Grade 9 Unit B Notes
Matter and Chemical Change

CHEMISTRY – Greek for "khemeia", - juice of a plant

1.1 Safety In The Science Laboratory & WHMIS

See textbook (discussed in class)

1.1 Organizing Matter

Matter - anything that has mass and occupies space.
States of Matter
a) solid e.g. Iron
b) liquid e.g. Water
c) gas e.g. Oxygen.
Changing From One State To Another (Details on P. 99)
a. Melting- solid to liquid. Usually requires addition of heat energy.
b. Evaporation (vaporization) – liquid to gas. Requires heat energy.
c. Condensation – gas to liquid. Loss of heat energy.
d. Freezing – liquid to solid. Loss of heat energy
e. Sublimation – solid to gas (bypass liquid stage) e.g. $CO_{2(s)}$ to $CO_{2(g)}$
f. Deposition – gas to solid

Properties of Matter – characteristics that identify a specific type matter.
Physical change - state of matter changes but chemical composition stays the same.
Physical properties - colour, luster (shininess), melting temp, freezing temp, boiling temp, (List at top of P 99. text)
Chemical change - occurs when two or more substances react to form one or more different substances.
Chemical properties - describes how a substance interacts with other substances e.g. Reaction with acids, ability to burn, rxn with water, behavior in air, rxn to heat

Pure substance - is made up of one kind of matter with unique properties of its own.

i. Elements: - matter that cannot be broken down into any other simpler substance
-only contain one type of atom
- represented by a capital letter or capital letter followed by one or two lower case letters.
[Organized in the Periodic Table of Elements]

ii Compound - a substance formed by chemically combining two or more elements chemically in fixed proportions e.g. H_2O – two atoms of H + 1 atom of O.

Mixture - two or more substances physically (not chemically) combined

- possesses properties of all ingredients

Types of Mixtures:

a. **Heterogeneous mechanical mixture** e.g. Dirt – some or all particles are visible and this mixture may be physically separated by screens or manually by mass e.g. Gold in sand or wheat and chaff
b. **Homogeneous mixtures (solutions)** – one substance dissolved in another. If a substance is dissolved in water it is an aqueous solution.
c. **Suspension** - when the dissolved medium is suspended in the dissolving medium e.g. Smoke, blood cells in plasma. The constituents may be separated by centrifusion or filtration.
d. **Colloid** - usually a cloudy mixture where the particles are suspended and difficult to separate e.g. Cell contents, or milk

[**Refer to Concept map on page 103]**

1.3 Observing Changes in Matter

- Changes in matter may be difficult to see.

Physical change – when a substance changes appearance or state, but does not change in composition.

Chemical Change - two or more materials react to form one or more different materials. The new material(s) formed have completely different properties from the original reactant materials e.g. $H_2O_{(l)} + CO_{2(g)} = C_6\,H_{12}O_{6(s)}$

- To identify a chemical change, look for following evidence
  a. Change in colour
  b. Change in odour (if present)
  c. Formation of a solid or gas
  d. Release or absorption of thermal energy

[Practical Applications of Matter Changes – P108]

Freeze Dried Food - steps in preparation

a. foods frozen-water turns to ice
b. food subject to low pressure - ice to gas
c. water gas is removed
d. freeze dried food tleft behind (10% original mass)

- Other useful matter change applications at top of P.109

2.0 Understanding Matter Over Time

2.1 Evolving Theories Of Matter

A. Stone Age Chemists:

- lived before 8000 BC in Middle East

- metals not discovered yet
- used "stone" tools
- learned to start, control and use "fire" usefully e.g. Cooking, glass, ceramics and bricks.

B.6000BC-1000BC

- chemists worked with metals of high value to humans
  gold: lusterous, ductile, malleable, no tarnish
- copper: ductile and malleable when heated e.g. Pots, coins, tools jewelry
- ____________: 4500BC, made from copper and tin for "strong" weapons and tools
- iron: 1200BC – middle east Hittites extracted iron form rock then came iron +carbon = steel which was used for hardened weapons, armour and tools.
- During this time, extensive attempts were made to extract natural plant juices and oils for human use
  e.g. _____________ - mummies wrapped in juniper resins

Describing and Defining the composition of Matter (Atoms) – Past to Present

2500 BC Greeks broke rocks down into powder

_______ BC – Greek philosopher Democritus developed the word "atomos" (indivisible) smallest particle you can break matter down into. Democritus believed each different type of matter had its own different "___________" that gave each material its own unique set of properties. By mixing different atomos, it gave you different materials with different unique properties.

