of CO react with excess oxygen, how many moles of CO2 are produced?**

Moles of CO = 5.23 mol

need to find moles of CO2 produced

From equation, 2 moles of CO react with 1 mole of O2 to make 2 moles of CO2, meaning ratio is 2:2 --> 1:1

Using the given moles of CO and the ratio, calculate moles of CO2 produced

Moles of CO2 = (given moles of CO) X moles of CO2/ moles of CO)

= 5.23 mol x 2 mol CO2/2 mol CO

= 5.23 x 1

moles of co2 = 5.23 mol

when 5.23 moles of CO react, 5.23 moles of CO2 are produced

**How many oxygen molecules were required to react all the CO?**

The equation shows us that 2 moles of CO react with 1 mole of O2 to produce 2 moles of CO2, so the ratio between CO and O2 is 2:1

Moles of O2 = (given moles of CO) x moles of O2/moles of CO

= 5.23 x 1 mol O2/2 mol CO

= 5.23/2

= Moles of O2 = 2.615

Convert to molecules

1 mole of substance contains 6.022 x $10^{23}$ molecules, so we multiply 2.615 by this number

= 1.572 x $10^{24}$

exponant increases by 1 (23-24) bc when we convert moles to molecules, we are multiplying by avogrados number - 6.022 x $10^{23}$ molecules per mole.

if we have 2 moles of a substance, we have 2 x 6.022 x $10^{23}$ molecules, which is 1.2044 x $10^{24}$ molecules

## Moles produced and molecules to react (cont)

- each additional mole increases the number of molecules in Avo's number

when we increase the number of moles by 1, the exponant of 10 increases by 1 in the scientific notation represeantation of the number of molecules

## Electronic configuration

Understand the subshells

Electronic configuration describes the distribution of electrons in the atomic orbitals of an atom

each subshell is labelled with the principal quantum number (n) and the orbital type (s,p,d,f)

1s2, 2s2, 2p4

- n is 1 for the 1s subshell, 2 is for the 2s and 2p subshell
- the value of n represents the energy level of the orbital

the superscript after each subshell represents the number of electrons in that subshell

- 1s2, 1s subshell is filled with 2 electrons
- 2s2, 2s subshell is filled with 2 electrons
- 2p4, 2p subshell filled with 4 electrns

To determine the element that corresponds to the electron configuration, you use the periodic table

findthe element with the atomic number that matches the sum of the superscripts in the electron configuration

**Elements and ions in their ground state**

identify the atomic number (z) of an element

- carbon has a z of 6 - 6 protons and 6 electrons in its neutral state

determine the shell occupied by the valence electrons

- C has an atomic number of 6, so we fill the electrons into the available order of increasing energy

use the Aufbau principle

- electrons fill the lowest energy orbitals before moving to the higehr energy ones
- fill the 1s, then the 2s, and then the 2p orbitals

For carbon (z=6), the electronic configuration is 1s2 2s2 2sp2

- 2 electrons in 2s orbital, 2 electrons in the 2s orbital and 2 in the 2p orbital

## Moles

1 mole = 6.022 x $10^{23}$

1 mol of carbon atoms = 6.022 x $10^{23}$ atoms of Carbon

1 mol of CO2 = 6.022 x $10^{23}$

2 mol of carbon = 2 x 6.022 x $10^{23}$

4 mol of C

4 mol C/1 x 6x$10^{23}$ C atoms/1 mol C

= 4 x 6 = 24

= 24 x $10^{23}$

Move the decimals to the left <-- = $^{23}$ goes up by as many places as you moved to the left

Move decimals to the right --> it goes down

## Moles

The mass number of an element also represents the 'molar mass'

- 1 mol of an element has a mass of (its mass number)
- Nitrogen's mass number is 14 = 1 mol of N has a mass of 14g; 14g of N contains 6.022 x $10^{23}$ atoms
- Mole is proportional to it's 'molar mass'
- 2 mol of N = 28g N

Figuring out the molar mass of a compound can be done by identifying the molar mass of each element present and adding them together

**O3**

- 1 oxygen atom has an mass number of 16, so 6 of them would be 3x16 = 48
- Molar mass of ozone/O3 = 48g/mol

**CO2**

- Carbon mass number is 12.01, Oxygen mass number is 16, so 16x2 = 32
- 32 + 12.01 = 44.01g/mol

