Basic Chemistry -Preparation for Grade 12 University Chemistry

Matter

<u>Chemistry:</u> study of matter and its reactions
<u>Matter:</u> anything that has mass and takes up space

Properties of Matter

<u>Physical properties:</u> physical appearance and composition of a substance
<u>Chemical properties:</u> ability to change into a new substance
<u>Chemical Change:</u> transformation into a new substance. Evidence of a chemical change includes:

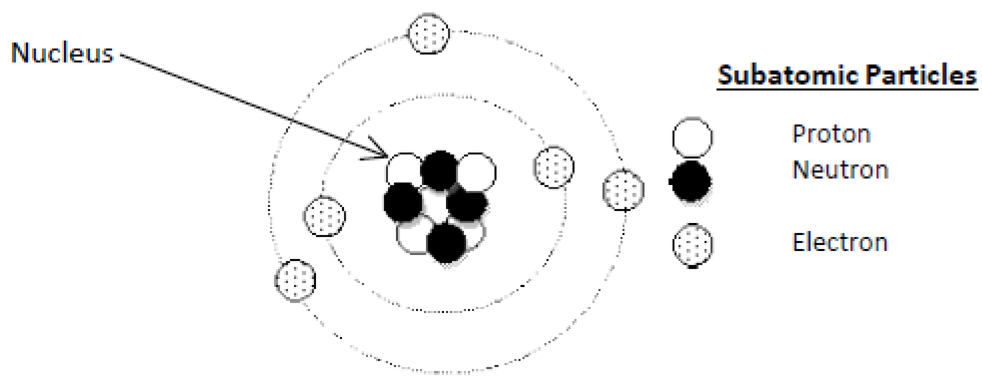
1. Colour change
2. Heat/light given off
3. Formation of precipitate
4. New substance formed
5. Difficult to reverse

Layout of the Periodic Table

Label the following on the attached periodic table: metals, non-metals, metalloids, transition metals

Atomic Structure

Atom: smallest unit of matter
The atom is made up of three subatomic particles: electrons, protons and neutrons.
The neutrons and protons are located within the <u>nucleus</u> and the electrons move around the nucleus.



Subatomic Particle	Charge	Location	Relative Mass
Electron	negative	Outside nucleus	1/1837
Proton	positive	nucleus	1
Neutron	neutral	nucleus	1

Periodic Table and Subatomic Particles

The number of each subatomic particle can be determined by using the periodic table.
<u>Atomic number:</u> equals number of protons/electrons
<u>Atomic mass:</u> equals number of neutrons **plus** number of protons

