Chapter 3

Atoms: The Building Blocks of Matter

The Atom: From Philosophical Idea to Scientific Theory

Section 3.1

Objectives

- **Explain** the *law of conservation of mass,* the *law of definite proportions,* and the *law of multiple proportions.*
- **Summarize** the five essential points of Dalton's atomic theory.
- **Explain** the relationship between Dalton's atomic theory and the law of conservation of mass, the law of definite proportions, and the law of multiple proportions.

1700's and before…

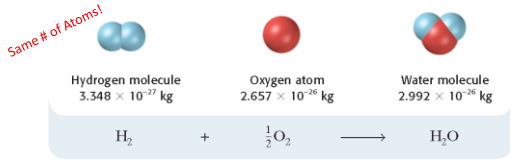
- Scientists believed…
  - Elements _____be broken down any further
  - Elements combine to form cmpds _____
  _____
  _____
    - C and O have different props than _____

1790's

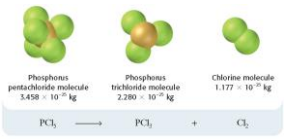
- Technology allowed scientists to study matter on a different level using updated balances, microscopes….
- They came up with many basic laws, including…
  - _____
  - _____
  - _____

Law of Conservation of Mass

- **Law of conservation of mass:** mass is neither created nor destroyed during ordinary chemical reactions or physical changes



Law of Cons. Of Mass



Law of Definite Proportions

- **Law of definite proportions:** a chemical compound contains the _____

_____

_____

Law of Multiple Proportions

- **Law of multiple proportions:** if two or more different compounds are composed of the same two elements, then the ratio of the masses of the second element combined with a certain mass of the first element is always a ratio of small whole numbers

- Ex. - _____and _____

Law of Multi. Prop.

Name of compound	Description	As shown in figures	Formula	Mass O (g)	Mass N (g)	Mass O (g) / Mass N (g)
Nitrogen monoxide	colorless gas that reacts readily with oxygen		NO	16.00	14.01	$\frac{16.00\ g\ O}{14.01\ g\ N} = \frac{1.14\ g\ O}{1\ g\ N}$
Nitrogen dioxide	poisonous brown gas in smog		NO_2	32.00	14.01	$\frac{32.00\ g\ O}{14.01\ g\ N} = \frac{2.28\ g\ O}{1\ g\ N}$

Dalton's Atomic Theory

- In 1808, John Dalton came up with a theory that easily explained conservation of mass in a reaction as the result of the combination, separation, or rearrangement of atoms.

Dalton's Atomic Theory

1. All matter _____
2. Atoms of a given element _____
3. Atoms cannot _____
4. Atoms of different elements _____
5. In chemical reactions, _____

The Structure of an Atom

Section 3.2

Objectives

- **Summarize** the observed properties of cathode rays that led to the discovery of the electron.
- **Summarize** the experiment carried out by Rutherford and his co-workers that led to the discovery of the nucleus.
- **List** the properties of protons, neutrons, and electrons.
- **Define** *atom*

Structure of the Atom

- Even though Dalton's atomic theory stated "Atoms cannot be subdivided, created, or destroyed" upon further investigations and as technology advanced, it was discovered that atoms were made of something!
- An **atom** is _____

_____

Structure of an Atom

- An atom contains subatomic particles called _____, _____, and _____.
- The *nucleus* is a _____.
- The nucleus is made up _____ _____
- Surrounding the nucleus is a region _____ _____.

Discovery of the Electron

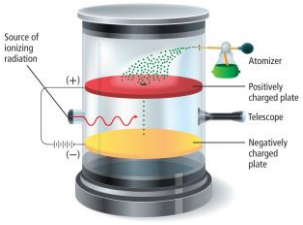
- Scientists used cathode-ray tubes to experiment with electric current
- After many investigations they noticed…
  - The ray was deflected by a _____
  - The rays were deflected _____
- This eventually led them to the conclusion that the particles were _____
- They called these particles, _____

Disc. of e-

- Joseph John Thomson's cathode-ray tube experiments measured the _____
  - He also came up with the "_____" model
- Robert A. Millikan's oil drop experiment measured the _____.
- With this information, scientists were able to determine the _____

Millikan Experiment

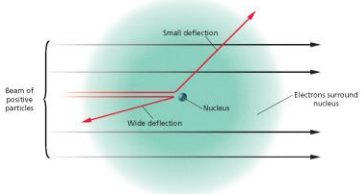
- Using this apparatus, Millikan was able to make the oil drops raise, slow down, or hover



Discovery of the Atomic Nucleus

- In 1911, Ernest Rutherford performed something called the "_____"
- The were "shooting" _____
- What they found was some of the particle were _____
- This experiment lead to the discovery of the _____!

