

Chemical Foundations: Elements, Atoms and Ions

- 3.1 The Elements
 - 3.2 Symbols for the elements
 - 3.3 Dalton's Atomic Theory
 - 3.4 Formulas of compounds
 - 3.5 The Structure of the Atom
 - 3.6 Introduction to the Modern concept of Atomic Structure
 - 3.7 Isotopes
 - 3.8 Introduction to the Periodic Table
 - 3.9 Natural States of the Elements
- (Skipping section 3.11 until after we finish chapter 11)

3.0 The Elements: A General Background

- Since ancient times humans have used _____ to their benefit.
- The Greek natural philosophers were the first to try to explain why chemical changes occur using their four element system: _____, _____, _____, and _____.
- The alchemists in their search for the the _____ or the eternal elixir were attempting to convert base metals into gold. In doing so, these early scientists advanced the knowledge of chemistry.
- _____ work with gases was most important because of his insistence of the importance of experimentation and recording both those that work AND recording the experiments that don't work.



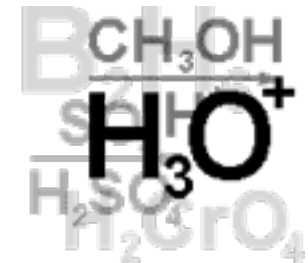
3.0 The Elements: A General Background

- Since ancient times humans have used **chemical reactions** to their benefit.
- The Greek natural philosophers were the first to try to explain why chemical changes occur using their four element system: **earth, air, fire, and water**.
- The alchemists in their search for the the **philosopher's stone** or the eternal elixir were attempting to convert base metals into gold. In doing so, these early scientists advanced the knowledge of chemistry.
- **Robert Boyle's** work with gases was most important because of his insistence of the importance of experimentation and recording both those that work AND recording the experiments that don't work.



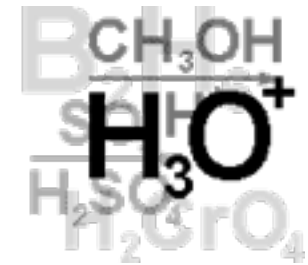
3.1 The Relative Abundance of Elements

- Everything on earth is composed of _____, which are _____ to form more *complex* substances called _____
- For example, the English language has 26 letters, but _____ of words have been derived from them. The same is true for the 110+ elements that combine to make billions of compounds.
- Analogy: Letters are to words as **elements** are to _____.



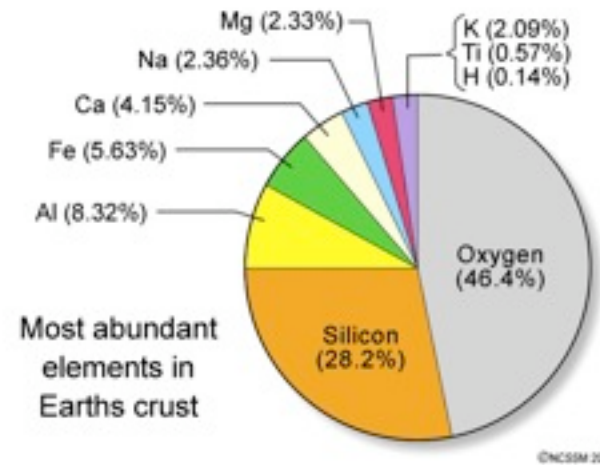
3.1 The Relative Abundance of Elements

- Everything on earth is composed of **elements**, which are **chemically combined** to form more *complex* substances called **compounds**
- For example, the English language has 26 letters, but **millions** of words have been derived from them. The same is true for the 110+ elements that combine to make billions of compounds.
- Analogy: Letters are to words as **elements** are to **compounds**.



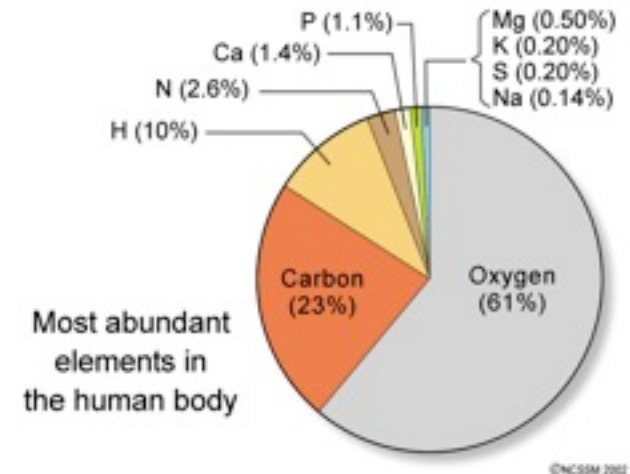
- Nearly 75% (by mass) of the _____ is made of _____ and _____, the main elements in sand and rock.

