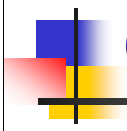


CHEM 1035 Lecture 5

Atomic Theory of Matter

Matter

Anything that has mass and occupies volume.

- This is virtually everything
- But is all matter the same?

Different types of Matter

- Elements
- Compounds
- Mixtures

The Fundamental Unit of Matter

Atom- the smallest unit beyond which elements cannot be divided

- Elements are made up of atoms of one type
- Compounds are made up of molecules, and molecules are combinations of:
  - A defined number of atoms bound to each other,
  - A defined proportion of each type of atom, and
  - A defined arrangement of the atoms

Conservation of Mass

Definition

The total mass of an isolated chemical system does not change during a Chemical Reaction.

Conservation of Mass

Matter can neither be created nor destroyed.

Law of Constant Composition

A pure compound is composed of elements in constant proportion by mass.

- **Mass Fraction** = The fraction of the total mass of a compound contributed by a particular element

- **Mass Percentage** = The mass fraction expressed as a percentage.

How do you determine?

How can you calculate the mass percentage from the mass fraction?

Example problem

- Magnesium Oxide (MgO) forms when the metal burns in air. If 1.25 g of MgO contains 0.754 g of Mg, what is the mass fraction Mg? of O?, How many grams of Mg are contained in 435 g of MgO?

Dalton's Atomic Theory

- All matter consists of atoms. Atoms are tiny indivisible particles of an element that can not be created nor destroyed.
- Atoms cannot be converted from on element to another
- All atoms of an element have identical mass and properties, and these are different from the atoms of another element
- Compounds result from the chemical combination of atoms in definite proportions

Dalton's Atomic Theory - 1808

- J. J. Thomson measures the mass/charge ratio of the "electron" in 1897
- Millikan determines the charge of the electron and is able to calculate the mass of an electron in 1909
- 1910, Rutherford discovers that matter is made up of mostly empty space occupied by electrons surrounding a small,dense, positively charged region that he called the nucleus

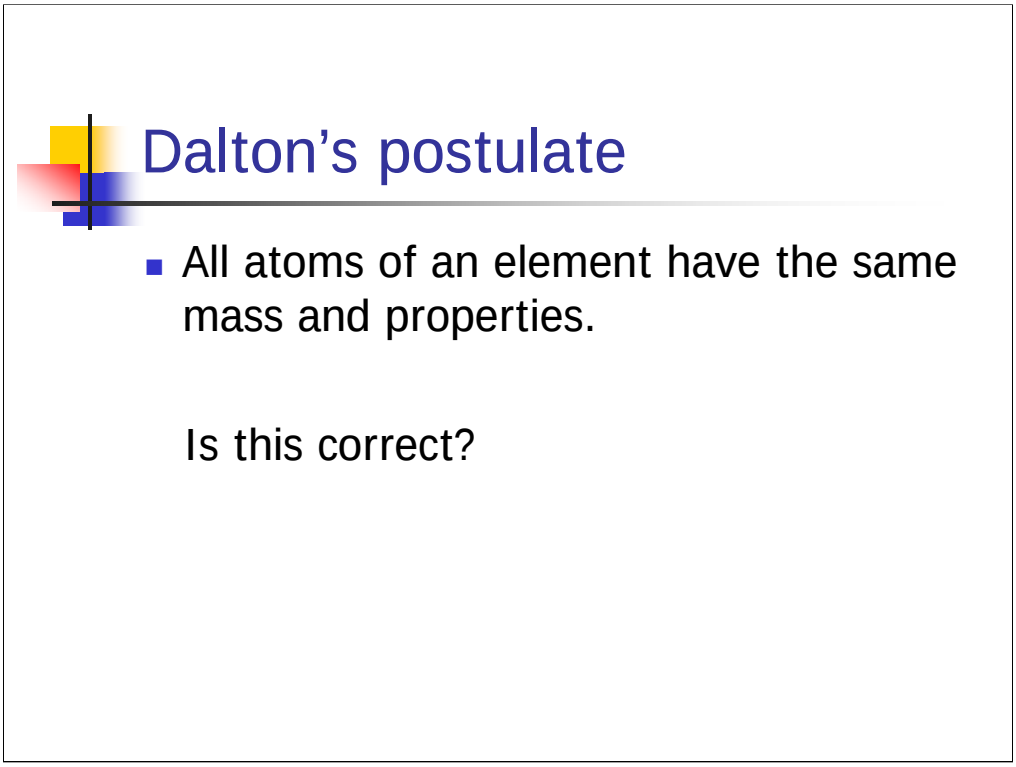
Atomic Structure

- Atoms are roughly spherical entities that have no net charge; are made up of charged electrons, protons, and uncharged neutrons.
- The electrons have a negative charge and move about in all of the available volume of the atom, but contribute very little of the total mass of the atom (< 0.03%).
- The nucleus is centrally located and is very massive and dense. It contributes only about $1/10^{13}$ of the total volume of the atom, but essentially all of the mass

Is this description fact? No, it is simply a model that is used to explain experimental observation. Note that this model is approximately 100 years old. Dalton put forward his model of Atomic Structure in 1808, and the key experiments that refuted his hypothesis were conducted approximately 100 years after the model was initially proposed.

Representation of Atomic Structure

Atoms are represented by this designation. The superscript (A) is representative of the Mass Number, The subscript (Z) is representative of the Atomic Number. The atomic number of an element is equal to the number of protons in an atom. Because all atoms in their native state are electrically neutral, the atomic number is also representative of the number of electrons in an atom. The mass number is representative of the total number of protons and neutrons present in the atoms nucleus. Why is this called the mass number? Because the majority of the mass of an atom is contained within the nucleus of the atom (e.g. contributed by the protons and neutrons). X is the atomic symbol for the element. The symbol is based on the name of the element (often the Latin or Greek name)



Yes and No. The mass number of an atom is determined primarily by the total number of protons and neutrons in the nucleus of the atom. All atoms of an elements have the same number of protons, that is what makes each element unique. However, different atoms of the same element may have different numbers of neutrons. The neutrons contribute mass, but they do not have an impact on the chemical properties of an element. Atoms with the same atomic number, but different mass numbers are known as Isotopes.

Examples of isotopes. Hydrogen and Deuterium. Chlorine-35 and Chlorine-37. Carbon-12 and Carbon-14. U-235 and U-238

Mass of Atoms

Very careful measurements over history have shown that:

A proton has a mass of 1.673×10^{-27} kg

A neutron has a mass of 1.675×10^{-27} kg

An electron has a mass of 9.109×10^{-31} kg

What is the mass of a Hydrogen atom? 1.674×10^{-27} kg

The kg (the SI unit for mass) is not a very convenient unit for representing the mass of an atom. Define a new unit – the Atomic Mass Unit (amu), more recently the amu has been renamed to the Dalton

Dalton

The unit “Dalton” is a relative mass that is defined using ^{12}C as an atomic mass standard. ^{12}C as the atomic mass standard is defined as having a mass of exactly 12 Daltons (amu’s). Therefore, 1 Dalton is defined as being equal to exactly 1/12 the mass of ^{12}C