Discovery of the Atomic Nucleus



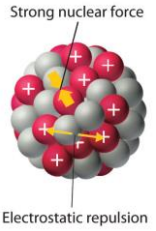
Rutherford reasoned that each atom in the gold foil contained a small, dense, positively charged nucleus surrounded by electrons. A small number of the alpha particles directed toward the foil were deflected by the tiny nucleus (red arrows). Most of the particles passed through undisturbed (black arrows).

What is the Nucleus made of?

- Protons (_____) and neutrons (_____)
- The protons are _____and the neutrons are _____
- The #of _____= the # of _____
  - The atom is _____charged
- Different elements have a different amount of _____
  - The # of _____

What holds a nucleus together?

- **Nuclear Forces** are short range forces , between p^+ and p^+, p^+ and n^0, and n^0 and n^0, that hold a nucleus together



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How big is an atom?

- As you may have guessed…
  Atoms are extremely small.
- Atoms are measured in picometers (pm)
- 1 meter = 1000000000000 pm or ($1x10^{-12}$)

Properties of Subatomic Particles

Particle	Symbols	Relative electric charge	Mass number	Relative mass (amu*)	Actual mass (kg)
Electron	e^-, ${}^{0}_{-1}e$	–1	0	0.000 5486	9.109×10^{-31}
Proton	p^+, ${}^{1}_{1}\mathrm{H}$	+1	1	1.007 276	1.673×10^{-27}
Neutron	n^0, ${}^{1}_{0}n$	0	1	1.008 665	1.675×10^{-27}

*1 amu (atomic mass unit) = $1.660\,540 \times 10^{-27}$ kg

Page 72

Counting Atoms

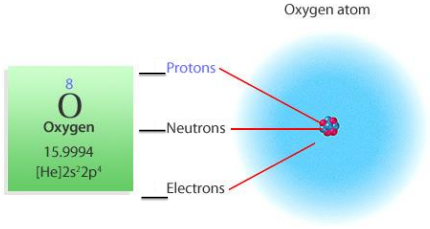
Section 3.3

Objectives

- **Explain** what isotopes are.
- **Define** *atomic number* and *mass number,* and **describe** how they apply to isotopes.
- Given the identity of a nuclide, **determine** its number of protons, neutrons, and electrons.
- **Define** *mole, Avogadro's number,* and *molar mass,* and state how all three are related.
- **Solve** problems involving mass in grams, amount in moles, and number of atoms of an element.

Atomic Number (Z)

- All atoms are made of p^+, e^-, and n^0
- The difference is the # of _____
- Atoms of the same element have the same # of _____
  - If you change the # of ____, you change the ____
- The # of p^+ is called the _____
- It is located on the _____ of the periodic table box



Isotopes

- **Isotopes** are atoms of the same _____ that have different _____
- These atoms have the same # of _____but a <u>different</u> # of _____
- Most elements consist of a mixture of isotopes
  - This is why their atomic masses are not _____
- The _____is the total number of protons and neutrons that make up the nucleus of an isotope.

Fig 3.3 on pg 74

- How are H isotopes different from each other?

Naming Isotopes

- There are 2 ways..
- Hyphen notation: The mass number is written with a hyphen after the name of the element.

_____ OR _____

- Nuclear symbol: The superscript indicates the mass number and the subscript indicates the atomic number.

Naming Isotopes

- To find the number of n^0 you perform the following equation…
- Mass #– atomic #= # of n^0
- See Fig 3.4 on pg 75

Sample Problem

- How many protons, electrons, and neutrons are there in an atom of chlorine-37?
- p^+ = _____
- e^- = _____
- n^0 = _____

- Practice problems 1-3 on pg 76

Relative Atomic Mass

- **Atomic mass unit (amu)** is = to the mass of 1/12 the mass of a C-12 atom
  - This was arbitrarily chosen

Calculating Ave. Atomic Mass

- **Average atomic mass** is the _____ average of the atomic masses of the naturally occurring isotopes of an element

Calculating Ave Atomic Mass

- Copper consists of 69.15% copper-63, which has an atomic mass of 62.929 601 amu, and 30.85% copper-65, which has an atomic mass of 64.927 794 amu
- The average atomic mass of copper can be calculated by multiplying the atomic mass of each isotope by its relative abundance (expressed in decimal form) and adding the results.