- ✓ 49.2 % Oxygen, O
- ✓ 25.7 % Silicon, Si



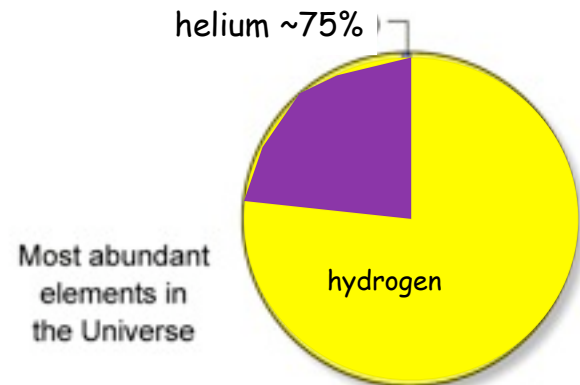
- Nearly 93% (by mass) of the _____ is made of _____, _____, and _____.

- ✓ 65 % Oxygen, O
- ✓ 18% Carbon, C
- ✓ 10% Hydrogen, H



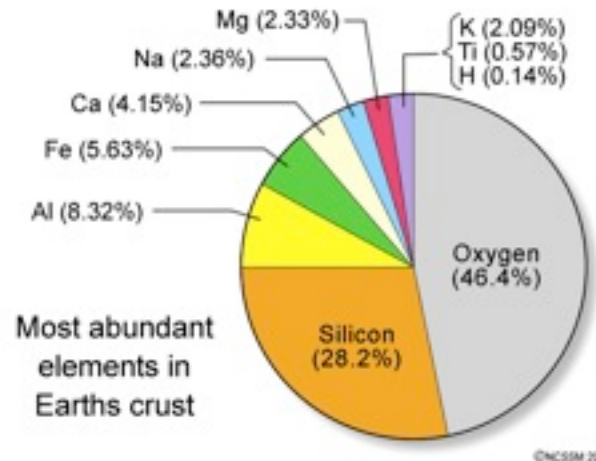
- Nearly all of the atoms in the _____ are _____ and _____ atoms.

- ✓ 75 % hydrogen, H
- ✓ 25 % helium, He



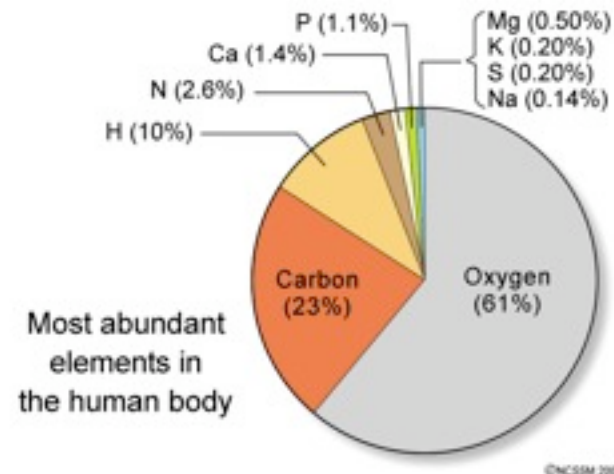
- Nearly 75% (by mass) of the **earth's crust** is made of **oxygen** and **silicon**, the main elements in sand and rock.

- ✓ 49.2 % Oxygen, O
- ✓ 25.7 % Silicon, Si



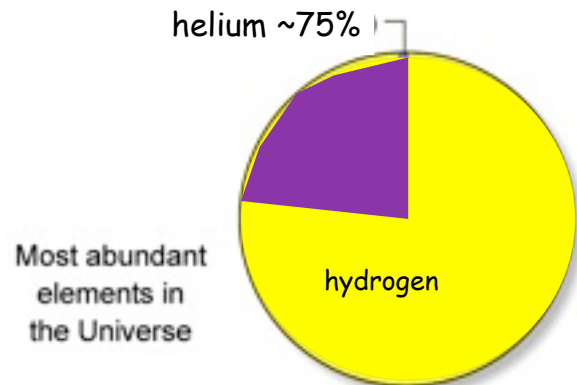
- Nearly 93% (by mass) of the **human body** is made of **oxygen**, **carbon**, and **hydrogen**.

