Chemistry 60

Welcome to the Summer 2010 Session

What you need to know

- My name: Dr. John Milligan
- Email addr:
  dr.milligan@ars-chemia.net
- Web site:
  www.ars-chemia.net
- Grading criteria

What you need to have

- Incredible desire to learn
- Textbook:
  Introduction to Chemical Principles, 9th ed. (Custom), Stoker
- Lab Manual:
  Laboratory Manual for Chemistry 60/68, ©2010
- Safety Goggles
- Scientific Calculator

What is Chemistry?

- What isn't chemistry?
- Chemistry is the study of matter and energy
- Chemistry is fun

Why do we study chemistry?

- Because we are made to… ☹
- Because it's interesting ☺
- To be better informed about our world (DHMO or not)

Concepts about matter

What is matter? How can we classify it?

Physical States

- Solid
  - o Definite shape and volume
- Liquid
  - o Definite volume
  - o Indefinite shape
- Gas
  - o Indefinite shape and volume

Properties of matter

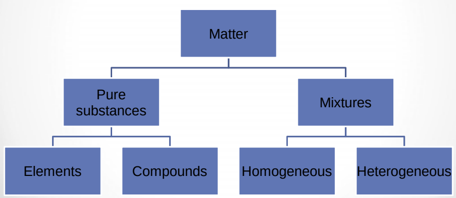
- Can be used to identify substances.
- Two kinds of properties
  - o Physical properties – can be observed without changing the identity of the substance
  - o Chemical properties – describes the way in which the substance changes or resists changes.

Physical vs. Chemical changes

- Changes the substance(s) present
- Examples:
  - o Burning
  - o Rusting
  - o Decomposing

- Does not involve a change in the substance(s) present
- Examples:
  - o Melting
  - o Breaking
  - o Boiling

Matter



Pure substances

- Will either be elements or compounds
  - o Elements contain only one kind of atom
  - o Compounds contain more than one kind of atom
- Cannot be broken down into small components by physical processes
- Compounds can be separated by chemical processes

Mixtures

- Can be homogeneous or heterogeneous
  - o Homogeneous contains only one phase
  - o Heterogeneous contains more than one phase
- Can be separated by physical processes

Elements

- Which ones do you need to know?
  - Numbers 1—57
  - Numbers 72—89
  - Number 92—94
- You only need to know the name and the symbol

13

Atoms and molecules

Atoms

- The word atom comes from Greek *atomos* which means indivisible
- Atoms are so small that 250,000,000 will fit in the space of one inch
- Atoms combine to form molecules

Atoms require a scanning tunnelling microscope or an atomic force microscope to see them.

The idea of atoms extends back to the ancient Greeks, notably Democritus.

It was revived again in the 1800s by John Dalton

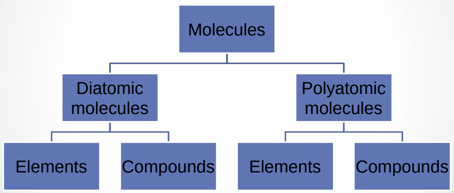
Dalton's atomic theory

1. All matter is composed of small particles called atoms. A type of atom corresponds to a different element.
2. All atoms of a given element are similar to one another and very different from other elements.
3. The relative number and arrangement of the elements contained in a pure substance determines its identity.
4. A chemical change is a rearrangement of the atoms to give new substances.
5. Only whole atoms can participate in a chemical change.

Molecules

- A molecule is a combination of two or more atoms
- Not all combinations of atoms are molecules, only those where electrons are shared.
- Molecules can have more than one kind of atom or only one kind of atom
- The formula tells how many of each kind of atom is present

Types of molecules



Elements that are molecules (Diatomic molecules) (MEMORIZE)

- Hydrogen (H_2)
- Nitrogen (N_2)
- Oxygen (O_2)
- Fluorine (F_2)
- Chlorine (Cl_2)
- Bromine (Br_2)
- Iodine (I_2)

Elements that are molecules (Polyatomic) (do not memorize)

- Sulfur (S_8)
- Phosphorus (P_4)

Compounds that are not molecules

- These are called ionic compounds
- They are assembled from the attraction of positive and negative ions
- The formula shows the ratio of ions in the compound.

Natural or Synthetic?

- Are natural compounds better for you than synthetic compounds?
- Is there a difference between the two?
- Is it worth it to pay more for a "natural" compound instead of a "synthetic" one?