**Calcium phosphate**

- 3 calcium atoms, 2 phosphate groups with 1 P atom and 4 oxygen atoms
- first, balance the formula
- Calcium has 3 atoms
- 1 P atom in each phosphate group, since there are 2 groups, that's 2 P in total
- Each group has 4 O atoms, so 4x2 = 8 O atoms in total

## Moles (cont)

= Ca3(PO4)2

- Molar mass of C = 40.08 x 3 = 80.16
- Molar mass of P = 30.97 x 2 = 61.94
- Molar mass of O = 16 x 4 = 64

Then you add them together

Molar mass of Calcium phosphate/Ca3(PO4)2 = 310.18g/mol

## oxidation state of an atom in a compound

**General rules**

- Oxidation state of an atom in its elemental form is always 0
- For monatomic ions, the oxidation state is equal to the charge of the ion
- The sum of the oxidation state of all atoms in a neutral compound is 0, and it equals the charge of the compound if it's an ion
- In compounds, some elements have fixed oxidation states (Group 1 metals always have an oxidation state of +1, group 2 metals always have an oxidation state of +2, oxygen s usually -2)

Start with the elements that have a fixed oxidation state/are in elemental form, and assign their states based on rules above

If an element has variable oxidation states, use these rules

- Assign the oxidation state of oxygen as -2, unless it's in a peroxide or when combines with fluroine, where it has a positive state
- Hydrogen usually has a +1 state, except when bonded with metals where it's -1
- Group 1 metals are +1, group 2 metals are +2, group 13 are +3 in compounds
- in compounds, flourine is always -1
- the sum of oxidation states in neautral compounds is 0

After assigning states to each atom, check that the sum of the states is equal to the total charge of the compound or ion, and if its neautral it should be 0

**Example**

NH3

H usually is +1, O is usually -2

The sum of the oxidation states should equal 0 as its neutral

H is typically +1, so all 3 atoms in NH3 will equal a +3 charge.

## oxidation state of an atom in a compound (cont)

$NH_3$ is neutral, so the sum of oxidation states must equal 0, so Nitrogen must have a state that offsets the total charge from the H atoms - +3
N's state can be calcualted by substracting the sum of oxidation states of H from 0
Oxidation state of N is x
- x + 3(+1) = 0
- x + 3 = 0
- x = -3

Nitrogen's oxidation state therefore is -3
**example**
Nitrate ion has a -1 charge, and O has a -2 charge
lets say the nitrogen state is x
- 3 O atoms, each -2 - 3(-2) = -6

The sum of oxidation states must equal the charge of the ion, -1, so nitrogen must have an oxidation state that offsets the total charge of the oxygen atoms -6.
x + -6 = -1
x = -1 + 6
x = +5
so the oxidation state of $NH_3$ is -1, and the nitrate ion has a state of +5, while the O atom has a state of -2

## Hydrated ionic compound empirical formula

Identify the ionic compound and the number of water molecules in it
Determine the masses of each component separately, including the mass of the andhydrous salt (w/o water) and the mass of the water molecules.
These can be find from the given total mass of the compound.
Calculate the molar mass
Determine molar mass of the andhydrous salt by summing the molar masses of each element in the compound
To find the molar mass of the anhydrous salt, sum each of the molar masses in the compound
- molar mass of compound = molar mass of each atom added together

Then, determine the molar mass of $H_2O$
Calculate the moles

## Hydrated ionic compound empirical formula (cont)

Use the masses and the molar masses to find the number of moles in each component
For the anhydrous salt, use this formula:
- Moles of A.salt = mass of A.salt/molar mass of A. salt

for the water:
- Moles of water = mass of water/molar mass of water

Determine the simplest ratio
divide the number of moles of each component by the smallest number of moles calculated, to get the simplest ratio of ions to water molecules
Round to whole numbers if not already whole numbers
Write the empirical formula using the whole number ratios
- the subscripts in the formula represent the number of ions or water molecules in one formula unit of the compound

**Example**
Copper (II) sulfate pentahydrate - $CuSO_4$ + $5H_2O$
- made of copper (II) sulfate - $CuSO_4$ - and 5 $H_2O$/water molecules.