- ✓ 65 % Oxygen, O
- ✓ 18% Carbon, C
- ✓ 10% Hydrogen, H



- Nearly all of the atoms in the **universe** are **hydrogen** and **helium** atoms.

- ✓ 75 % hydrogen, H
- ✓ 25 % helium, He



3.2 The Symbols of Elements

- Many elemental names were derived from many _____, such as _____, German, Spanish, _____, and English.
- You may recognize that some of the English names honor _____ or _____.
- Today, while the names of elements are unique to each language, _____ languages use the same _____ or _____ symbols.
- These single letter or two letter abbreviations are called _____.

Oxygen

Gold (*aurum*)

Einsteinium

Polonium

O

Au

Es

Po

3.2 The Symbols of Elements

- Many elemental names were derived from many **different languages**, such as **Greek**, German, Spanish, **Latin**, and English.
- You may recognize that some of the English names honor **people** or **places**.
- Today, while the names of elements are unique to each language, **all** languages use the same **single letter** or **two letter** symbols.
- These single letter or two letter abbreviations are called **chemical symbols**.

Oxygen

Gold (*aurum*)

Einsteinium

Polonium

O

Au

Es

Po

3.4 Formulas of Compounds

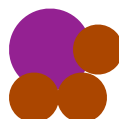
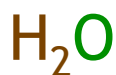
- You know that _____ represent the particles of the more complex forms of matter known as _____.
- It is important to realize that it's the _____ that compounds are made of that are *solely* responsible for the _____ these substances possess.
- A compound is represented by a _____ in which the symbols of different elements are written together, representing the number of atoms bonded together within the substances.



- Notice that the _____ following the symbol indicates the _____ of the previous symbol's element present.

3.4 Formulas of Compounds

- You know that **molecules** represent the particles of the more complex forms of matter known as **compounds**.
- It is important to realize that it's the **molecules** that compounds are made of that are *solely* responsible for the **unique properties** these substances possess.
- A compound is represented by a **chemical formula** in which the symbols of different elements are written together, representing the number of atoms bonded together within the substances.



- Notice that the **number₂** following the symbol indicates the **number of atoms** of the previous symbol's element present.

3.3 and 3.5 The Historical Development of Human Understanding of the Atom and its Structure

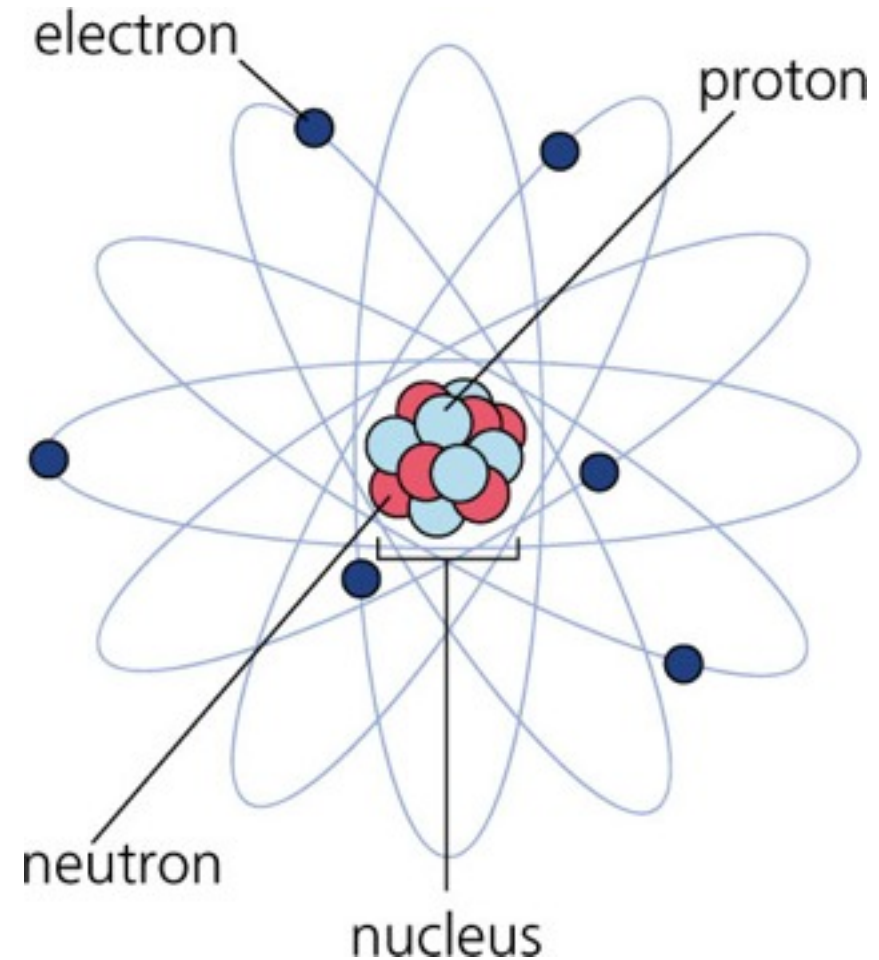
- Robert Boyle - the Importance of _____, right or wrong.
 - ✓ Pressure and Volume are inversely proportional
- _____ and _____
 - ✓ Law of Conservation of Mass
- Joseph Proust
 - ✓ Law of _____
- Joseph Gay-Lussac
 - ✓ Law of _____ of Gases
- John Dalton
 - ✓ Used the Laws above to propose the _____
- J.J. Thomson
 - ✓ Use of _____ tubes to find the _____ (and proton) and propose the _____ model of the atom.
- Ernest Rutherford
 - ✓ _____ Experiment to propose the _____ atom