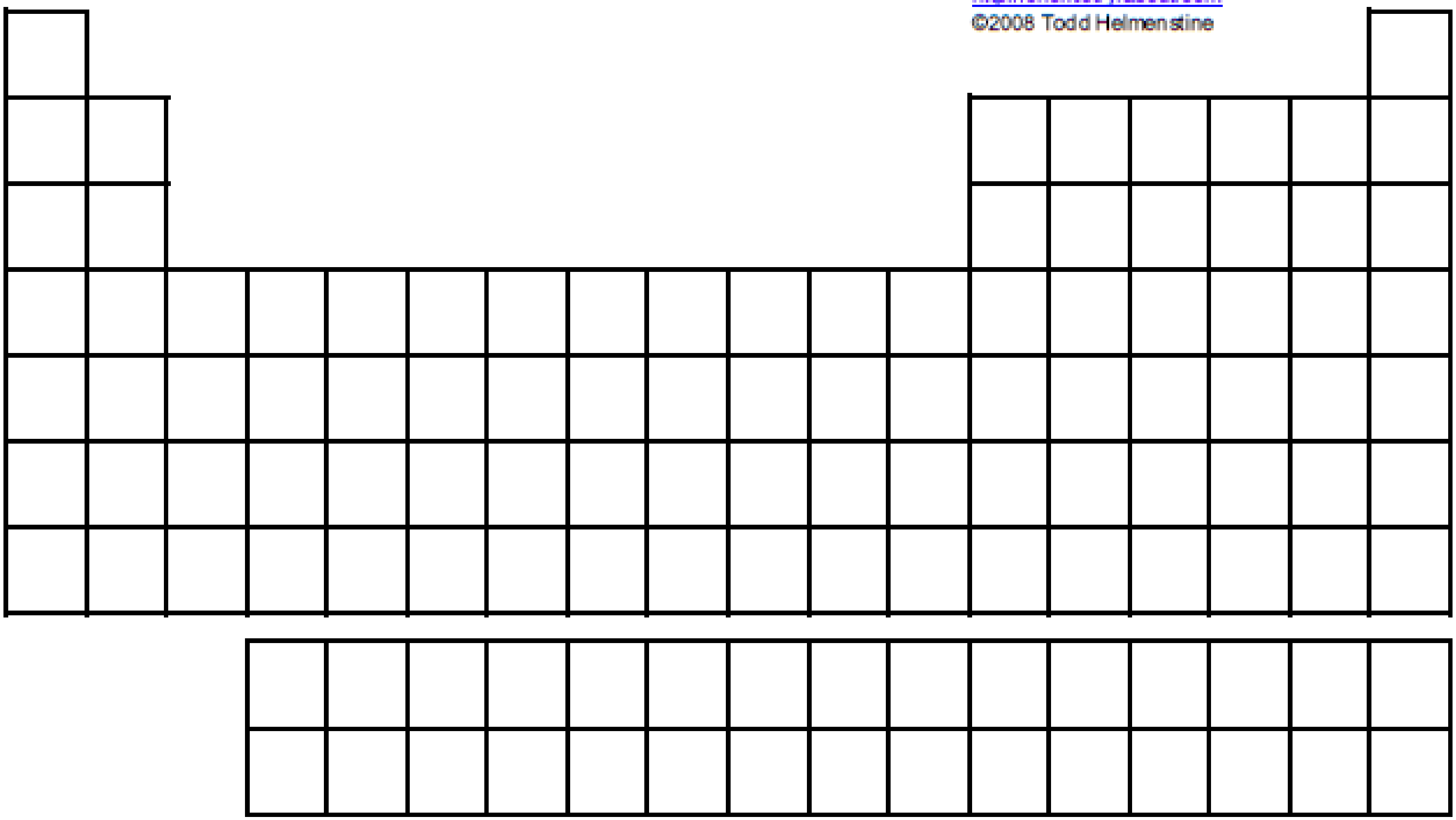
Eg. Lithium: atomic number = 3, atomic mass = 7
electrons = 3
protons = 3
neutrons = 7 -3 = 4

Eg. Nitrogen: atomic number = , atomic mass =
electrons =
protons =
neutrons =

***see attached practice*

Blank Periodic Table of the Elements

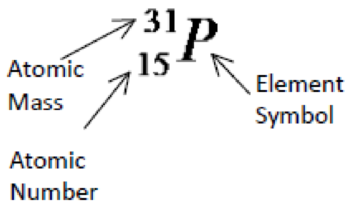
http://chemistry.about.com



Standard Atomic Notation

Periodic tables often change the format in location of atomic number and mass, but scientists have a set notation to easily represent an element's atomic number and mass.

Eg. Phosphorous Eg. Oxygen Eg. Sulfur



Bohr-Rutherford Diagrams

A simple way to represent a model of the atom is Bohr-Rutherford diagrams. In order to draw these diagrams, these rules must be followed:

1. Number of protons and neutrons are written in the nucleus.
2. Electrons fill the orbit closest to the nucleus and move outwards from there.
3. Electrons half-fill each orbit first before pairing up.
4. The maximum number of electrons in each orbit is 2, 8, 8, and 8. (Do not worry about elements with more electrons than this).

See attached for examples & practice.

Counting Atoms in a Compound

Before we look forming compounds, we need to learn how to count atoms in an compound. The rules for counting atoms in a compound are:

1) The **subscripts** (smaller numbers) represent the number of the atom immediately preceding it. If there is no subscript, it is assumed that a **one** is there.

Eg. $CaCl_2$ — Ca = , Cl =

Al_2O_3 — Al = , O =

(2) When a subscript is outside of brackets, it is multiplied by the subscripts of **each** element **inside** the brackets.