Lets say we have 250 grams, to determine the mass of the A.salt ($CuSO_4$) and the mass of water by weighing the sample
Calculate molar masses
$CuSO_4$ molar mass = 159.55 g/mol
$H_2O$ molar mass = 18.02 x 5 = 90.10 g/mol
calculate moles
$CuSO_4$ = 100/159.55 = 0.627 mol
5 $H_2O$ = 50/90.10 = 0.554 mol
Determine the simplest ratio
divide the number of moles of each component by the smallest number of moles calculated
- 0.627/0.554

= 1.13
Round to nearest whole number
= 1
The ratio is therefore 1:5, so the empirical formula is $CuSO_4$ + $5H_2O$

## Empircal formula from % composition

Convert % to grams

Start by assuming you have 100g sample of the compound, and convert the percentages of each element to grams

- if a compound contains 40% carbon, it means there are 40/100 x 100g =40g of carbon in 100g of the compound

Convert grams to moles

use the molar mass of each element to convert to moles

- Moles = grams/molar mass

Determine simplest ratio

Divide number of moles of each element by the smallest number of moles calculated

- if the ratios obtained aren't whole numbers, then round them to the nearest whole number.
- if the numbers are close to whole numbers, you can multiply all ratios by the same number to make them whole

Write formula

use the whole number ratios to write the empirical formula of the compound.

the subscripts in the formula represent the number of atoms of each element in one molecule of the compounds

**Example**

Compound with 40% carbon, 6.7% hydrogen, and 53.3% oxygen by mass

Convert % to grams

C = 40.0g, H= 6.7g, O= 53.3g

Convert G to moles

Using the molar mass

- moles = mass (grams)/molar mass (grams/mol)
- C: 40.0/12.01 = 3.33 moles
- H: 6.7/1.01 = 6.67 moles
- O: 53.3/16 = 3.33 moles

Determine the simplest ratio

Divide the number of moles of each element by the smallest number of mles

The ratio of C:H:O = 1:2:1

They are close enough to whole numbers, and therefore don't need to be rounded.

## Empircal formula from % composition (cont)

The empirical formula would therefore be:

$CH_2O$

**Example**

Analyses of a compound found it to contain, by mass: 63.68% C, 12.38% N, 9.80% H and 14.14% O. Calculate the empirical formula for this compound

Carbon: 63.68/12.01 = 5.30

N: 12.38/14.01 = 0.884

H: 9.80/1.008 = 9.72

O: 14.14/16 = 0.900

Divide number of moles each by the smallest number, which is 0.884 from Nitrogen

5.30 and 8.884 and 9.72 and 0.900 all divided by 0.884

= 6, 1, 11, 1 after simplifying

= empirical formula becomes $C_6NH_{11}O_1$

Divide mass percentage of each element by its molar mass to find number of moles

Determine simplest whole-number ratio of moles by dividing each number of moles by the smallest number of moles

Write the empirical formula

Analyses of a compound found it to contain, by mass: 63.68% C, 12.38% N, 9.80% H and 14.14% O. Calculate the empirical formula for this compound

Carbon: 63.68/12.01 = 5.30

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Divide number of moles each by the smallest number, which is 0.884 from Nitrogen

5.30 and 8.884 and 9.72 and 0.900 all divided by 0.884

= 6, 1, 11, 1 after simplifying

= empirical formula becomes $C_6NH_{11}O_1$

## Mass of excess reactant

Write balanced equation, find limiting reactant, calculate theoretical yield of the product, and determine the excess reactant.
Now, calculate the amount left over by subtracting the amount of excess reactant that reacted from the initial amount of excess reactant given.
Convert to mass
Use the molar mass of the reactant to convert the amount of excess reactant left from moles to grams.