3.3 and 3.5 The Historical Development of Human Understanding of the Atom and its Structure

- Robert Boyle - the Importance of **Experimentation**, right or wrong.
 - ✓ Pressure and Volume are inversely proportional
- **Antoine** and **Marie Lavoisier**
 - ✓ Law of Conservation of Mass
- Joseph Proust
 - ✓ Law of **Constant Composition**
- Joseph Gay-Lussac
 - ✓ Law of **Combining Volumes** of Gases
- John Dalton
 - ✓ Used the Laws above to propose the **Atomic Theory**
- J.J. Thomson
 - ✓ Use of **cathode ray** tubes to find the **electron** (and proton) and propose the **plum pudding** model of the atom.
- Ernest Rutherford
 - ✓ **Gold Foil** Experiment to propose the **nuclear** atom

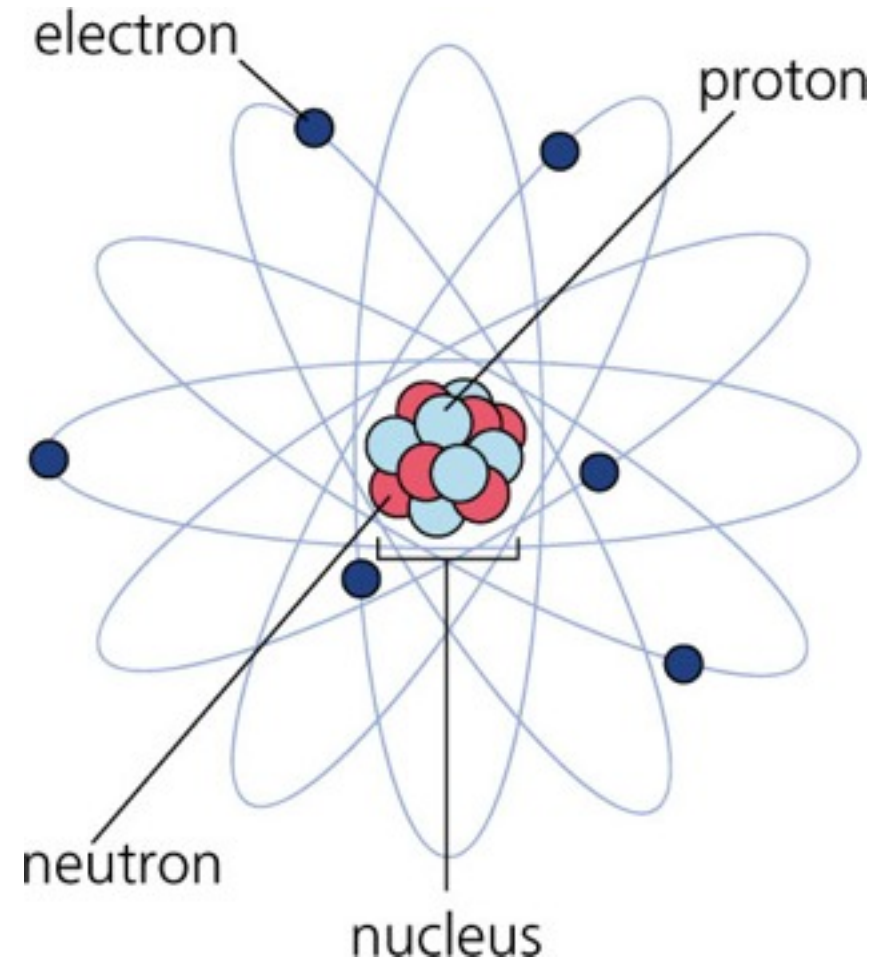
3.6 Modern Concept of Atomic Structure

- Atoms are made of _____ subatomic particles:
- _____ & _____; that reside inside of the nucleus. (Remember that the relative size of the nucleus in this diagram is much too large.
- _____; that whirl in a cloud around the outside the nucleus.
