What is Chemistry?

→ The study of matter and changes in matter.

* matter is anything that has mass and takes up space.

Vocabulary

Pure Substance → composition is constant & uniform.

Mixture → (impure substance) composition is variable and may or may not be uniform throughout the sample.

Heterogenous mixture → non-uniform and may consist of more than one phase.

Homogenous mixture → uniform and consist of only one phase

Solutions → pure substances and homogeneous mixtures.

Chemical Decomposition → separating a compound into its elements.

Elements → cannot be broken down into simpler chemical substances by physical or chemical means.

Atom → the smallest particle of an element that is still characteristic of that element.

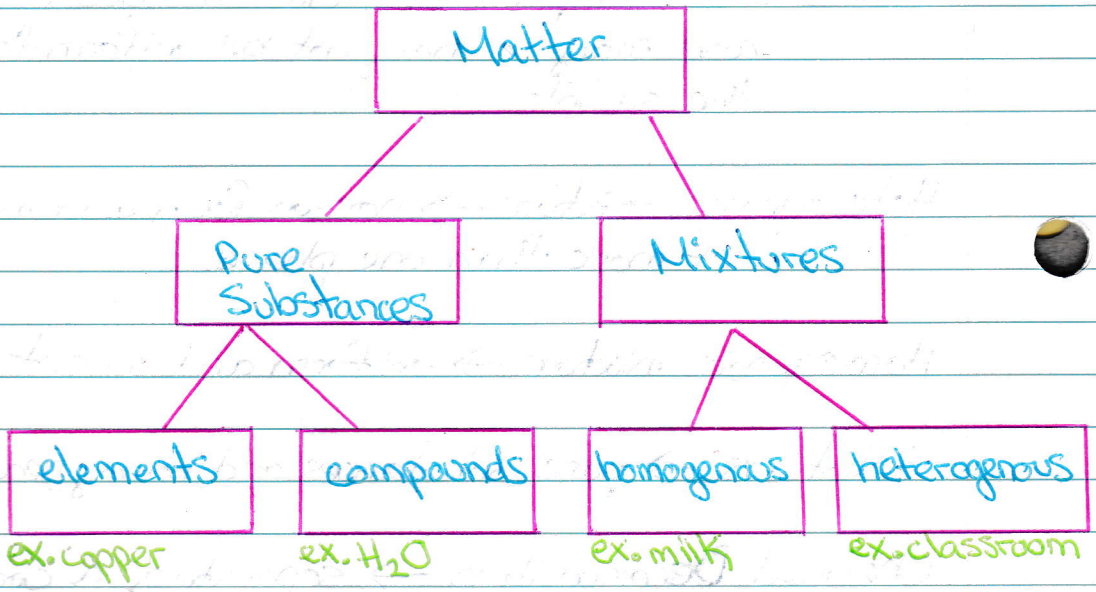
Compounds → contain atoms of more than one element combined in a definite fixed proportion.

Molecules → distinct particles composed of two or more atoms.

Classifying Matter

1) Pure Substances: can either be elements or compounds

2) Mixtures: Homogenous (looks the same throughout)
Heterogenous (visible differences throughout)



How are compounds broken down into elements?
→ heating, electrical current

Elements

- all elements have mass
- melting, freezing points
- all listed on the periodic table
- elements are composed of the same atom type
- pure substances that cannot be broken down any further.
- elements can be represented by symbols.
  1) can be one capital letter. ex. (K)
  2) can be 2 letters, one capital, one lower case. ex. (Sn)

- elements can be metals or non-metals
- some elements bond to themselves forming diatomic elements:

7 diatomics: Oxygen (O_2)
Iodine (I_2)
N_2, F_2, Cl_2, Br_2, H_2

Compounds

- pure substances made of 2 or more elements.
- represented by chemical formulas ex. KNO_3, H_2O

2 Types:

1) Ionic - metal & non-metal
   - held together by opposite charges
   - ionic solutions conduct electricity ex. NaCl

2) Covalent - 2 non-metals
   - held together by sharing electrons (molecular)
   ex. CO_2, NO