350BC - _____________ hypothesized that all matter was composed of earth, air, fire and water. He was more famous and respected that Democritus therefore his description of matter was preferred and accepted till the mid 1600's AD.

350BC – 1600 AD - numerous alchemists (Arabic for "alkimiya" – the chemist) practiced their pseudo-science (magic and simple experiments) trying to change various metals into gold. Alchemists contributed useful lab tools from their practice e.g. Beakers, filters and flasks. They even discovered plaster of Paris used today in orthopedic casts.

1597AD- German alchemist, Andreas Libau published the first chemistry text – "_______________"

1500's AD on – scientists had greater interest in nature of matter and change and based their theories on observations and experimentation rather than guesses and conjectures.

1600's – Robert Boyle experimented with gases and came up with proof supporting 400BC Democritus's tiny particle theory. Boyle believed matter was composed of tiny particles with _____________ shapes and sizes that grouped together to form other individual substances. He wanted to determine what each type of particle was.

1770's – Antoine Lavoisier (French scientist) studied chemical interactions and naming the elements: hydrogen, oxygen and carbon. He was given the title of "___________ of Modern Chemistry."

1808 – John Dalton (English scientist), suggested matter was made up of elements that are pure substances that contain no other substances. He put forward the first modern theory of atomic structure i.e. each element is composed of a particle called an atom. All atoms of a specific element have identical masses. Different elements have different atoms of different masses. He developed the "___________ ball model" i.e. atoms are solid spheres.

Later 1800's – J.J. Thompson (British physicist), discovered negatively charged sub-atomic particles electrons. He proposed the "__________ bun model" of atomic structure i.e. Atom is a positive centre with negative electrons embedded in it like raisins in a bun (see P 119-Fig. 2:14). Electrons balance protons therefore atom has no electrical charge.

1904 – Hantara Nagaoka (Japanese Physisist), proposed an atomic model that resembled a miniature __________ system (Fig. 2.5). The center had a large positive charge and negative electrons circled the positive center like planets orbiting the sun.

1908 – Ernest Rutherford (British scientist), working at McGill won the Nobel Prize for work in radioactivity. (Fig. 2.16). His model suggests that atoms were empty spaces which positive particles could pass thru with a positive central core (nucleus). He calculated the nucleus to be 1/10000 size of an atom. Like comparing a small green pea in a _____________ field.

1922- Niels Bohr, Nobel Physics Prize, subjected that electrons move in specific circular orbits (electron shells) and they jumped between shells by ____________ or ____________ energy. (Fig 2.18)

Late 1920"s – James Chadwick (British Physisist), discovered the nucleus contains protons (+ charge) and neutrons (no charge). Protons and neutrons have same masses. Electron has __________ of 1/1832 of either a proton or neutron.

Early 1930's – Quantum Theory, explains electrons existing in a charged _________ around the nucleus (Fig. 2.10).

2.2 Organizing and Naming Elements

- Early chemists looked for "patterns and property similarities" between elements.
- This idea didn't work because chemists grouped patterns differently.

Early 1800's – John Dalton (English chemist), developed symbols for the elements known at that time (Fig. 2.22). His system was too hard and confusing.

1814 – Jons Berzelius (Swedish chemist), used the first letter (capitalized) of the element name as the symbol e.g. hydrogen H. If there were more than two elements starting with same alphabetical letter – use a small second letter behind the capital e.g. helium He. This system prevails today.

Putting Elements Into Some Order – Past to Present

Atomic Mass: is the average mass of one atom of an element compared to a standard Carbon atom at ________ amu's (atomic mass units).
One could now list atoms in order of increasing atomic mass.

1864: John Newlands (English chemist), recognized a pattern when elements were listed by increasing atomic mass i.e. element's properties repeat themselves at regular intervals.

1869 Dmitri Mendeleev (Russian chemist), organized elements according to patterns in the properties of the elements. He showed that properties of elements vary periodically with _____________ atomic masses. His chart had "gaps" for future elements to be discovered that had properties and atomic masses to fit those gaps.

2.3 Today's Periodic Table

Mendeleev's chart had 63 elements. Today, a Periodic Table has around _____ elements. Some of these elements are very unstable and were discovered using closed laboratory conditions.