- Some of the particles are charged ...
Protons are _____
Electrons are _____
Neutrons are _____



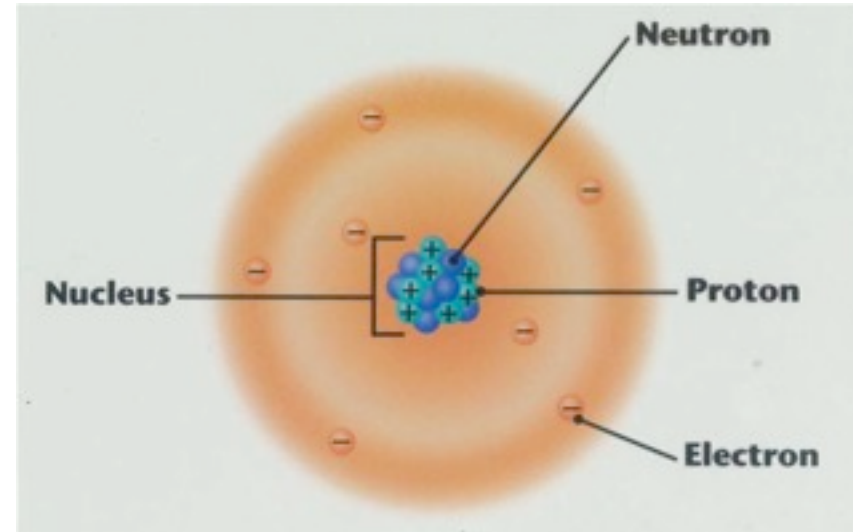
3.6 Modern Concept of Atomic Structure

- Atoms are made of **three** subatomic particles:
- **Protons** & **Neutrons**; that reside inside of the nucleus. (Remember that the relative size of the nucleus in this diagram is much too large.)
- **Electrons**; that whirl in a cloud around the outside the nucleus.
- Some of the particles are charged ...
Protons are **positive**
Electrons are **negative**
Neutrons are **neutral**



Remember about Size and Mass

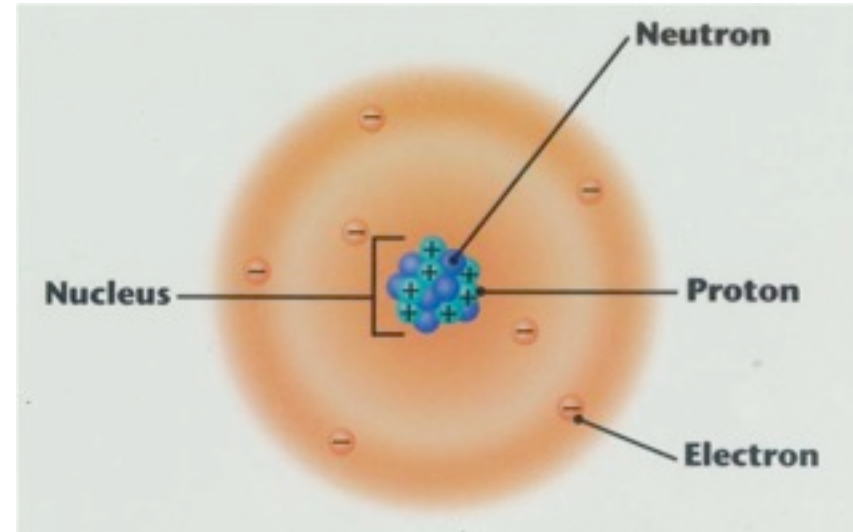
- The nucleus is very _____ in size, though the protons and neutrons are extremely _____ in mass.
- The electrons are very _____ in mass, (approximately 1/_____th of a proton) but their collective movement causes _____ of the size (volume) of the atom.
- The relative-size relationship is best demonstrated at the bottom of the page relative the purple ring to represent the electrons.