Eg. $Ca(OH)_2$ — Ca = , O = , H =

$Be_3(PO_4)_2$ — Be = , P = , O =

(3) If a **coefficient**(large number) is in front of the compound, it is multiplied by **every** element in the compound.

Eg. 2 Na_2S — Na = , S = , O =

3 $Mg(NO_3)_2$ — Mg = , N =

*** see attached practice*

Valence Electrons & Ions

When elements react with one another, it is the electrons that react. However, only the electrons in the outermost ring will be involved. These electrons are called valence electrons. It is important to know how many valence electrons each element has and it is quite easy to do so by looking at your periodic table.

Eg. Number of Valence electrons in: (a) O = (b) F = (c) Mg = (d) Al =

When elements react, they like to ensure their outermost orbit is full. And, from doing Bohr-Rutherford diagrams you know that the maximum number in an orbit is 8 (except H and He, which is 2). So atoms will either gain or lose electrons to meet this number, and the atom will now become an ion.

Ion: charged atom; caused by the addition/loss of electrons

To determine how many electrons an atom will gain or lose you:

(1) Count the number of valence electrons

(2) Add/Subtract (which is less) to reach 8 electrons

a) Adding electrons = negative ion (gaining negative charges)

b) Losing electrons = positive ion (losing negative charges)

Eg. Li Ca O F C Ne

Forming Compounds (Drop & Swap)

When two elements react together and bond, they form a compound. When they bond, positive ions will bond with negative ions to form the compound. Compounds are written as chemical formulae.

Example: lithium + oxygen

(1) Write the element symbol for each element (metal first) Li O

(2) Write the charge of each element $Li^{+1}O^{-2}$

(3) **Drop** the numbers down and **drop** the charges Li_1 O_2

(4) **Swap** the charges Li_2O_1

(5) Reduce to lowest terms and remove any ones Li_2O

Eg. Mg + S Na + C Al + S

*** see attached practice*

Naming Inorganic Compounds

<u>Ionic bond:</u> metal + non-metal --> write metal then non-metal with "ide" name

eg. NaCl = sodium chloride

* check if metal has multiple charges, if so use roman numerals or latin name

$FeCl_2$ = iron (II) chloride or ferrous chloride

$FeCl_3$ = iron (III) chloride or ferric chloride

<u>Covalent/molecular bond</u>: two non-metals --> write prefixes in front of both to represent how many atoms present

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

CO_2= carbon dioxide CO = carbon monoxide P_2O_3 =diphosphorous trioxide

<u>Polyatomic Ion:</u> covalent elements forming an ion; usually bonds with a metal --> write metal & polyatomic

NaOH = sodium hydroxide K_2CO_3= potassium carbonate $PbCO_3$= lead (II) carbonate

<u>Acid:</u> starts with "H"

(1) H + without oxygen --> use prefix "hydro", add "ic" to non-metal, then write "acid"

HCl = hydrochloric acid H_3N = hydronitric acid HCN = hydrocyanic acid

(2) H + with oxygen

a) Polyatomic ends with "ate" --> change to "ic", then write "acid"

HNO_3(hydrogen nitrate) = nitric acid

b) Polyatomic ends with "ite" --> change to "ous", then write "acid"

HNO_2(hydrogen nitrite) = nitrous acid

*** see attached practice*

Chemical Equations

(1) word equations: writes all chemicals involved in the reaction in words

Eg. sodium metal reacts with chlorine gas to form sodium chloride

(2) chemical equations: writes all chemicals involved as chemical formulae

Eg. Na (s) + Cl_2(g) --> NaCl (s)

Writing Word Equations as Chemical Equations

(1) all rules of drop & swap still apply

(2) all single elements are written by just their element symbol, eg. Na, Mg, Fe, etc.

Exception: the following elements are diatomic gases(gases that exist with 2 atoms):

I_2, H_2, N_2, Br_2, O_2, Cl_2, F_2 (**I** **H**ave **N**o **Br**ight **O**r **C**lever **F**riends)

** diatomic gases only exist as two by themselves! When they are in a compound, follow the rules of drop and swap based off of charges!!