How Today's Periodic Table is Organized

________ – 7 horizontal rows
_________ (Family) – 18 vertical columns (each Family has similar chemical properties.
Each element box contains:

- full name of the element (under the symbol)
- element's symbol – abbreviation for the name in the center of the box
- where discovered e.g. Au – aurum- gold or Ca – Californium
- who discovered it e.g. Curium – Marie Curie.

Atomic Number - __________ the symbol

- Indicates # protons or electrons in an electrically neutral atom
- Atomic numbers increase by one from left to right within the "Periods".

Atomic mass – number below the name

Total mass of all protons and neutrons in the nucleus i.e. average mass of element's atoms

Atomic mass measured in amu's – atomic mass units where one amu = 1/12 mass of a carbon-12 atom. Each has a mass of 1 amu.

Mass number – is the sum of the number of __________ and ___________ in an electrically neutral atom.

#neutrons =mass number – atomic #

<u>See Periodic Table of Elements on page 126 & 127</u>

METALS - shiny, malleable, ductile, conduct electricity.

Found on the left side over to the right past middle (Lithium 3 to Polonium 84)

NON METALS - solids (dull and brittle) or gases, don't ____________ electricity (insulators)

On far right- Carbon 6 to Radon 86

METALOIDS OR TRANSITION ELEMENTS - have both metallic and non-metallic properties. Found between metals and non-metals.

GROUPS -18 vertical columns referred to by the first element in the column. All elements in group columns have similar appearance and _____________.

PERIODS - 7 horizontal rows. Left metals to right non-metals. E.g. period 4 K (metal) to Kr (non-metal). Left side is more chemically reactive than the right side, which is less chemically reactive

GROUP 1 ELEMENTS: (not including H) are **"<u>alkali metals,</u>"** most chemically reactive with air or water. Reactivity increases as you go down the group.

GROUP 2 ELEMENTS - "<u>alkaline-earth metals,</u>" also react with air or water but not as vigorously as Grp. 1.

GROUP 17 - "__________" – most reactive non-metals. E.g. Fl, Cl, Br all react readily with Group 1 elements to produce useful compounds e.g. NaCl – common table salt.

GROUP 18 - "_____________" – very stable and unreactive. These gases combine with other elements under specialized lab techniques.

<u>3.1 Naming Chemical Compounds (Nomenclature)</u>

______________ – two or more different elements chemically combined.

Chemical formula e.g. NaCl chemical name for sodium chloride.
- It identifies what element(s) are in the formula
- Identifies how much of each element is in the compound formula

1787 – Guyton do Morveau – used the chemical name for each element in the cpd. – metal element names came first.

1920 – I.U.P.A.C. (International Union of pure and Applied Chemistry) is now responsible for naming all chemical compounds discovered.

Interpreting Chemical Names and Formulas From Compounds:

1) Simple Formulas

Formula	chemical name
NaCl	sodium chloride

1 atom sodium (Na) chemically joins with 1 atom of chlorine (Cl)

2) Subscript Numbers:
Subscript numbers indicate the number of atoms of elements that must combine to form the compound. It is placed after the symbol and down e.g. H_2O in the post subscript position.

3) Indicating Physical State of Element or Compound
After the chemical formula as subscripts put:
(s) for a solid compound. E.g. $KCl_{(s)}$
(l) for a __________ compound. e.g. $H_2O_{(l)}$
(g) for a gaseous compound. e.g. $CO_{2(g)}$
(aq) compound dissolved in water e.g. $NaOH_{(aq)}$

3.2 Ionic Compounds

Characteristics - pure substances in unique crystal formation
- solids at room temp
- high melting point e.g. salt m.p. 801degrees C
- good electrical _____________ in aqueous solution (this property led to the invention of ____________)

Compounds formed - from attraction of positively charged ions (___________) to negatively charged ions (____________) e.g. K^+ and Br^-.

IONS

A. **monotomic-** a single atom that has a positive or negative electrostatic charge e.g. Ba^{+} or I^{-}

B. **polyatomic –** a group of atoms that behaves as a single unit with a positive or negative electrostatic charge e.g. NO_3^- nitrate.

NOTE: the charges are placed in a post superscript position.

Naming Ionic Compounds

Rule #**1**. the chemical name of the metal (positive ion ie. cation) comes first followed by the name of the non-metal (negative ion i.e. anion), but no charges are shown. E.g. CaO is calcium oxide

Rule #**2**. Name of the non-metal (negative anion) changes to an "ide" suffix e.g. Al_2O_3 – aluminum ox<u>ide</u>.