3. Classify each of the following chemicals as elements or compounds.
   (a) $C_{12}H_{22}O_{11(s)}$ (sugar)
   (b) $Fe_{(s)}$ (in steel)
   (c) $CO_{(g)}$ (poisonous)
   (d) sodium chloride (salt)
   (e) oxygen (20% of air)
   (f) calcium (reactive)
4. Classify each of the following elements as metals or nonmetals.
   (a) lead (poisonous)
   (b) phosphorus (reactive)
   (c) chlorine (poisonous)
   (d) $U_{(s)}$ (nuclear reactors)
   (e) $Hg_{(l)}$ (liquid)
   (f) $Br_{2(l)}$ (liquid)
5. Classify each of the following compounds as ionic or molecular.
   (a) $C_6H_{12}O_{6(s)}$ (glucose)
   (b) $Fe_2O_3 \cdot 3H_2O_{(s)}$ (rust)
   (c) $H_2O_{(l)}$ (water)
   (d) nitrogen dioxide (pollutant)
   (e) potassium chloride (fertilizer)
   (f) zinc sulfide (zinc ore)
6. Draw a flowchart showing the classification of pure substances, elements, metals, nonmetals, compounds, ionic, and molecular.
7. Why do chemists create classification systems for chemicals?

3 a) compound
b) element
c) compound
d) compound
e) element
f) element

4a) metal
b) non-metal
c) non-metal
d) metal
e) metal
f) non-metal

5a) molecular
b) ionic
c) molecular
d) molecular
e) ionic
f) ionic

Predicting Names and Formulas of Binary Ionic Compounds

- the metal is always named or written first.
- the non-metal change its suffix to -ide

Naming:

$NaCl \rightarrow$ sodium chloride

sodium + chlorine

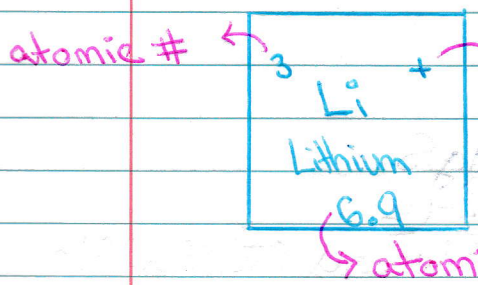
$MgO \rightarrow$ magnesium oxide

$AlCl_2 \rightarrow$ aluminum chloride

$K_2S \rightarrow$ potassium sulphide

$Ca_3N_2 \rightarrow$ calcium nitride

Writing Formulas for Binary Ionic Compounds



ex. Sodium Chloride

Na^{+1} Cl^{-1}

1 1 $= NaCl$

ex. Aluminum Chloride

Al^{+3} Cl^{-1}

1 3 $= AlCl_3$

ex. Calcium Nitride

Ca^{+2} N^{-3}

3 2 $= Ca_3N_2$

PRACTICE QUESTIONS

1) CaO = calcium oxide
2) $CaCl_2$ = calcium chloride
3) ZnS = zinc sulphide
4) MgO = magnesium oxide
5) BeF_2 = beryllium fluoride

6) Lithium Bromide = $LiBr$
7) Sodium Oxide = Na_2O
8) Potassium Iodide = KI
9) Magnesium Nitride = Mg_3N_2
10) Calcium Sulfide = CaS

Multivalent Metals

$Mn^{+2,+3,+4}$ ← most common charge written first.

Iron (III) oxide

Fe^{+3} O^{-2}

$= Fe_2O_3$

HgS

$(+2)+(-2)$

∴ Mercury (II) Sulphide

FeO

$(+2)+(-2) = \emptyset$

MnO_2

$+4$ -2^2

$+4$ -4

∴ Manganese (IV) Oxide

1) Determine the negative charges present.
2) Determine the positive charges needed to add to zero.