← nucleus

Remember about Size and Mass

- The nucleus is very **tiny** in size, though the protons and neutrons are extremely **heavy** in mass.
- The electrons are very **light** in mass, (approximately $1/2000^{\text{th}}$ of a proton) but their collective movement causes **most** of the size (volume) of the atom.
- The relative-size relationship is best demonstrated at the bottom of the page relative the purple ring to represent the electrons.



← nucleus

3.7 Element information within the periodic table

- All elements are identified by their _____.

✓ Atomic number (X) tells us the # of _____, which also equals the # of _____ within a neutral atom.

- The other recorded elemental value is the _____.

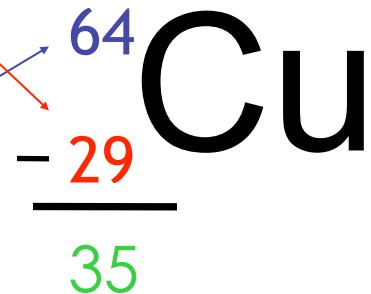
✓ Average mass is the mass in grams of a very large number of atoms.

✓ If that value is rounded to the nearest whole number, it is called the _____ (_____).

The _____ equals “# of protons + neutrons

Thus _____ minus “_____” = _____

29
Cu
Copper
63.546



3.7 Element information within the periodic table

- All elements are identified by their **atomic number**.
 - ✓ Atomic number (X) tells us the # of **protons**, which also equals the # of **electrons** within a neutral atom.
- The other recorded elemental value is the **average atomic mass**.
 - ✓ Average mass is the mass in grams of a very large number of atoms.
 - ✓ If that value is rounded to the nearest whole number, it is called the **mass number (A)**.

29
Cu
Copper
63.546

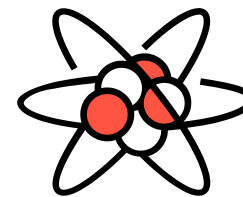
$$\begin{array}{r} 64 \\ - 29 \\ \hline 35 \end{array} \text{Cu}$$

The **mass #** equals “# of protons + neutrons

Thus **mass #** minus “**atomic #**” = **neutrons**

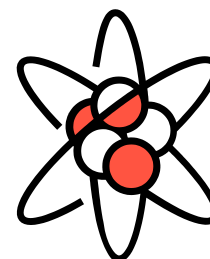
Why is Atomic Mass an Average Mass?

- All atoms of a particular element have the same # of _____ and _____.



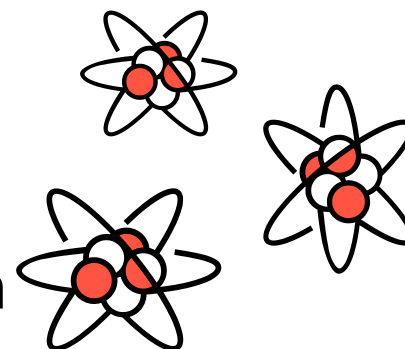
- However, the number of _____ can vary from atom to atom particular element.

- An atom of an element which has a different number of neutrons is called an _____.



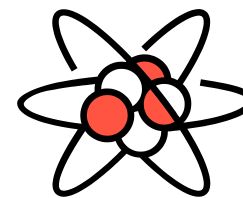
- Since neutrons (and protons) create much of the mass of the atom, these isotopes will have a distinctly different _____.

- The masses of all particles within an element are averaged together to provide an average atomic mass for the element. Because this average is dependent upon the amount of each isotope found in nature and it is called a _____ average.



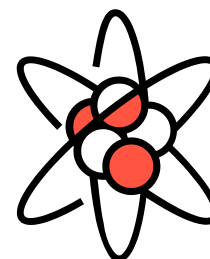
Why is Atomic Mass an Average Mass?

- All atoms of a particular element have the same # of **protons** and **electrons**.