Rule #**3**. If an element like copper (1^+ or 2^+) is used, add a Roman numeral (I) or (II) after the word Copper. E.g. copper (II) sulfate is $CuSO_4$.

Writing Ionic Compound Formulas

Follow Rules #1-#3 inclusive on P. 147. **Always** have a copy of the Periodic Table handy to refer to.

[**A Periodic Table is provided by the teacher for all quizzes and exams**.]

Ionic Charge Patterns

(i) _____________ metals (group 1 – far left side) have 1 + change
(ii) alkaline earth metals (group 2 – left side) have a 2+ charge
(iii) _____________ (far right in group 17) – have a 1- charge
(iv) group _____ – (right side) have a 2- charge.

3.3 Molecular Compounds

- A molecular compound consists of one or more non-metallic atoms e.g. CO, H_2O, CH_4.

- Characteristics:
  1) can be solids, liquids or gases at room temp.
  2) _________ electrical conductors i.e. insulators
  3) have ________ melting and boiling points
  4) all molecular elements are non metallic

Writing Molecular Compound Formulas

Formula will show:

1) what elements are present
2) proportion of atoms in a molecule e.g. $O_{2(g)}$ has 2 oxygen atoms.

Naming molecular Compounds

IUPAC recommends that molecular compounds should be named using the prefix system only. In the prefix system, Greek or Roman prefixes are used to indicate the number of each kind of atom bonded to one another.

Rules;

1) The first element in the formula should be named in full. The second element in the formula should be shortened and given an "ide" suffix.

2)The prefix "mono" may be omitted. However, do not omit numerical prefixes past mono.

3) Hydrogen compounds are molecular. However, most common hydrogen compounds have trivial names. Some preferred trivial names are: water for H_2O (vs. dihydrogen oxide), ammonia for NH_3 (vs. nitrogen trighydride and hydrogen sulfide for H_2S (vs. dihydrogen sulfide).

4) Prefix + first element name then prefix + second element (with "ide" ending).
   [**Refer to P. 152.]**

4.0 Chemical Reactions

Chemical Reaction – when two or more ionic or molecular substances combine to form new substances. E.g. space shuttle launch – $O_{2(l)} + H_{2(l)}$

Chemical reactions can be written as chemical word equations:

Ex) A + B → C + D
(reactants) (products)

paper + oxygen → carbon dioxide + water + released energy.

'+' signs separate reactants and products
'→' indicate direction of reaction

Evidence of a Chemical Rxn

1) colour change
2) odor
3) gas or solid formation
4) release (exothermic) or absorption (endothermic) of heat

CAUTION: be careful in the interpretation of the above criteria e.g. bubbles could mean boiling or some solids release heat when dissolved.

Chemical Changes Involving Oxygen

1) ___________ - oxygen reacts with a substance to produce a new substance plus heat.
   Ex) Wood + O_2 → heat + light + exothermic energy

2) ___________ (Rusting) - a slow chemical change involving oxygen with some metals
   Ex) Iron + oxygen   rusted iron

3) _______________ Respiration - occurs in all aerobic (oxygen) consumers.
   Ex) Food + oxygen → carbon dioxide + water + energy
   $C_6H_{12}O_{6(s)}$ $O_{2(g)}$ → $CO_{2(g)}$ $H_2O_{(l)}$ exothermic

4.2 Conservation of Mass in Chemical Reactions.

Law of Conservation of Matter and Mass - Matter and Mass cannot be destroyed but can change form in a "closed" controlled laboratory system. E.g. reactants → products
100 g → 100 g

- Matter is not ___________ nor ___________ during a chemical rxn. However, this being said, some matter such as gases may and usually escape and not be accountably measured in an "open system" reaction as performed in most school labs.

4.3 Factors Affecting Rate of Chemical Reaction

1) Presence of a ___________ (a substance added to a rxn. To speed it up but it is not in itself used up or destroyed during the rxn. E.g. enzymes are organic catalysts used extensively in the digestive system of the human body to break down various food groups and materials.
2) Concentration of reactants – greater the conc. The faster the rxn.
3) _______________ of the reactants – higher the heat – faster the rxn.
4) Surface area of reactants – greater the surface area (e.g. powder vs. chunks) the more surface area will be available for the rxn. To occur and the faster the rxn will occur.