## Dilution

First determine initial volume and concentration of the solution before dilution
Then determine the final volume of the solution after dilution by adding the initial volume of the solution to the volume of the solvent added during dilution
Caclualte the initial amount of solute by using the initial volume and concentration to calculate the amount of solute (substance being diluted) present in the solution before dilution.
- Amount of solute (initial) = initial volume x initial concentration
Now determine the final concentration
- Final concentration = amount of solute (initial)/final volume

**if we dilute 100ml of a 1.0 M (concentration) of KCl to 400ml with 300ml of water, what will the final concentration be?**

Initial volume = 100ml
initial concentration = 1.0 M
Final volume = initial volume + volume of solvent added
= 100ml + 400ml = 500ml
Use the initial volume and concentration to calculate the amount of solute (KCl) present in the solution before dilution
- initial solute amount = initial volume x initial concentration
= 100ml x 1.0 M = 100 moles
Final concentration
= amount of solute (initial)/final volume
= 100 moles/500ml = 0.2 M

## A grams - B grams

Balance equation and identify given and unknown qualities.
Convert grams of A to moles
use the given mass of A and it's molar mass
- moles = mass (grams)/molar mass (grams/mol)
Use the molar ratios
Convert moles of A to B by using the molar ratio
- multiply A moles by appropriate molar ratio
Convert moles of B to grams
- mass (grams) = moles x molar mass (grams/mol)
Conclude by showing the mass of B formed or reacted based on the given mass of A

## Stoichiometry: Moles Formed in Reaction

Write balanced chemical equation
Identify the given and unknown qualities
- given: initial amount of moles
- unknown: moles that will be formed
Use the molar ratio to determine the answer
Example:
How many moles of SO3 will form when 3.4 moles of sulfur dioxide react with excess oxygen gas?
Write the balanced equation
Balance the equation for the reaction between SO2 and O2 to form sulfur trioxide
- SO2 + O2 --> SO3
- 2SO2 + O2 --> 2SO3
Given: 3.4 moles of SO2
Unknown: moles of SO3 formed
Use the molar ratio:
The balanced equation shows us that 2 mole of SO2 react to form 2 moles of SO3, which means the molar ratio between them is 1:1.
Therefore, if 3.4 moles of SO2 react, 3.4 moles of SO3 will form
The reaction proceeds to completion, meaning all of the reactant (SO2) is consumed and converted into products - there no limiting factors that would prevent the complete consumption of the reactant.

## Stoichiometry: Moles Formed in Reaction (cont)

In the reaction btwn SO2 and O2 to form SO3, if SO2 is provided in excess, it implies theres enough oxygen to completely react with the SO2 presented. Excess oxygen ensures that all the SO2 molecules will find oxygen molecules to react with, thus the reaction can occur till all the SO2 is consumed.
Because the reaction proceeds to completion and all the SO2 is consumed, the number of SO3 moles formed will be equal to the number of SO2 moles initially present.
Therefore, the number of moles of SO3 formed will also be 3.4 moles.
- 3.4 moles of SO3 will form when 3.4 moles of SO2 react with excess O2.

## Dilution p3

**Dilute 250 mL of a 0.100 M solution from a 2.00 M solution**
Initial volume = ?
Initial concentration = 2.00
Final volume = volume of diluted solution (250ml)
Final concentration = 0.100m
Calculate amount of initial volume
- since its unknown, we cant directly calculate the amount of solute from it, but we know that the amount of solute in the stock solution is equal to the amount of solute in the diluted solution after dilution (since no solute is added or removed during dilution)
So we can calculate the amount of solute using the final concentration and volume of the diluted solution.
Amount of initial solute = final concentration x final volume
= 0.100 M x 250mL = 25 moles
To find out how much of the stock solution (2.00M) we need to dilute to obtain the desired amount of solute (25 moles), we use this formula
- Final volume = Amount of solute (initial) / Initial concentration
= 25 moles / 2.00 M = 12.5 mL
Calculate amount of water needed
this is the difference btwn final volume of the stock solution and the volume of the diluted solution
Water needed = Final volume of the stock solution - Final volume of the diluted solution
= 12.5 mL - 250 mL = -237.5 mL

## Dilution p3 (cont)

The amount of water is negative so we dont need to add additional water to the stock solution for the desired concentration of 0.100M
We just remove 12.5mL of the stock solution and then add water to make up the remaining volume to reach 250mL, giving us the desired diluted solution with a concentration of 0.100M
Formula for dilution is C1V1 = C2V2, C1 and V2 are initial concentration and volume, and C2 V2 are final concentration and volume
Rearrange the formula to solve for v1
V1 = C2V2/C1
A laboratory technician is required to prepare 1.00 m3 of 0.100 M H2SO4. What volume of 10 M H2SO4 is required?
C1 = 10M, V2=1.00m^3, C2 = 0.100M
V1 = 0.100Mx1.00m^3/10M
= 10L