(3) write the state of each compound in brackets after each compound

(s) = solid, (l) = liquid, (g) = gas, (aq) = aqueous --> dissolved in water

Determining State

(1) most elements are solids

(2) diatomic gases, and elements in far right column of periodic table are gases

(3) salts (end with -ide, -ite, -ous, -ate) are solids

(4) acids, solutions are aqueous

(5) water is liquid, water vapour is gas

(6) rest will be stated in question

*** see attached practice*

Balancing Chemical Equations

All chemical equations must be balanced to show that atoms are not created or lost. This involves placing coefficients in the equation to make sure the number of atoms on the left (**the reactants**) equals the number of atoms on the right (**the products**). To balance:

(1) Write word equation of chemical reaction

(2) Transform word equation into chemical equation

(3) Count number of atoms on both sides of equation

(4) Using coefficents, balance atoms individually on both sides (leave O and H to the end)

(5) Balance O and H

(6) Double check

*** see attached practice*

Types of Chemical Reactions

(1)Synthesis: two or more compounds coming together A + B --> AB

2Na + Cl_2 --> 2NaCl

(2) Decomposition: one compound breaking apart into two or more AB --> A + B

$2H_2O$ --> $2H_2$ + O_2

(3) Single Displacement: one element swapping places with another element in a compound A + BC --> B + AC

2K + FeO --> Fe + K_2O

(4) Double Displacement: two elements swapping places in two compounds AB +CD --> CB + AD

$AgNO_3$ + NaCl --> AgCl + $NaNO_3$

(5) Combustion: hydrocarbon plus oxygen yields carbon dioxide & water

CH_4 +O_2 --> CO_2 + H_2O

(6) Neutralization: acid (starts with "H") plus base (ends with "OH") yields water plus leftover salt

HCl + NaOH --> H_2O + NaCl

Stoichiometry

In chemistry, the most commonly used measurement is the mole. A mole is equal to 6.02 x 10^{23}particles! Often substances will be measured according to number of moles, moles/litre, etc.

*** use attached mole map for the following calculations!*

Moles vs. Number of Particles

When given the number of particles (eg. atoms, molecules, etc) and asked to find the number of moles, you divide the number of particles by **Avogadro's number (6.02 x 10^{23}).**

Eg. 1.53 x 10^{22}atoms ÷ 6.02 x 10^{23}= 0.0254 mol

When given the number of moles and asked to find particles, you multiply by Avogadro's number.

Eg. 1.51 mol x 6.02 x 10^{23}= 9.09 x 10^{23}atoms or molecules or particles, etc.

Note: a given number of moles will always equal the same amount of particles, regardless of what compound it is. Eg. 1 mole of $CaCl_2$ and 1 mole of NaOH will both have 6.02 x 10^{23}molecules

Moles vs. Mass

Molar mass (mm): how many grams there are in 1 mole of a substance. Use atomic masses from periodic table to determine molar mass.

Eg. Na	Cl	I
mm = 23 g/mol	mm = 35.45 g/mol	mm =
NaCl	P2O5	Fe(OH)2
mm = 23.0 + 35.45 = 58.45 g/mol	mm = (2 x 31.0) + (5 x 16.00) = 142 g/mol	mm =

When given moles and asked to find mass (m) , you multiply by the molar mass. ** mass is always in grams!

Eg. 3.2 moles of Ba(OH)2--> mmBa(OH)2= (137.3 + 2x16.00 + 2x1.01) = 171.32 g/mol

m = *n*x mm = 3.2 x 171.32 = 548.224 g

When given mass and asked to find moles, you divide the mass by the molar mass.

Eg. 50 g of NaCl --> mmNaCl= 23.0 + 35.45 = 58.45 g/mol

n= m/mm = 50/58.45 = 0.8554 mol

When given moles and mass and asked to find mm, you mass by moles.

Eg. 3 moles of a 426 g substance. mm = m/*n*= 426/3 = 142 g/mol.

Mass vs. Particles

Using a combination of the above 2 procedures, you can convert mass to particles and vice versa!