PRACTICE QUESTIONS

1) Cobalt (II) Fluoride = CoF_2
2) Nickel (III) Nitride = NiN
3) Vanadium (V) Oxide = V_2O_5

4) $CuCl$ = Copper (I) Chloride
5) Cr_2S_3 = Chromium (III) Sulphide
6) $AuBr_3$ = Gold (III) Bromide
7) $CoCl_3$ = Cobalt (III) Chloride
8) Ni_3N_2 = Nickel (II) Nitride
9) Ti_3P_4 = Titanium (IV) Phosphide
10) Mn_3P_4 = Manganese (IV) Phosphide

Ionic Compounds Containing Polyatomic Ions

- ions that contain multiple atom types covalently bonded.
- if the name does not end in -ide, look at the polyatomic ion table.

ex. carbonate CO_3

$CaCO_3$ = calcium carbonate
Li_2CrO_4 = lithium chromate
$Al(NO_3)_3$ = aluminum nitrate
$Co_2(CO_3)_3$ = cobalt carbonate

Potassium Permanganate = $KMnO_4$
Magnesium Phosphate = $Mg_3(PO_4)_2$
Calcium Nitrate = $Ca(NO_3)_2$
Sodium Borate = Na_3BO_3
Iron (III) Sulfate = $Fe_2(SO_4)_3$

Ionic Summary

- is it ionic? metal + non-metal
- is the metal multivalent? Roman numeral
- is there a polyatomic ion present?

Naming & Writing Formulas for Covalent (Molecular) Compounds

Covalent molecules: non-metal + non-metal

ex. CO_2 = carbon dioxide

* prefixes are used to indicate the number of atoms present.

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

PRACTICE QUESTIONS

1) N_2O = dinitrogen monoxide
2) NO_2 = nitrogen dioxide
3) NO_3 = nitrogen trioxide
4) N_2O_4 = dinitrogen tetraoxide
5) Tetraphosphorus Decaoxide = P_5O_{10}
6) Sulfur dioxide = SO_2

Review

* When naming or writing formulas, watch for 2

m + nm
1. Ionic — or — nm + nm Covalent

Covalent → use prefix system

Ionic → 2. Polyatomic Ions, Multivalent metal

Polyatomic Ions → no "ide" ending; more than 2 elements

PRACTICE QUESTIONS

1) $NaHS$ = sodium hydrogen sulfide
2) MgO = magnesium oxide
3) CO = carbon monoxide
4) $Mg(ClO_3)_2$ = magnesium chlorate
5) S_2F_{10} = disulpher decafluoride
6) Ammonium sulfite = $(NH_4)_2SO_3$
7) Potassium Acetate = KCH_3COO
8) Vandium (V) chromate = $V_2(CrO_4)_5$
9) Gallium Phosphate = $GaPO_4$
10) $Fe_2(SiO_3)_3$ = Iron (III) Silicate
11) $CuMnO_4$ = Copper (I) permanganate
12) Diiodine hexachloride = I_2Cl_6
13) Triphosphorus heptachloride = P_3Cl_7
14) Calcium Carbonate = $CaCO_3$
15) S_4O_8 = tetrasulfur octaoxide

This assignment is to be handed in for marks.

1. Write the name or the formula for the following compounds. Each question is worth 2 marks.

a) LiBr

b) Na_2S

c) Cu_2O

d) Mn_2Te_3

e) Ca(HS)2

f) $Sc_2(CO_3)_3$

g) Be_3N_2

h) NO_2

i) H_2SO_4

j) P_3S_5

k) $Mn_3(PO_4)_2$

l) $Be(OH)_2$

m) HBr

n) Iron (III) tetraborate

o) tetrasilicon heptafluoride

p) ammonium nitrate

q) scandium oxide

r) chlorous acid

s) gold (I) sulfide

t) sodium hydroxide

Naming & Writing Formulas For Acids and Bases

ACIDS → ionic compounds with hydrogen on the left of their formulas
→ pH is less than 7
ex. HCl hydrochloric acid

3 Rules for naming Acids, all based on the negative ion.

① If negative ion ends in **-ide**, the acid is called hydro_____ic acid

Formula → IUPAC name → common name

HCl → hydrogen chloride → hydrochloric acid
HBr → hydrogen bromide → hydrobromic acid
HF → hydrogen fluoride → hydrofluoric acid

ex. going backwards
hydrophosphoric acid → hydrogen phosphide → H_3P

② If negative ion ends in **-ate**, the acid is called _____ic acid.