Chemical formulas

- Chemical formulas show what is in the compound
- Pay attention to case: $COCl_2$ is not the same as $CoCl_2$ and NACL does not exist.
- A formula can be more complicated, for example $(NH_4)_2SO_4$.

Protons, Neutrons and Electrons (Oh, My!)

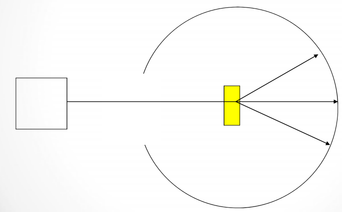
- Atoms have two main parts, the nucleus and the electrons.
- The nucleus has at least one proton
- It may also contain one or more neutrons

Parts of the atom

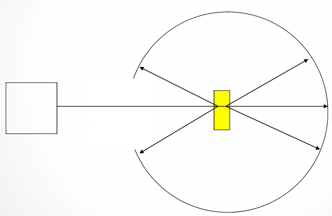
Particle	Mass	Location	Charge
Proton	1	Nucleus	+1
Neutron	1	Nucleus	0
Electron	~0	Outer part	-1

Evidence for the structure of the atom

Rutherford's gold foil experiment



The unexpected result!



Implications of the gold foil experiment

- The atom must have a nucleus that is very heavy
- The nucleus contains all of the positive charge.
- The negative charge is most of the volume of the atom.

Atoms (again)

- Most atoms come in more than one kind, called ***isotopes***
- The mass of the isotopes and the relative number of isotopes determine the mass we see in the periodic table
- Each isotope has a symbol associated with it

Isotopes

Most elements come in more than one "flavor."

Hydrogen has three isotopes $^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$

What does each of these mean?
The symbol shown has the following form:

Mass number → A
Atomic number → Z
$^{A}_{Z}E$ ← Atomic symbol

Definitions

- Mass number
  Number of protons + number of neutrons
- Atomic number
  Number of protons

Therefore, the number of neutrons in the nucleus is the mass number – atomic number.

$^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$

The first isotope has **1 proton** and 0 neutrons

The second isotope has **1 proton** and 1 neutron

The third isotope has **1 proton** and 2 neutrons

It is the atomic number, or the number or protons, that determines the identity of the atom.

Complete the following table

Name	Complete Symbol	Atomic Number	Mass Number	# of Protons	# of Neutrons
Hafnium	$^{179}_{72}Hf$	72	179	72	107
Technetium	$^{98}_{43}Tc$	43	98	43	55
Scandium	$^{44}_{21}Sc$	21	44	21	23
Cadmium	$^{113}_{48}Cd$	48	113	48	65

Relative average atomic masses

- The masses in the periodic table are relative average atomic masses.

Why relative? Relative to what? Why average?

Relative

- We use relative masses because we need a reference point for the mass of the atoms.
- All masses in the periodic table are relative to the mass of Carbon-12, which is defined to have a mass of exactly 12 amu.
- This is purely an arbitrary definition. It was, at one point, defined relative to Oxygen-16 as being exactly 16 amu.

Average

- The masses are then calculated as a weighted average of the relative masses of the all the isotopes of the element.

A weighted average takes into account the greater or lesser presence of each isotope.

How to calculate the weighted average relative atomic mass

- Convert the percent abundances to decimal (i.e., 76.54% is 0.7654)
- Multiply each fractional abundance by the corresponding isotopic mass
- Add the products together

$$M_{avg} = M_1 A_1 + M_2 A_2 + \cdots + M_n A_n$$

Example

Naturally occurring silicon has three isotopes

Isotope	mass (amu)	% abundance
silicon-28	27.97692653	92.22
silicon-29	28.97649472	4.69
silicon-30	29.97377022	3.09

What is the relative average atomic mass of silicon?

$$(0.9222)(27.97692653\ \text{amu}) = 25.8\underline{0}032165\ \text{amu}$$

$$(0.0469)(28.97649472\ \text{amu}) = 1.3\underline{5}8997602\ \text{amu}$$

$$(0.0309)(29.97377022\ \text{amu}) = 0.092\underline{6}189499\ \text{amu}$$

$$25.8\underline{0}032165\ \text{amu} + 1.3\underline{5}8997602\ \text{amu} + 0.092\underline{6}189499\ \text{amu} = 28.0\underline{8}550875\ \text{amu}$$

$$= 28.09\ \text{amu}$$