Mass --> Particles (m/mm x Avogadro's #)

Particles --> mass (particles/Avogadro's # x mm)

Determining Volumes of Gases

** **note:**the unit for pressure is kPa (kilopascals); the unit for temperature is K (Kelvin)

** to convert degrees celsius to Kelvin, **add 273**

Volume of a gas can be determined in one of 3 ways:

(1) **STP (Standard Temperature & Pressure)**

Constant temperature of 0˚C (273 K), pressure of 101.3 kPa, and molar volume of 22.4 L/mol

To find volume, V = *n*x 22.4

Eg. Calculate the volume of 3 moles of H_2gas at STP V = 3 x 22.4 = 67.2 L

(2)**SATP (Standard Ambient Temperature & Pressure)**
Constant temperature of 25˚C (298 K), pressure of 100 kPa, and molar volume of 24.8 L/mol
To find volume, V = *n*x 24.8
Eg. Calculate the volume of 3 moles of H_2gas at SATP V = 3 x 24.8 = 74.4 L
(3) **Other Temperatures & Pressures**
Use PV = nRT P = pressure (kPa), V = volume (L), n = moles, R = 8.31, T = temperature (K)
Eg. Determine the pressure of a 2.0 mol of gas at 15˚C, with a volume of 10 L.
T = 15 + 273 = 288 K
PV = nRT P = nRT/V = (2.0 x 8.31 x 288) / 10 = 478.7 kPa

Some Things to Know About Solutions

Solute: substance that is dissolved in another
Solvent: substance dissolving the solute
Soluble: can dissolve in a known solvent
Insoluble: cannot dissolve in a known solvent
Sparingly soluble: dissolves to an extent in a known solvent

Types of Solutions

Saturated: maximum amount of solute is dissolved
Unsaturated: more solute could be dissolved
Supersaturated: more than the maximum amount of solute is dissolved

Dissolving Ionic Compounds in Water

When an ionic compound dissolves in water, it separates into its ions.

Eg. $NaCl (s) \rightarrow Na^{+} (aq) + Cl^{-} (aq)$

Eg. $CaCl_2 (s) \rightarrow Ca^{2+} (aq) + 2Cl^{-} (aq)$

Practice. *Write balanced ionic equations for the following substances.*

a) *BaO*
b) *CuF_2*
c) *$NaHCO_3$*

Determining Concentration of a Solution

Concentration: the amount of solute dissolved in a solvent.
c = n/V c = concentration (mol/L or M), *n*= moles (mol), V = volume (L)
** also called molar concentration!!
Eg. What is the concentration of 15 g of NaCl dissolved in 100 mL of water?
n_{NaCl}= m/mm = 15/58.45 = 0.2566 mol V = 0.1 L
c = n/V = 0.2566/0.1 = 2.566 mol/L or 2.566 M

Other measurements of Concentration

Mass/ volume percent (**m/v % = mass of solute/vol of sol'n * 100**)
Mass/mass percent (**m/m % = mass of solute/mass of sol'n * 100**)
Volume/volume percent (**v/v % = vol of solute/vol of sol'n * 100**)
Parts/million (**ppm = mass of solute/mass of sol'n * 10^6**)

Dilutions and Serial Dilutions

Often solutions are not at the required concentration and must be diluted, sometimes several times, to reach the desired amount.

Dilution $$\frac{[solution]}{V_{to\_use}} = \frac{[needed]}{V_{needed}}$$

Eg. How would you make a 10 mL solution that is 2 M, if you are given a 5M solution to work with?

Serial Dilution: Making a solution repeatedly more dilute using a dilution factor.
Dilution Factor: How much you are diluting a solution. For example, a solution with a factor of 1:100 contains 1 part solution, 99 parts water.