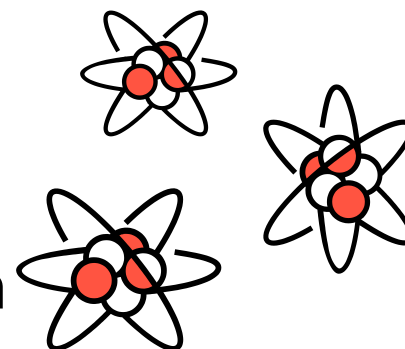
- However, the number of **neutrons** can vary from atom to atom particular element.

- An atom of an element which has a different number of neutrons is called an **isotope**.



- Since neutrons (and protons) create much of the mass of the atom, these isotopes will have a distinctly different **mass**.

- The masses of all particles within an element are averaged together to provide an average atomic mass for the element. Because this average is dependent upon the amount of each isotope found in nature and it is called a **weighted** average.



3.8 Introduction to the Periodic Table

- In the 1860's a Russian chemistry teacher named Dmitri Mendeleev was searching for a way to categorize and make sense of the growing number of elements for his students and invented the Periodic Chart.
- He placed the elements in columns (groups or vertical columns) according to their similar chemical and physical properties and in rows (periods) by increasing mass.
- The chart is periodic because the chemical and physical properties of the elements repeat again and again. The same way that a calendar is periodic.
- His brilliance came because of his willingness to leave gaps where he expected elements to be in his chart, but where none had yet been discovered. Sure enough in a few years three more undiscovered elements were isolated to fit in the holes in his chart



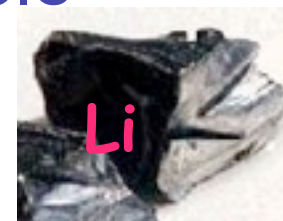
3.8 Introduction to the Periodic Table

- In the 1860's a Russian chemistry teacher named **Dmitri Mendeleev** was searching for a way to categorize and make sense of the growing number of elements for his students and invented the Periodic Chart.
- He placed the elements in columns (**groups** or **families**) according to their similar chemical and physical properties and in rows (**periods**) by increasing mass.
- The chart is **periodic** because the chemical and physical properties of the elements repeat again and again. The same way that a calendar is periodic.
- His brilliance came because of his willingness to **leave spaces** where he expected elements to be in his chart, but where none had yet been discovered. Sure enough in a few years three more undiscovered elements were isolated to fit in the holes in his chart



Particular Groups on the Periodic Table

- Group 1A is made of very reactive gases called the _____.
- _____, also reactive is called the alkaline earth metals.
- Group 7 are called the _____.
- Group 8 are called the _____ or _____ gases.
- Elements in the section between the alkaline earth metals and the aluminum group are called the _____ metals.
- There are far _____ metal than nonmetal elements, and it is important to know about the “stair-step” dividing line.