Formula → IUPAC name → common name

H_2SO_4 → hydrogen sulphate → sulfuric acid
H_2CO_3 → hydrogen carbonate → carbonic acid

ex. going backwards
phosphoric acid → hydrogen phosphate → H_3PO_4

③ If negative ion ends in **-ite**, then the acid is called _____ous acid.

Formula → IUPAC name → common name

H_2SO_4 → hydrogen sulfite → sulphurous acid
HNO_2 → hydrogen nitrite → nitrous acid

ex. going backwards
chlorous acid → hydrogen chlorite → $HClO_2$

BASES → contain (OH) on the right side of formulas.
→ pH is greater than 7.
→ no common names
ex. NaOH Sodium hydroxide

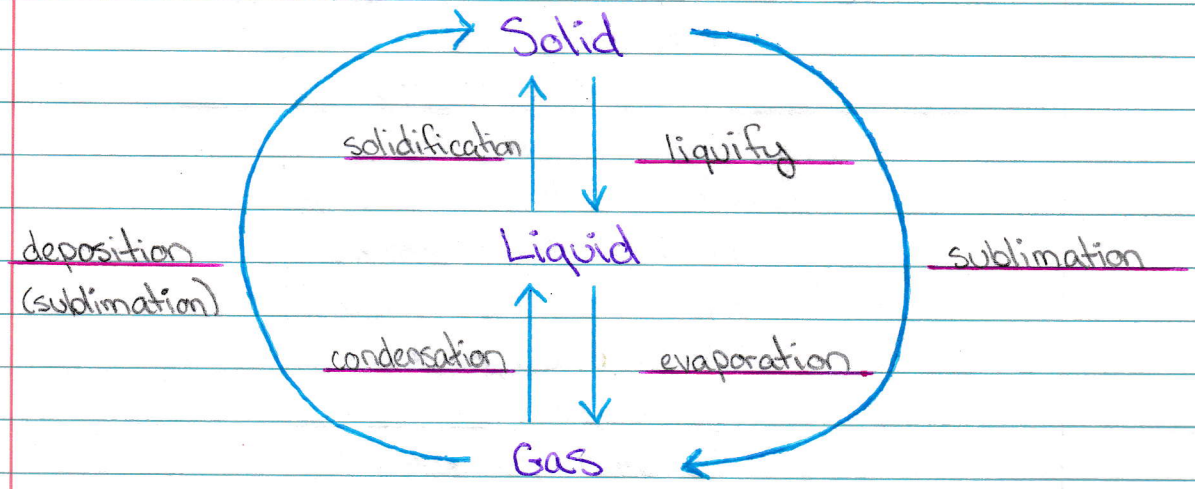
PRACTICE QUESTIONS

1) H_2S = hydrosulfuric acid
2) H_2CrO_4 = chromic acid
3) $HClO$ = hypochlorous acid
4) hydrophosphic acid = H_3P
5) carbonic acid = H_2CO_3
6) nitrous acid = HNO_2
7) $LiOH$ = lithium hydroxide
8) Beryllium hydroxide = $Be(OH)_2$

Changes in Matter

→ Matter can change in 3 ways:
1) Chemical
2) Physical
3) Nuclear

Chemical	Physical	Nuclear
- chemical bonds are broken - new substances are formed. - color change & odour produced. - involve a medium energy ex. $2H_2O \rightarrow 2H_2(g) + O_2(g)$ burning/combustion $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ rotting	- properties of matter stay the same. - chemical formulas are unchanged. - spaces between molecules can change. ex. state changes, dissolving $NaCl(s) \rightarrow Na^+ + Cl^- + H_2O$	- changes in an atoms nucleus. - new elements are produced. - radiation is released. - involve a large amount of energy. ex. $Ra \rightarrow Rn + He$ $Po \rightarrow Pb + He$