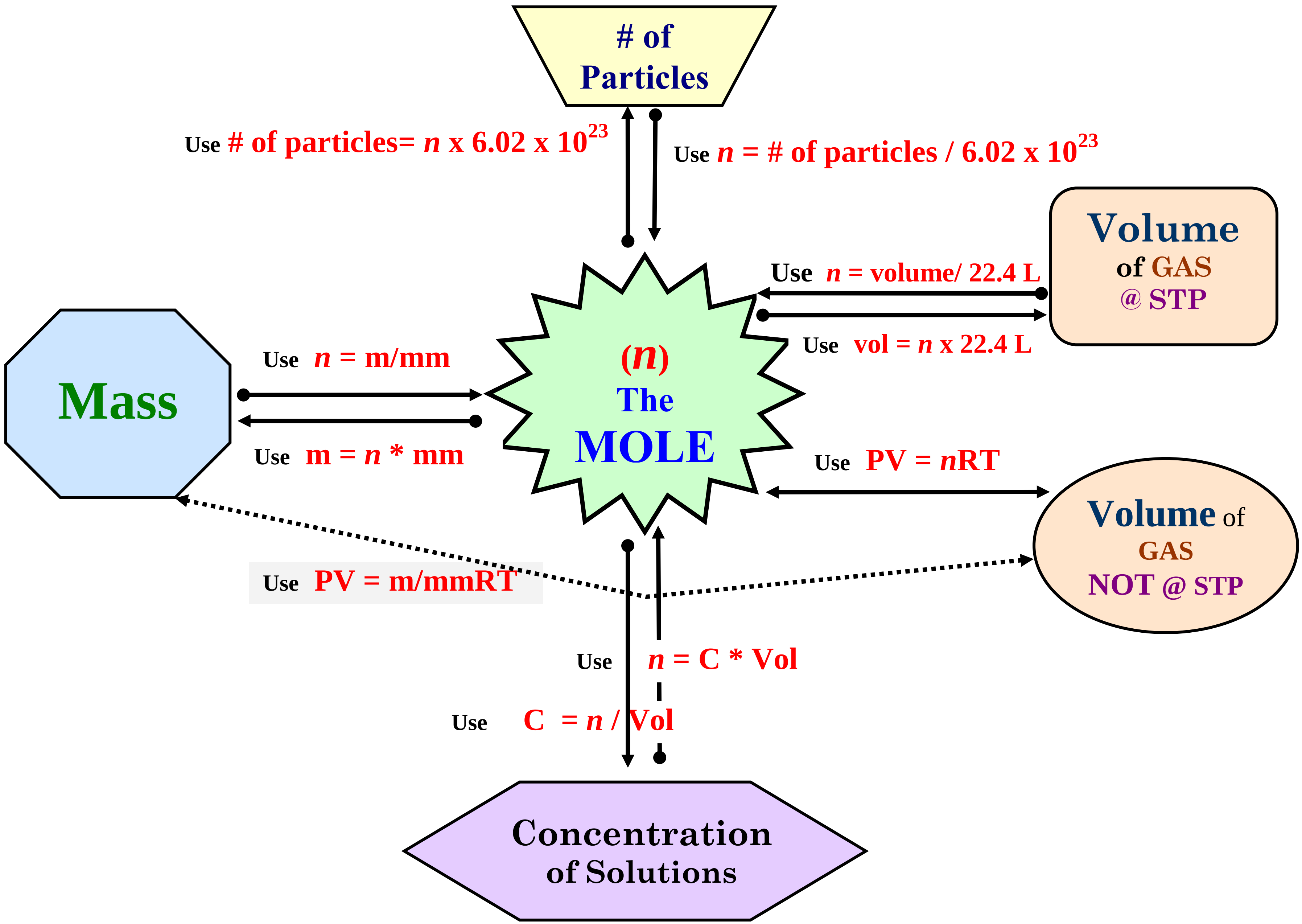
Eg. How would you dilute a 10 mL solution of sodium chloride to 1/100 of it's original [ ]?

Other Concentration Calculations

In other situations you will be informed of the concentration of a solution and you must calculate how much you will use. This is particularly useful in the medical field

Eg. A particular drug is to be administer at 0.2 mg/mL/kg. A patient is 40 kg. What volume of the drug would be administered?

THE MOLE MAP



# of Particles
Use # of particles= n x 6.02 x 10^23
Use n = # of particles / 6.02 x 10^23
Volume of GAS @ STP
Use n = volume/ 22.4 L
Use vol = n x 22.4 L
Mass
Use n = m/mm
Use m = n * mm
(n) The MOLE
Use PV = nRT
Volume of GAS NOT @ STP
Use PV = m/mmRT
Use n = C * Vol
Use C = n / Vol
Concentration of Solutions

FLOWCHART FOR NAMING SIMPLE INORGANIC COMPOUNDS