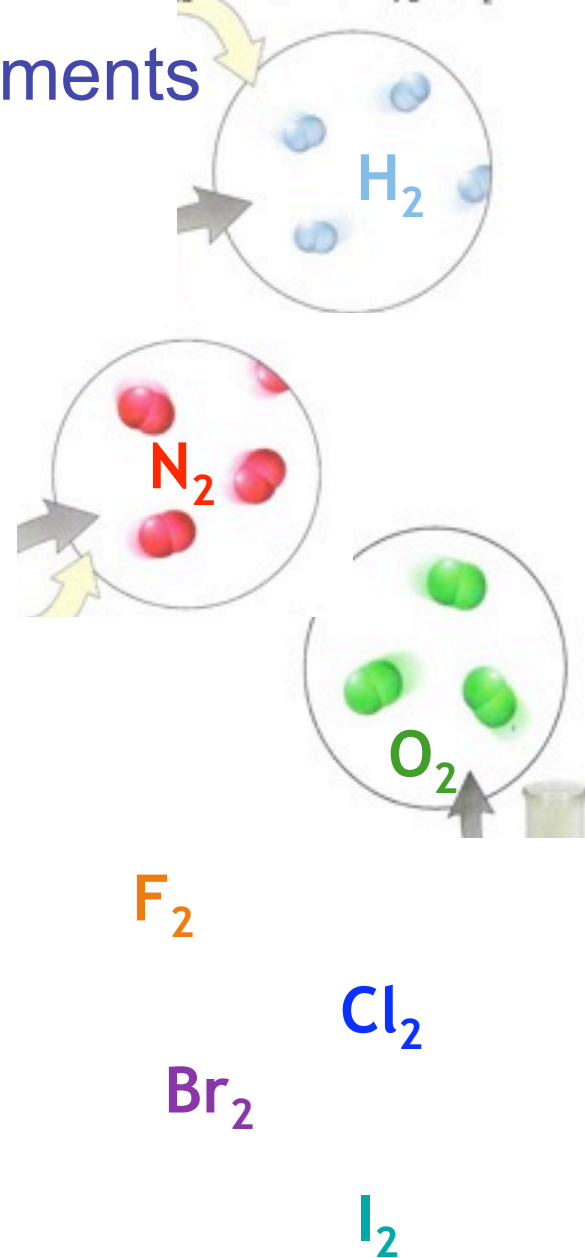
Particular Groups on the Periodic Table

- Group 1A is made of very reactive gases called the **alkali metals**.
- **Group 2A**, also reactive is called the alkaline earth metals.
- Group 7 are called the **halogens**
- Group 8 are called the **Noble** or **Inert** gases.
- Elements in the section between the alkaline earth metals and the aluminum group are called the **transition** metals.
- There are far **more** metal than nonmetal elements, and it is important to know about the “stair-step” dividing line.



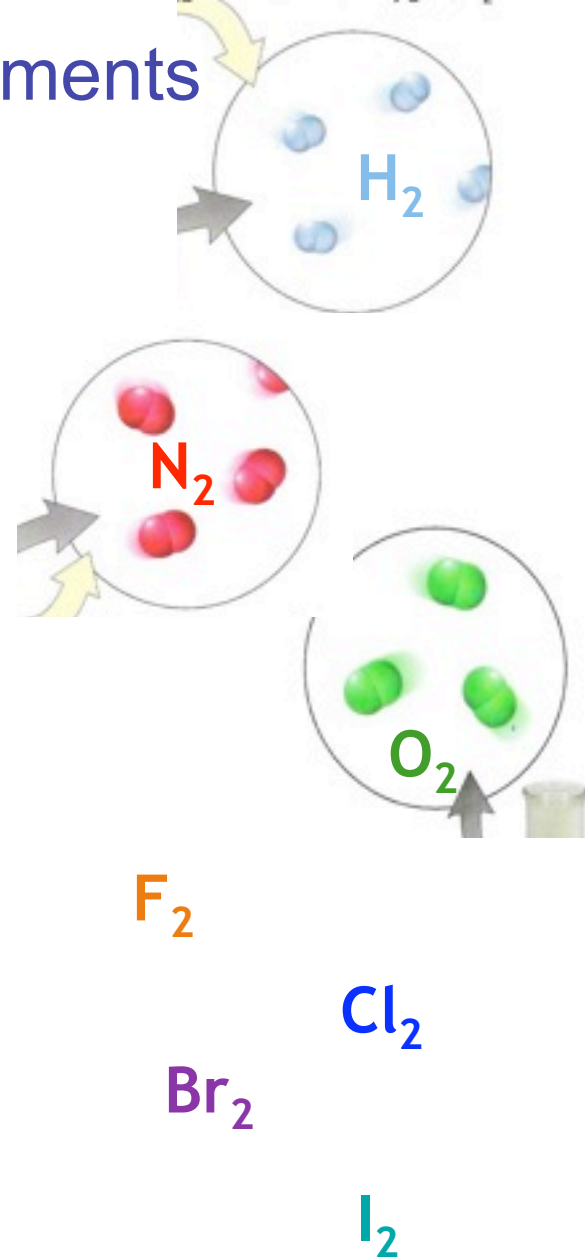
3.9 Natural States of the Elements

- The particles of some elements are not made of individual atoms but rather are made of _____.
- They're still elemental substances because every atom in the molecule is the _____ element.
- Instead of being singular atomic particles, they're found in nature as _____
- This phenomena is restricted to just _____ elements and they are known as the _____.



3.9 Natural States of the Elements

- The particles of some elements are not made of individual atoms but rather are made of **molecules**.
- They're still elemental substances because every atom in the molecule is the **same** element.
- Instead of being singular atomic particles, they're found in nature as **molecules**
- This phenomena is restricted to just **seven** elements and they are known as the **diatomic molecules**.



Different Forms of the Same Element

- Don't forget that there are different forms of the same element. These different forms are called **allotropes**.
- Oxygen gas, O_2 and Ozone, O_3 are allotropes of the element oxygen.
- Diamond, Graphite, and Bucky Balls are all allotropes of carbon. Their different **arrangement of atoms** manifests in different physical properties.