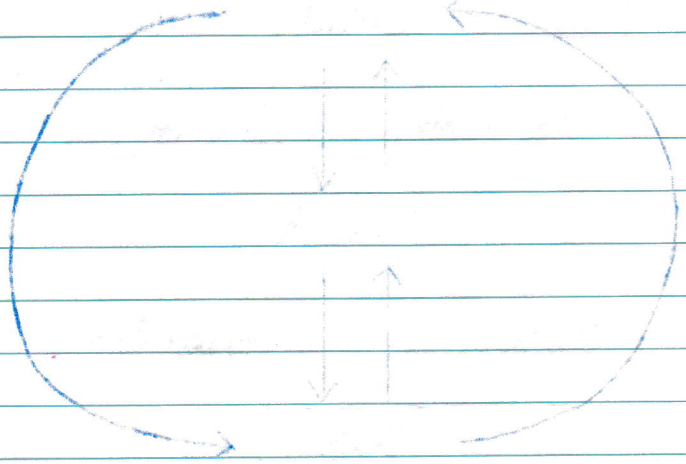
ex. $H_2O(s) \xrightarrow{\text{energy}} H_2O(l) \xrightarrow{\text{energy}} H_2O(g)$

QUESTIONS:

1) Provide 2 examples each for a physical change, a chemical change and a nuclear change.
Physical → dissolving salt, solidify water
Chemical → rotting fruit, wood burning
Nuclear → nuclear bomb, x-ray radiation

2) Compare the energy changes involved in physical, chemical and nuclear changes.
Physical — low
Chemical — ↓
Nuclear — high

3) For each type of change, describe which actual particles or property of matter is being rearranged.
Physical → spaces between particles
Chemical → elements are being rearranged, and chemical bonds are rearranging, new molecules are forming.
Nuclear → nuclear bonds



Physical Properties

→ properties we can see, hear, smell, or feel.

- color
- odor
- density
- boiling point
- melting point
- viscosity

→ measurable without destroying matter

Chemical Properties

→ how matter reacts with other matter.

→ matter will be changed after the reaction

- combustability
- reactivity with acids/bases

Technique	Description	Examples
pg 38-39 Mechanical	One or more components are picked out of the mixture either manually or by use of a magnet for magnetic substances (iron, cobalt, nickel)	Aluminum recycling
Settling	Some heterogeneous mixtures can be separated by letting one of the components settle to the bottom. Spinning the mixture at high speed (centrifuging) may be used to accelerate this process.	A water treatment settling tank.
Flotation	Oil, detergents, or other chemicals are added to the heterogenous mixture and air is blown through. The froth containining desired component floats, and is skimmed off the surface.	A flotation tank in a metal refinery.

Technique	Description	Examples
Filtration	a heterogeneous mixture, usually a solid in a liquid or gas, is passed through a screen or filter. The solid is trapped and separated from the liquid or gas.	an ordinary furnace filter separates dust and other particulates from the air.
Extraction	the mixture is mixed with a solvent that dissolves one or more, but not all, components. For example, table salt and sand can be separated by using water to dissolve (extract) the salt.	a coffee maker uses hot water to extract some of the components from ground coffee beans.
Fractional Distillation	A liquid mixture is boiled and one or more components are separated as they vaporize from the mixtures at different temperatures.	Oil refinery has fractional ~~components~~ distillation towers to separate the various components of crude oil.
Crystallization	A dissolved solid is separated from a solution by cooling or concentrating the solution to crystallize the solid.	Crystallization occurs naturally as salt water evaporates.
Chromatography	A mixture is carried by a solvent through a stationary, porous medium such as a column of solids or a filter paper. Separation occurs because components of the mixture move at different rates in the porous medium.	Paper chromatography reveals the components of a variety of industrial dyes.

Separating Mixtures

→ mixtures can be homogenous or heterogenous

* matter rarely exists in a pure form.
* chemists often must separate mixtures into pure components
* society uses matter in its pure form often:
  - Copper - used for electrical wires
  - Gold - used in jewellery
  - Nickel - coins, batteries
  - Tungsten - hard steel
  - H_2O - drinking & bathing