Page 78

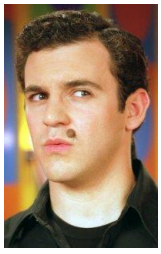
- Fig 3.5
- Find the average atomic mass for oxygen and copper
- Did you get the same answer as the book?

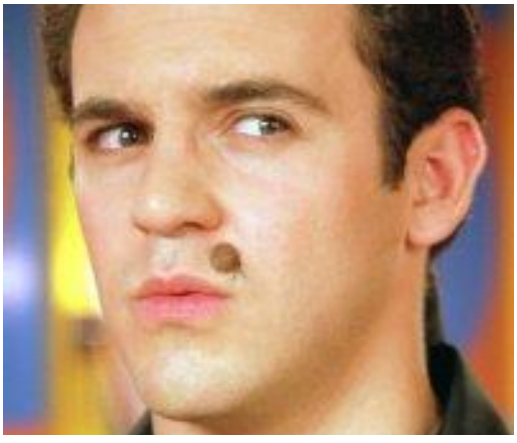
Mass to # of atoms

- The _____ is the SI unit for amount of substance.
- 1 mole is the amount of atoms in _____ g of pure carbon-12, or _____ atoms.
- The number is called _____

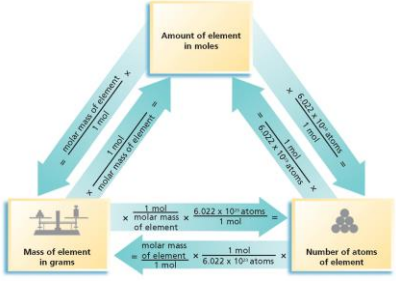
The Mole - Demo

- I have a mole of in each of the containers on the side table. Please look at them and decide why there are different amounts in each of them.
- Then think about how much volume a mole of m&m's would require? Also, estimate the mass.

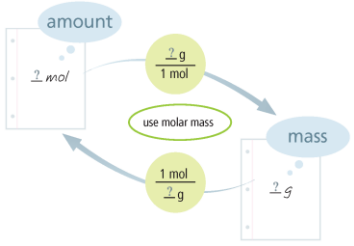




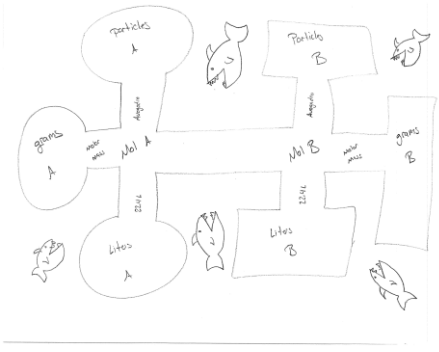
The Book Version….



The Book Version Continued……



Mole Island!



How many moles of Na in 1.9×10^{24} atoms of Na?

$$\frac{1.9 \times 10^{24} \text{ atoms Na}}{\text{\_\_\_\_\_ atoms Na}} \quad \frac{1 \text{ mole Na}}{}$$

How many atoms of Ag in 2.5 moles of Ag?

$$\frac{2.5 \text{ moles of Ag} \quad | \quad \_\_\_\_\_ \text{ atoms Ag}}{1 \text{ mole Ag}}$$

How many grams of Hg in 3 moles Hg?

$$\frac{3 \text{ mole Hg} \quad | \quad \_\_\_\_\_ \text{ g Hg}}{1 \text{ mole Hg}}$$

How many moles of Ag in 1234 g of Ag?

$$\frac{1234 \text{ g Ag} \quad | \quad 1 \text{ mole Ag}}{\_\_\_\_\_ \text{ g Ag}}$$

How many grams in 2.1×10^{25} atoms of Ca?

$$2.1 \times 10^{25} \text{ atoms Ca} \left| \frac{1 \text{ mole Ca}}{\_\_\_\_\_ \text{ atoms Ca}} \right| \frac{\_\_\_\_\_ \text{ g Ca}}{1 \text{ mole Ca}}$$

How many atoms of Si in 74.9 grams?

$$74.9 \text{ g Si} \left| \frac{1 \text{ mole Si}}{\_\_\_\_\_ \text{ g Si}} \right| \frac{\_\_\_\_\_ \text{ atoms Si}}{1 \text{ mole Si}}$$